

# THE HYPANIS FLUVIAL-DELTAIC-LACUSTRINE SYSTEM IN XANTHE TERRA

Workshop Abstract #1051

Sabrina Delta

Hypanis Delta

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CTX

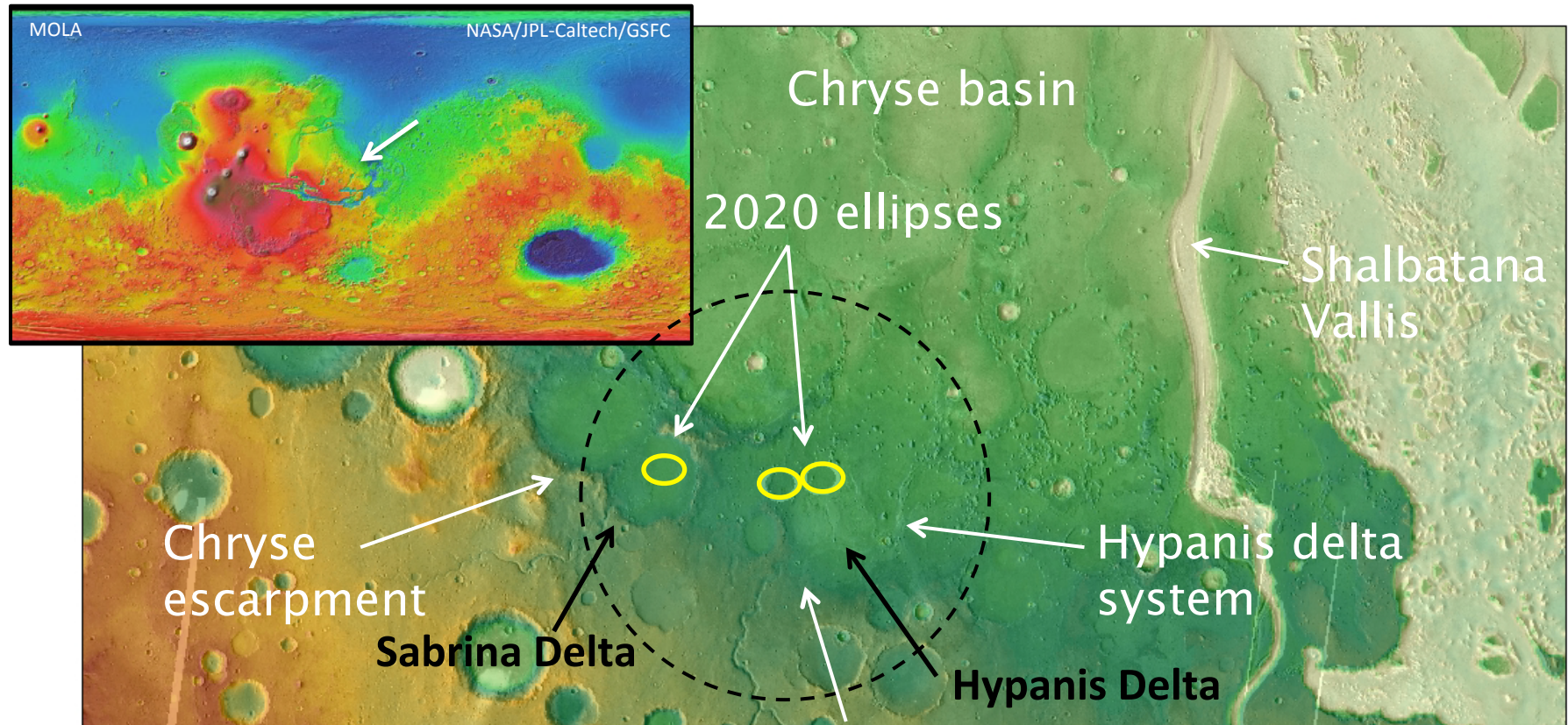
NASA/JPL-Caltech/MSSS

50 km

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# MOLA Topography: Overview location of Hypanis system in Xanthe Terra



## A delta at the edge of a Chryse sea?





SROI 12

SROI 9

SROI 11

SROI 10

RROI 1

RROI 2

SROI 5

RROI 3

SROI 7

SROI 8

# Exploration Zone Map

Lederberg

| SROI | Latitude (°N)* | Longitude (°E)* | Altitude (km) | Dist. (km)** | Description    |
|------|----------------|-----------------|---------------|--------------|----------------|
| 1    | 11.523         | 314.772         | -2.695        | 5            | Delta main     |
| 2    | 11.940         | 314.978         | -2.700        | 30           | Delta lobe     |
| 3    | 11.977         | 315.444         | -2.729        | 53           | Delta finger 1 |
| 4    | 11.699         | 315.708         | -2.664        | 51           | Delta finger 2 |
| 5    | 11.741         | 313.173         | -2.553        | 62           | Sabrina        |
| 6    | 11.160         | 314.342         | -2.428        | 27           | Channel 1      |
| 7    | 10.852         | 314.108         | -2.318        | 57           | Channel 2      |
| 8    | 10.634         | 313.994         | -2.236        | 68           | Channel 3      |
| 9    | 12.740         | 314.461         | -2.945        | 51           | Volcanic cones |
| 10   | 12.231         | 314.232         | -2.634        | 21           | L. Rim 1       |
| 11   | 12.529         | 314.653         | -2.826        | 38           | L. Rim 2       |
| 12   | 13.296         | 314.864         | -3.030        | 92           | Bedrock 1      |
| 13   | 10.624         | 314.841         | -2.331        | 70           | Bedrock 2      |
| 14   | 12.424         | 315.687         | -2.865        | 76           | Ejecta contact |

\*Approx. coord. of center; \*\* Approx. line of sight distance from Field Station.

Hypanis  
Vallis

50 km

SROI 14

SROI 3

SROI 2

SROI 4

SROI 1

SROI 6

SROI 13



Geologic map by Peter Fawdon

**Map Key**  
Delta/channel units  
Plains material  
Crater rim/highlands  
Rounded buttes  
Crater ejecta

SROI 12

SROI 9

SROI 11

SROI 10

RROI 1

RROI 2

SROI 5

RROI 3

SROI 7

SROI 8

Lederberg

(11.7°N, 314.7°E, -2.7km)

Landing Site

ISRU Site

Magong

Sabrina Delta

Hypanis Delta

Hypanis Vallis

SROI 14

SROI 3

SROI 2

SROI 4

SROI 1

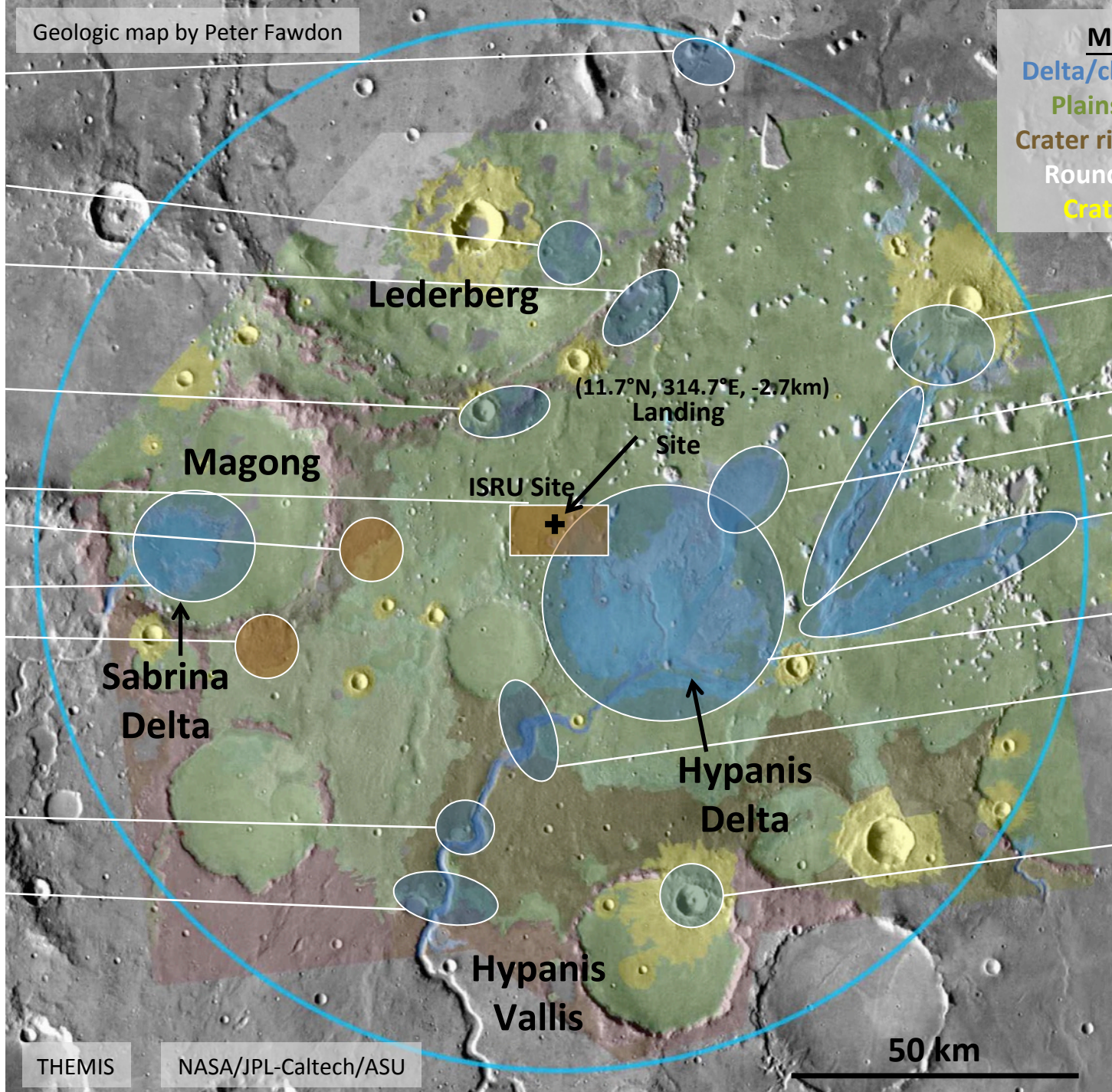
SROI 6

SROI 13

THEMIS

NASA/JPL-Caltech/ASU

50 km





# Science ROIs Rubric

1<sup>st</sup>EZ Workshop for Human Missions to Mars



| Site Factors          |                     |            |        | SROI1                                                 | SROI2 | SROI3 | SROI4 | SROI5 | iROI6 | iROI7 | iROI8 | iROI9 | ROI10 | ROI11 | SROI12 | SROI13 | SROI14 | EZ SUM |
|-----------------------|---------------------|------------|--------|-------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|
| Science Site Criteria | Astrobio            | Threshold  | AND/OR | Potential for past habitability                       | ●     | ●     | ●     | ●     | ●     |       |       |       |       |       |        |        | ?      | 8,1    |
|                       |                     |            |        | Potential for present habitability/refugia            |       |       |       |       |       |       |       |       |       |       |        |        |        | 0,0    |
|                       |                     | Qualifying |        | Potential for organic matter, w/ surface exposure     | ●     |       |       |       |       |       |       |       |       |       |        |        |        | 9,1    |
|                       | Atmospheric Science | Threshold  |        | Noachian/Hesperian rocks w/ trapped atmospheric gases |       |       |       |       |       |       |       |       |       |       |        |        |        | 2,1    |
|                       |                     | Qualifying |        | Meteorological diversity in space and time            | ●     |       |       |       |       |       |       |       |       |       |        |        |        | 6,2    |
|                       |                     |            |        | High likelihood of surface-atmosphere exchange        | ●     |       |       |       |       |       |       |       |       |       |        |        |        | 14,0   |
|                       |                     |            |        | Amazonian subsurface or high-latitude ice or sediment |       |       |       |       |       |       |       |       |       |       |        |        |        | 0,0    |
|                       |                     |            |        | High likelihood of active trace gas sources           | ?     |       |       |       |       |       |       |       |       |       |        |        |        | 0,0    |
|                       | Geoscience          | Threshold  |        | Range of martian geologic time; datable surfaces      |       |       |       |       |       |       |       |       |       |       |        |        |        | 14,0   |
|                       |                     |            |        | Evidence of aqueous processes                         | ●     |       |       |       |       |       |       |       |       |       |        |        |        | 10,3   |
|                       |                     |            |        | Potential for interpreting relative ages              | ●     |       |       |       |       |       |       |       |       |       |        |        |        | 13,1   |
|                       |                     | Qualifying |        | Igneous Rocks tied to 1+ provinces or different times | ○     |       |       |       |       |       |       |       |       |       |        |        |        |        |
|                       |                     |            |        | Near-surface ice, glacial or permafrost               |       |       |       |       |       |       |       |       |       |       |        |        |        |        |
|                       |                     |            |        | Noachian or pre-Noachian bedrock units                |       |       |       |       |       |       |       |       |       |       |        |        |        |        |
|                       |                     |            |        | Outcrops with remnant magnetization                   |       |       |       |       |       |       |       |       |       |       |        |        |        |        |
|                       |                     |            |        | Primary, secondary, and basin-forming impact deposits | ●     |       |       |       |       |       |       |       |       |       |        |        |        |        |
|                       |                     |            |        | Structural features with regional or global context   |       |       |       |       |       |       |       |       |       |       |        |        |        |        |
|                       |                     |            |        | Diversity of aeolian sediments and/or landforms       | ●     |       |       |       |       |       |       |       |       |       |        |        |        |        |

## Key Points

- **GREAT** environment [Summons et al., 2011] for organic formation, concentration, and preservation
- Both Noachian bedrock and Hesperian units
- Clear evidence of aqueous activity
- Addresses major global question: **Was there a Chryse Sea?!**

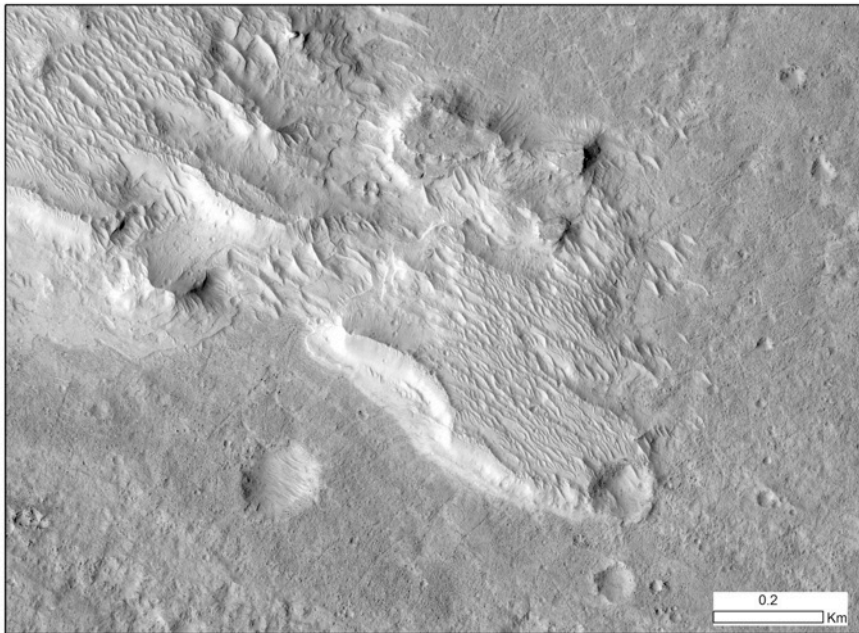


# Science ROIs 1-4,6-7

1<sup>st</sup> EZ Workshop for Human Missions to Mars



## Image of SROI 1



HiRISE: ESP\_037651\_1920

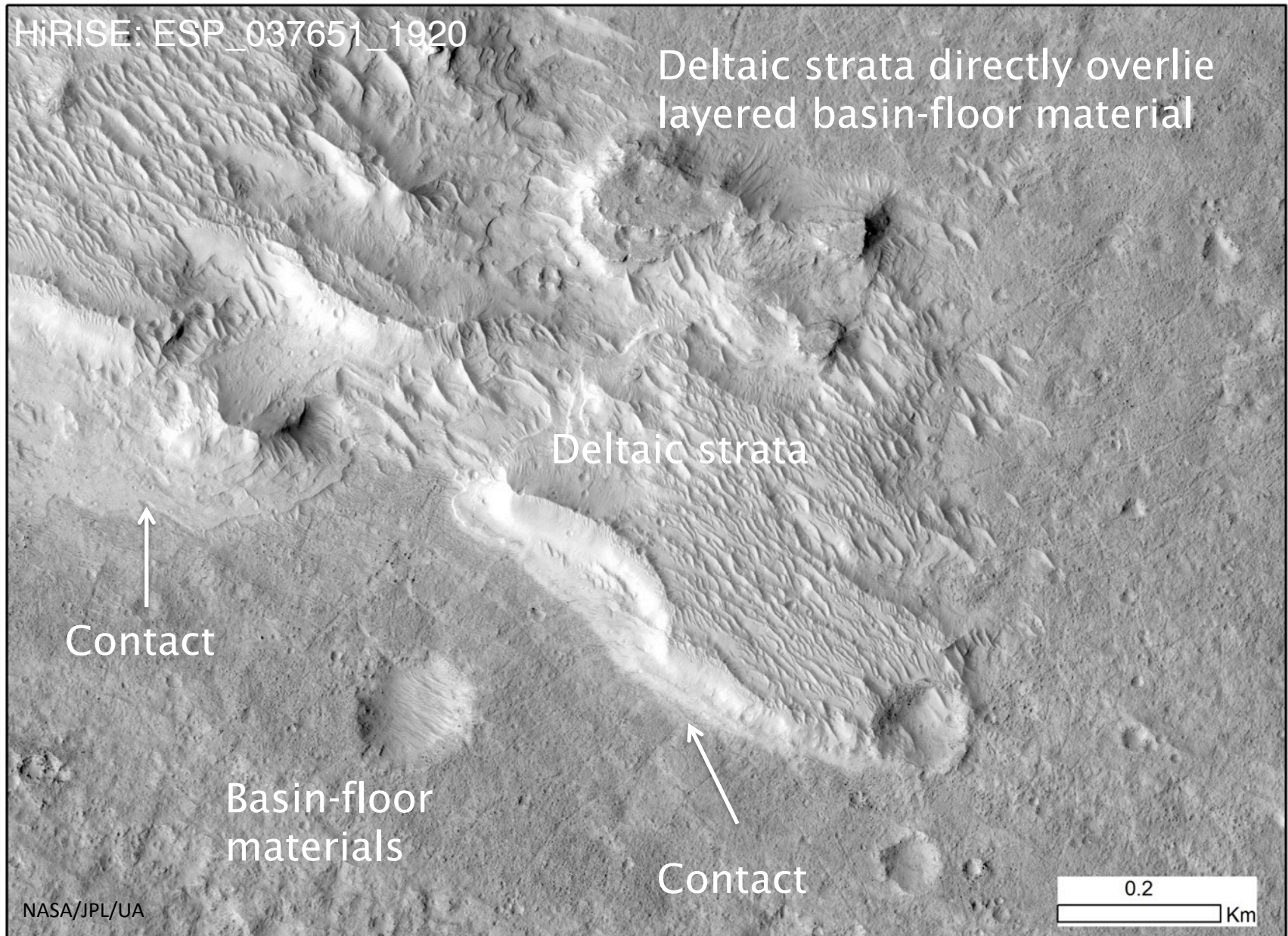
NASA/JPL/UA

### Hypanis Delta and Inverted Fluvial Channels

- Delta main: 11.5°N, 314.8°E, -2.7 km
- Layered sedimentary strata in lobes of Hypanis delta and in inverted channel complexes
- Threshold:
  - Potential for past habitability
  - Clear evidence for aqueous processes
  - Identifiable stratigraphic contacts
  - Outcrop units with a range of ages
- Qualifying:
  - Access to deposits with potential for containing organic matter



# SROI 1 Hypanis Deltaic strata

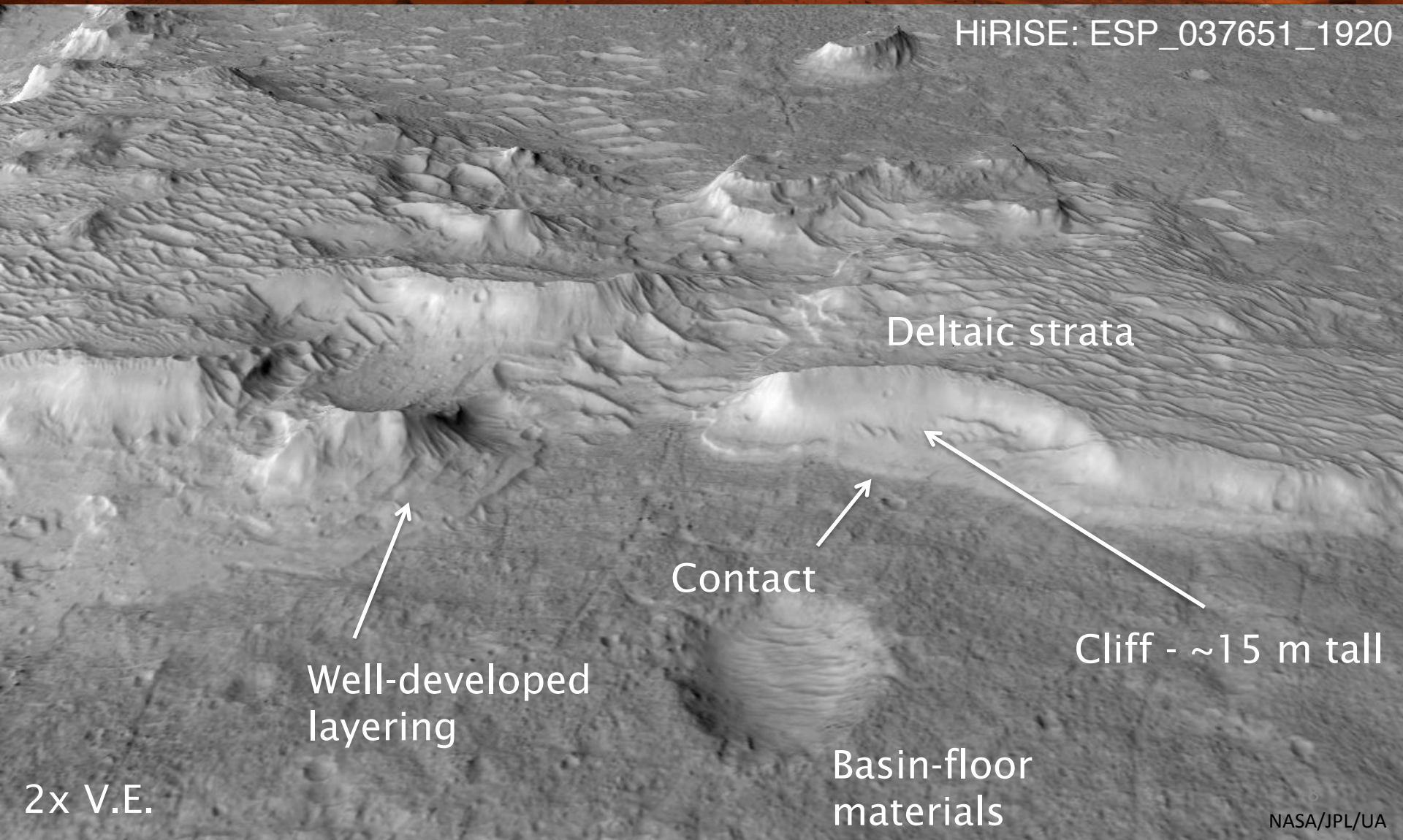




# Perspective view of SROI 1



HiRISE: ESP\_037651\_1920



2x V.E.

Well-developed  
layering

Contact

Deltaic strata

Cliff - ~15 m tall

Basin-floor  
materials



# SROI 1 Hypanis Deltaic strata



HiRISE: ESP\_036277\_1920

Deltaic strata directly overlie  
layered basin-floor material

Contact



Deltaic strata

Basin-floor -  
lacustrine  
strata?

Contact



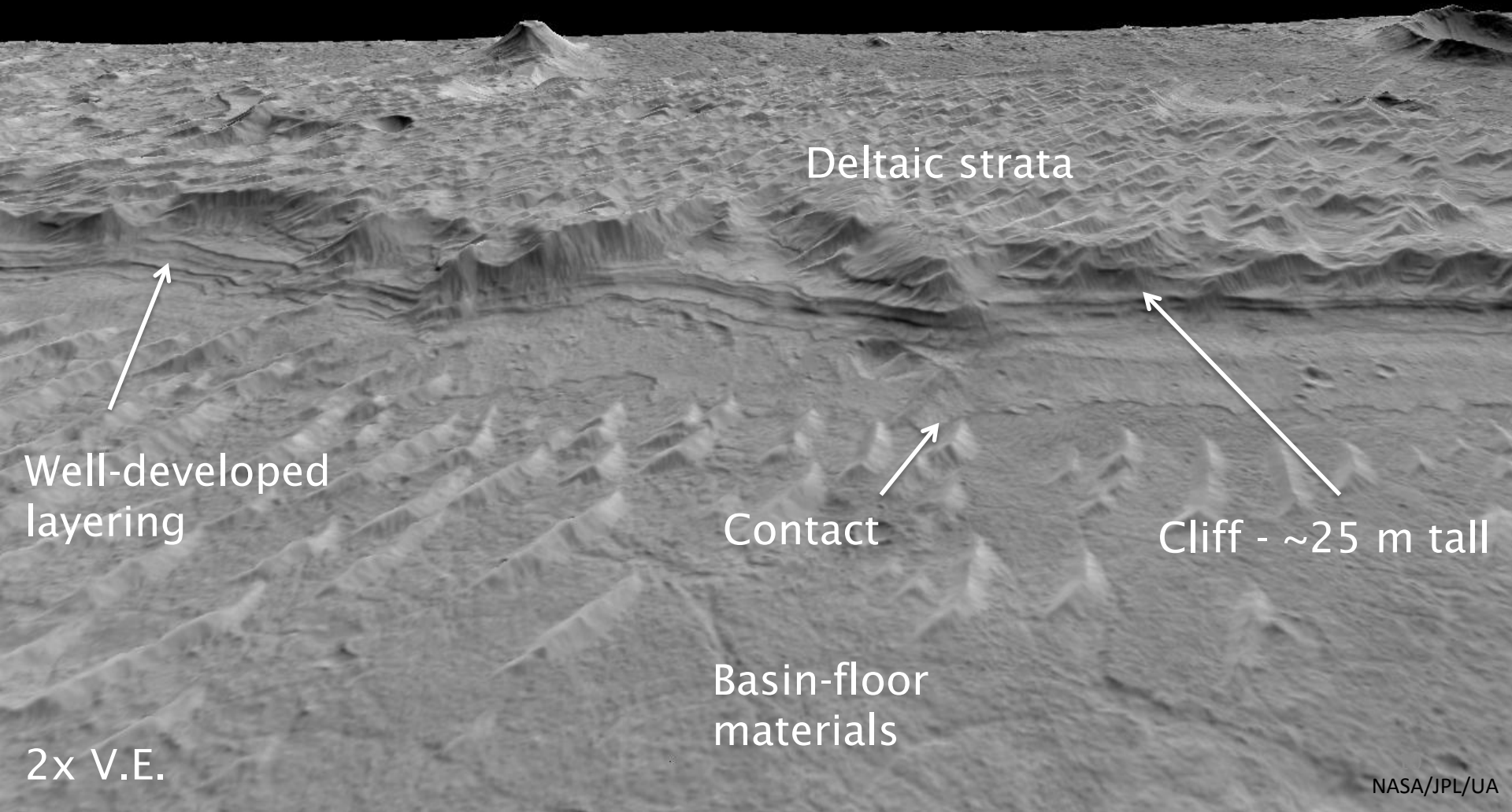
Well-developed  
sedimentary  
layering





# Perspective view of SROI 1

HiRISE: ESP\_036277\_1920



Well-developed  
layering

Deltaic strata

Contact

Cliff - ~25 m tall

Basin-floor  
materials

2x V.E.



# Science ROIs 1-4,6-7

1<sup>st</sup> EZ Workshop for Human Missions to Mars



## Image of SROI 2

### Hypanis Delta

- Prominent lobe: 11.9°N, 314.9°E, -2.7 km
- Layered sedimentary strata in lobes of Hypanis delta and in inverted channel complexes
- Threshold:
  - Potential for past habitability
  - Clear evidence for aqueous processes
  - Identifiable stratigraphic contacts
  - Outcrop units with a range of ages
- Qualifying:
  - Access to deposits with potential for containing organic matter

Delta lobe

Prominent  
feeder channel

2.5 km

HiRISE: ESP\_03494\_1920

NASA/JPL/UA



# Perspective view of SROI 2



HiRISE: ESP\_03494\_1920

Deltaic strata

Contact

Cliff - ~40 m tall

Well-developed  
layering

Abundant  
TARs

Basin-floor  
materials

2x V.E.



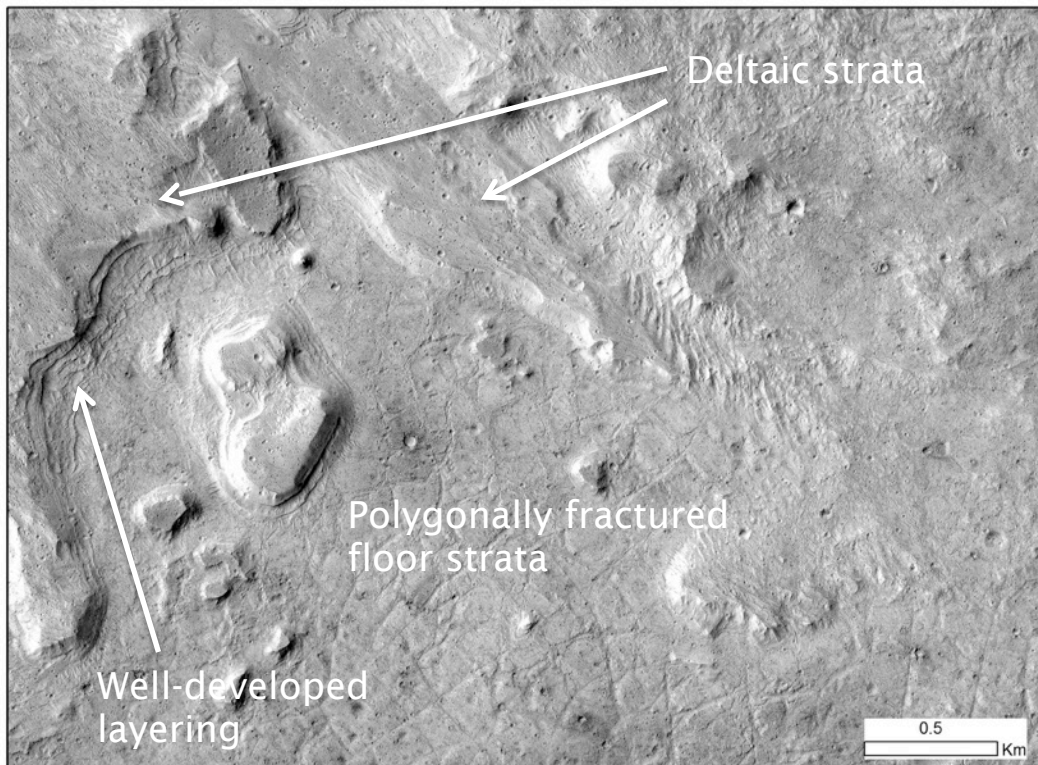
# Science ROI 5

1<sup>st</sup> EZ Workshop for Human Missions to Mars



## Image of SROI 5

### Sabrina Delta



- 11.7°N, 313.1°E, -2.5 km
- Layered sedimentary strata in lobes of Hypanis delta and in inverted channel complexes
- Threshold:
  - Potential for past habitability
  - Clear evidence for aqueous processes
  - Identifiable stratigraphic contacts
  - Outcrop units with a range of ages
- Qualifying:
  - Access to deposits with potential for containing organic matter

HiRISE: ESP\_026601\_1920



# Perspective view of SROI 5



HiRISE: ESP\_026601\_1920

Deltaic strata

Contact

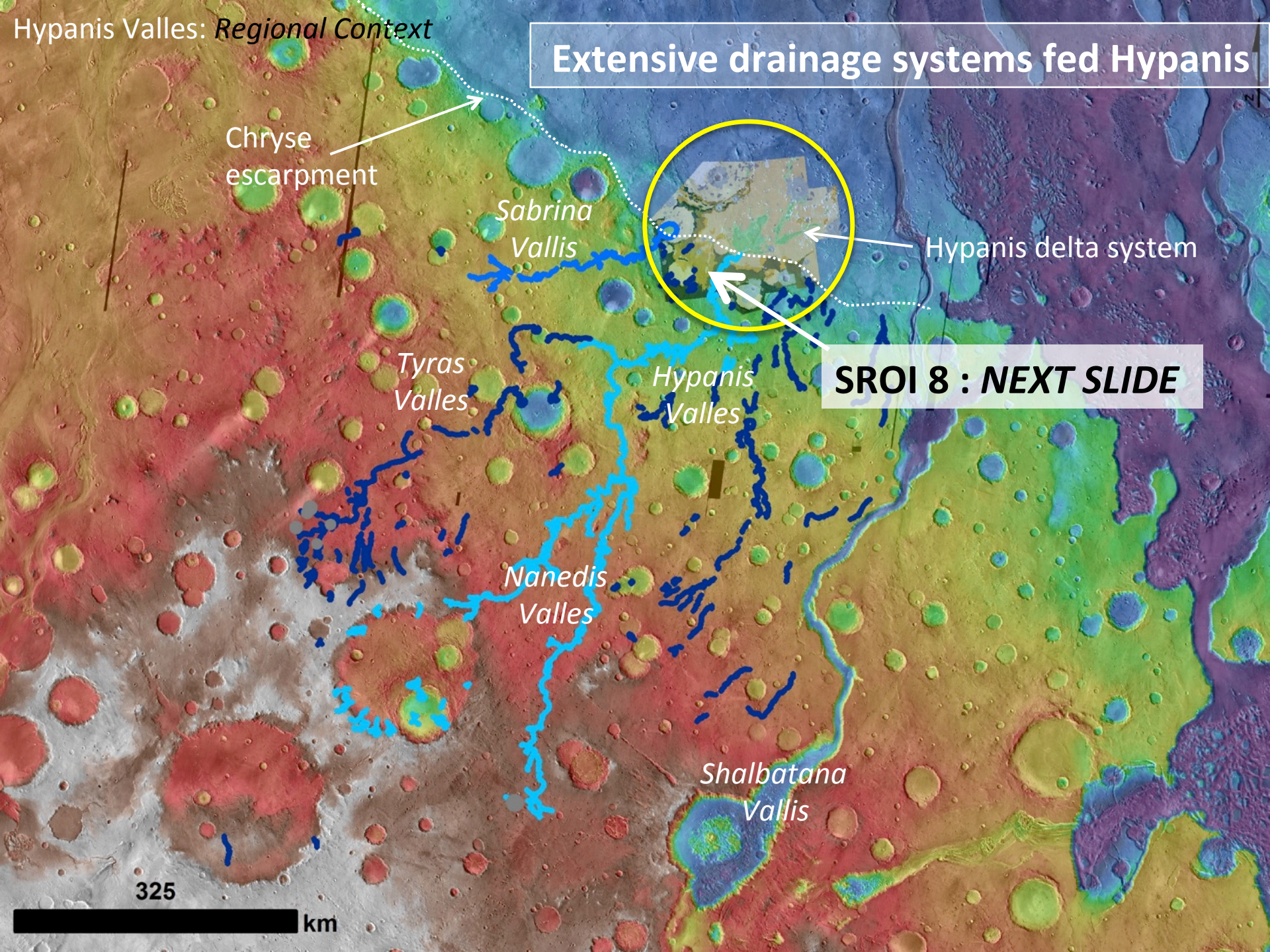
Cliff - ~30 m tall

Well-developed  
layering

Polygonally  
fractured basin-  
floor materials

2x V.E.





Hypanis Valles: *Regional Context*

Extensive drainage systems fed Hypanis

Chryse  
escarpment

Sabrina  
Vallis

Hypanis delta system

Tyras  
Valles

Hypanis  
Valles

SROI 8 : NEXT SLIDE

Nanedis  
Valles

Shalbatana  
Vallis

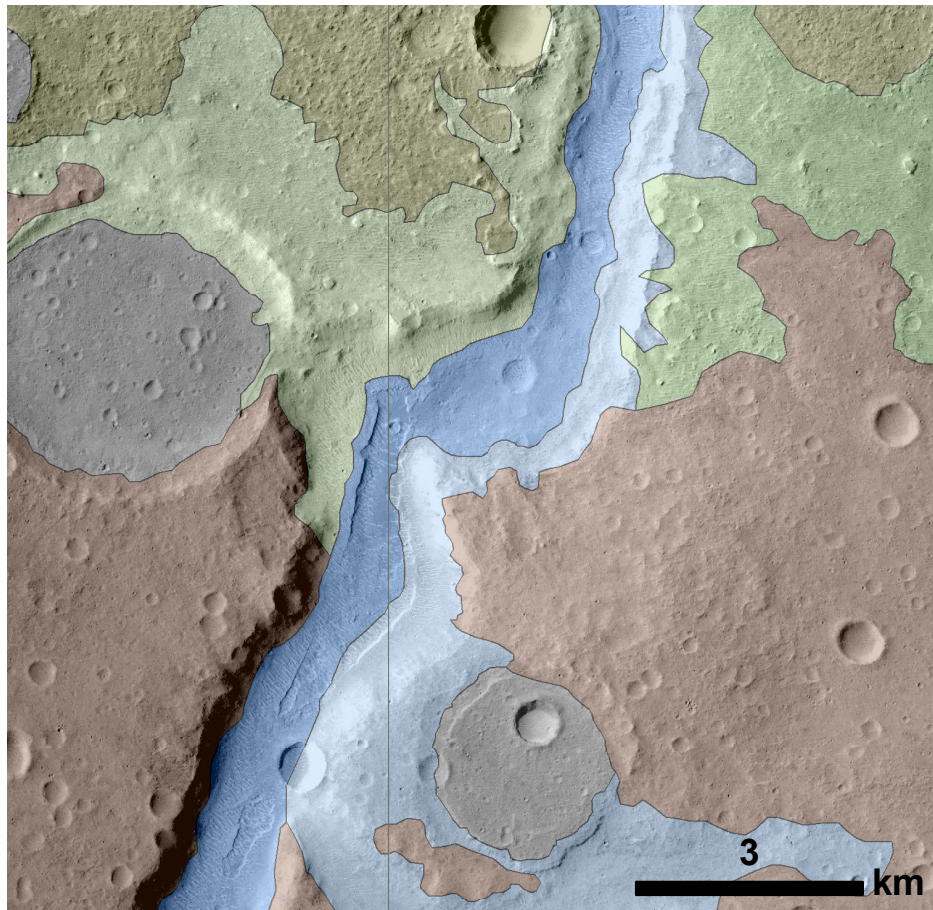
325

km



# Science ROI 8

1<sup>st</sup> EZ Workshop for Human Missions to Mars



## Channel Contact on Dichotomy Boundary

- 10.6°N, 313.9°E, -2.2 km
- Hypanis Valles channel exposes stratigraphy along the Martian Dichotomy Boundary
- Threshold:
  - Identifiable stratigraphic contacts
  - Range of datable surfaces (Noachian and Hesperian plains units)
- Qualifying:
  - Evidence of aqueous activity
  - Exposed Noachian bedrock

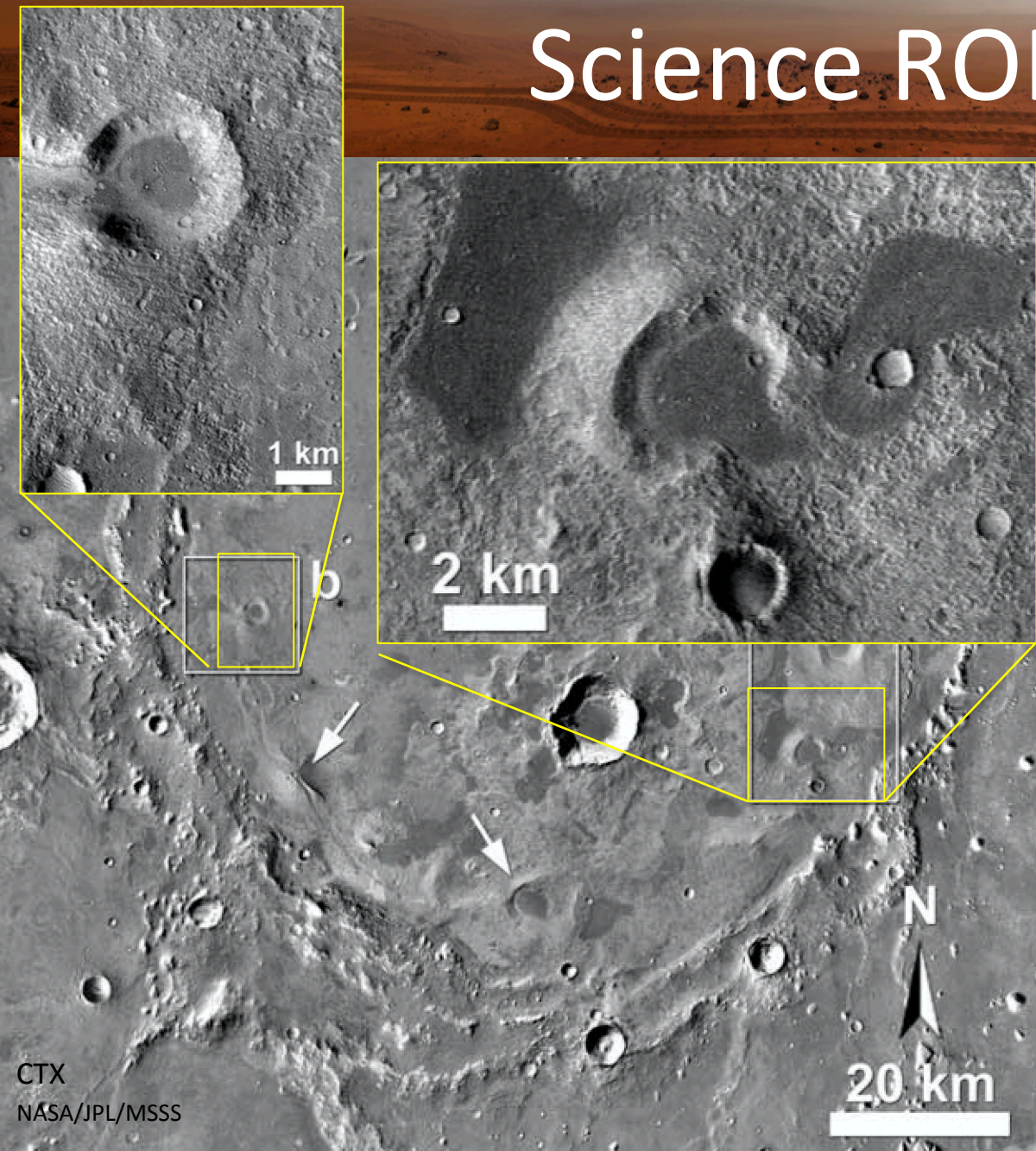


# Science ROI 9

1<sup>st</sup> EZ Workshop for Human Missions to Mars

## Possible Hydrovolcanic Features

- 11.7°N, 314.4°E, -2.5 km
- Conical landforms in Ledeborg Crater hypothesized to be tuff cones by Brož & Hauber (2013)
- Threshold:
  - Evidence of aqueous activity
  - Stratigraphic context Ledeborg and other units
- Qualifying:
  - Potential Hesperian igneous materials



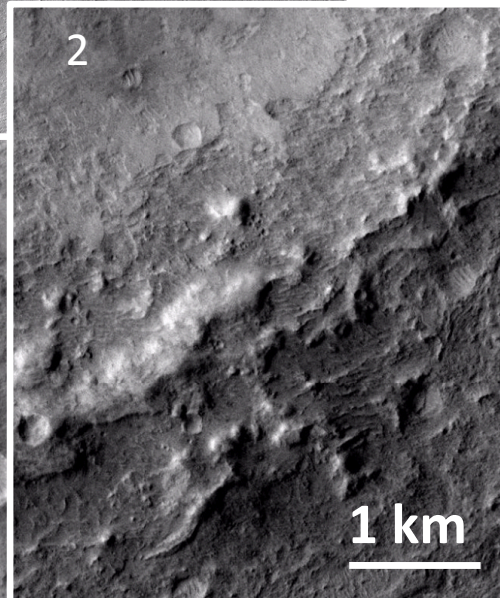
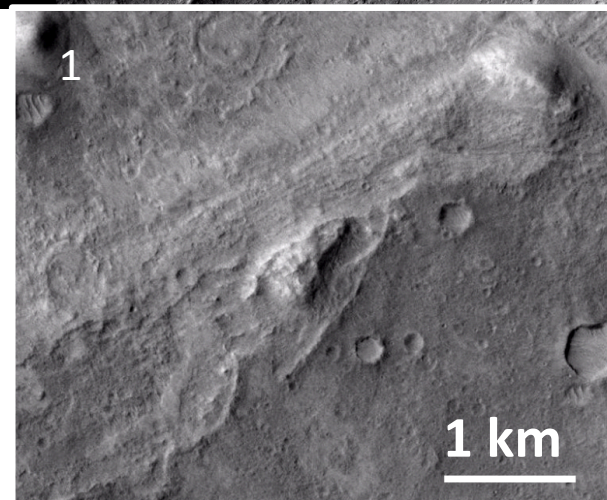
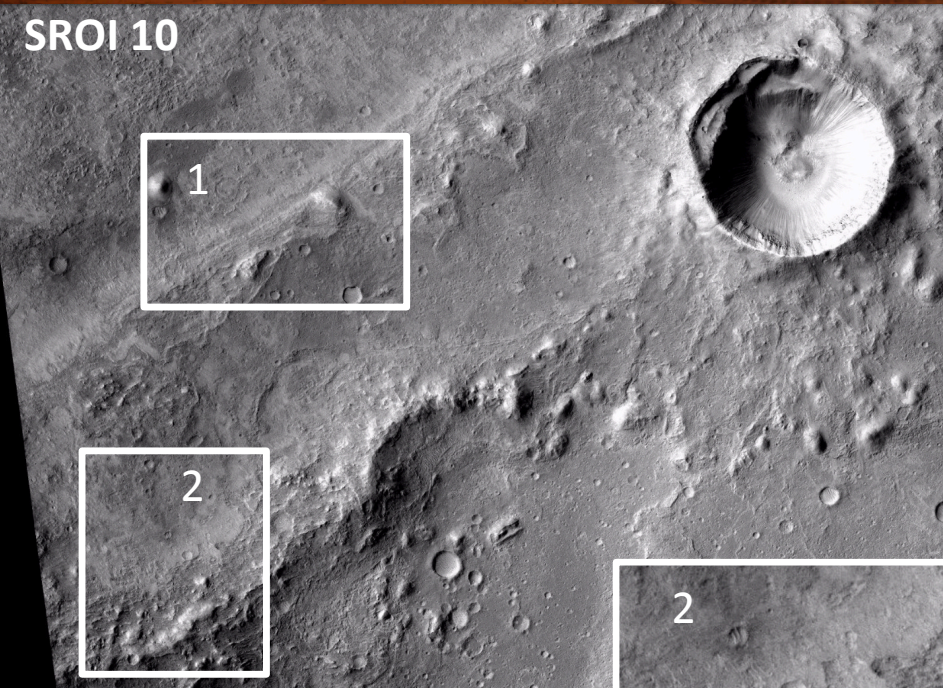


# Science ROIs 10-12



1<sup>st</sup> EZ Workshop for Human Missions to Mars

## SROI 10



## Lederberg Rim Outcrops

- SROI 10: 12.2°N, 314.2°E, -2.6 km
- SROI 11: 12.6°N, 314.6°E, h -2.8 km
- SROI 12: 13.3°N, 314.8°E, h -3.0 km
- Noachian bedrock exposed in crater rim
- Multiple units with some indication of layering
- Threshold:
  - Identifiable stratigraphic contacts
  - Potential for trapped gases in impact melts
- Qualifying:
  - Fresh impact structures
  - Exposed Noachian bedrock

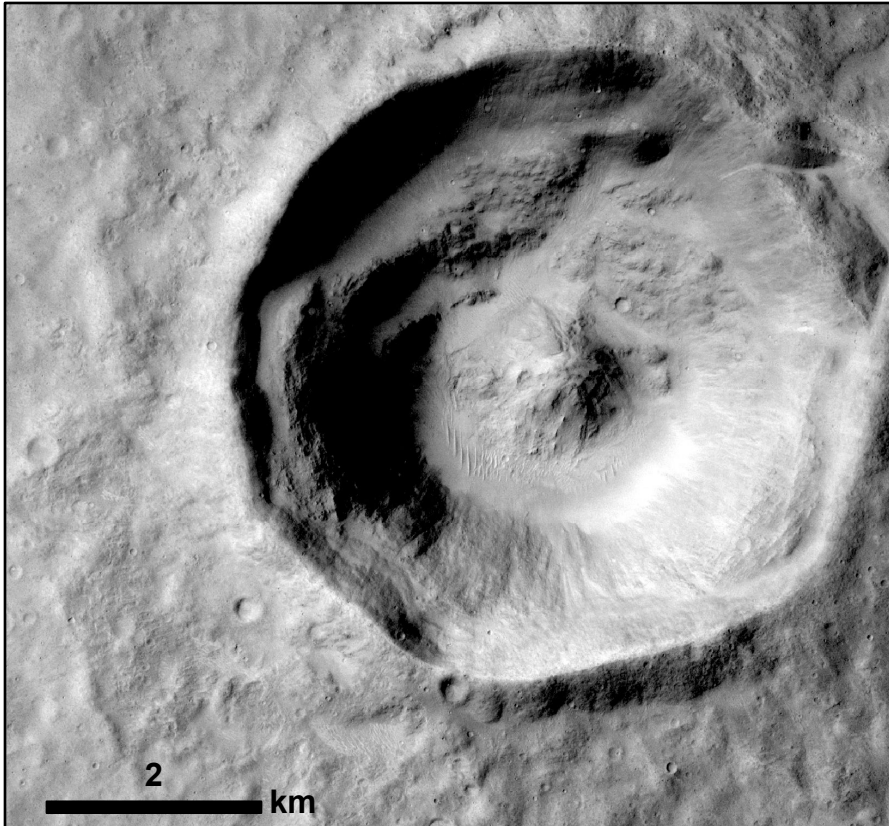


# Science ROIs 13-14

1<sup>st</sup> EZ Workshop for Human Missions to Mars



## SROI 13: Fresh Crater



## Craters and Ejecta

- SROI 13: 10.6°N, 314.8°E, -2.3km
- SROI 14: 12.4°N, 315.7°E, -2.8km
- Threshold:
  - Identifiable stratigraphic contacts between multiple EZ units
  - Potential for trapped gases in impact melts
- Qualifying:
  - Fresh impact structure
  - Exposed Noachian bedrock

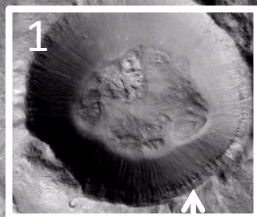


## SROI 14: Fresh Crater and Ejecta Contacts

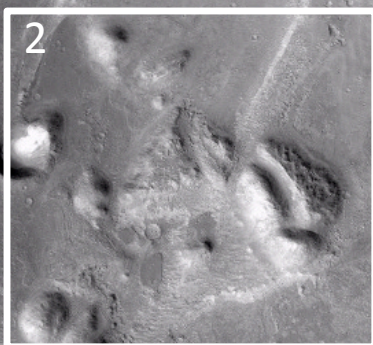
CTX: B09\_013296\_1920\_XI\_12N044W

NASA/JPL/MSSS

Delta unit →  
continues



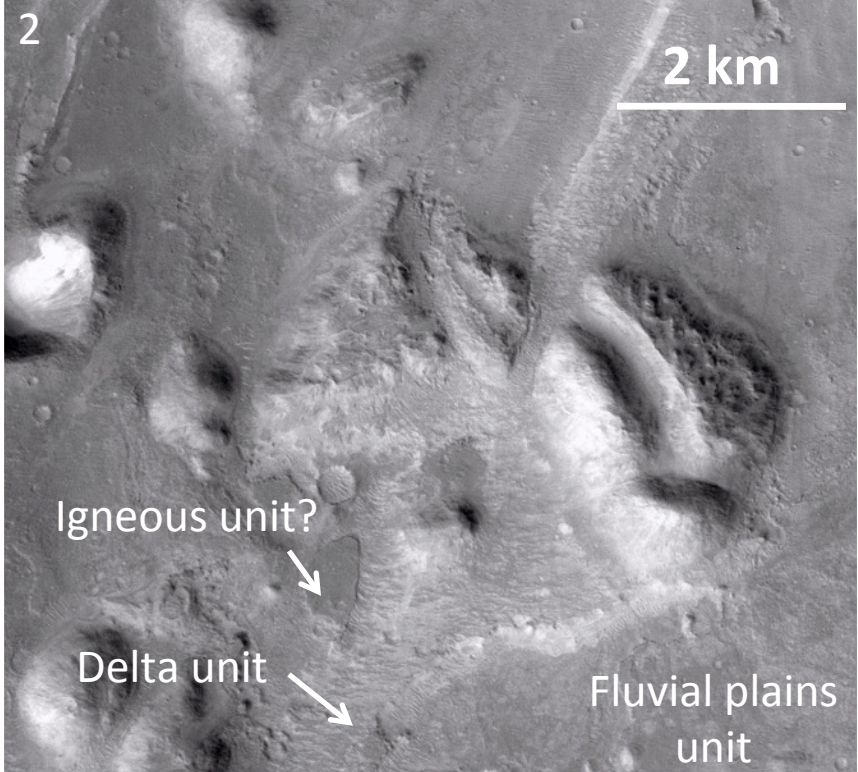
Bedrock layer in  
crater wall



To SROI 3 and  
Hypanis delta

5 km

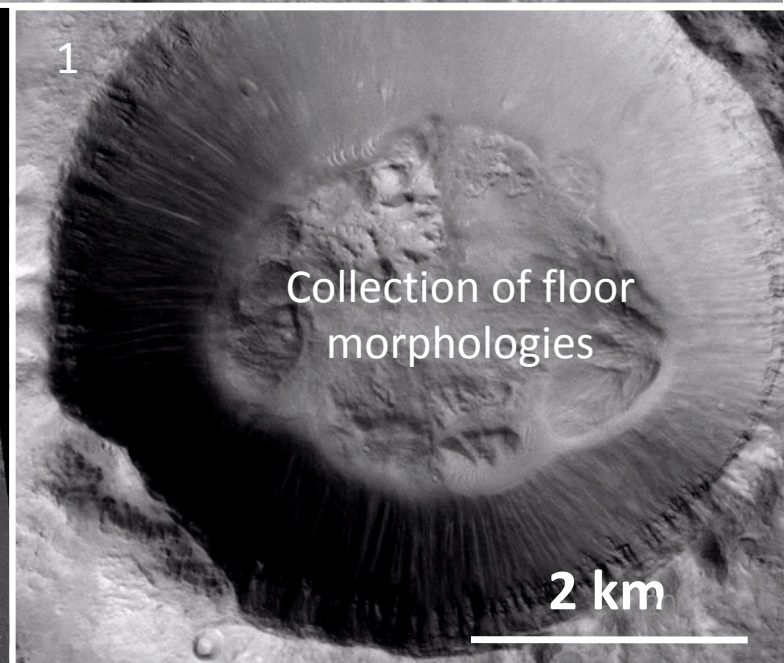
Erosion of  
ejecta lobe



Igneous unit?

Delta unit

Fluvial plains  
unit



Collection of floor  
morphologies

2 km



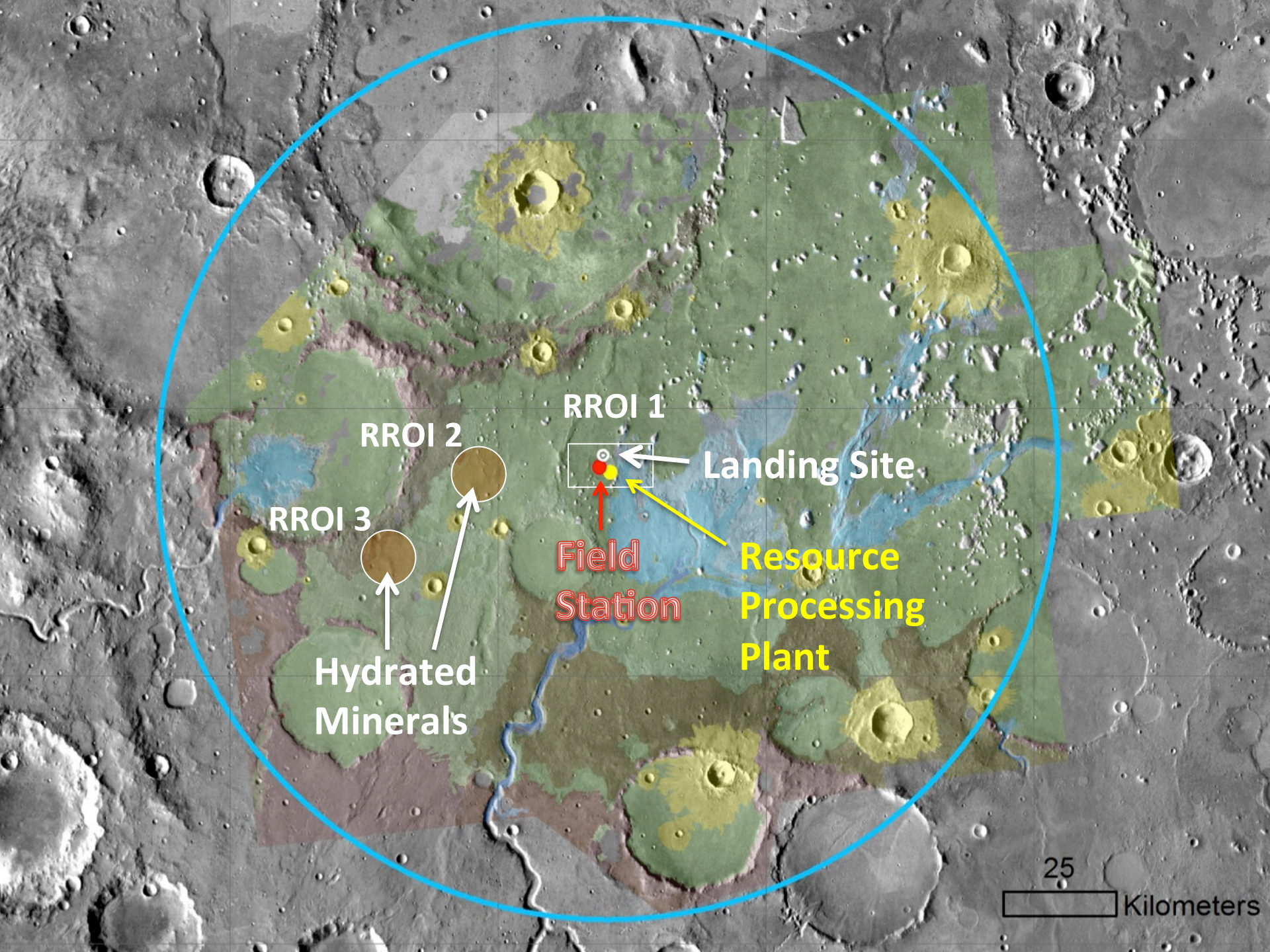
# Resource ROIs Rubric

1<sup>st</sup>EZ Workshop for Human Missions to Mars

| Site Factors                        |                              |            |                                                                                      | RROI1                                 | RROI2 | RROI3 | EZ SUM |     |
|-------------------------------------|------------------------------|------------|--------------------------------------------------------------------------------------|---------------------------------------|-------|-------|--------|-----|
| ISRU and Civil Engineering Criteria | Engineering                  |            | Meets First Order Criteria (Latitude, Elevation, Thermal Inertia)                    |                                       | ●     | ●     | ●      | 3,3 |
|                                     | Water Resource               | Threshold  | AND/<br>OR                                                                           | Potential for ice or ice/regolith mix |       |       |        | 0,0 |
|                                     |                              |            | Potential for hydrated minerals                                                      | ●                                     | ●     | ●     | 3,3    |     |
|                                     |                              |            | Quantity for substantial production                                                  | ●                                     | ●     | ●     | 3,3    |     |
|                                     |                              |            | Potential to be minable by highly automated systems                                  | ●                                     | ●     | ●     | 3,3    |     |
|                                     |                              |            | Located less than 3 km from processing equipment site                                | ●                                     | ●     | ●     | 3,3    |     |
|                                     |                              |            | Located no more than 3 meters below the surface                                      | ●                                     | ●     | ●     | 3,3    |     |
|                                     |                              |            | Accessible by automated systems                                                      | ●                                     | ●     | ●     | 3,3    |     |
|                                     |                              | Qualifying | Potential for multiple sources of ice, ice/regolith mix <b>and</b> hydrated minerals |                                       |       |       |        | 0,0 |
|                                     |                              |            | Distance to resource location can be >5 km                                           |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Route to resource location must be (plausibly) traversable                           |                                       | ●     | ●     | ●      | 3,3 |
|                                     | Civil Engineering            | Threshold  | ~50 sq km region of flat and stable terrain with sparse rock distribution            |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | 1–10 km length scale: <10°                                                           |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Located within 5 km of landing site location                                         |                                       | ●     |       |        | 1,0 |
|                                     |                              | Qualifying | Located in the northern hemisphere                                                   |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Evidence of abundant cobble sized or smaller rocks and bulk, loose regolith          |                                       | ●     |       |        | 1,0 |
|                                     | Utilitarian terrain features |            | ●                                                                                    |                                       |       | 1,0   |        |     |
|                                     | Food Production              | Qualifying | Low latitude                                                                         |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | No local terrain feature(s) that could shadow light collection facilities            |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Access to water                                                                      |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Access to dark, minimally altered basaltic sands                                     |                                       | ●     |       |        | 1,0 |
|                                     | Metal/Silicon Resource       | Threshold  | Potential for metal/silicon                                                          |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Potential to be minable by highly automated systems                                  |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Located less than 3 km from processing equipment site                                |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Located no more than 3 meters below the surface                                      |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              |            | Accessible by automated systems                                                      |                                       | ●     | ●     | ●      | 3,3 |
|                                     |                              | Qualifying | Potential for multiple sources of metals/silicon                                     |                                       | ●     |       |        | 1,0 |
|                                     |                              |            | Distance to resource location can be >5 km                                           |                                       |       |       |        | 0,0 |
|                                     |                              |            | Route to resource location must be (plausibly) traversable                           |                                       | ●     | ●     | ●      | 3,3 |

| Key |                            |
|-----|----------------------------|
| ●   | Yes                        |
| ○   | Partial Support or Debated |
|     | No                         |
| ?   | Indeterminate              |



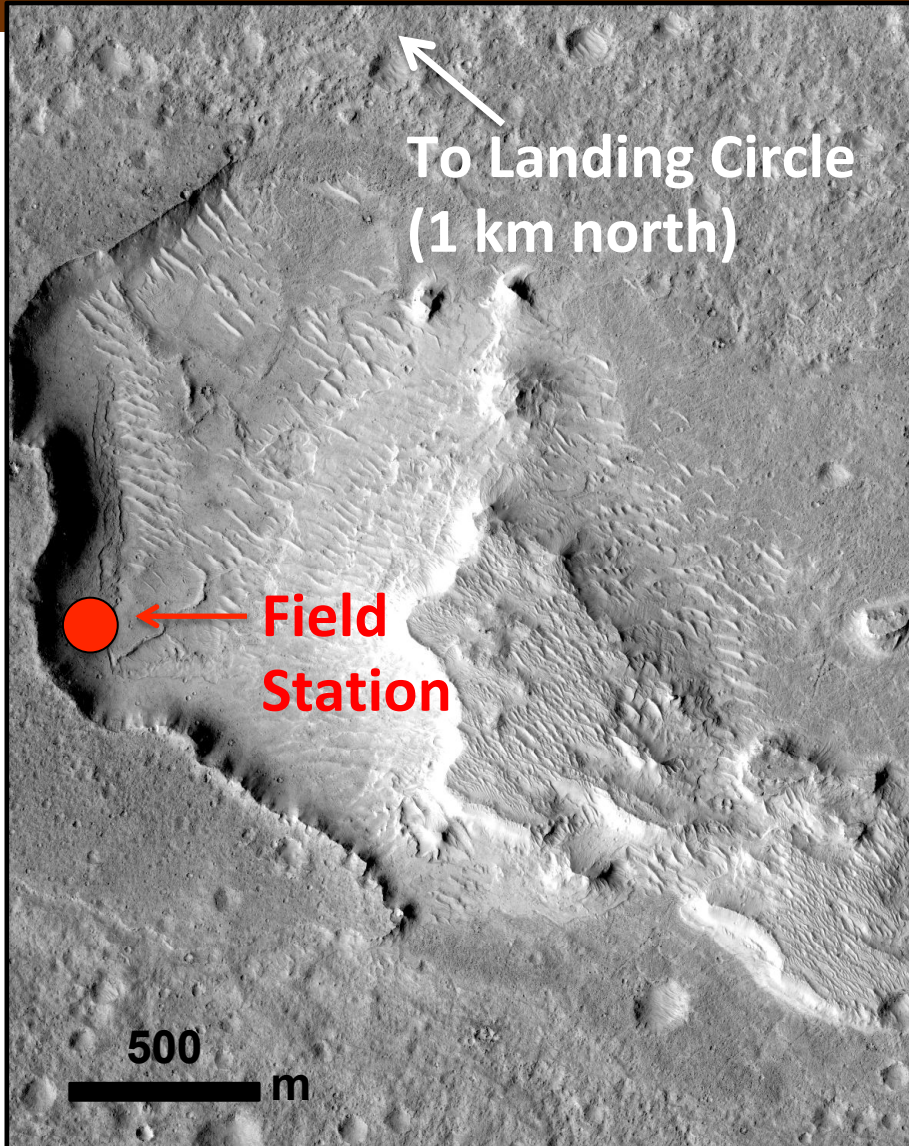




# Resource ROI 1



s to Mars



## Field Station

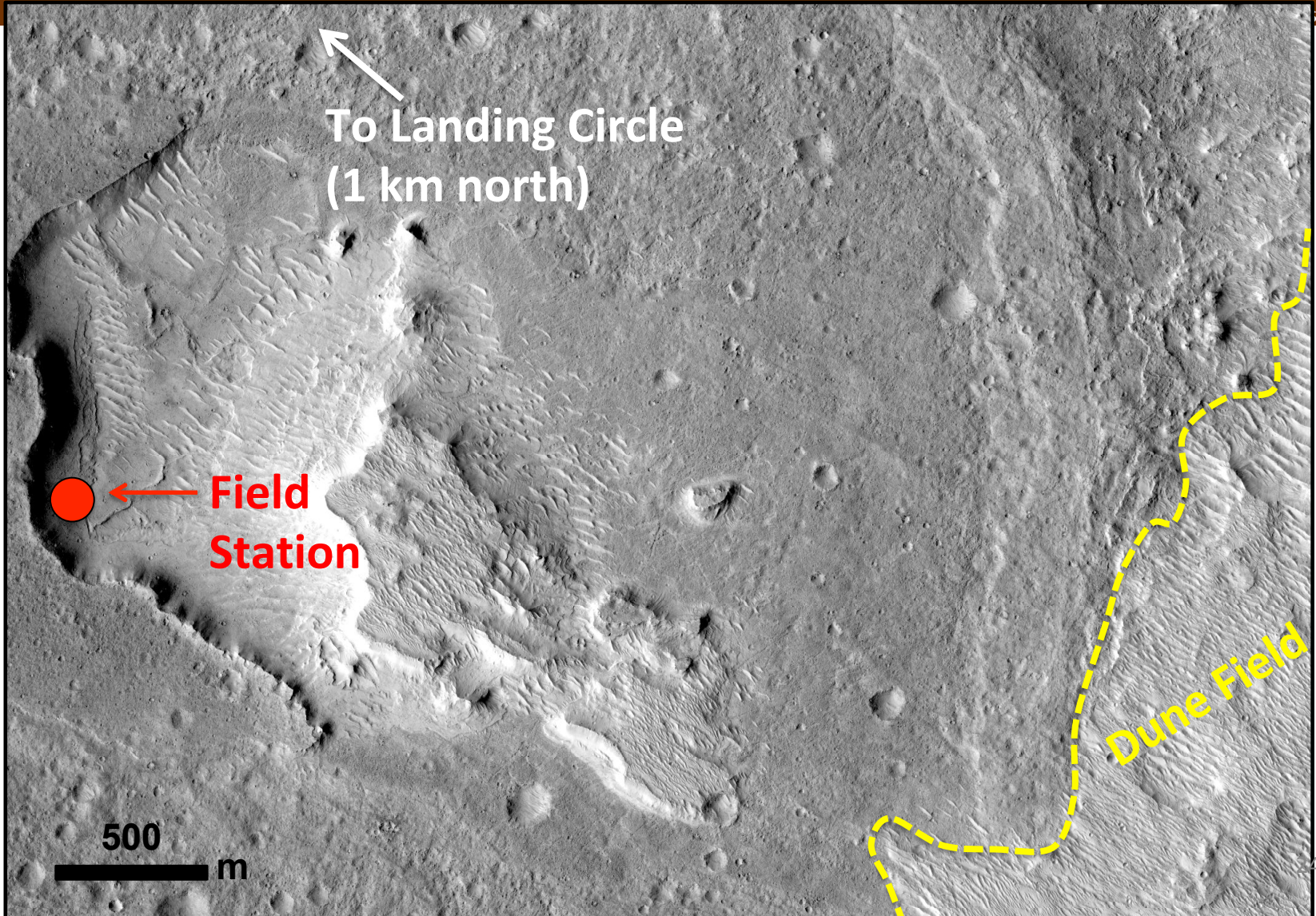
- Depression with steep cliffs forms a natural shelter with some protection from wind and radiation
- Easily traversable from landing site (3 km north)
- Easy traverse on smooth, compact terrain to processing plant and resources (2.5 km SE)



# Resource ROI 1



to Mars





# Resource ROI 1

1<sup>st</sup> EZ Workshop for Human Missions to Mars



SECTIONS



HOME



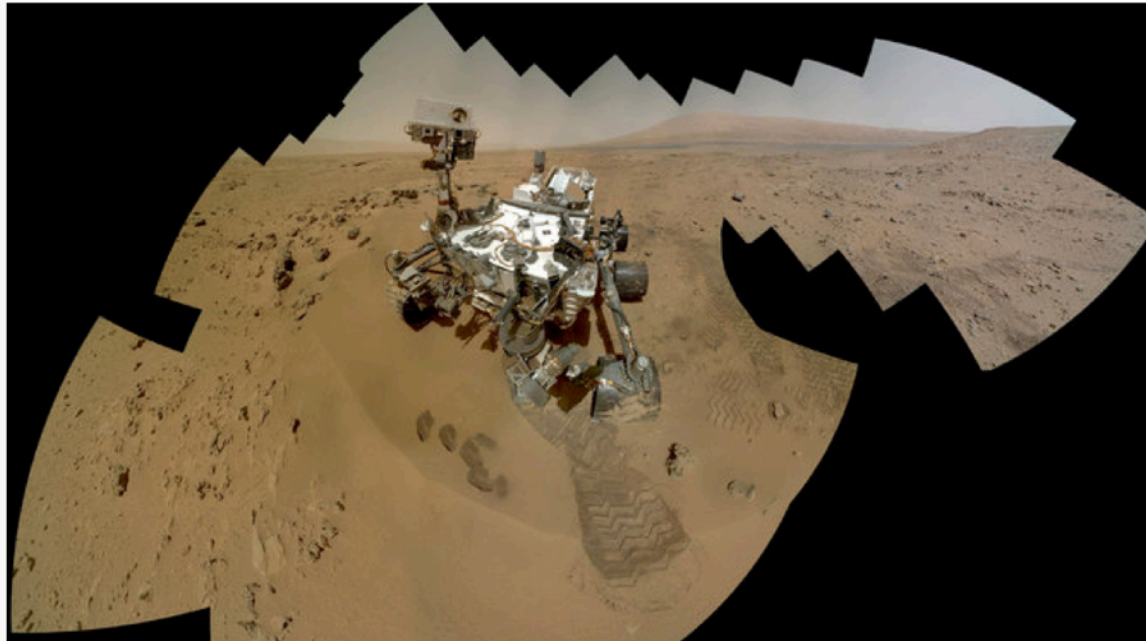
SEARCH

The New York Times

SPACE & COSMOS

## *Hitting Pay Dirt on Mars*

By KENNETH CHANG SEPT. 30, 2013



Hypanis Delta Exploration Zone

### Water and Metal Resource: Dunes

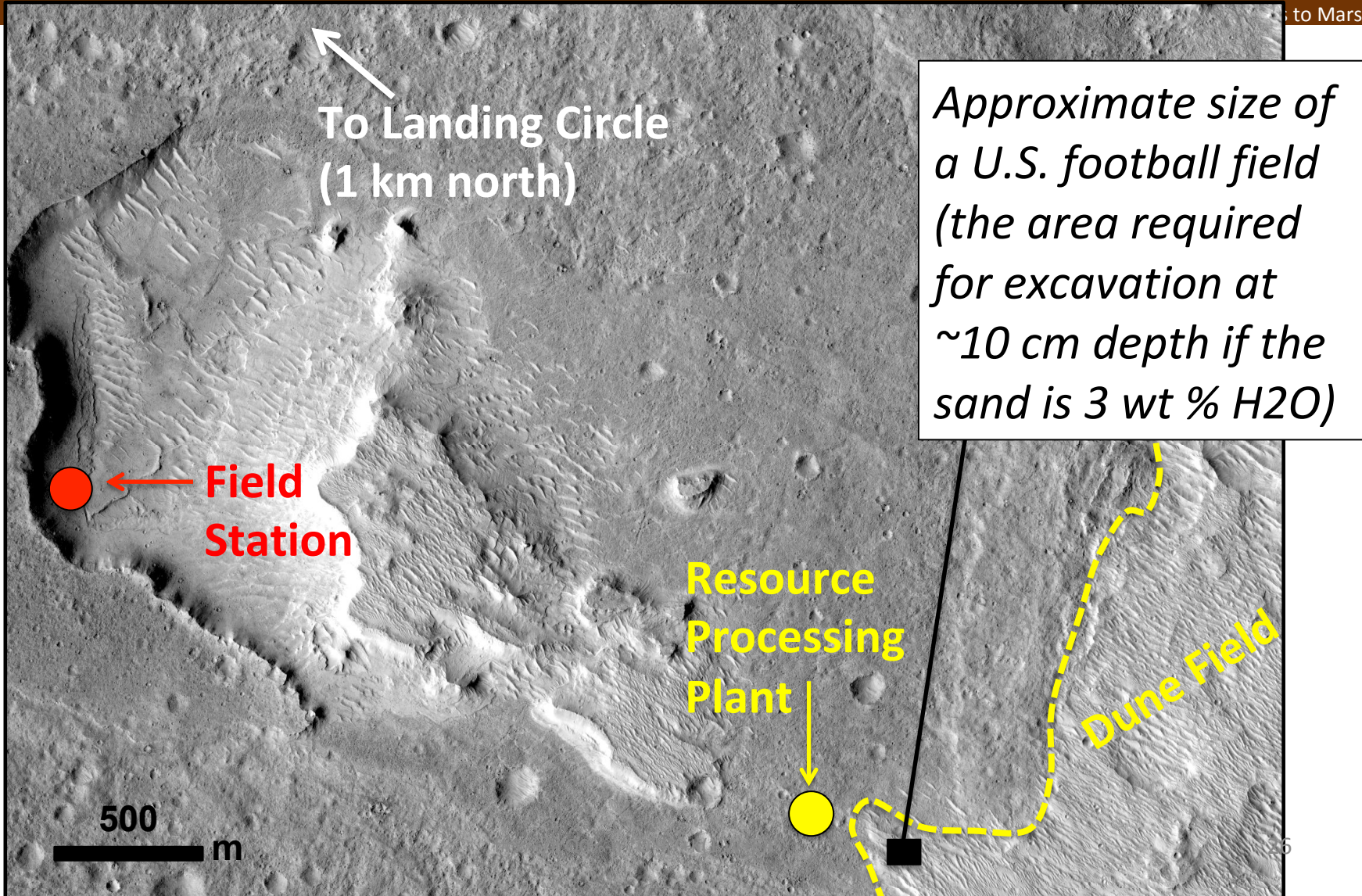
- In-situ water resources are potentially provided by the extensive aeolian dune sands
- Observations by MSL of atmospheric water adsorbed in dune sands (Meslin et al., 2013) and 3-6 wt. % H<sub>2</sub>O in sands at Rocknest (Leshin et al., 2013)
- Absence of crater retention indicates that the TARs are weakly indurated and could be easily mobilized to a processing facility constructed on adjacent, level bedrock
- Could provide metal and silicon resources and building material



# Resource ROI 1



to Mars



To Landing Circle  
(1 km north)

Field  
Station

Resource  
Processing  
Plant

*Approximate size of  
a U.S. football field  
(the area required  
for excavation at  
~10 cm depth if the  
sand is 3 wt % H<sub>2</sub>O)*

Dune Field

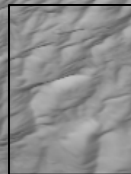
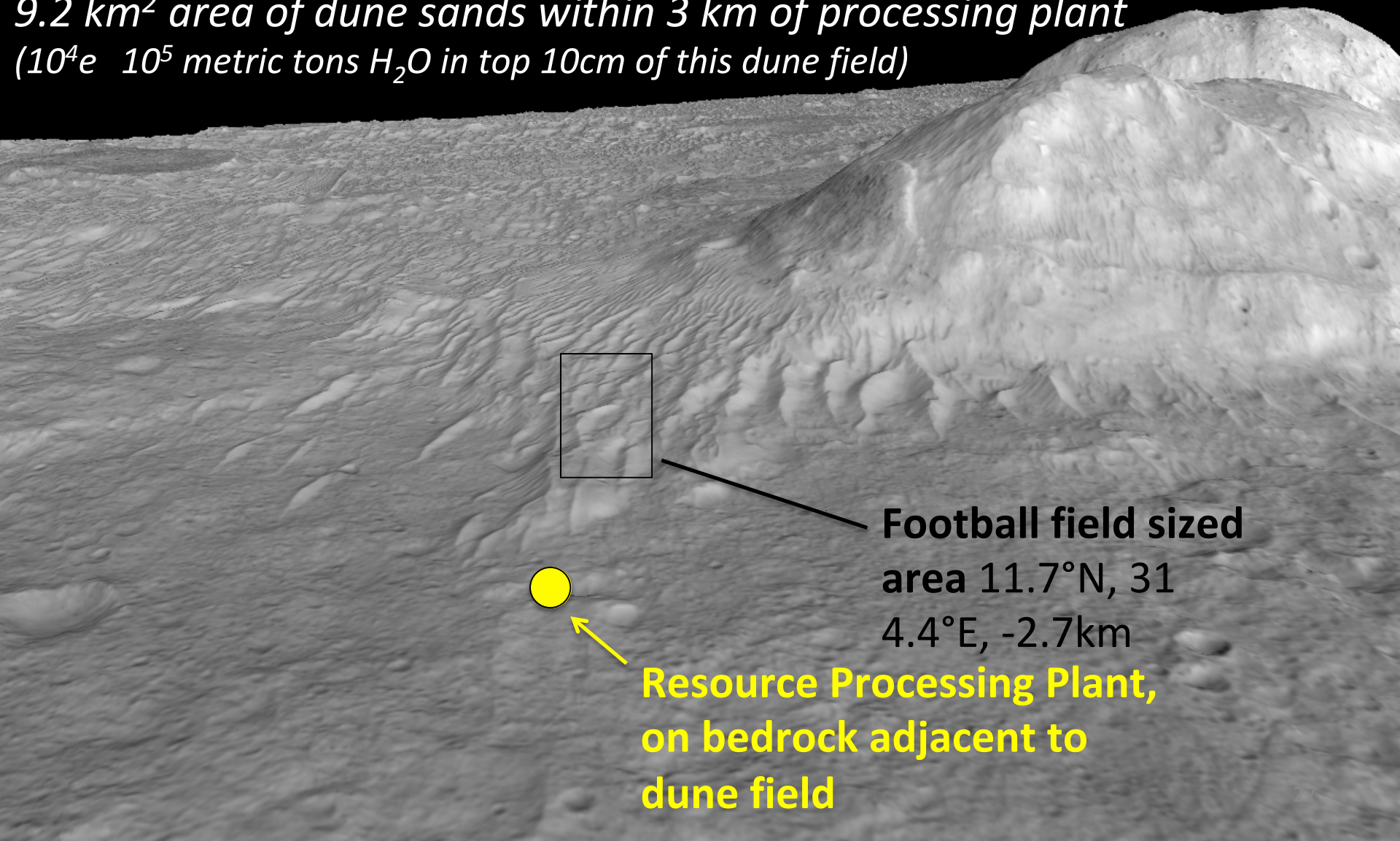
500  
m



# Dune Sands as Resources



*9.2 km<sup>2</sup> area of dune sands within 3 km of processing plant  
( $10^4$  to  $10^5$  metric tons H<sub>2</sub>O in top 10cm of this dune field)*



**Football field sized  
area 11.7°N, 31  
4.4°E, -2.7km**



**Resource Processing Plant,  
on bedrock adjacent to  
dune field**



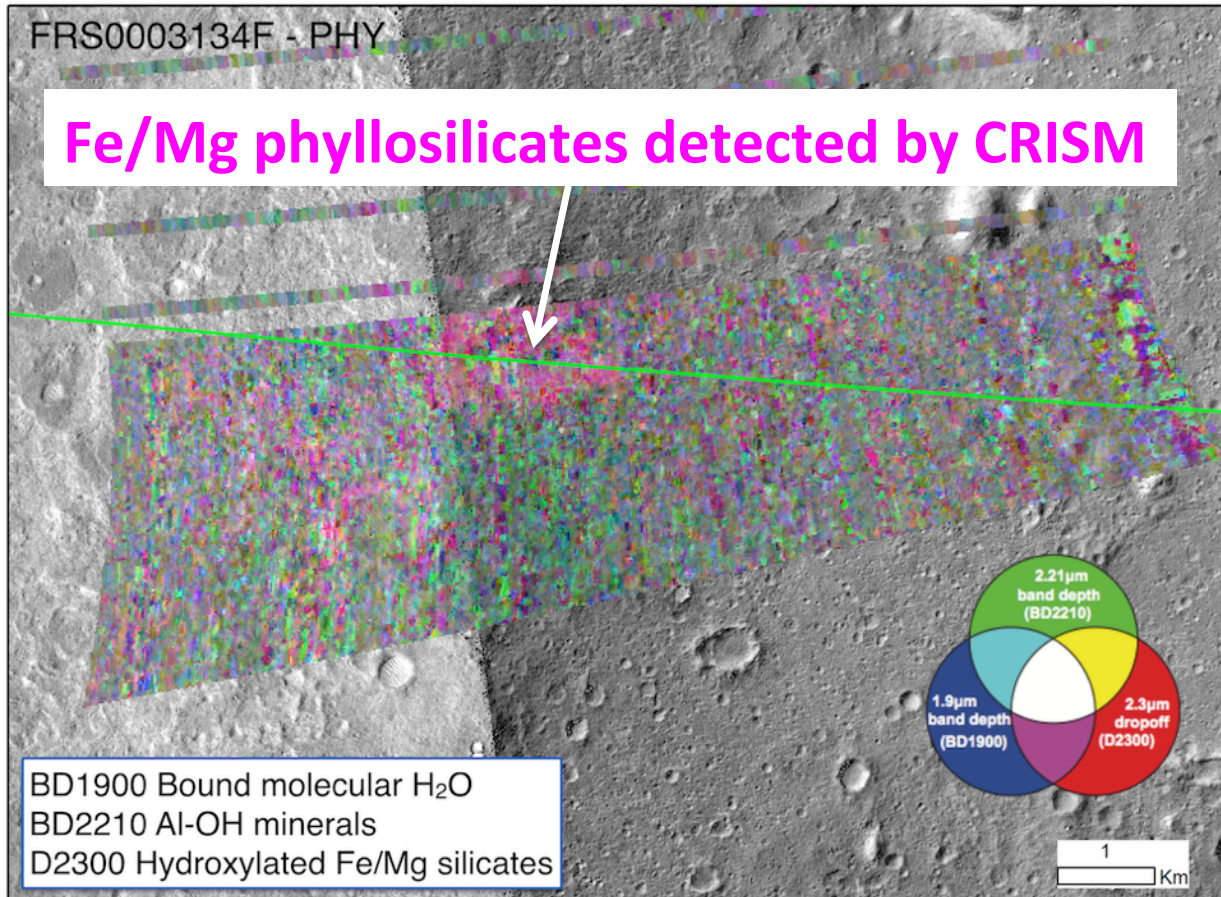
# Resource ROIs 2-3

1<sup>st</sup> EZ Workshop for Human Missions to Mars

## Water Resource: Hydrated minerals in multiple EZ locations

FRS0003134F - PHY

**Fe/Mg phyllosilicates detected by CRISM**



## Clays and Hydrated Units

- RROI 2: 11.8°N, 313.8°E, -2.5 km
- RROI 3: 11.5°N, 313.4°E, -2.3 km
- Fe/Mg phyllosilicates identified in CRISM FRT and MSP observations at multiple locations on the plains units
- Threshold:
  - Hydrated minerals
  - Multiple large exposures
  - Accessible and potentially easily-minable
- Qualifying:
  - Routes to all exposures are easily traversable from landing site

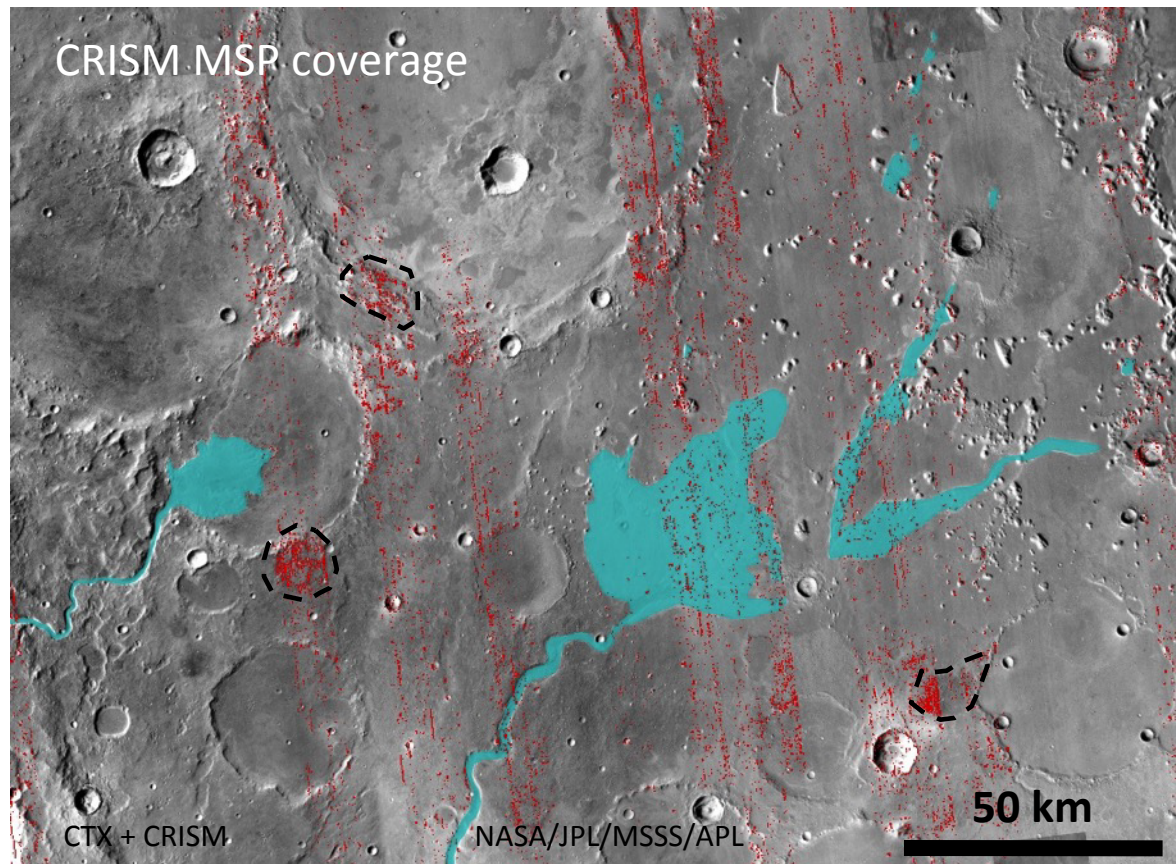


# Highest Priority EZ Data Needs

1<sup>st</sup> EZ Workshop for Human Missions to Mars

Most important to assess science: **CRISM FRTs**

Most important to assess resources: **CRISM FRTs**



Band depth at  $2.3\mu\text{m}$

$0.5\% < \text{D2300} < 3\%$



# Summary

1<sup>st</sup> EZ Workshop for Human Missions to Mars

- Hypanis delta is a great environment for potential habitability and astrobiological preservation
- Key stratigraphic contacts and ROIs are ideal for a human mission since can actually access these distant sites
- Resources are relatively easy to mine – processing and accessing is right next to landing site
- Science is fascinating and has GLOBAL implications: a delta along the dichotomy boundary, **Chryse sea?**



# **BACKUP SLIDES**



# Prioritization List of EZ Data Needs

1<sup>st</sup> EZ Workshop for Human Missions to Mars



## 1 – CRISM FRT images

- CRISM signatures in D2300 parameter low, but correlate with morphology
- The best potentially phyllosilicate bearing deposits have not been targeted in higher resolution

## 2 – HiRISE images

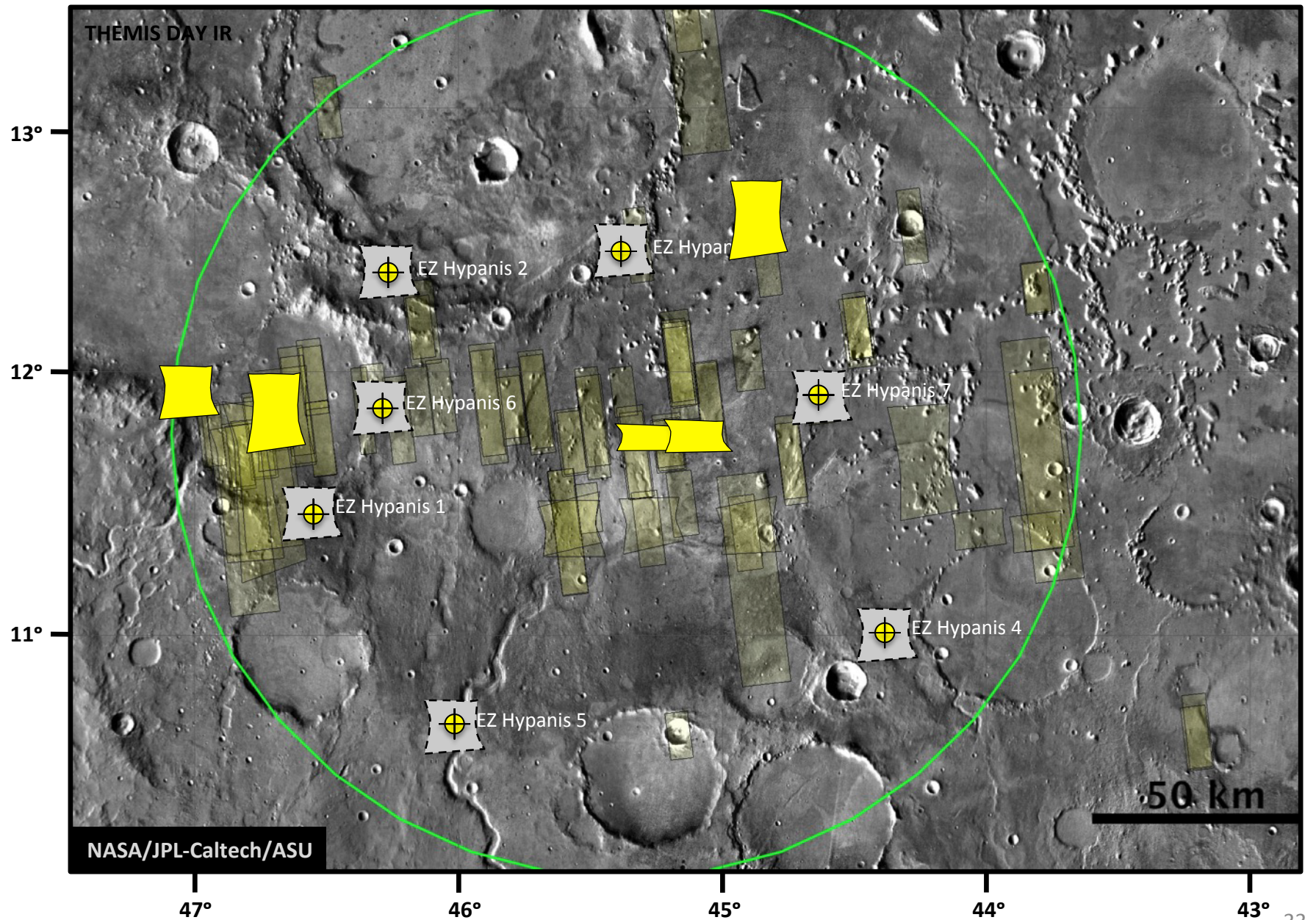
- Delta stratigraphy
- To couple with CRISM FRT spectral analysis of phyllosilicates

## 3 – CTX stereo pairs

- Delta slope analysis along proximal and distal lobes using CTX DTM

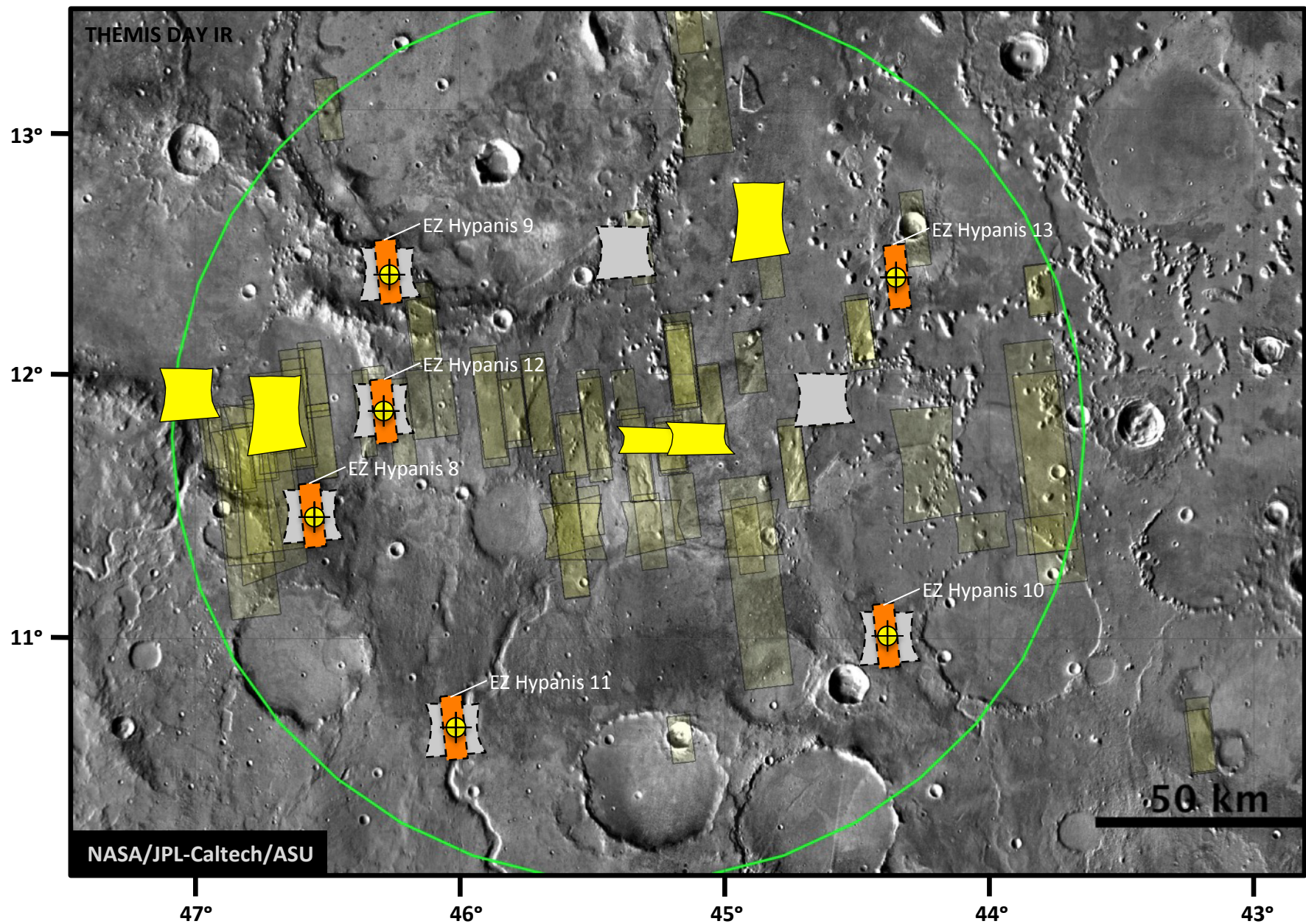


# Hypanis Human Exploration Zone CRISM Requests





# Hypanis Human Exploration Zone HiRISE Requests





# Hypanis – why is it a delta and not an alluvial fan?

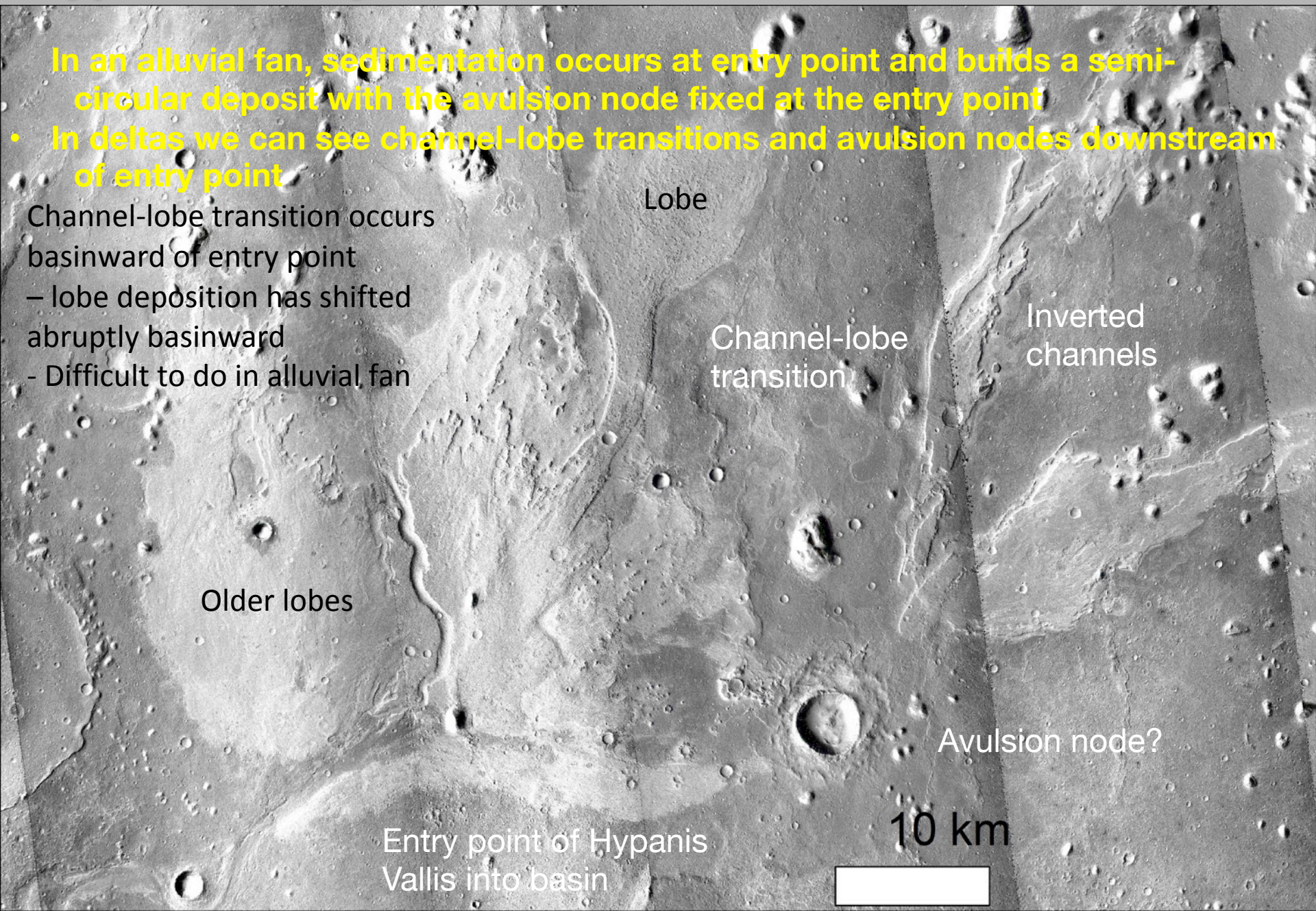
In an alluvial fan, sedimentation occurs at entry point and builds a semi-circular deposit with the avulsion node fixed at the entry point

- In deltas we can see channel-lobe transitions and avulsion nodes downstream of entry point

Channel-lobe transition occurs basinward of entry point

- lobe deposition has shifted abruptly basinward

- Difficult to do in alluvial fan



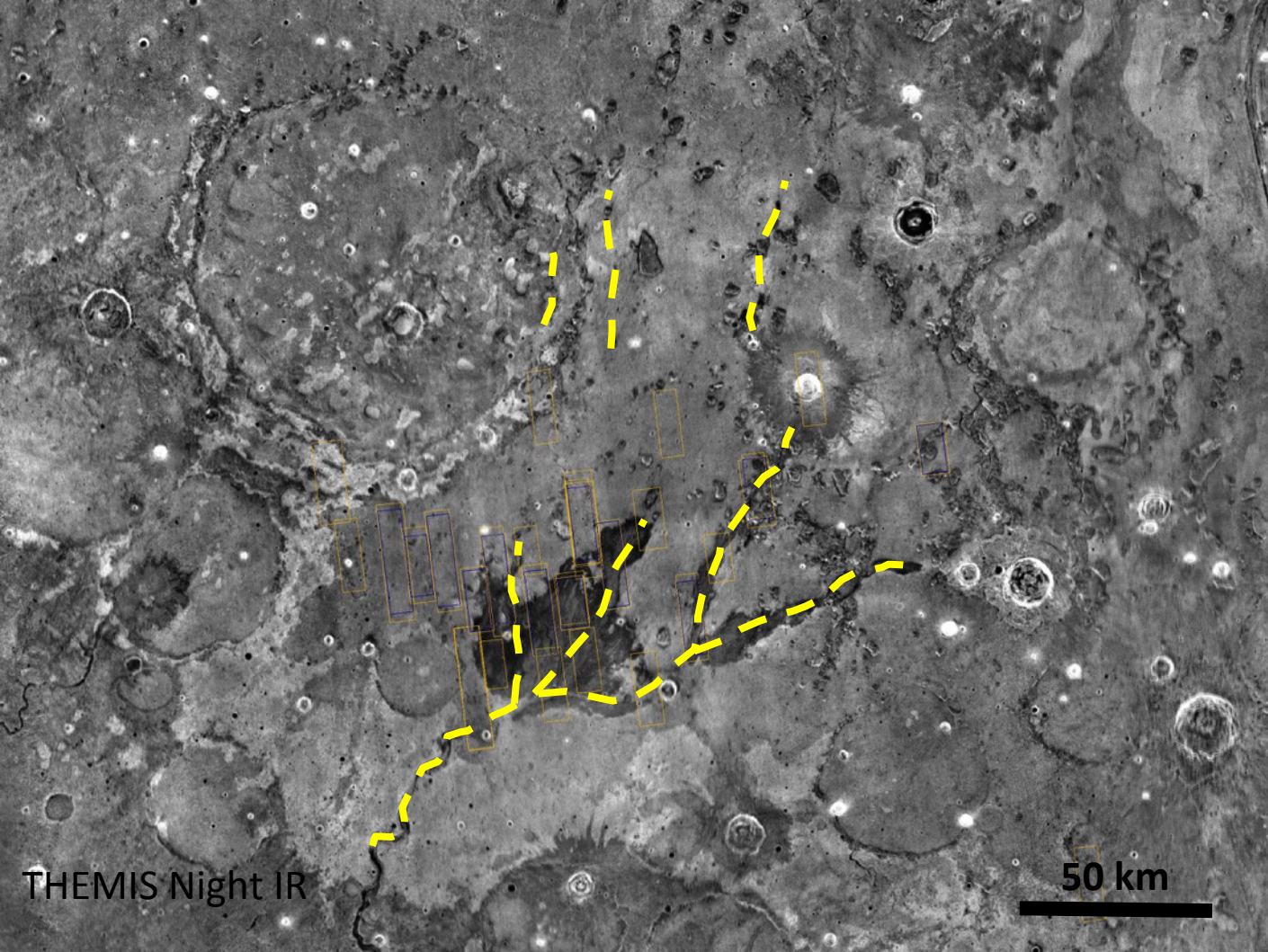
Entry point of Hypanis  
Vallis into basin

10 km



# Delta vs. Fan

1<sup>st</sup>EZ Workshop for Human Missions to Mars



- Need DTMs spanning downstream profiles
- Examine:
  - channel lobe transitions
  - avulsion node migration
  - slopes connecting farthest deposits
- Some HiRISE, CTX DTMs made
- HRSC will work, but CTX DTM of entire delta extent is better





# MINERALOGY

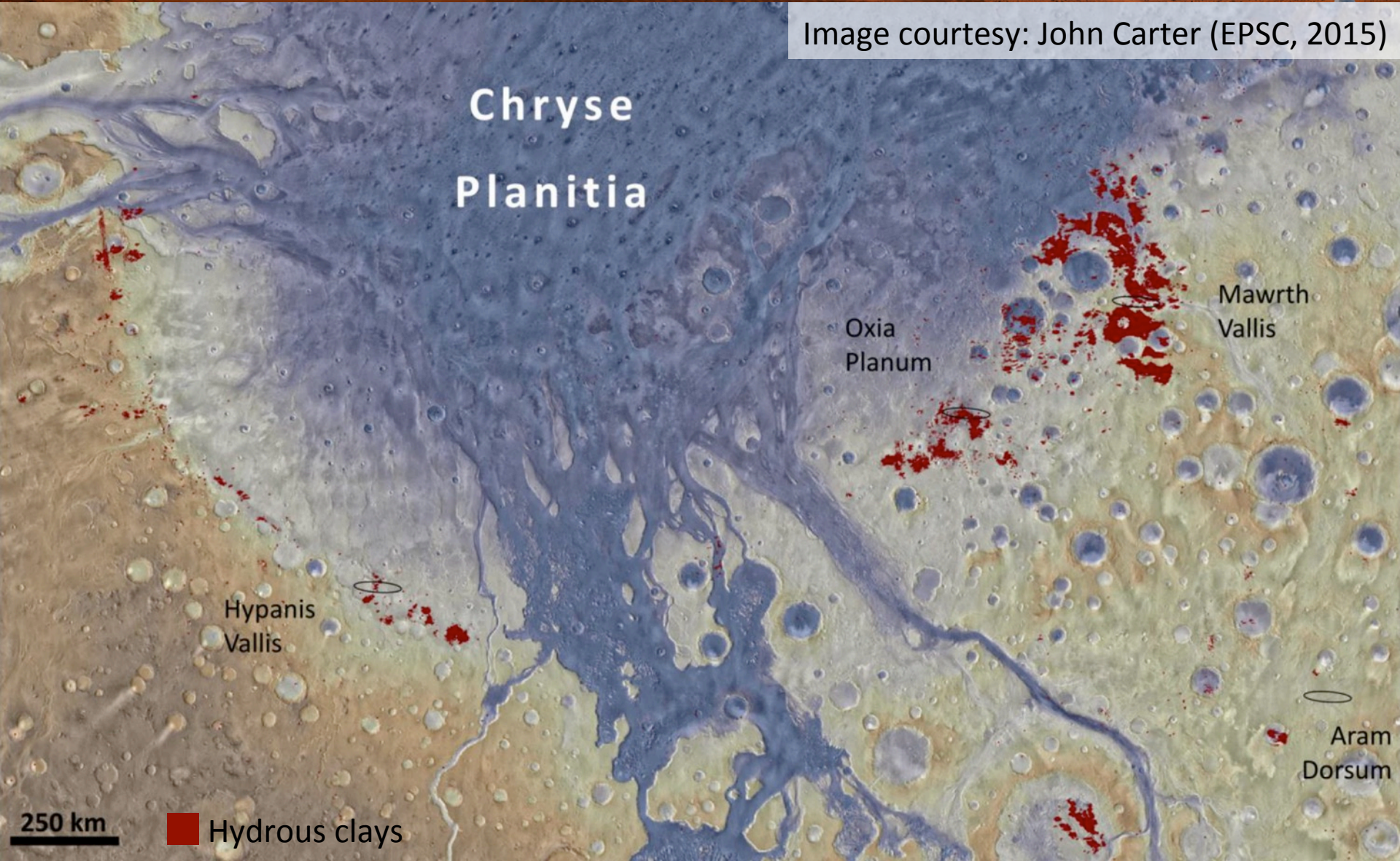


## Hypanis Valles: Mineralogy - OMEGA

- Hydrated signatures (hydrous clays) at Hypanis form part of the wider, circum-Chryse basin, 'bathtub' ring of deposits → *related to large water body in Chryse/beyond?*



Image courtesy: John Carter (EPSC, 2015)





**What is the bath-tub that ponded water?**



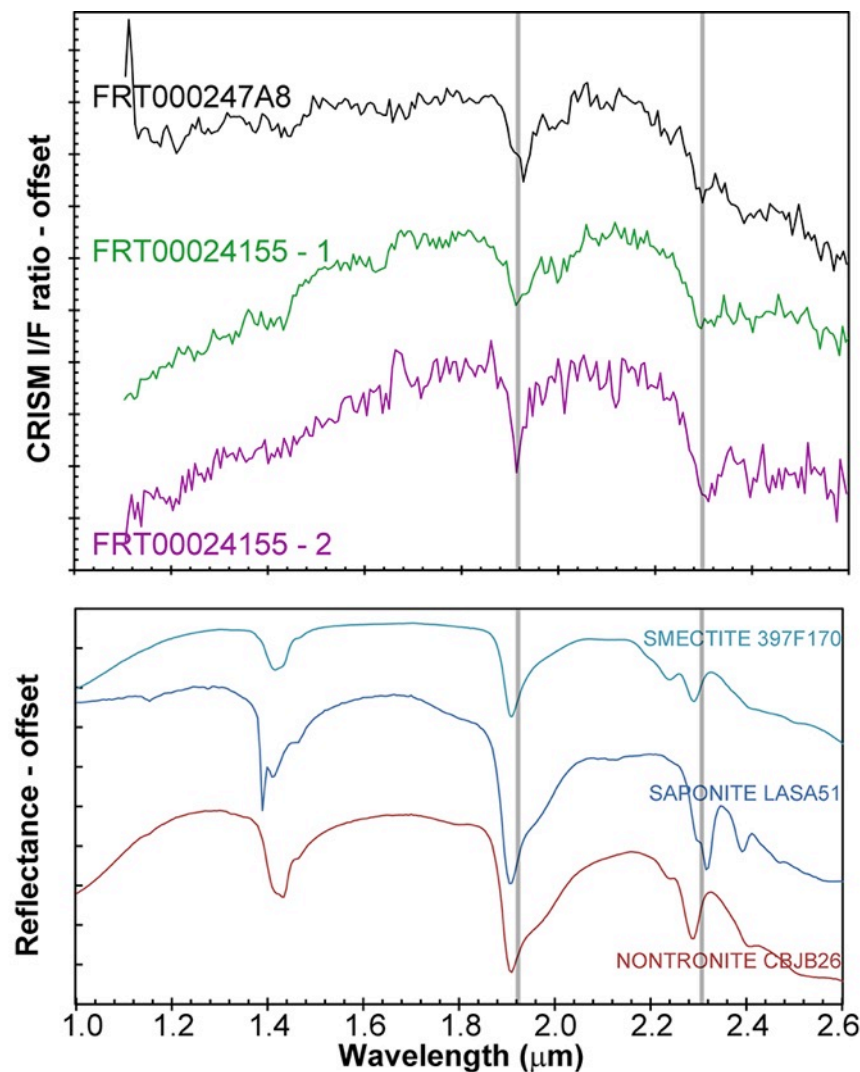
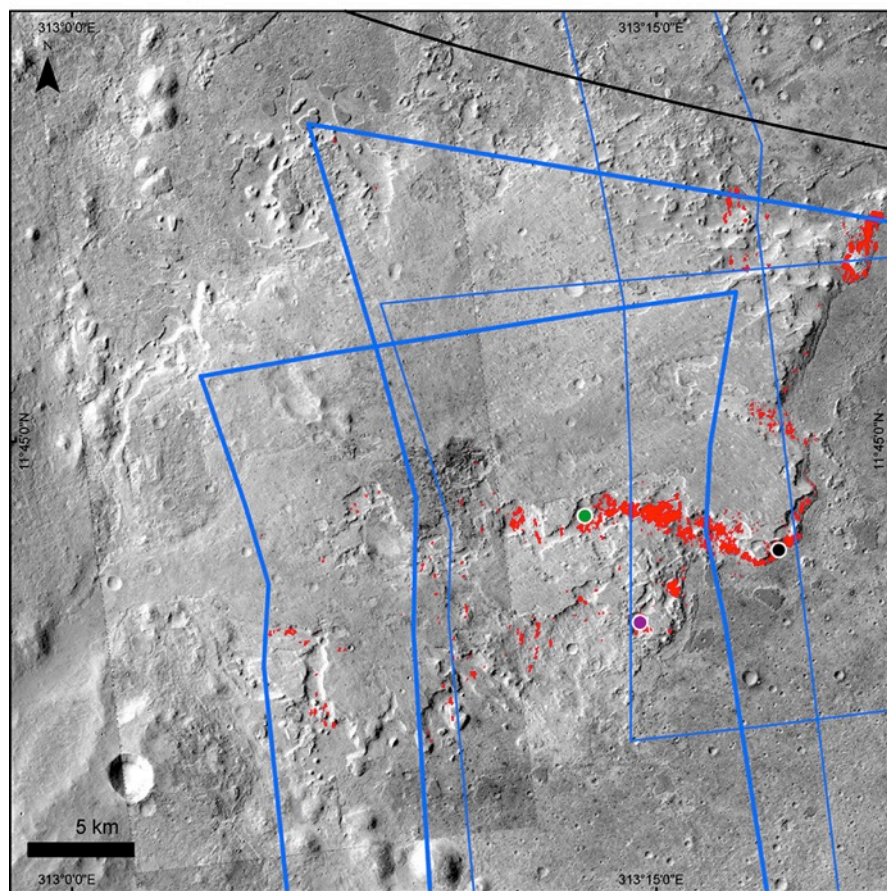
**Was the Chryse basin the bathtub?**



## Detrital Phyllosilicates

- Fe/Mg phyllosilicates (nontronite?) at low stratigraphic level in fan deposits
- Outside the ellipse to SW
- Across multiple (high SNR) CRISM observations

1<sup>st</sup> EZ Workshop for Human Missions to Mars



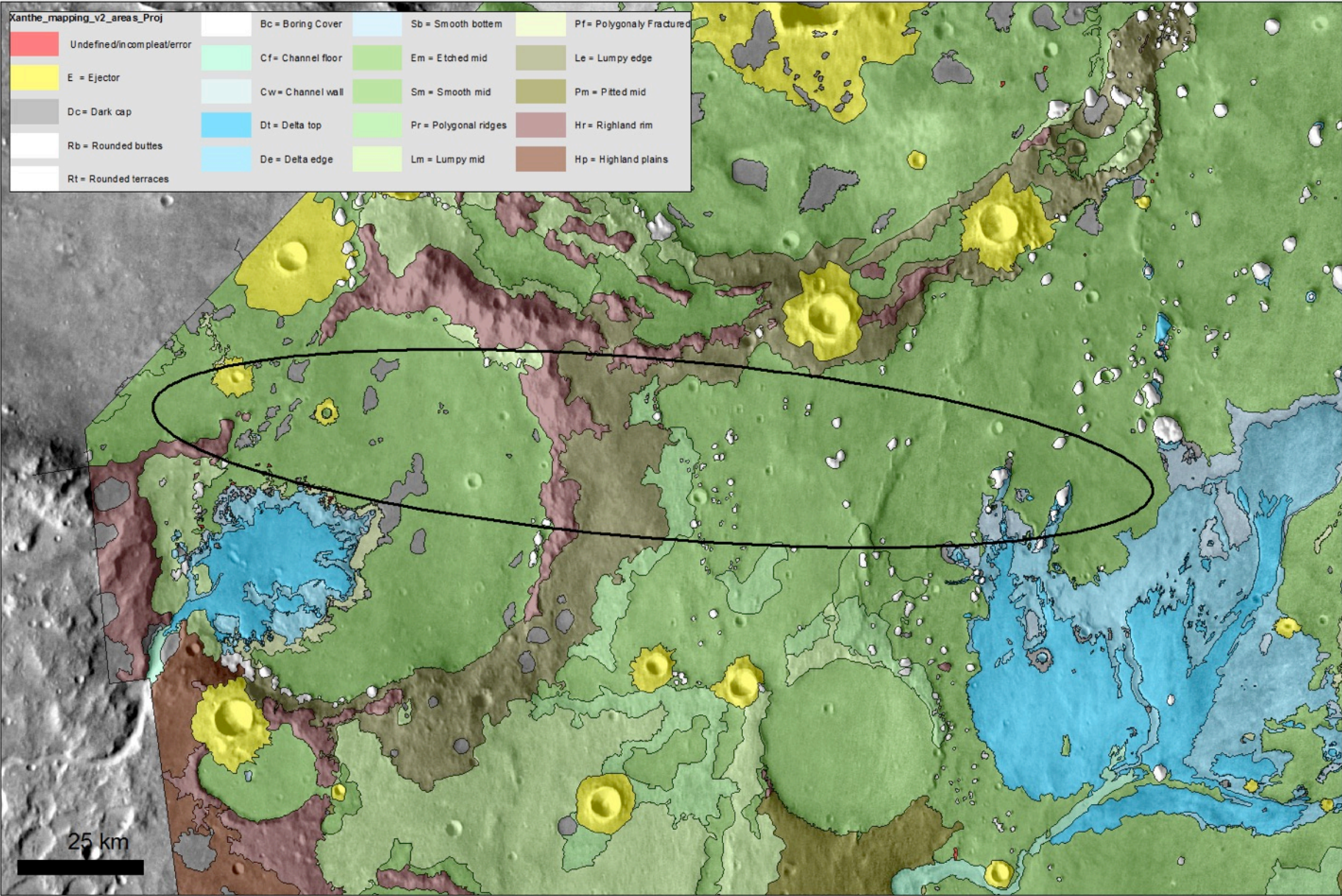




# GEOLOGIC MAP

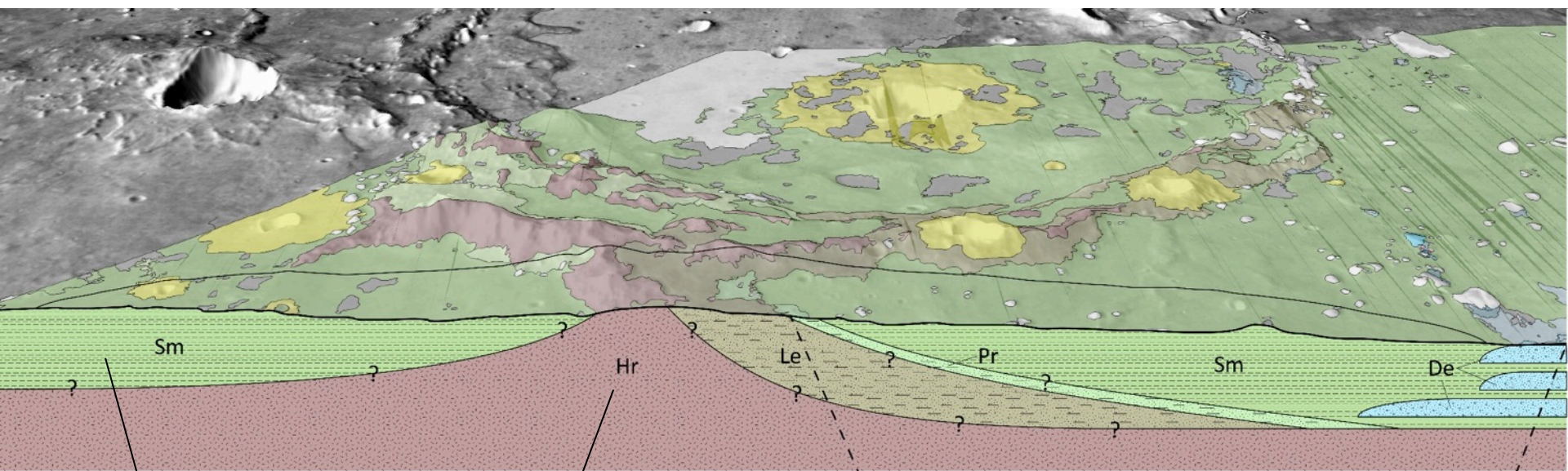


Hypanis Valles: Geological mapping – CTX basemap



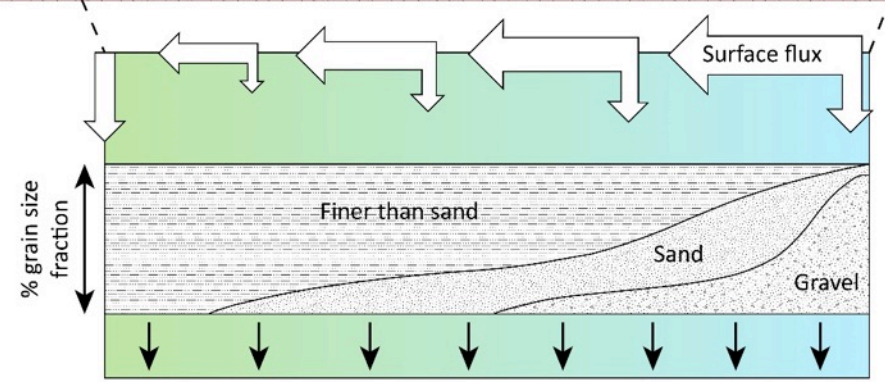


Hypanis Valles: Geological mapping – CTX basemap



Fine-grained distal  
deltaic-deposits

Noachian bedrock  
Fe/Mg phyllosilicates



After Michael et al. (2014)

Finer ← Grain size → Coarser





# BIOSIGNATURE PRESERVATION POTENTIAL



# What makes deltaic-lacustrine systems good for biosignature formation and



1<sup>st</sup> EZ Workshop for Human Missions to Mars

- 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



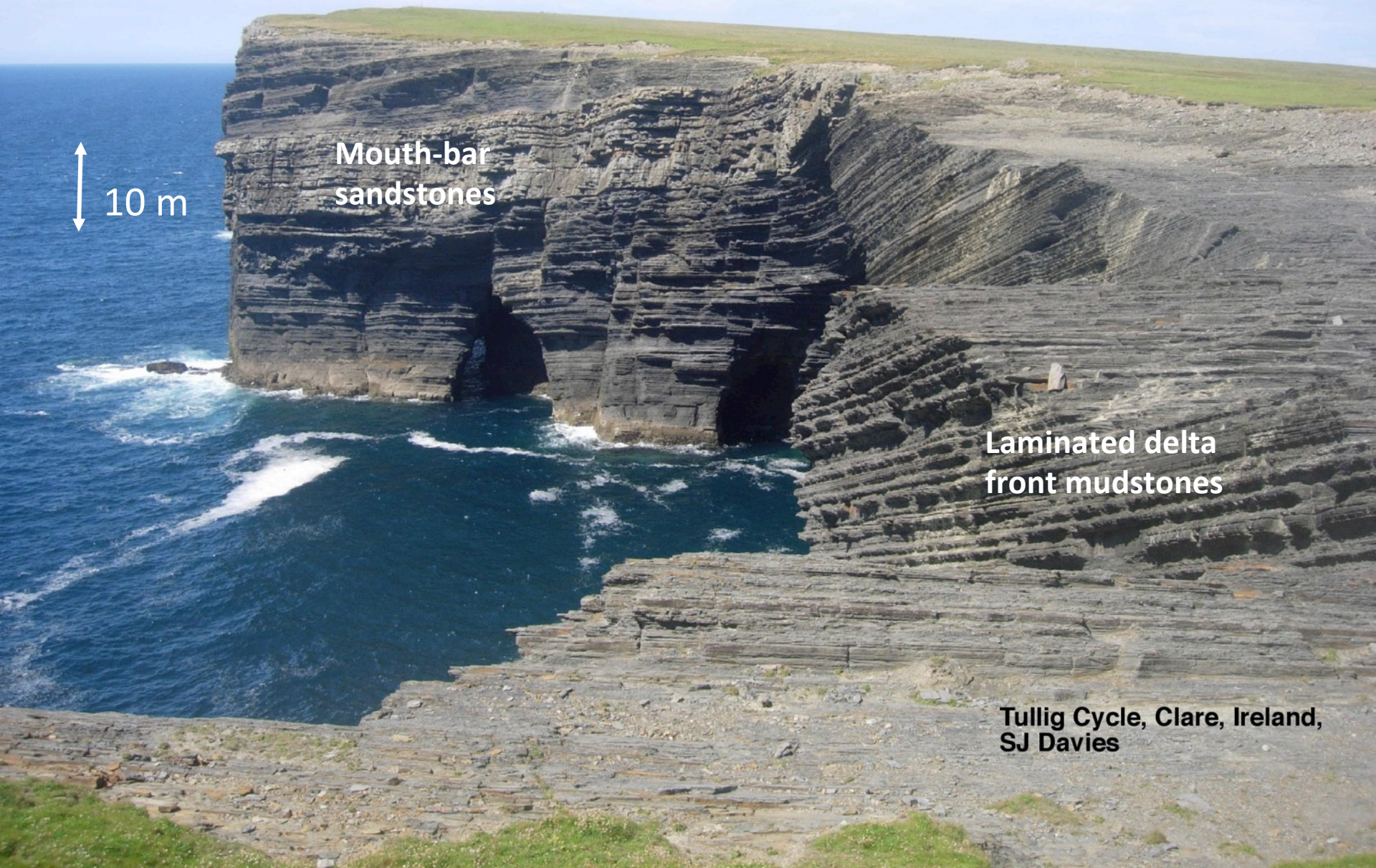
# Delta toe deposits interfingering with basinal mudstones



Mud glorious mud.....



# Preservation of deltaic deposits in the stratigraphic record



Mouth-bar  
sandstones

Laminated delta  
front mudstones

Tullig Cycle, Clare, Ireland,  
SJ Davies



Jezero

# Scales of deltas

2 km

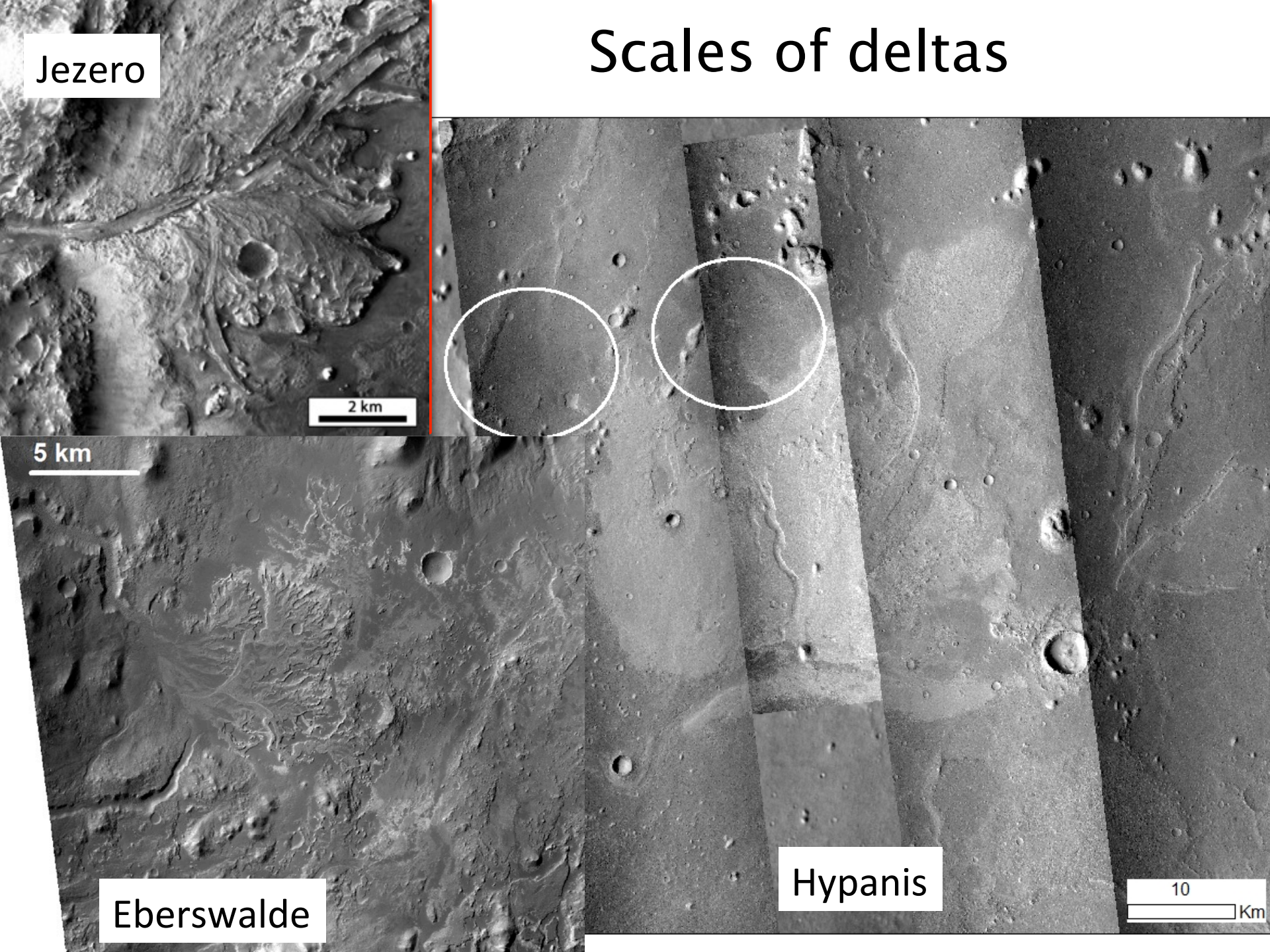
5 km

Eberswalde

Hypanis

10

Km

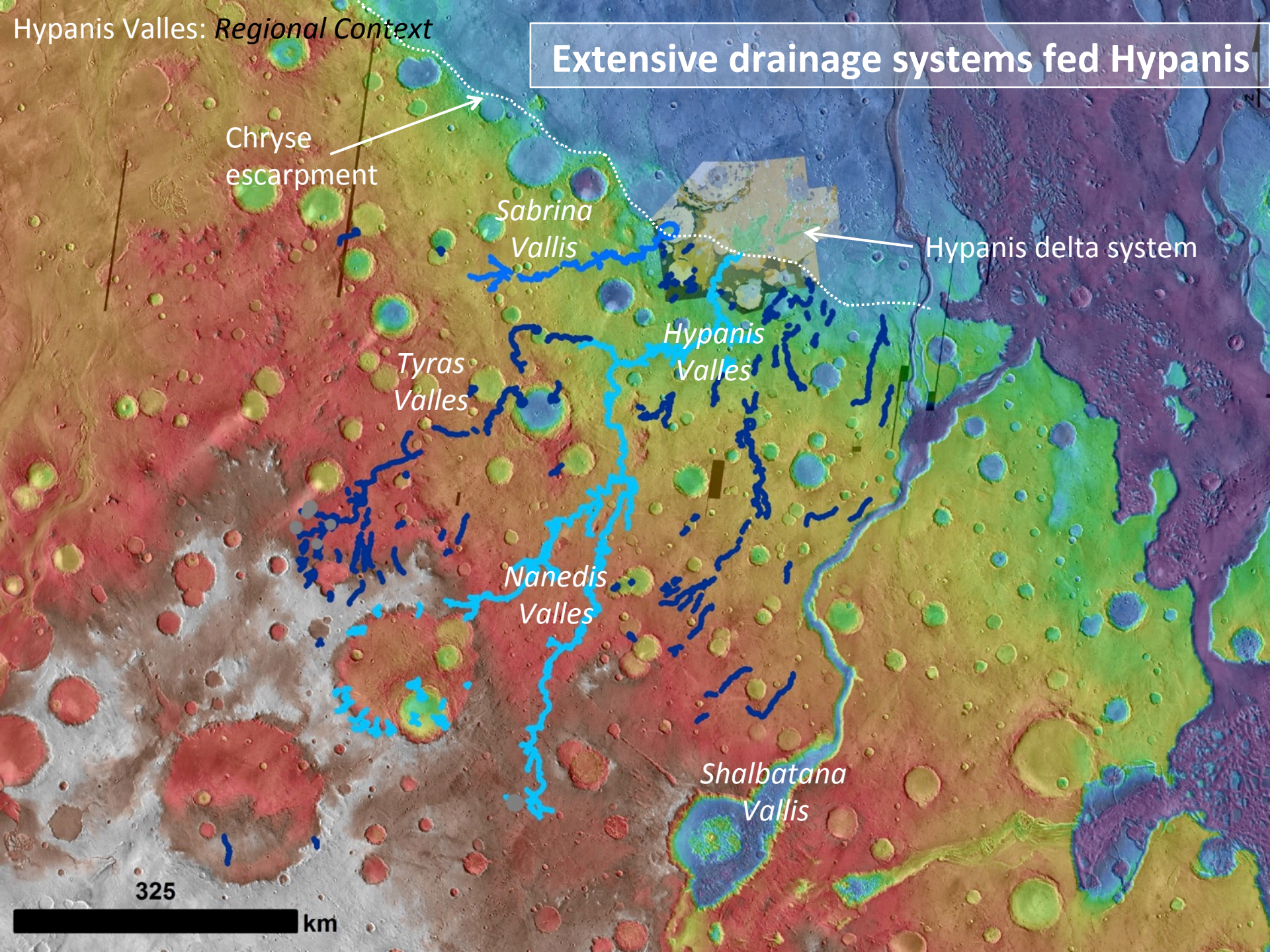




## Hypanis Valles: *Regional Context*

- Hypanis fan system is fed by a very extensive bedrock valley – Hypanis Valles – several hundred kilometres long (?), ~75 m deep
  - Hypanis Valles connected to Nanedi Vallis? NO
- Large volume of rock has been removed by fluvial erosion
- Valley network is very different to drainages sourced from crater rims (c.f. 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





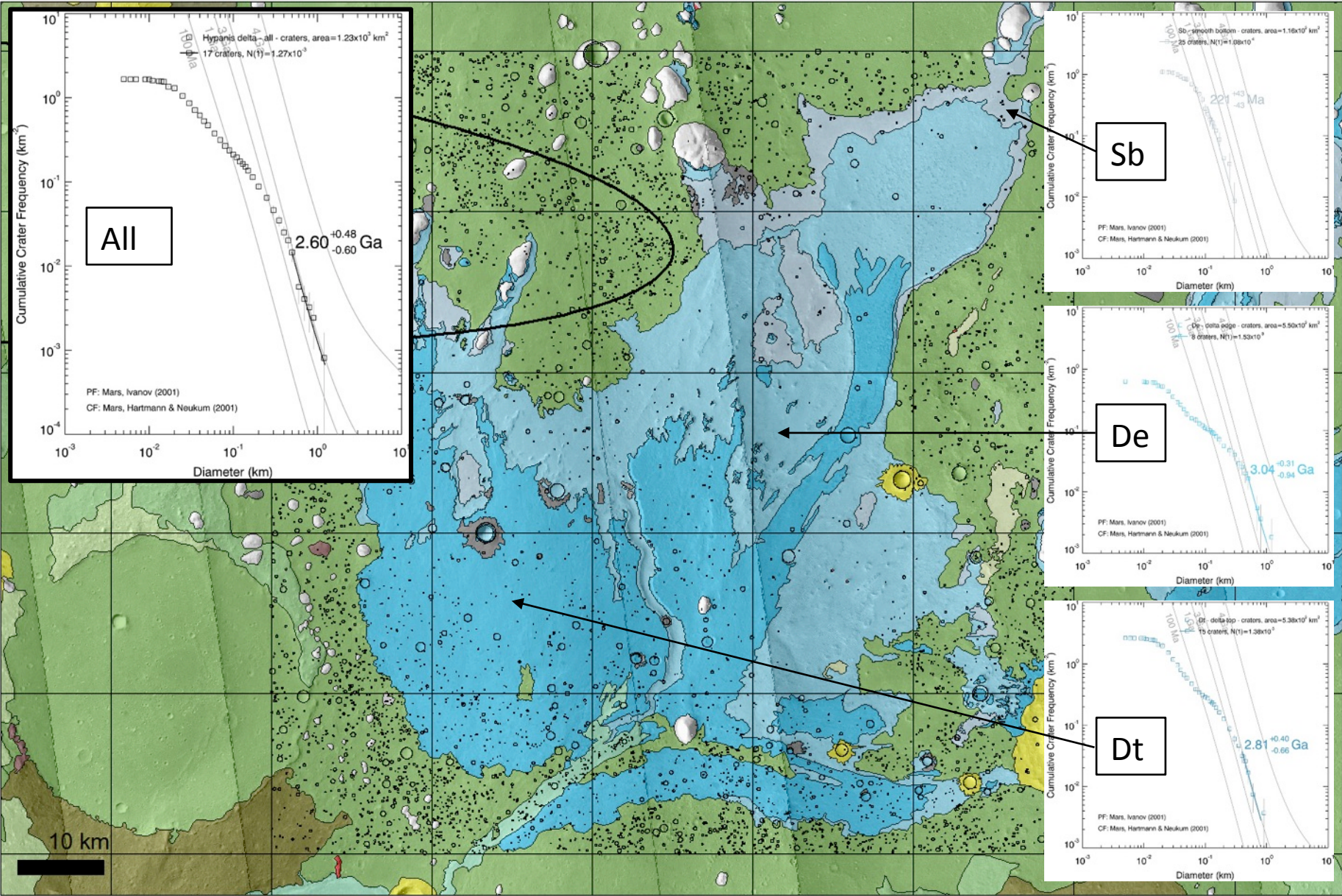




# CRATER COUNT AGE DATING



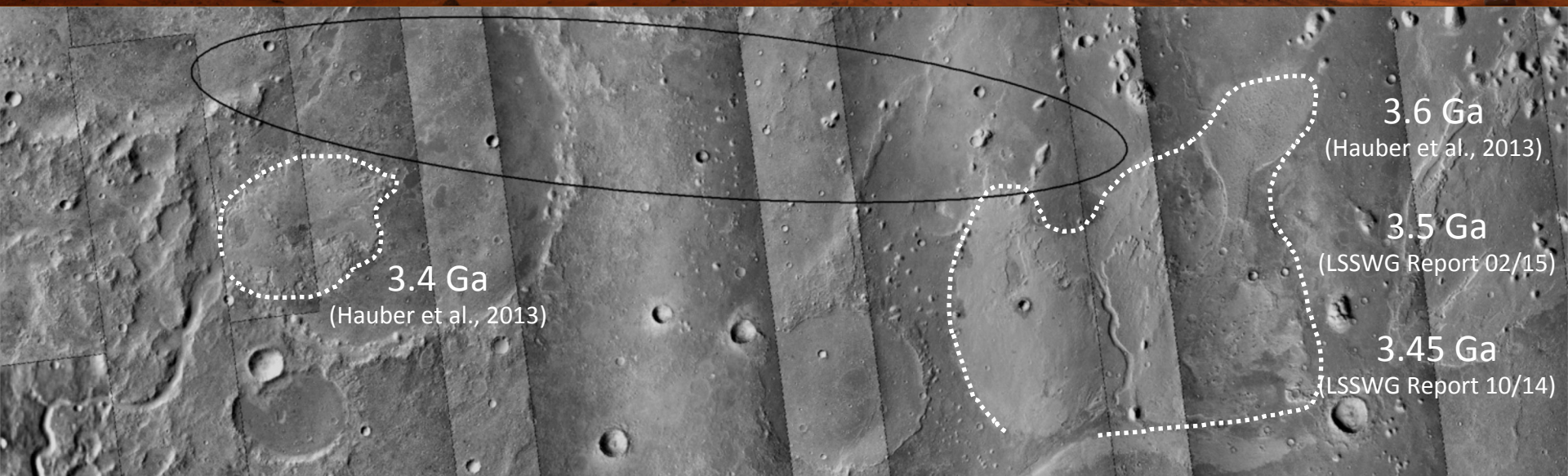
Hypanis Valles: Age - local





## Crater Counts on Deltas? Can we trust them?

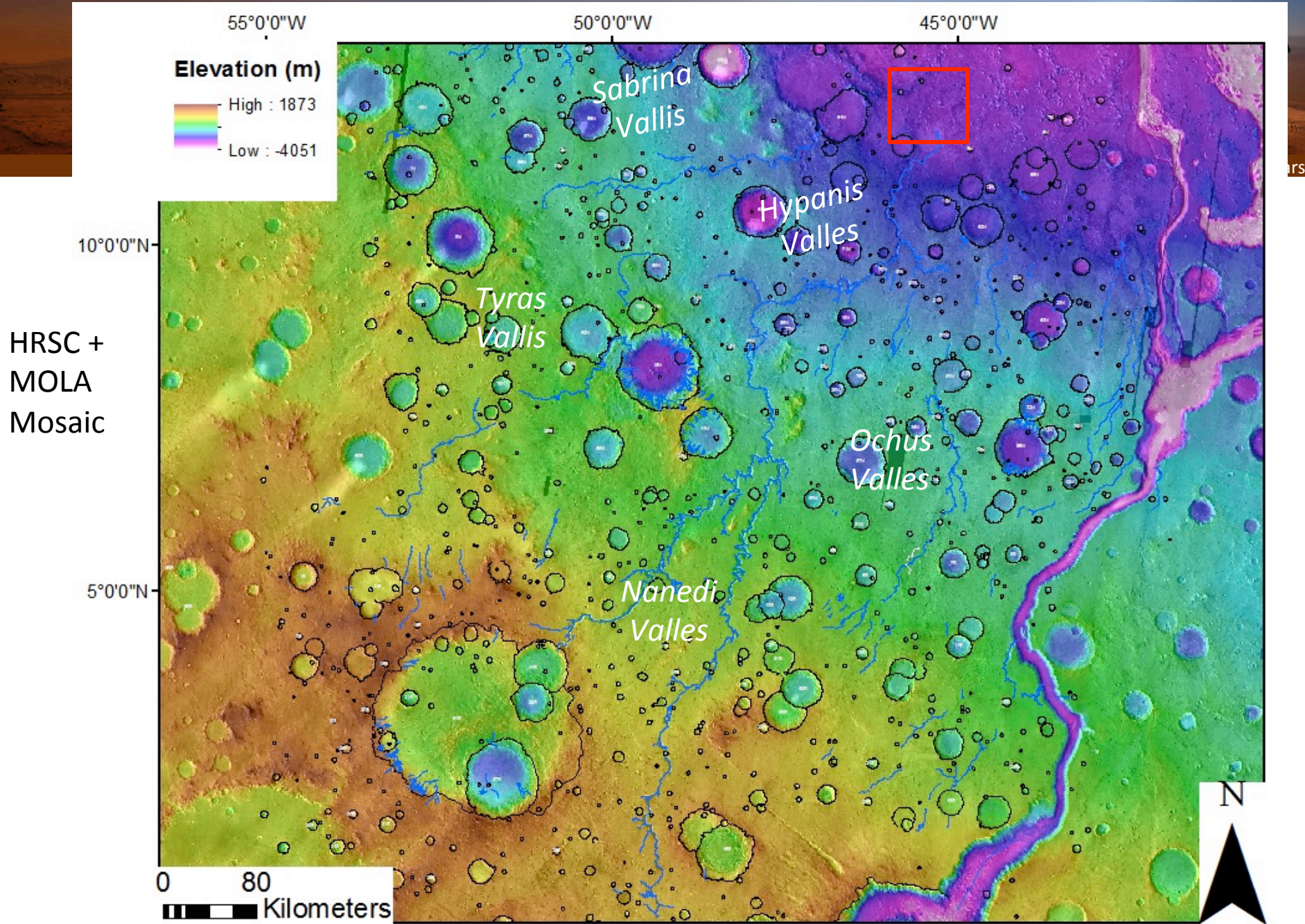
- Crater counting directly on deltas in Xanthe Terra (e.g. Hypanis Delta) has limitations.
  - Are Hypanis targets “*more recent than those at other sites*”? (LSSWG Report, 02/15)



- Area of typical deltas =  $10^1 - 10^2 \text{ km}^2$ , possibly too small for accurate crater counting given
  - (1) crater resurfacing
  - (2) the spatial variability of cratering as a random process.
- Deltas in this region show evidence for significant resurfacing (inverted landforms, isolated layered mesas and buttes, degraded craters) and do not preserve craters well.
- **Another more regional method of dating has also been applied.**

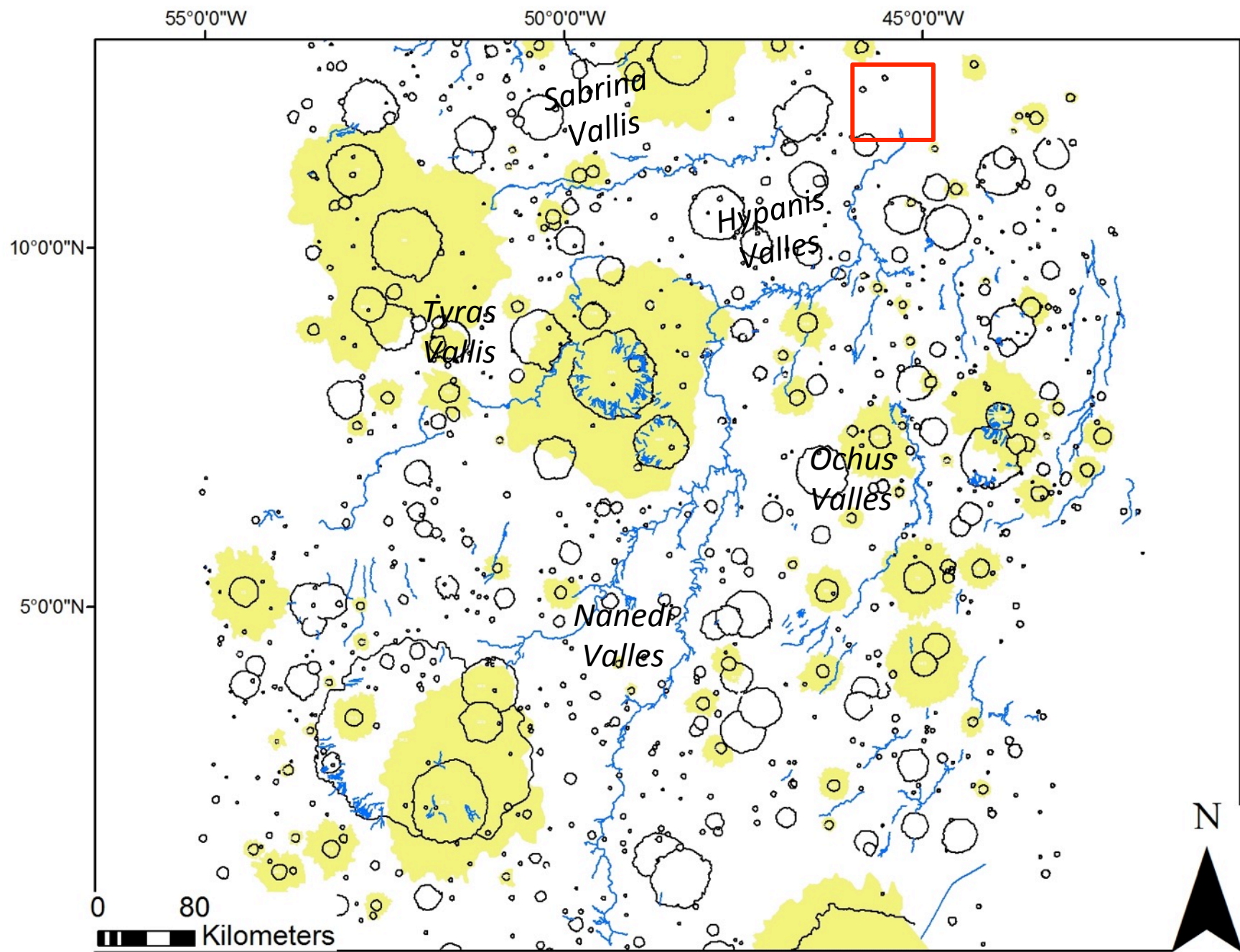


Hypanis Valles: Age - regional





# Hypanis Valles: Age - regional





**Objective:** How old is Hypanis Valles and its delta?

**Method:**

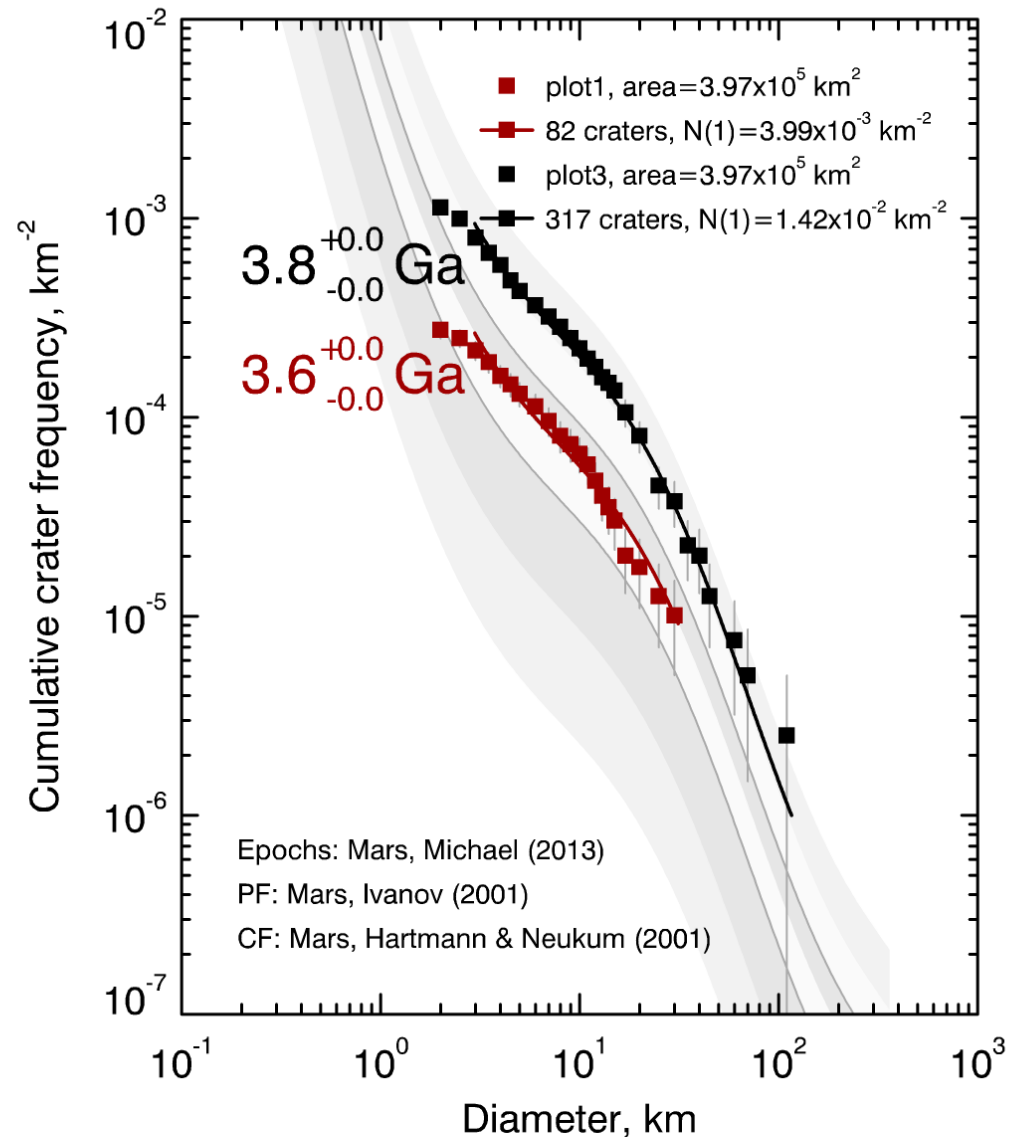
- Constructed a near complete CTX mosaic of Xanthe Terra upstream of Hypanis Delta.
- Mapped major river networks and  $> 2$  km diameter craters at 1:40,000 using CTX.
- Our focus: relative age of impact craters compared to river networks.
- Timing methods
  1. Crater counts on ejecta that pre and post-date valley networks.
  2. Size frequency distribution of  $> 2$  km craters at relative morphologic states (timescales of degradation of Xanthe craters).



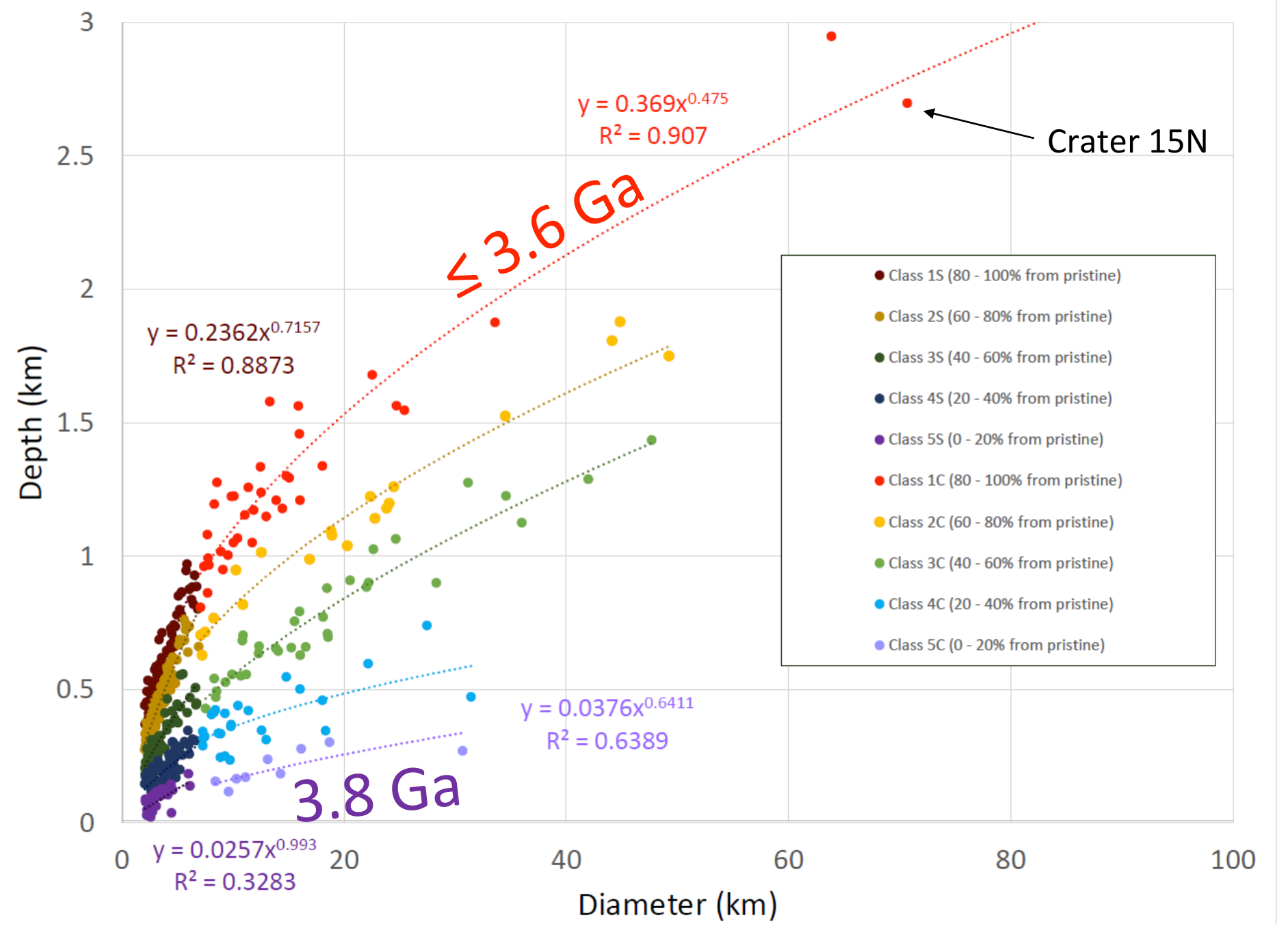


## Size Frequency Distributions (SFD)

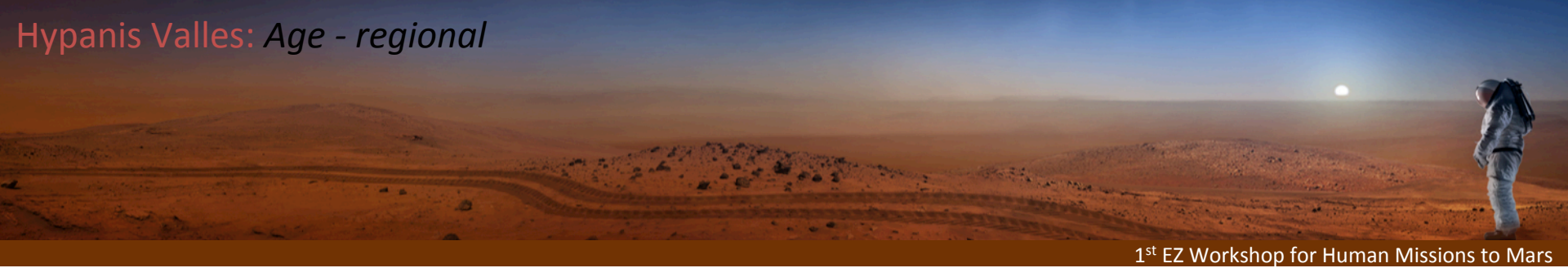
- SFD of all 317 craters = age of Xanthe Terra.
  - 3.8 Ga (Late Noachian)
- SFD of only the most pristine craters (<80% from pristine model depth)
  - 3.6 Ga (Early Hesperian)
- Consistent with rapid decrease in surface erosion rates in Hesperian.
- Most degradational work done over short interval from 3.8 – 3.6 Ga.











## Hypanis Valles Relative Age

### 1. Older than Nanedi Valles

- Suggests multiple fluvial events in this region.
- Consistent with fluvial channel superposition relationships elsewhere in Xanthe Terra.
- Nanedi Valles likely does not connect to Hypanis delta.

### 2. Hypanis Valles older than crater 15N

- Ejecta crater count = 3.7 Ga
- Crater degradation data: 15N is 80% from pristine  $d/D$  ( $\leq 3.6$  Ga)
- Hypanis Valles is likely Early Hesperian or older.

### 3. Nanedi Valles is younger than 15 N

- Nanedi Valles is  $\leq 3.6$  Ga
- Suggests multiple fluvial events spanning relatively long period of time (separated by large impact events).