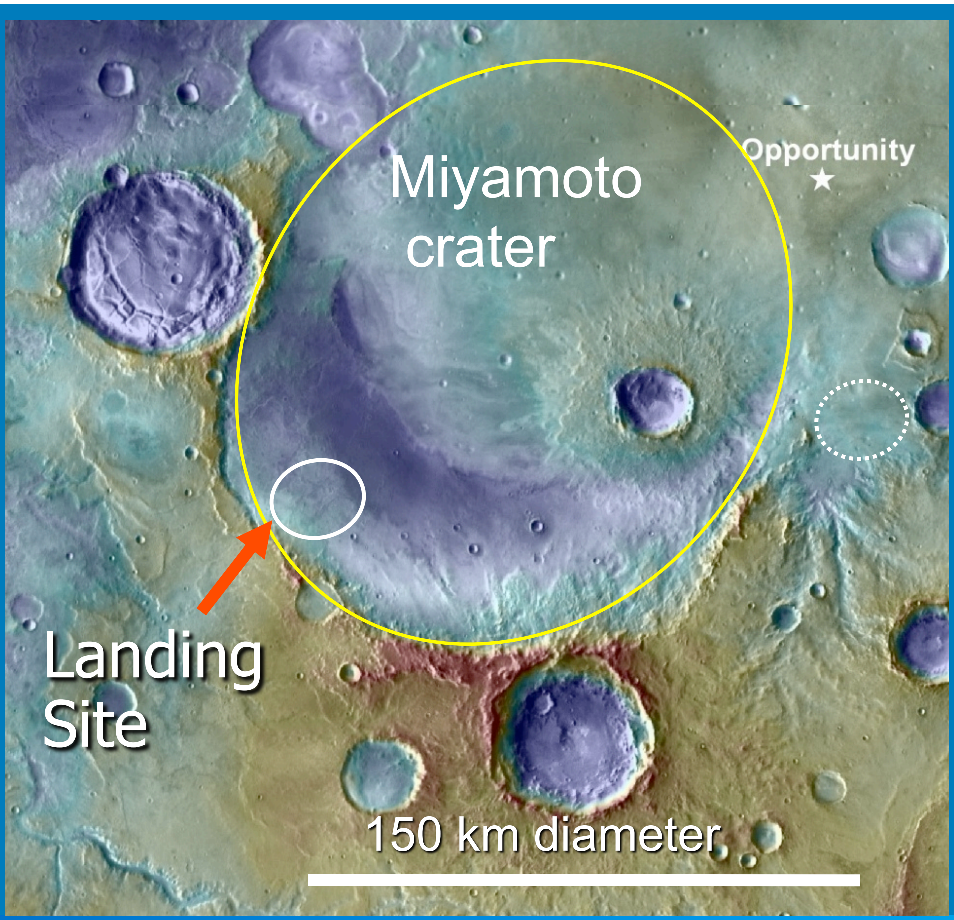


Miyamoto Crater – Sediments and Phyllosilicates in the Ancient Crust of Mars

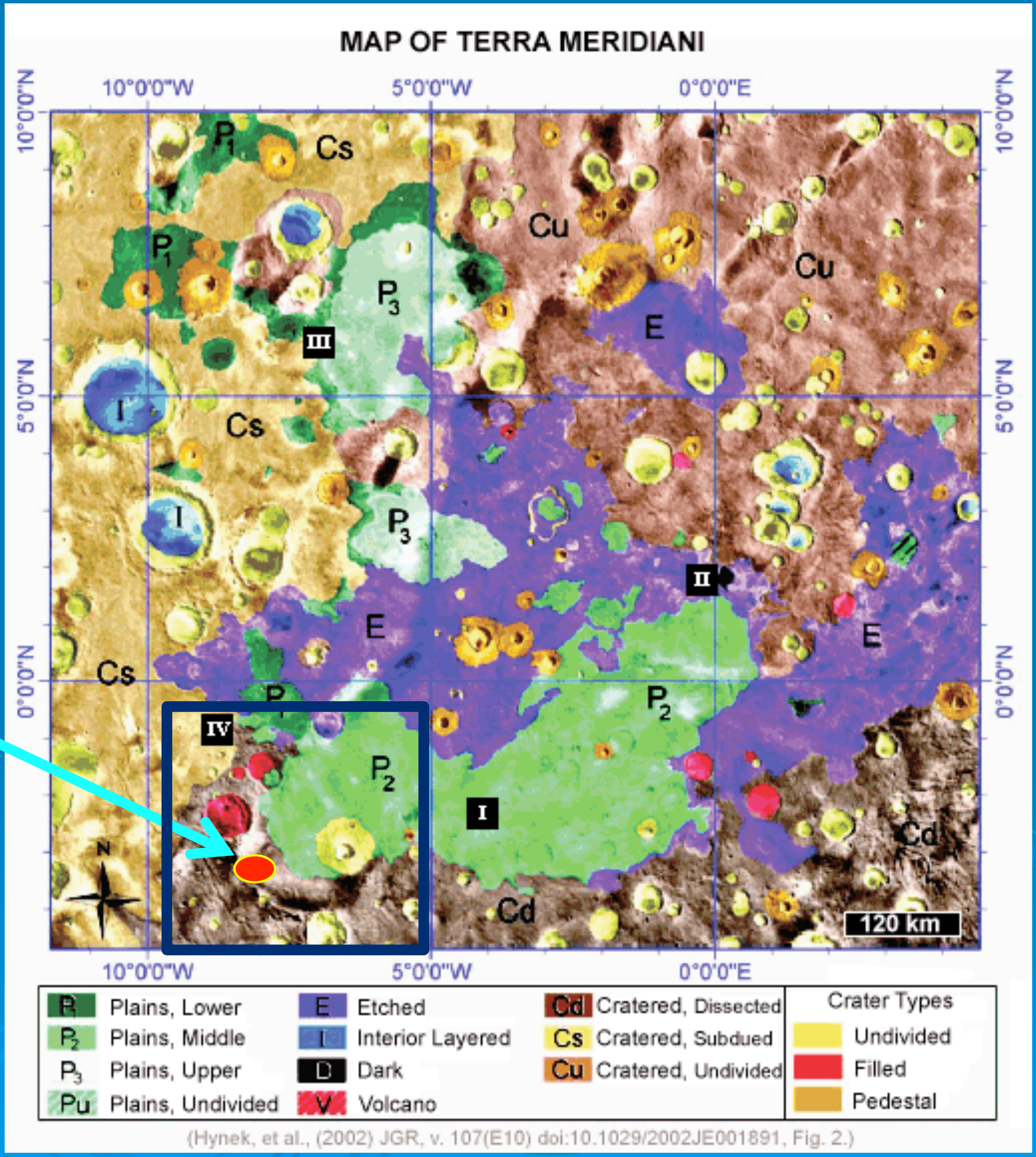
Horton Newsom, Ann Ollila, Nina Lanza, U. of New Mexico; Sandra Weisman, Wash. U.; Livio Tornabene, U. of Arizona; Chris Okubo, U.S.G.S.; Ted Roush, Giuseppe Marzo, Ames Res. Center; Larry Crumpler, NM Museum of Nat. Hist.; Mikki Osterloo, U. Hawaii

Miyamoto Crater – Responsive to MSL goals

1. A strong geological context
    1. Records materials and fluvial episode from deep Martian time
    2. Stratigraphy and lithology is similar to major units seen at Mawrth, and surfaces seen in Isidis basin margin, *all within ellipse* (L. Crumpler)
2. Diversity of materials and morphologies with a connection to water and habitability
    1. Phyllosilicates in distinct crater floor unit with possible layering
    2. Cemented river channel deposits forming inverted channel complex
    3. Putative chloride deposits, and Meridiani Planum sulfates and hematite (outside of ellipse)
3. Organic preservation potential
    1. In basal unit sediments with phyllosilicates
    2. In cemented channel deposits (silica or other cements)
4. Evidence of habitable environments
    1. Major fluvial erosion episode forming regional valley networks extending through Miyamoto Crater
    2. Alteration of crater floor basal materials by aqueous processes
    3. Cemented deposits from channel complex leading to inverted terrain

1. Regional Geologic History

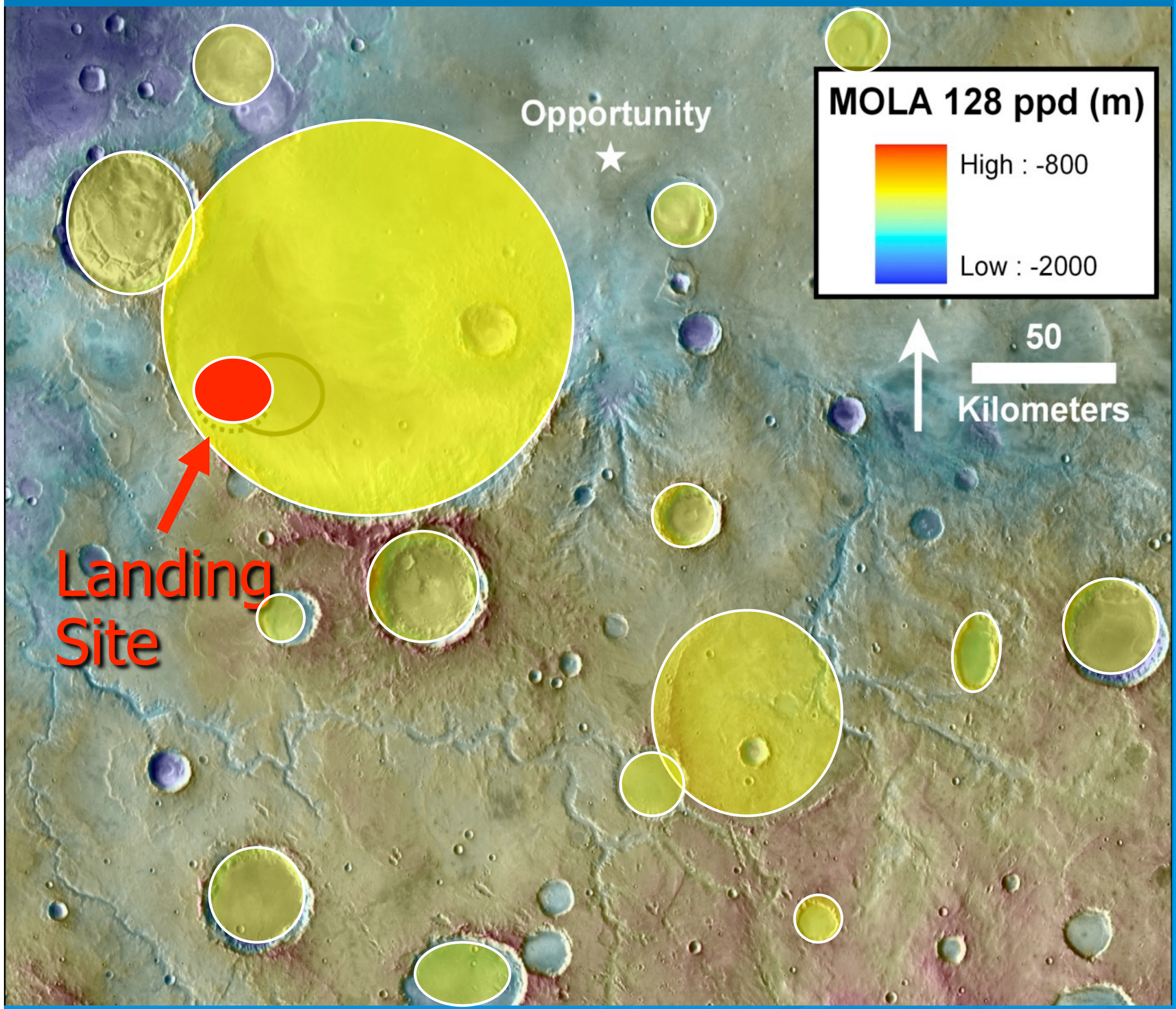
- Landing site located in cratered, dissected terrain (Cd), South West of hematite bearing plains (P2)



(Hynek et al., 2002)

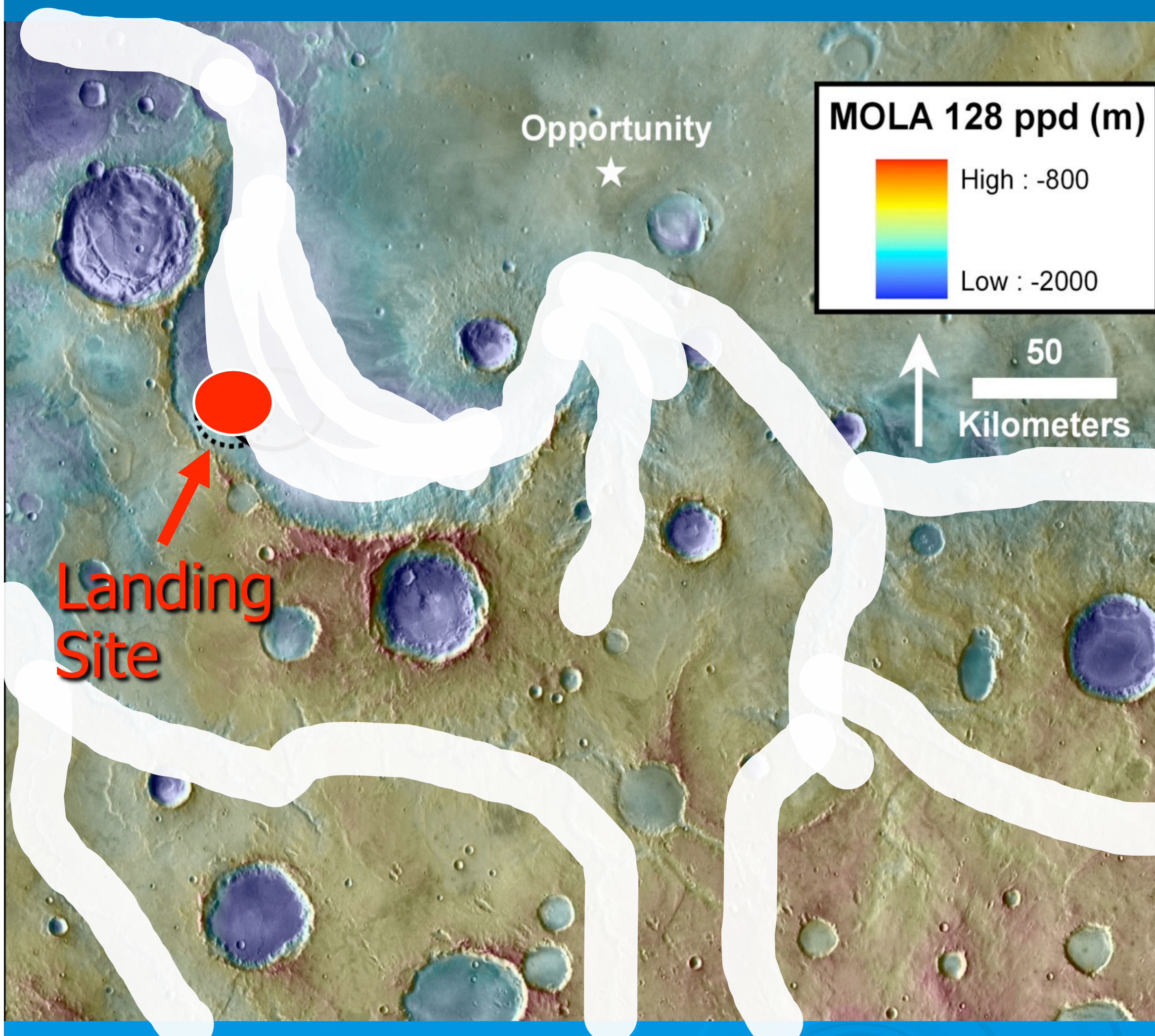
1 - Regional geological history

(Newsom et al., 2003; 2008)



1. Early crust and impact structures
2. Fluvial episode with erosion of major channels and formation of channel complex deposits in landing site
3. Burial by Meridiani Planum materials
4. Exhumation and erosion forming inverted channel deposits, and revealing the basal phyllosilicate-bearing materials

Regional geological history



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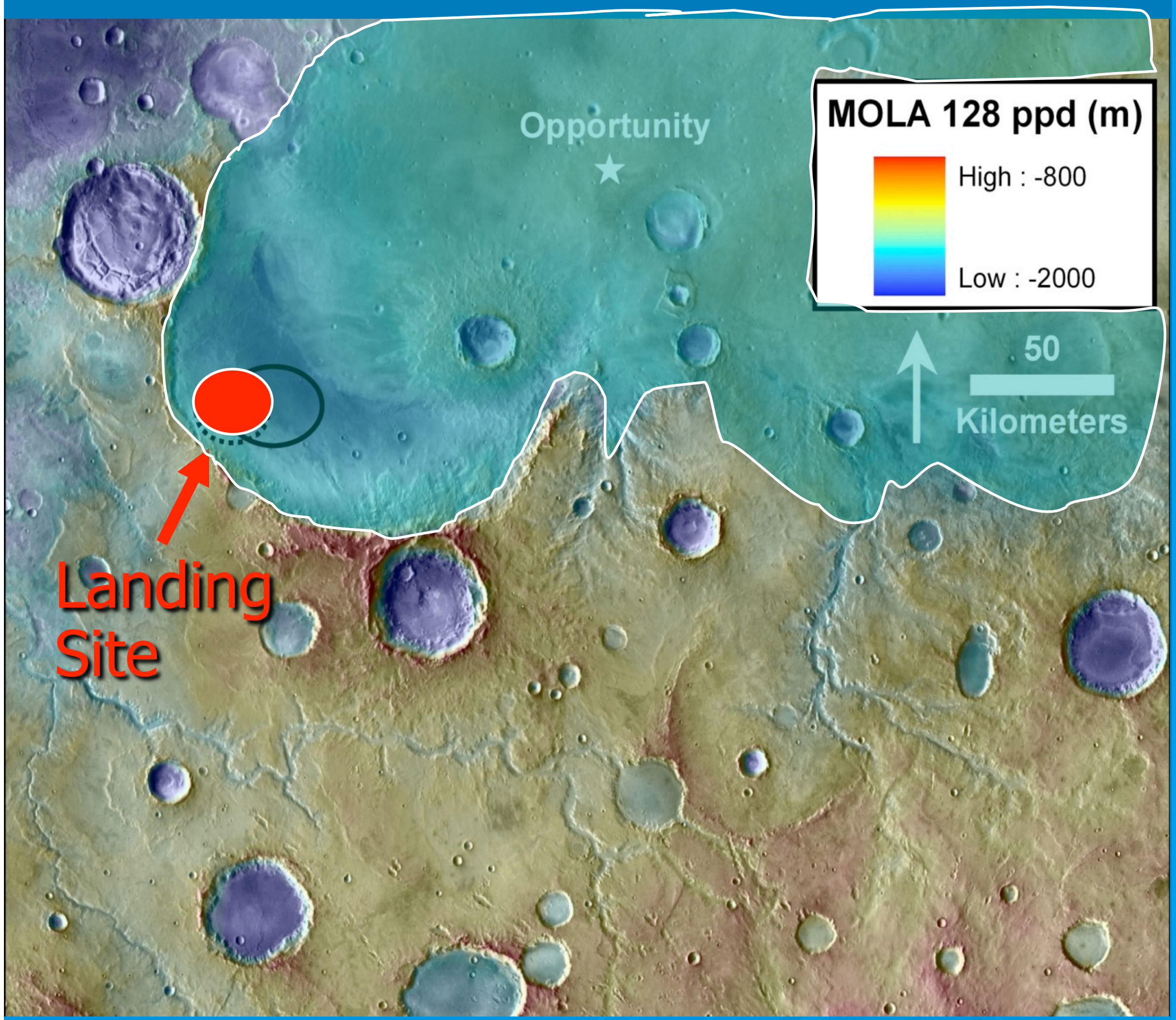

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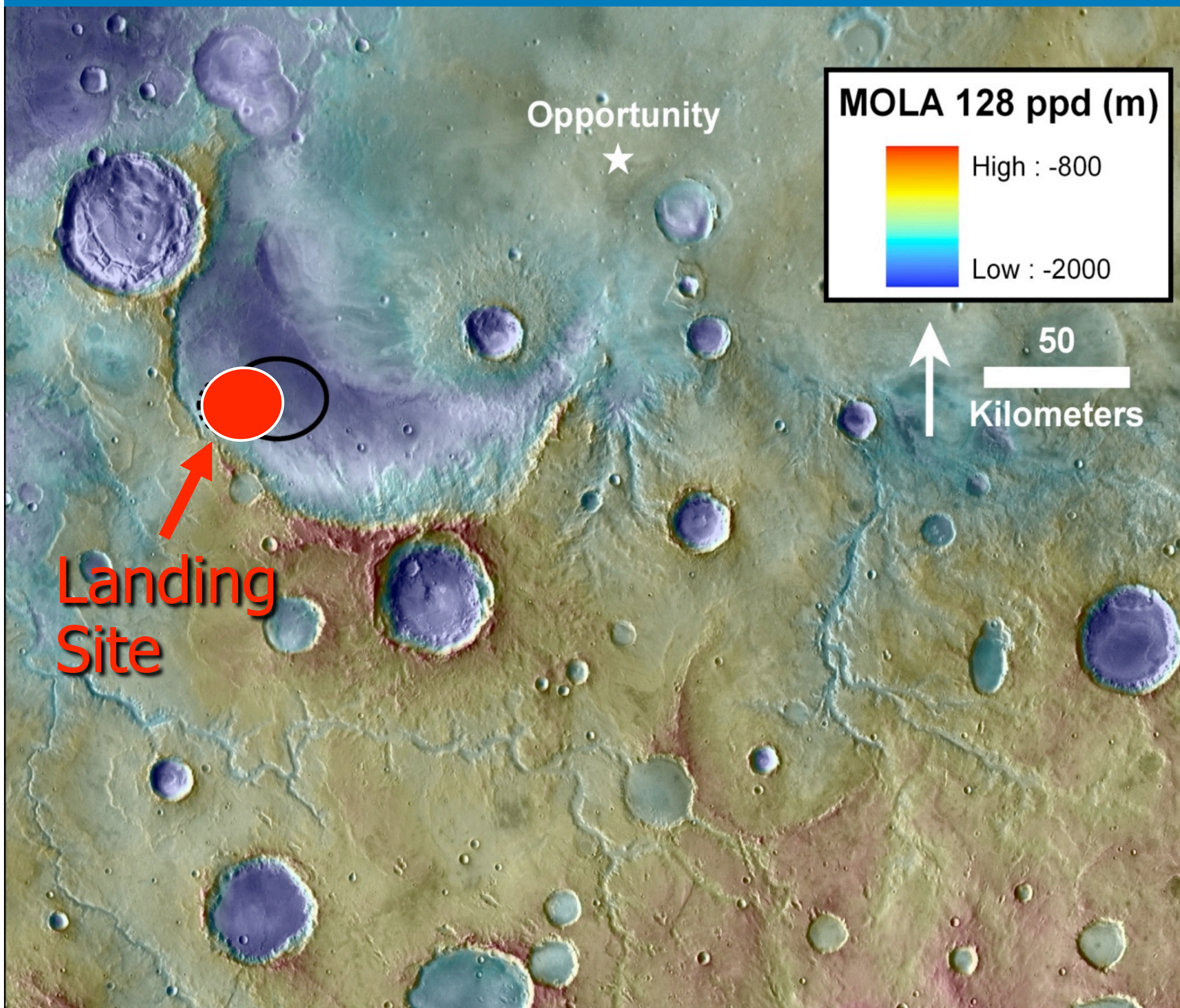


1. Early crust and impact structures
2. Deposition in landing site of layered sediments (with phyllosilicates) and river channel deposits
3. Burial by Meridiani Planum materials
4. Exhumation and erosion forming inverted channel deposits, and revealing the basal phyllosilicate-bearing materials

1. Geological Context - summary

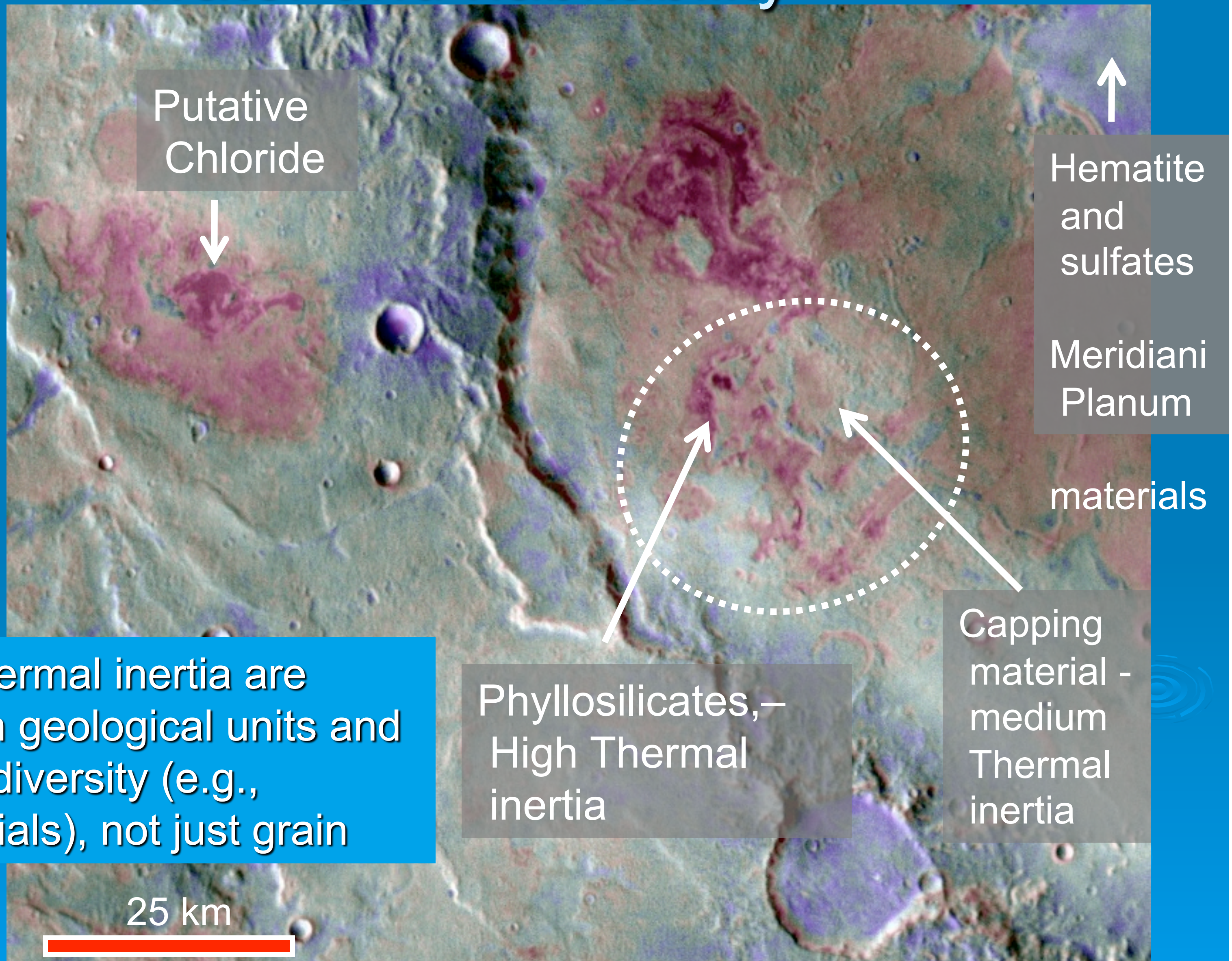
- The landing site can be place in a well established geological framework for the Meridiani Planum region
- The geological framework was developed beginning with site selection activities for the canceled 2001 mission and the MER rover mission (e.g., work by Hynek et al., 2002, Newsom et al., 2003, Weisman et al., 2008 et al., etc.)
- The crater and large valley networks are probably early to middle Noachian, the materials in the ellipse middle to late Noachian and the deposits were overlain by late Noachian / early Hesperian Meridiani Planum deposits (e.g., Hynek and Phillips 2001; Hynek 2002)

2.1 Diversity of mineralogy with a connection to water and habitability

Warmer night time temps

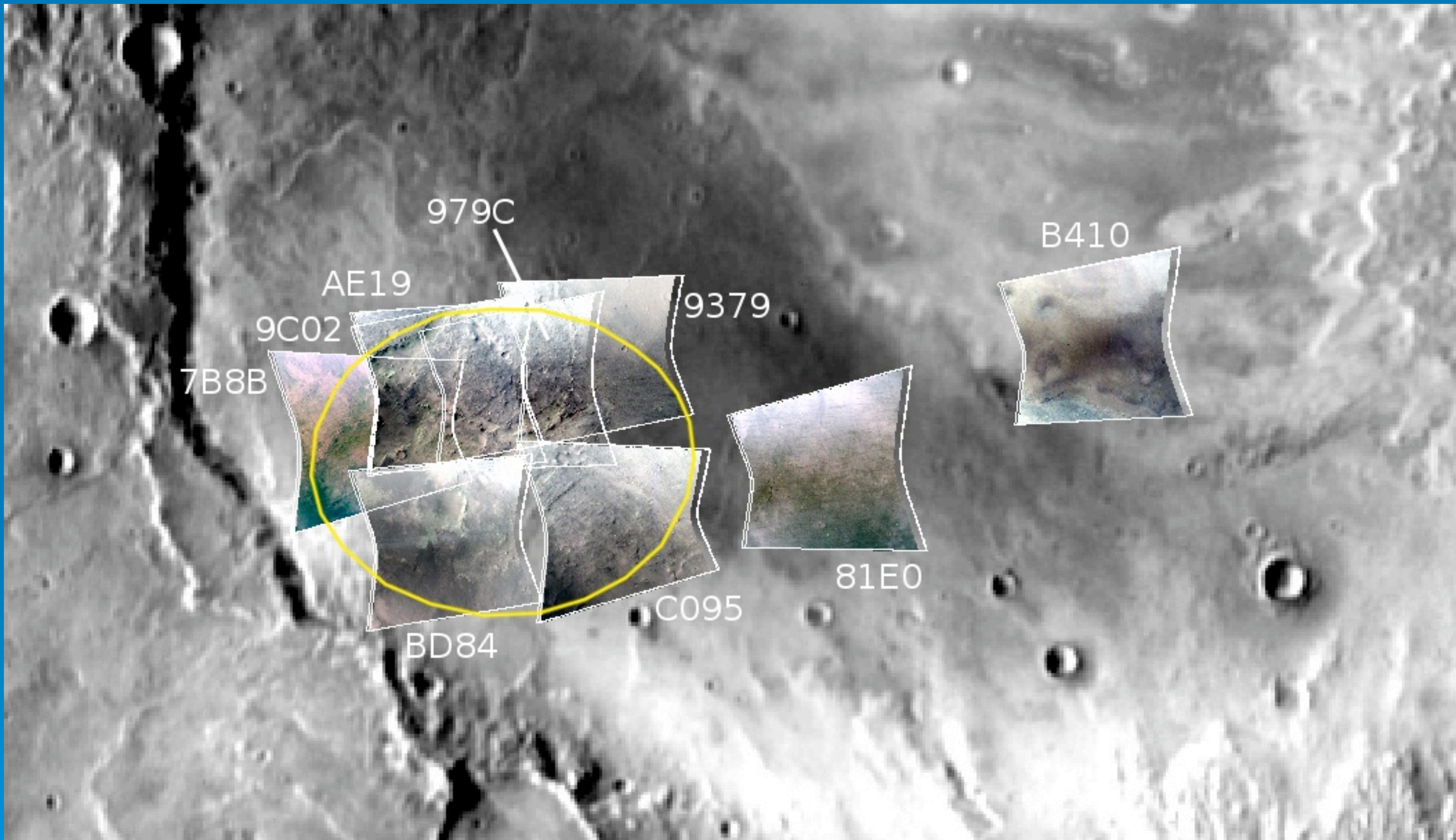
THEMIS colorized night IR over day mosaic

Cooler night time temps



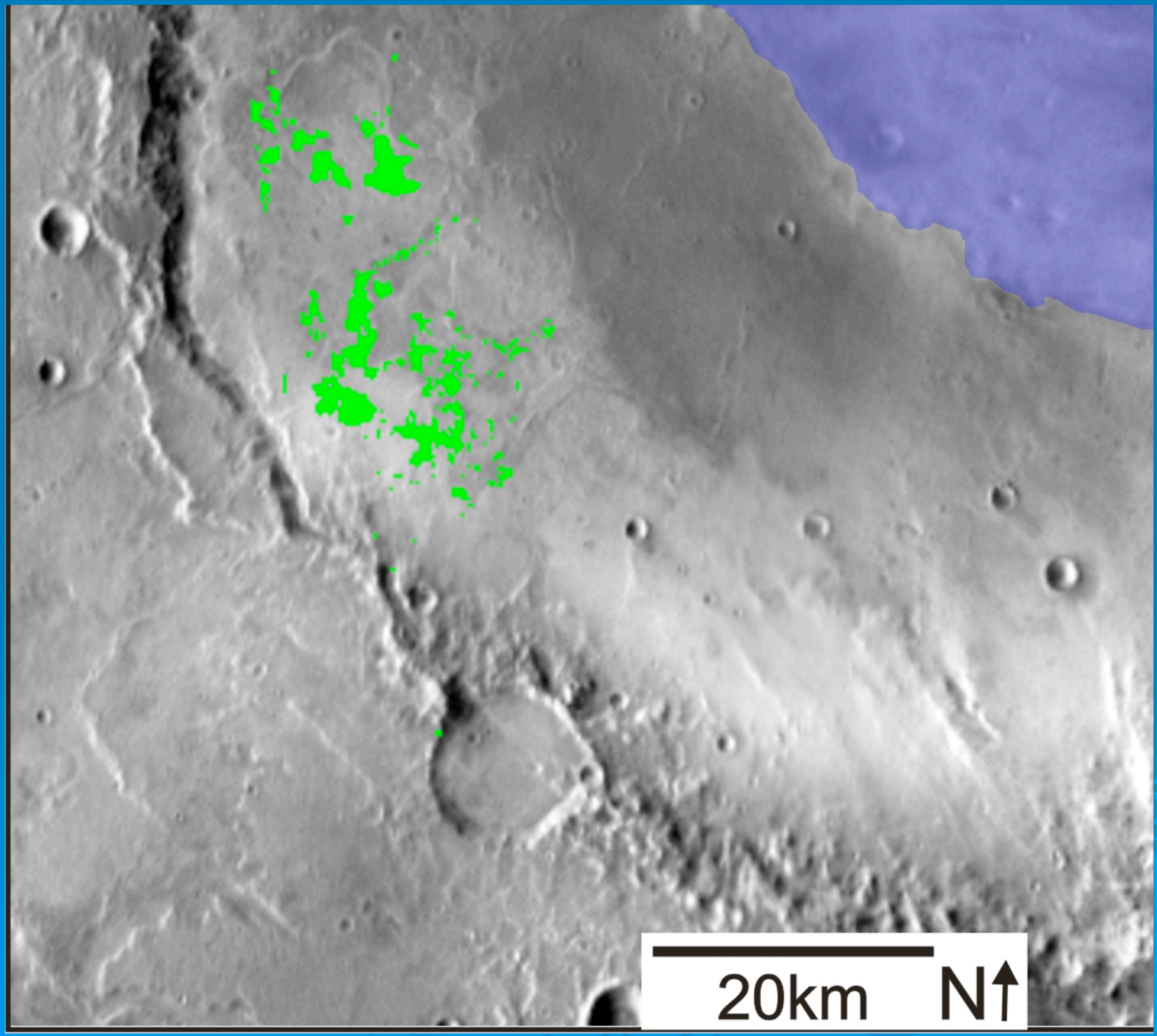
Variations in thermal inertia are consistent with geological units and mineralogical diversity (e.g., chloride materials), not just grain size

CRISM FRTs at Miyamoto Landing site



Colors are: R= 2.3 um, G= 1.5 um, B= 1.1 um. As a reminder, 7B8B and 81E0 were taken during relatively high dust loading.

Phyllosilicate detections

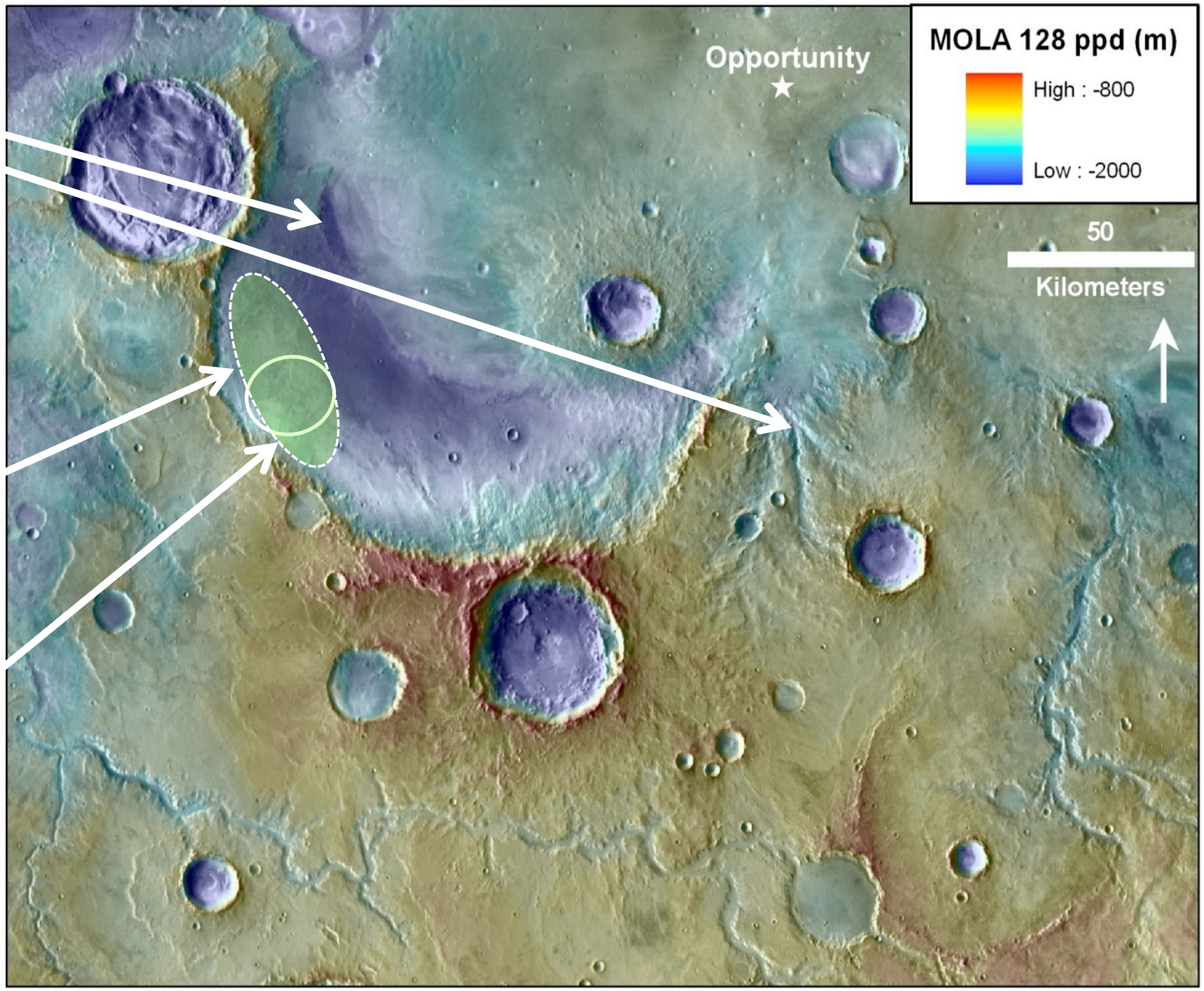


2.1 Diversity of Mineralogy - summary (See following talks by J. Bandfield and S. Wiseman)

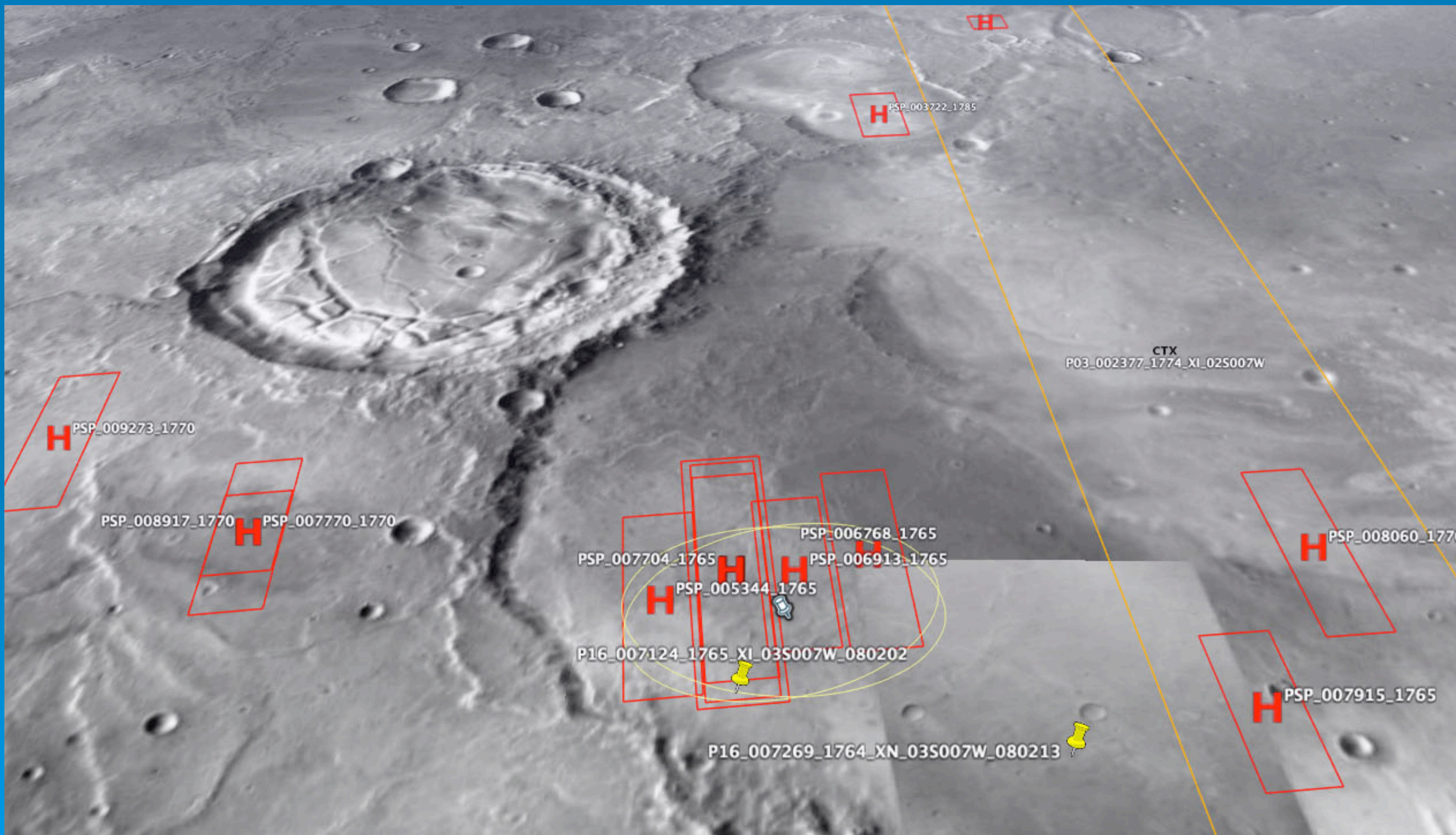
- THEMIS – TES (thermal IR)
  - Dust cover is not significant in landing site
  - Two major units in landing site (correspondence to map units)
  - Mafic/silica/anhydrous-sulfate phases may be indicative of variable alteration – possible presence of Meridiani Planum type materials
  - Hematite on the surface of Meridiani Planum located ~20-30 km east of the ellipse
  - Putative chloride deposits located ~ 30 km west of the ellipse
- CRISM – OMEGA (near IR)
  - Phyllosilicates are detected in landing site ellipse associated with outcrops of the underlying basin fill material
  - 2.3 μm absorption suggests a $Fe^{2+}/Fe^{3+}/Mg$ smectite
  - High correlation between mineralogy and outcrop morphology

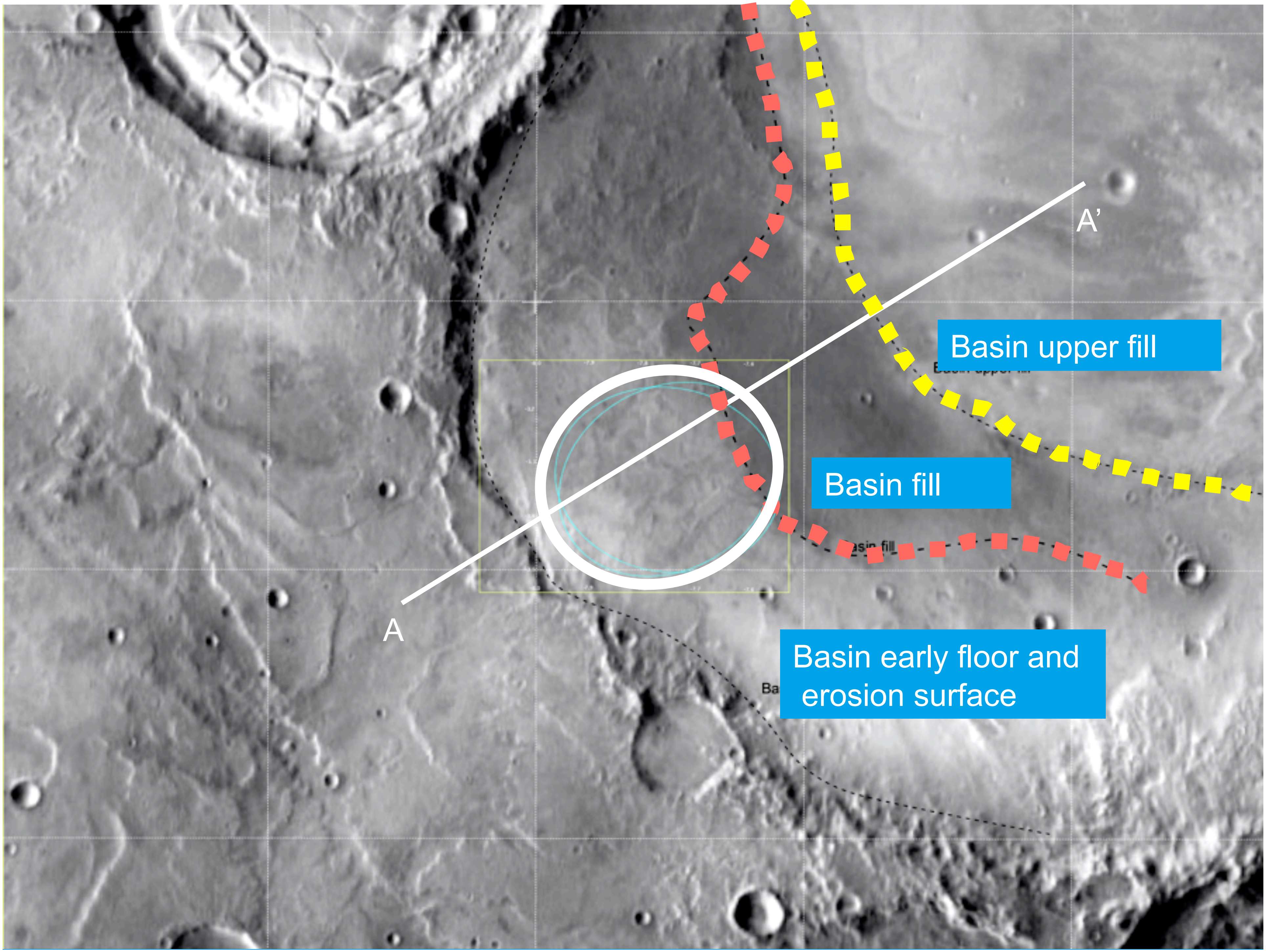
2.2 Diversity of geomorphology with a connection to water and habitability

1. Major regional channel systems
2. Inverted channel terrain in landing site ellipse
3. Basal unit (basin fill) with phyllosilicates



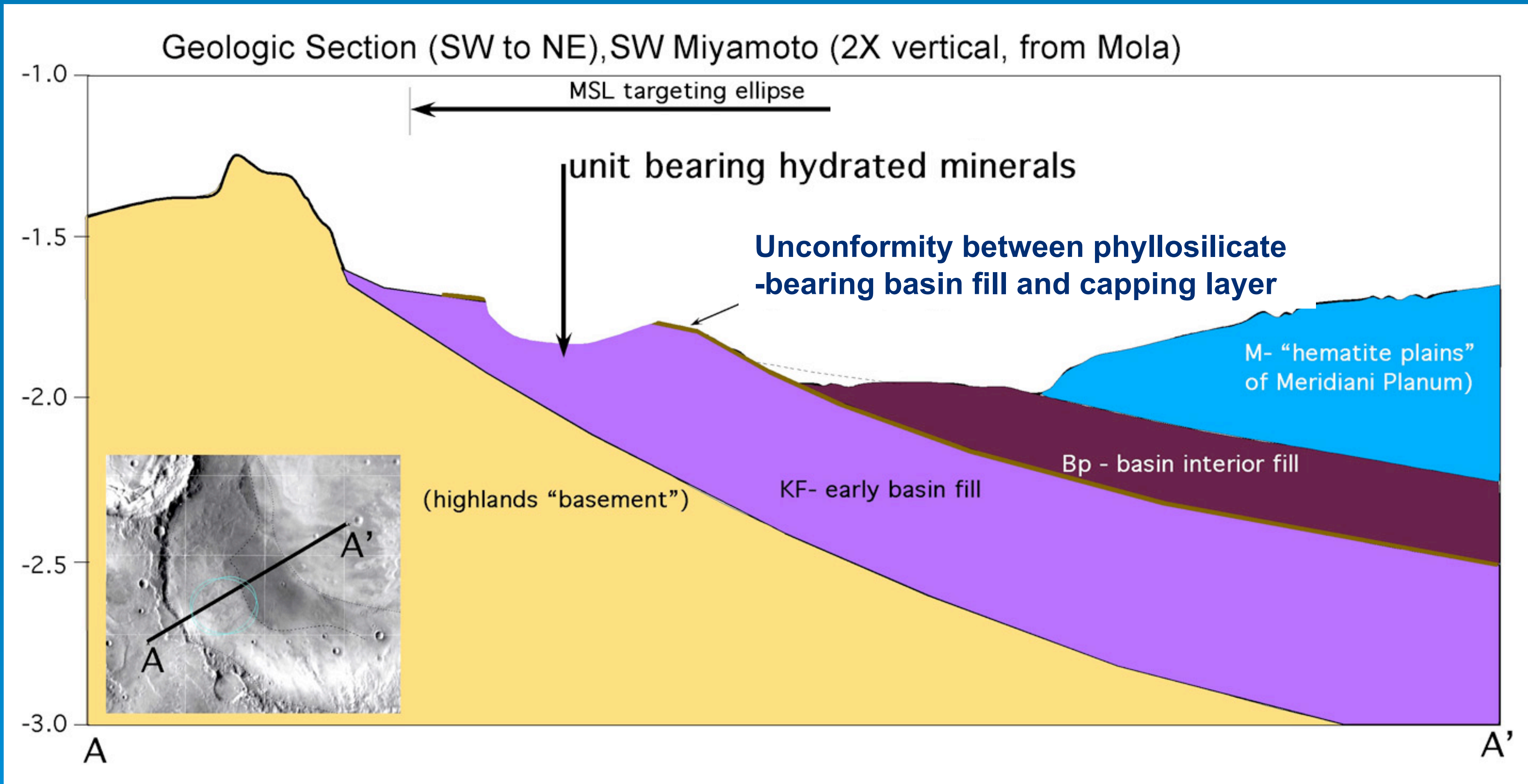
HiRISE coverage (9/5/08)
Note stereo coverage in some portions





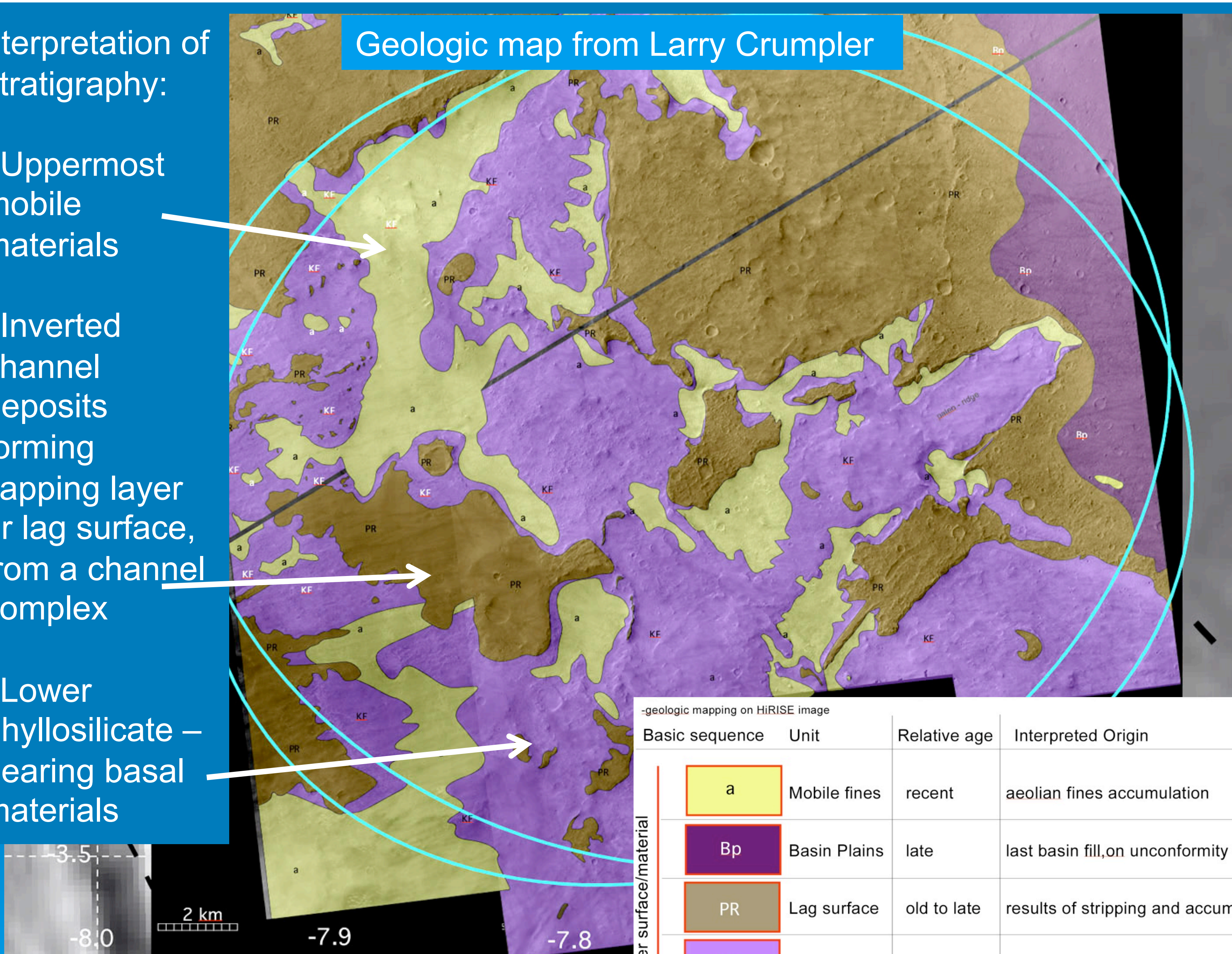
A'
Basin upper fill
Basin fill
A
Basin early floor and
erosion surface

Cross section (L. Crumpler)



Interpretation of stratigraphy:

- Uppermost mobile materials
- Inverted channel deposits forming capping layer or lag surface, from a channel complex
- Lower phyllosilicate – bearing basal materials

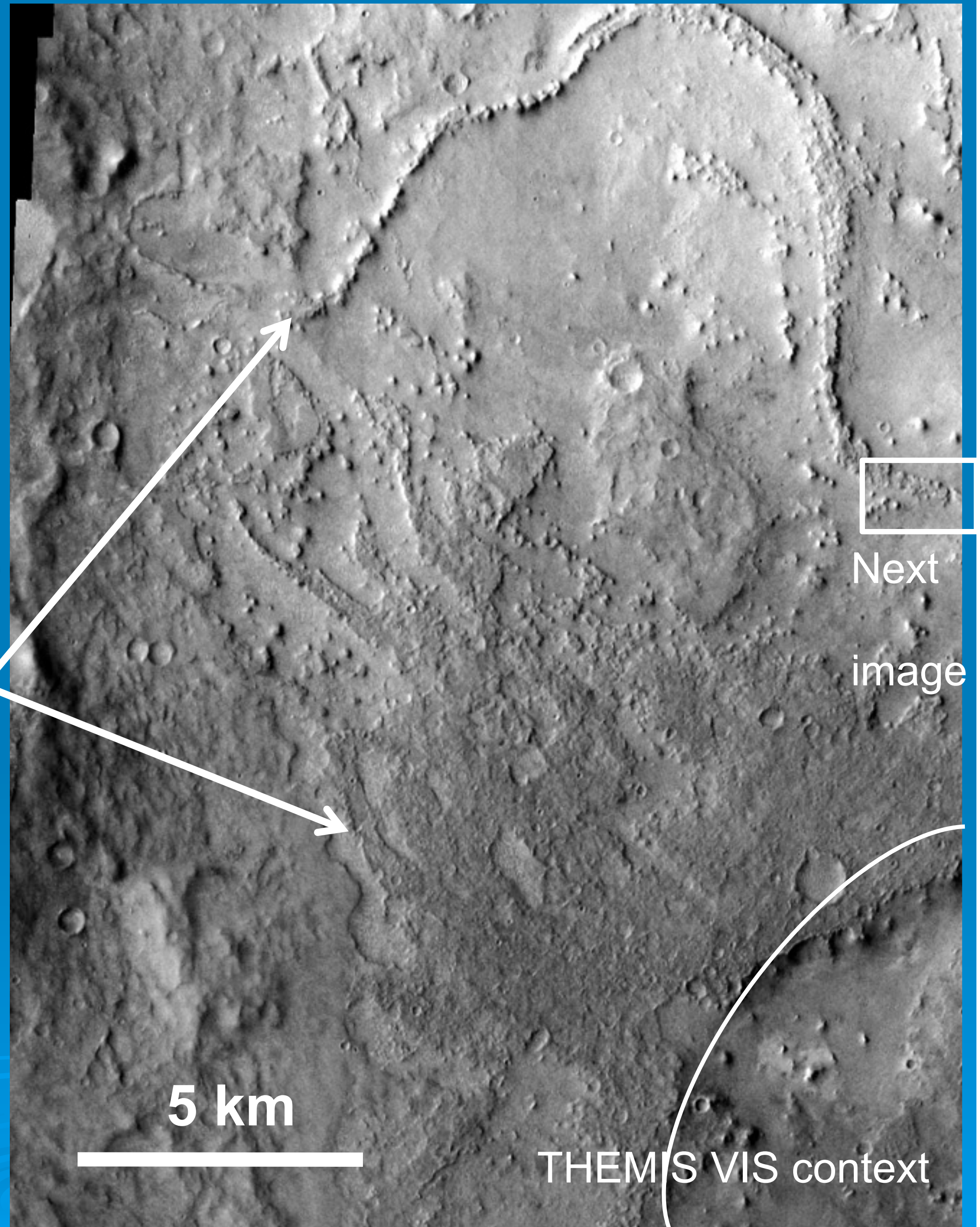


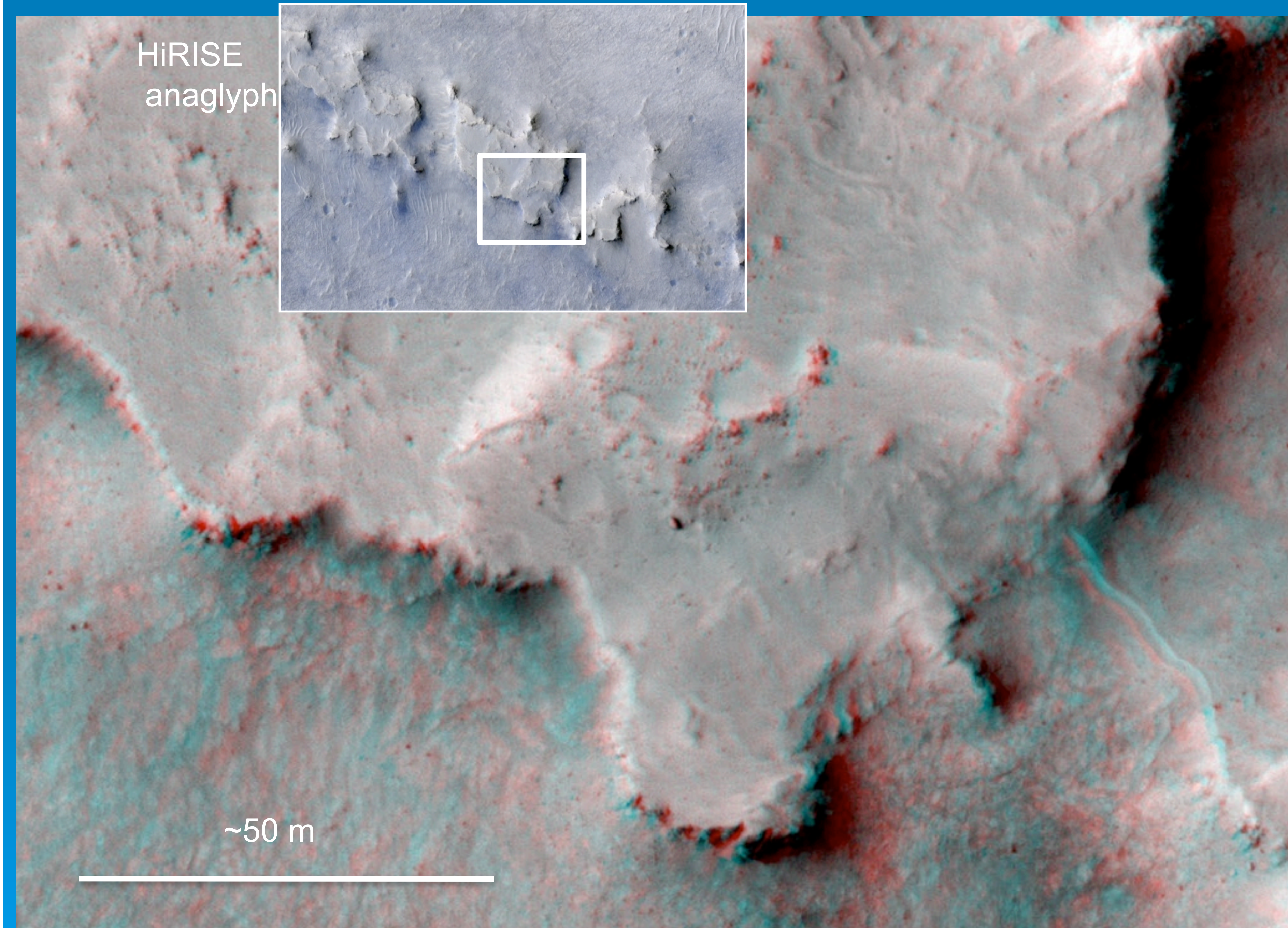
-geologic mapping on HiRISE image

Basic sequence (older surface/material ↓)	Unit	Relative age	Interpreted Origin
a	Mobile fines	recent	aeolian fines accumulation
Bp	Basin Plains	late	last basin fill,on unconformity
PR	Lag surface	old to late	results of stripping and accumulation
KF	Substrate	old	original ancient deposition

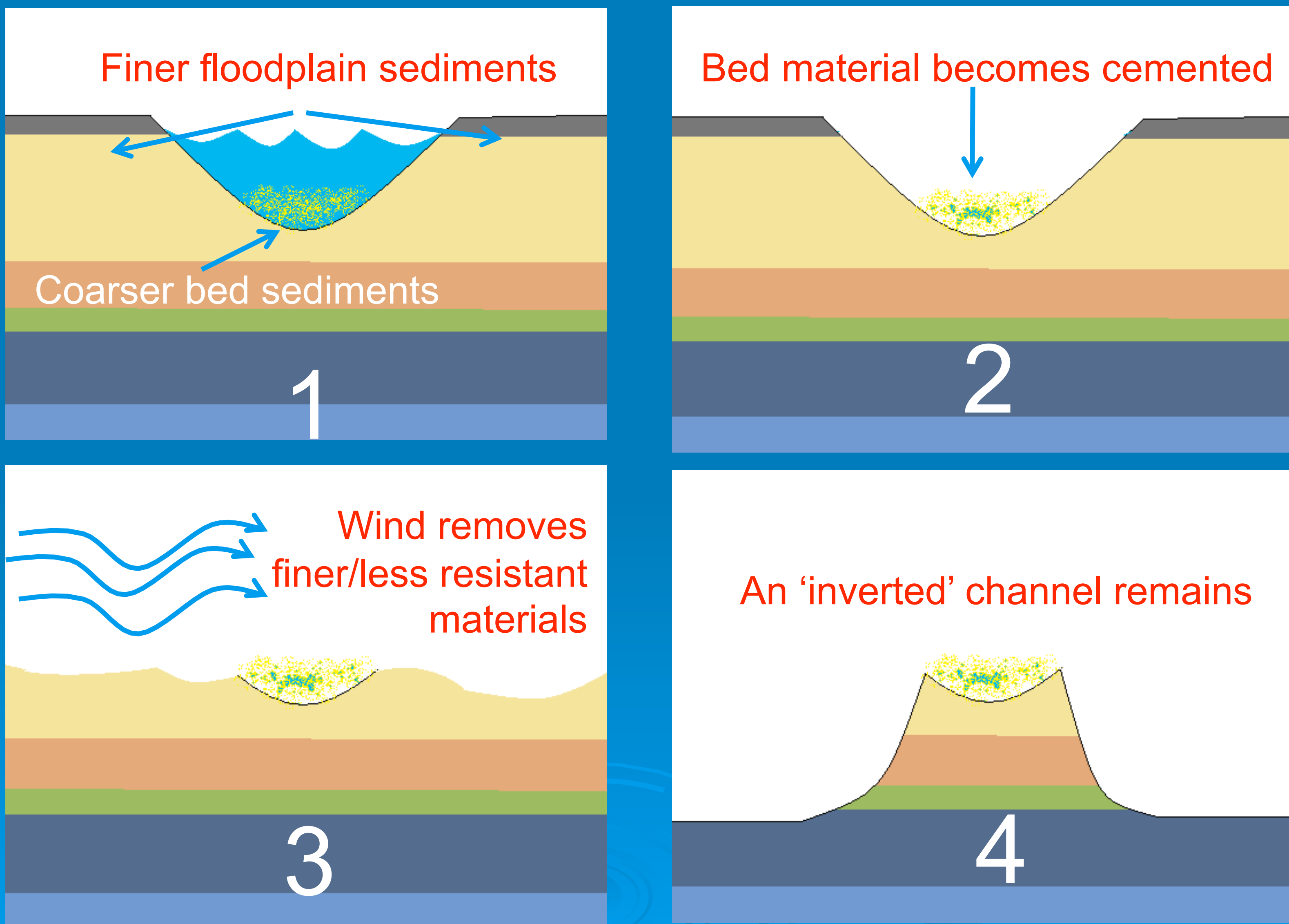
Miyamoto crater (SW Meridiani) - geomorphology

- Exhumed crater floor with upper basin fill to East
- Inverted channel deposits forming capping layer from a channel complex
- Absence of volcanism in the area and lack of lobate deposits argues against volcanism
- Lower phyllosilicate – bearing basal materials



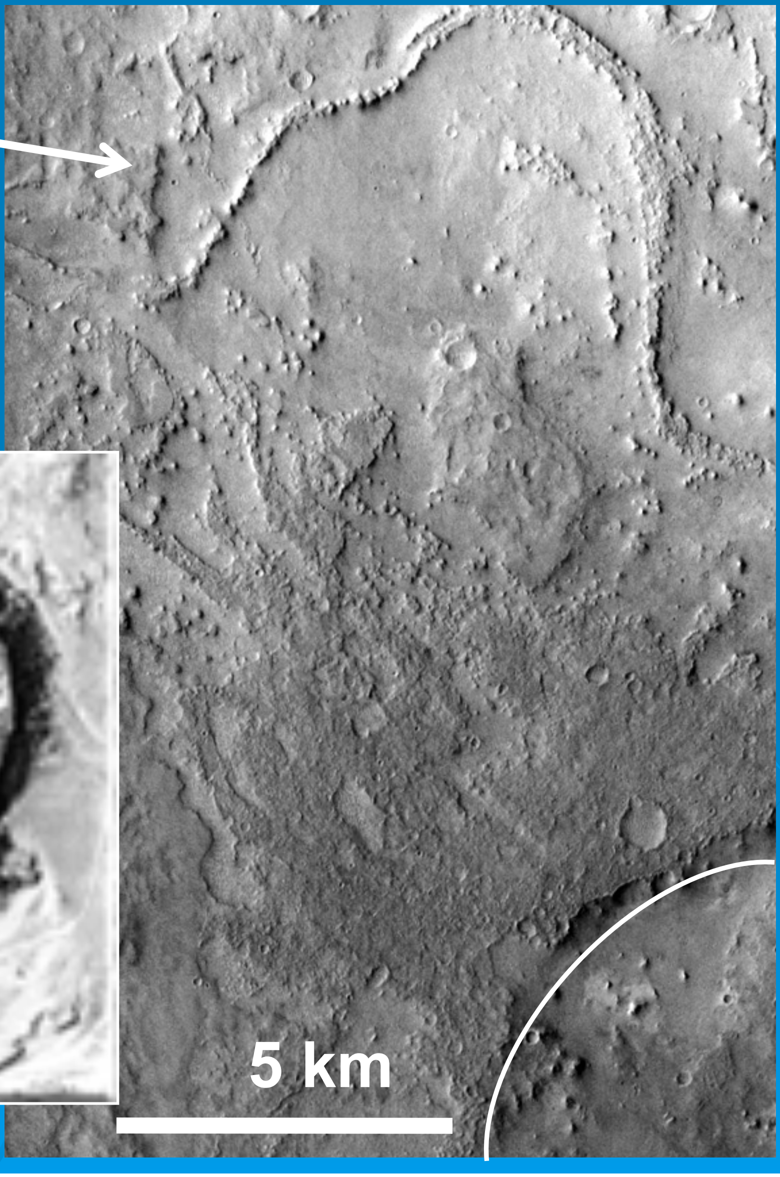

HiRISE
anaglyph
~50 m

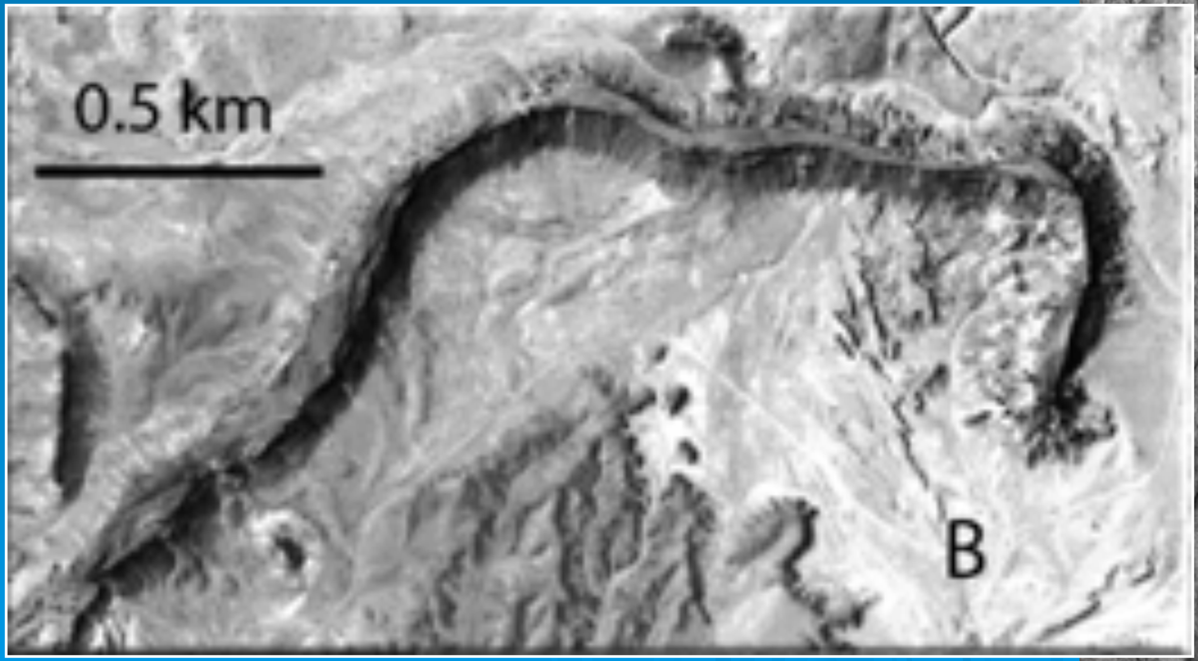
Inverted channel formation by bed cementation



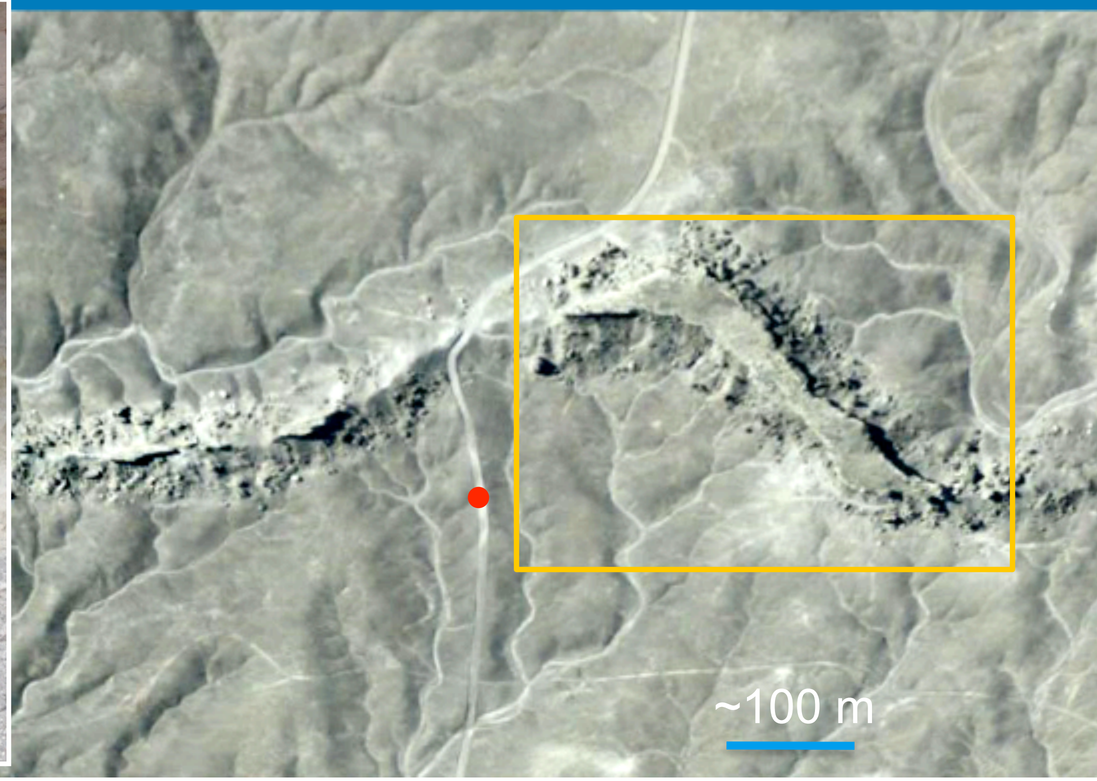
Inverted channel deposits – terrestrial analog - Green River

- Miyamoto Crater
- Green River, Utah

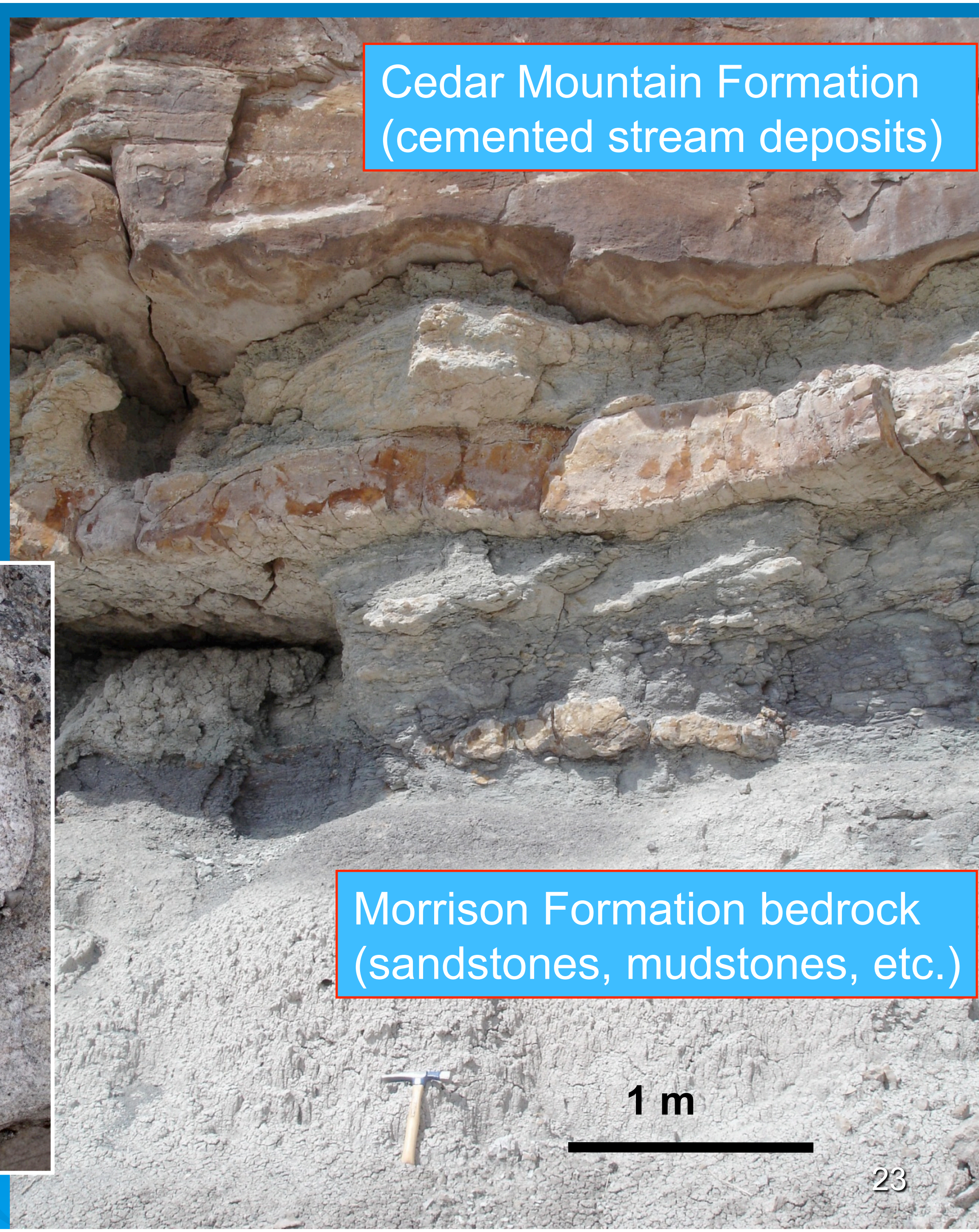




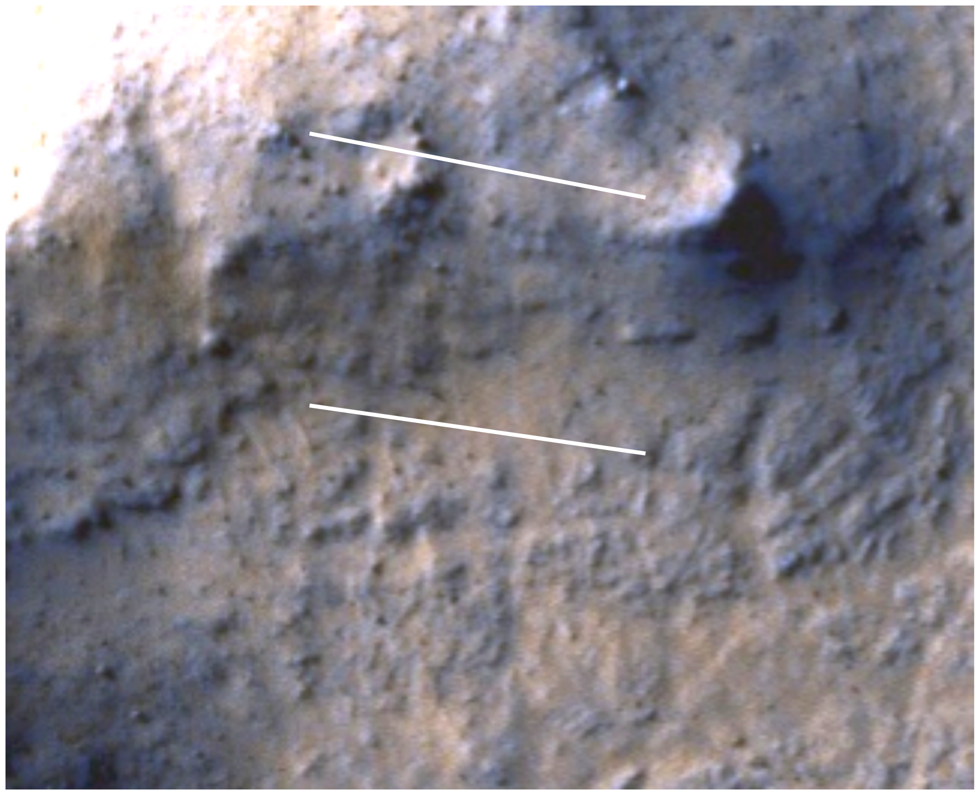

Green River Utah

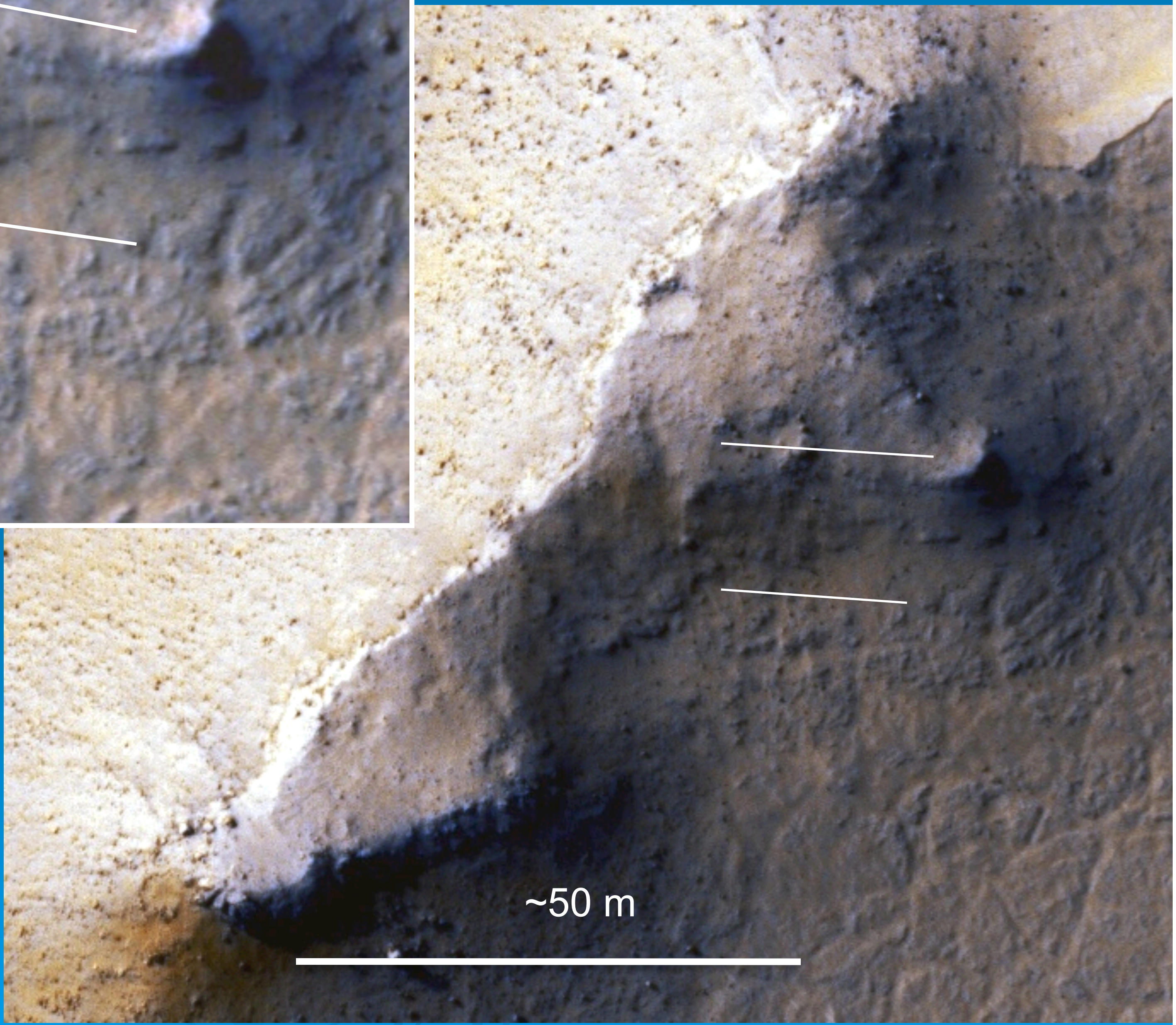

~100 m

Inverted channel cap rock - cemented sedimentary deposits



Inverted channel - layering in cap material

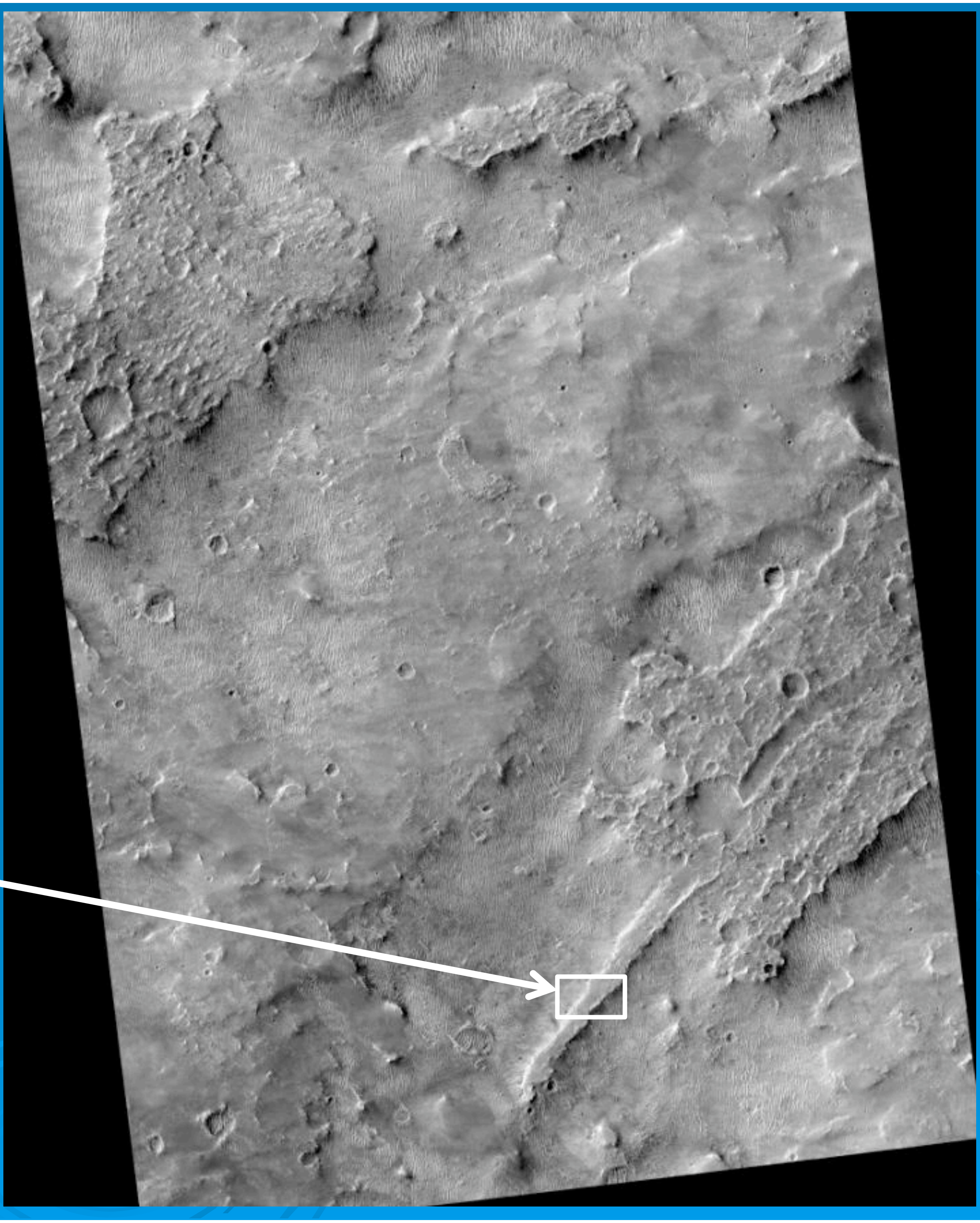




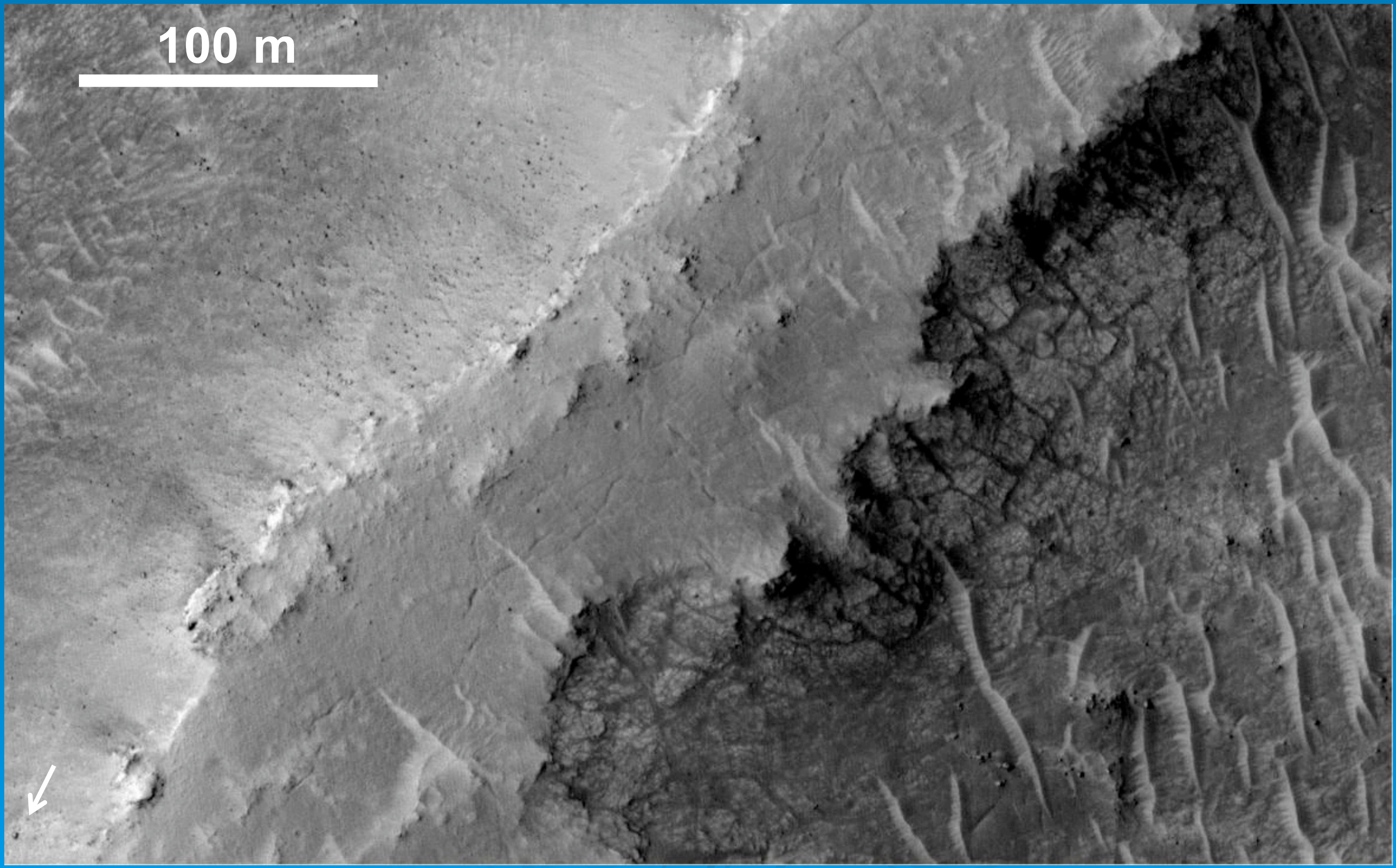
Brand new color HiRISE received yesterday thanks to Chris Okubo!

Inverted channel in center of landing site

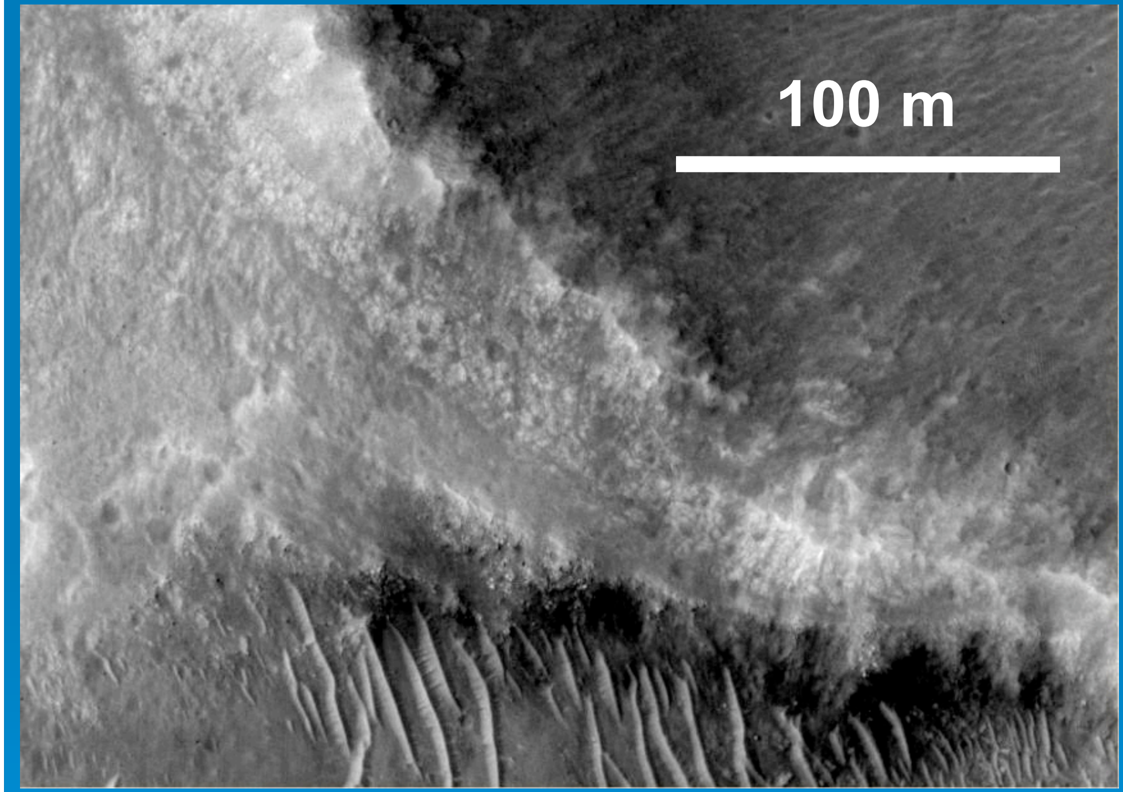
- Note the linear positive relief features (inverted channel assemblage)
- HiRISE Image, image width 6 km.

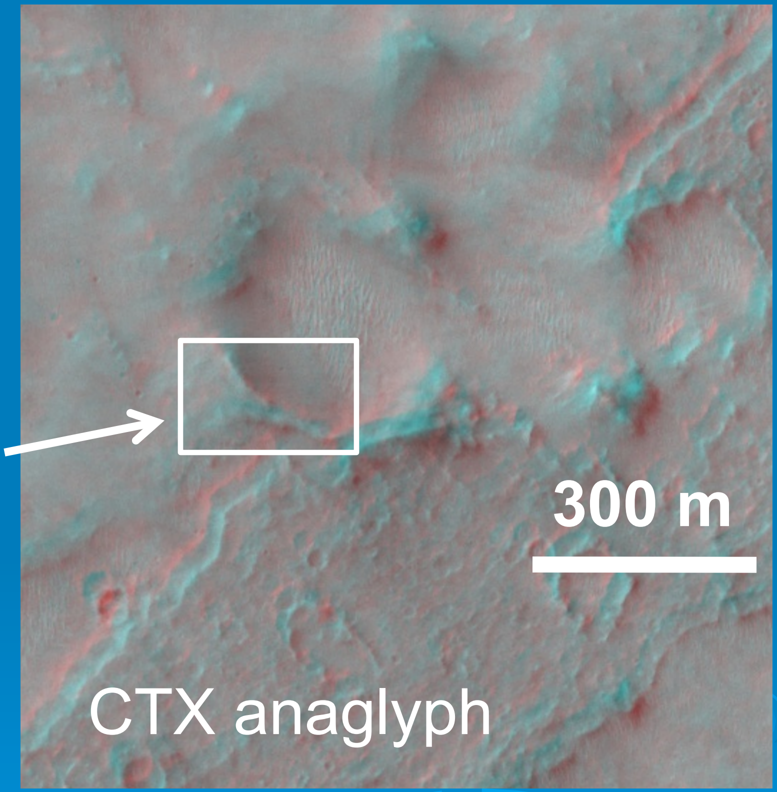


Close up of inverted channel deposit and phyllosilicate basal layer in ellipse



Nature of phyllosilicate-bearing basal layer - layering in upturned crater rim





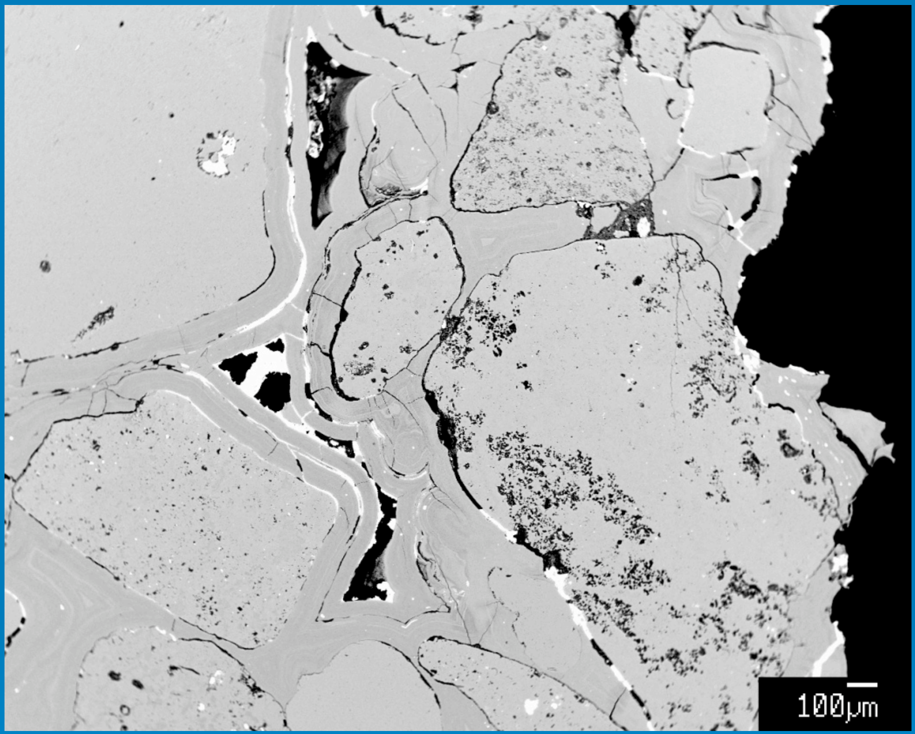
Definite layered structure of basal unit materials that contain phyllosilicates is consistent with sedimentary origin

2.2 Diversity of Miyamoto crater floor morphology - summary

1. The landing site is a classic truncated basin margin exposure, and there is an absolute correlation between the CRISM "phyllosilicates" and the basal unit within the ellipse
2. The basal unit is layered in some exposures and the presence of phyllosilicates provides evidence for alteration of this basin fill unit
3. The overlying capping unit consists of deposits related to an Inverted channel deposit complex
4. There is also evidence for a very late minor fluvial episode after the erosion creating the inverted channels

3. Preservation potential for organics

- Cementation of channel deposits that form capping unit
  - Silica - Consistent with Miyamoto remote sensing data (Bandfield and Rogers, cdp) – See example
  - Carbonates – no detection but found in meteorites
  - Chloride – no detection but identified in area near landing site
- Phyllosilicate bearing basal layer – potential for sequestration of organics during deposition



Backscattered electron image of the Cedar Mountain Formation, Utah (silica cemented stream deposits)

3. Fossil and organic preservation potential - summary

- Upper capping material suggests cementation of fluvial bed material
  - Channel deposits are likely sites for organic material
  - Silica and other cements have a high organic preservation potential
  - MSL can distinguish the different types of cements and nature of the capping material
- Lower phyllosilicate-bearing basal unit material may consist of altered basin fill
  - Possible fluvial or lacustrine sediments, with organic preservation potential Source to sink – consistent with source from major valley network erosion
  - Alteration of this material to form phyllosilicates is possible, both before or after sedimentation given the location within a major fluvial-lacustrine system
  - Late alteration by near surface processes is unlikely due to continued exhumation and erosion
- Nearby but outside of ellipse
  - Chloride deposits have high preservation potential
  - Sulfate deposits of Meridiani have high preservation potential

4. Habitability

Green River, Utah with inverted channel complex deposits

- Miyamoto site located in a huge crater along a major entrenched river system draining an area the size of Texas
- Basal layer with phyllosilicates - may be fluvial or lake deposits
- Capping material forming inverted channel deposits - may represent cemented channel bed materials from a channel complex on the floor of the crater

Miyamoto Crater – Conclusions

1. A strong geological context
   1. Records materials and fluvial episode from deep Martian time
   2. Stratigraphy and lithology is similar to major units seen at Mawrth, and surfaces seen in Isidis basin margin, *all within ellipse* (L. Crumpler)
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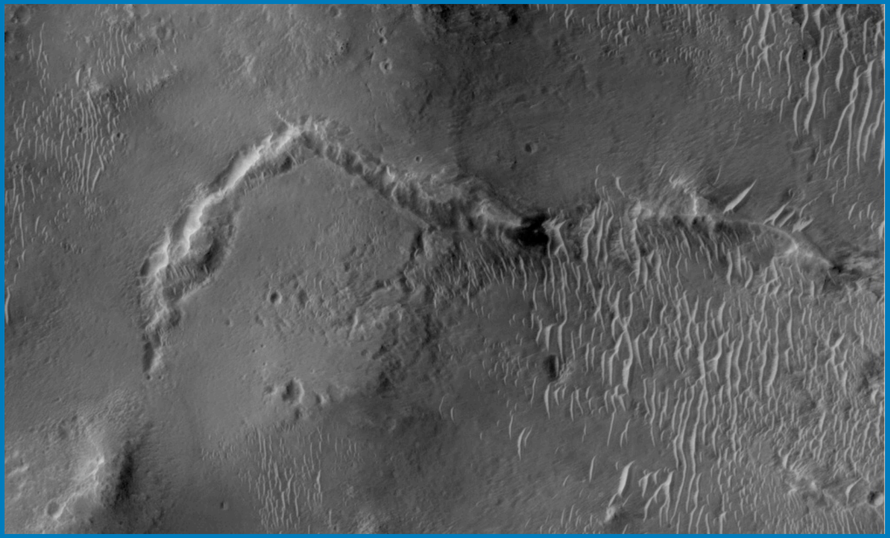
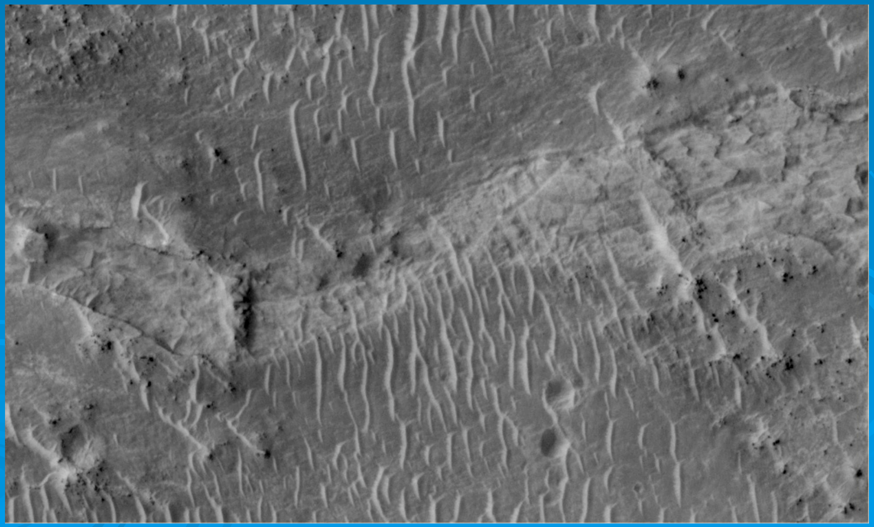
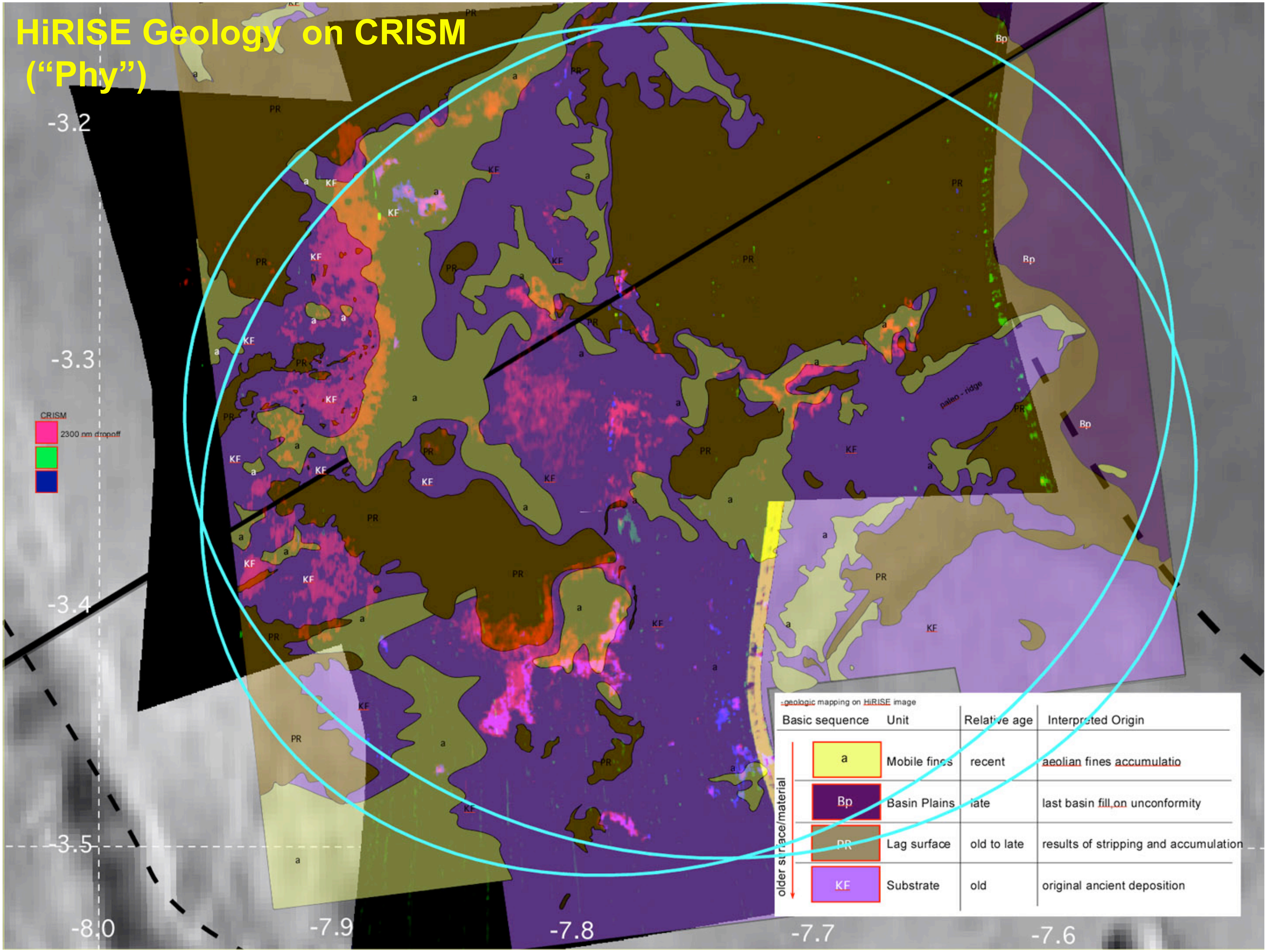
   2. In cemented channel deposits (silica or other cements)
4. Evidence of habitable environments
   1. Major fluvial erosion episode forming regional valley networks extending through Miyamoto Crater
   2. Alteration of crater floor basal materials by aqueous processes
   3. Cemented deposits from channel complex leading to inverted terrain

Evidence for late channel formation

- Upper reaches (Inverted channel)
- Lower reaches (cataract)
- Location suggests formation after major erosional epoch






HiRISE Geology on CRISM
("Phy")
-3.2
-3.3
-3.4
-3.5
-8.0
-7.9
-7.8
-7.7
-7.6
CRISM
2300 nm dropoff
paleo - ridge
geologic mapping on HiRISE image
Basic sequence
Unit
Relative age
Interpreted Origin
older surface/material
a
Mobile fines
recent
aeolian fines accumulatio
Bp
Basin Plains
late
last basin fill on unconformity
PR
Lag surface
old to late
results of stripping and accumulation
KF
Substrate
old
original ancient deposition

Miyamoto geologic map units

-geologic mapping on HiRISE image

Basic sequence	Unit		Relative age	Interpreted Origin
older surface/material ↓	a	Mobile fines	recent	aeolian fines accumulation
	Bp	Basin Plains	late	last basin fill,on unconformity
	PR	Lag surface	old to late	results of stripping and accumulation
	KF	Substrate	old	original ancient deposition