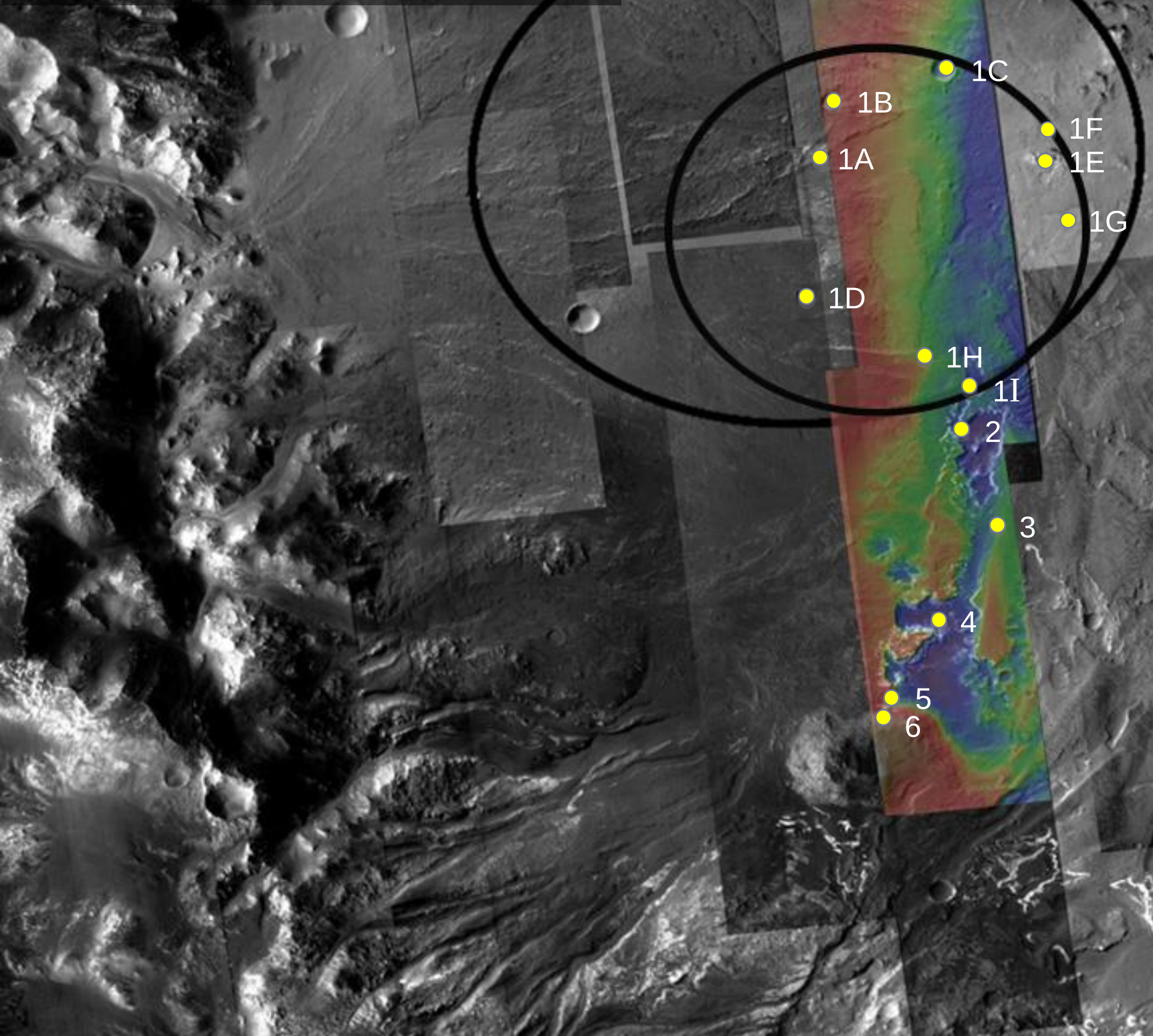
Summary Slides

Landing Site Factor	Mars 2020 Mission and Decadal Priority Science Factors																							
	Environmental Setting for Biosignature Preservation and Taphonomy of Organics								Type 1A & 1B Samples: Aqueous Geochemical Environments indicated by Mineral Assemblages									Type 2 Samples: Igneous		Context: Martian History Sampled, Timing Constraints				
	Deltaic or Lacustrine (perennial)	Lacustrine (evaporitic)	Hydrothermal (<100°C) surface	Hydrothermal (<100°C) subsurface	Pedogenic	Fluvial/Alluvial	No diagenetic overprinting	Recent exposure	Crustal phyllosilicates	Sedimentary clays	Al clays in stratigraphy	Carbonate units	Chloride sediments	Sulfate sediments	Acid sulfate units	Silica deposits	Ferric Ox./Ferrous clays	Igneous unit (e.g, lava flow, pyroclastic, intrusive)	2nd Igneous unit	Pre- or Early-Noachian Megabreccia	Oldest stratigraphic constraint	Youngest stratigraphic constraint	Stratigrapy of units well-defined	Dateable surface, volcanic (unmodified crater SFD)
No TRN Required																								
Gusev	○	~	●		~	○	●	~	~	○	~	●		●	●	●	●	●	●		LN	EH	~	●

Holden Crater Summary

R. Irwin, J. Wray, J. Grant



Inside non-TRN ellipse

1A-D: layered outcrops on alluvial fans

1E: knob of underlying material (megabreccia)

1F: upper LTL outcrops

1G: coarse material (distal Uzboi, poss. megabreccia)

1H: fan toe (exposed contact between alluvium and underlying LTL)

1I: LTL outcrop

[*Other outcrops of each material type are available*]

Extended mission

2: many LTL outcrops

3: layered flood deposits

4: LTL outcrops, higher phyllosilicate abundance

5: topographically higher LTL section

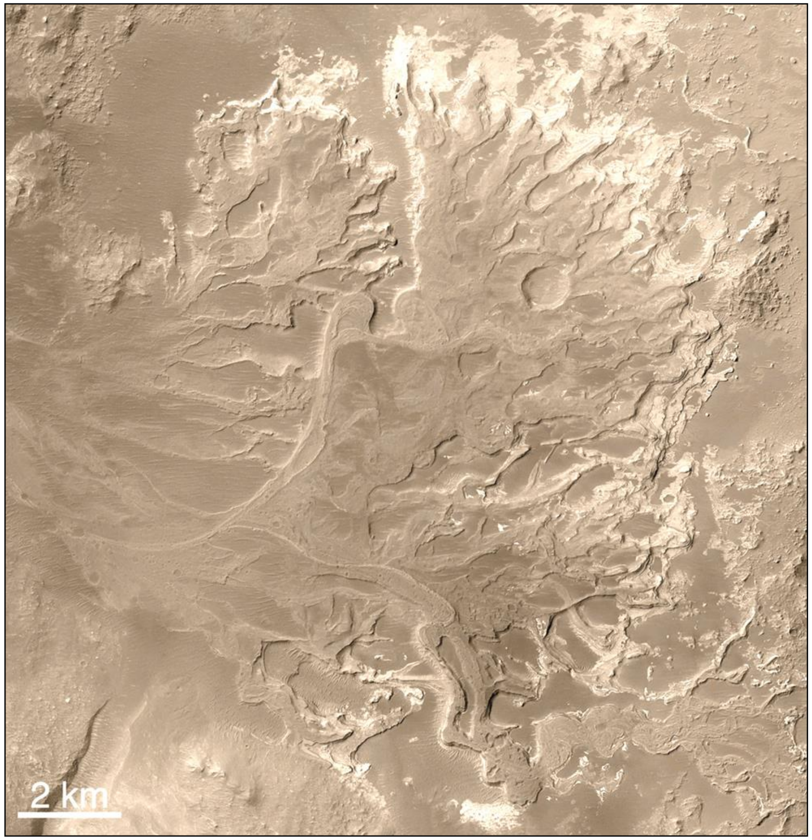
6: knob of underlying material (megabreccia)

Advantages

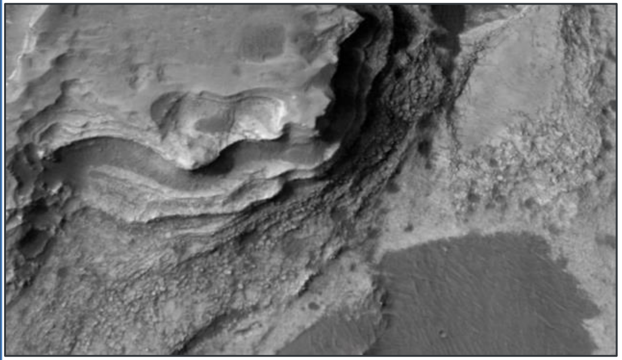
- Much more erosion than northern sites
- Ideal LTL lake deposits
- Cache within ellipse
- Vetted for MSL

Eberswalde Crater: *Spectacular context for habitability in a long-lived, fluvio-deltaic system*

Consensus that Eberswalde Crater held a Hesperian Martian lake: Malin and Edgett (2003), Moore et al. (2003), Bhattacharya et al. (2005), Lewis and Aharonson (2006), Wood (2006), Pondrelli et al. (2008, 2011), Rice et al. (2011, 2013), Mangold et al. (2012), Irwin et al. (2013)

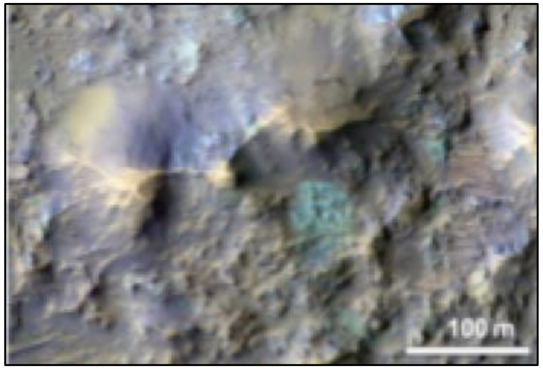


Evidence of Recent Exposure: Cliffs shedding boulders at the delta front (Rice et al., 2013)

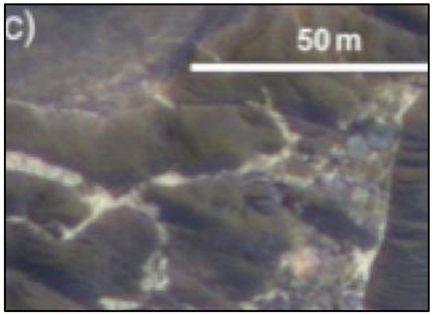


- ✓ **Fe/Mg clays** in the delta sediments and breccias (Milliken et al, 2010)
- ✓ **Opaline silica** in crater floor materials (Poulet et al., 2014)

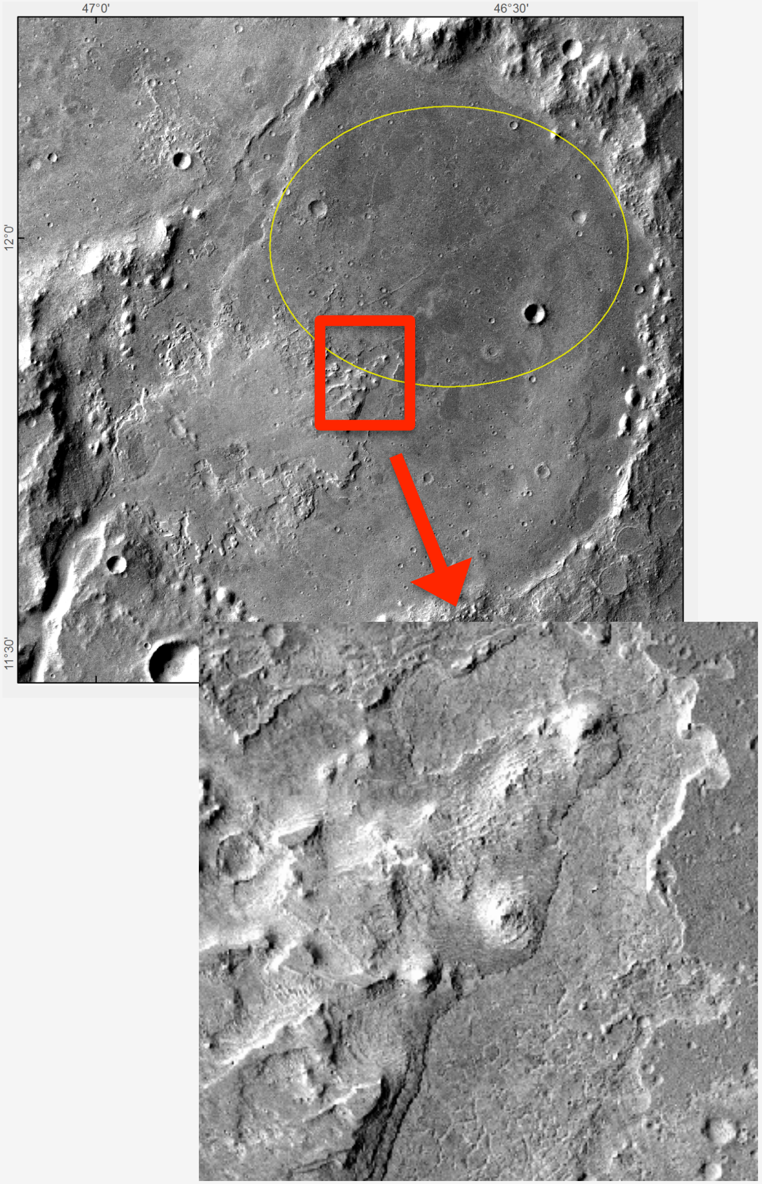
Megabreccias from Holden impact ejecta: (Rice et al., 2013)



Veins may indicate hydrothermal fluids: diverse morphologies in breccia and on crater floor (Rice et al., 2013)



Summary : Magong Crater (Sabrina Vallis delta)



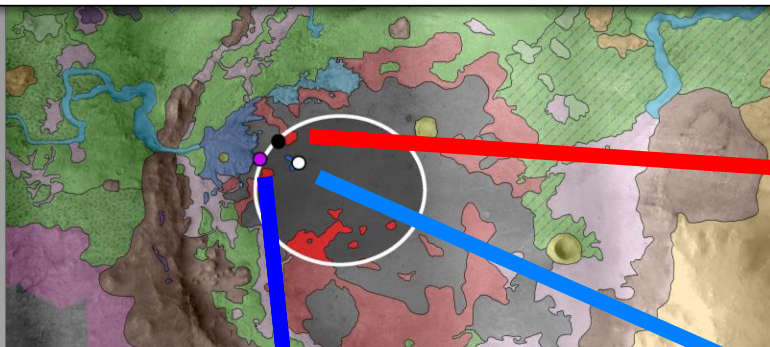
Old, heavily eroded and infilled Noachian crater
Good landing safety and traversibility

Large, eroding LN / EH Delta formation*
At the mouth of ~150 km Sabrina Vallis that cuts middle Noachian Highlands in Xanthe Terra.
Moat of flat polygonally-fractured terrain around delta is likely related to – and eroding from under - the delta.

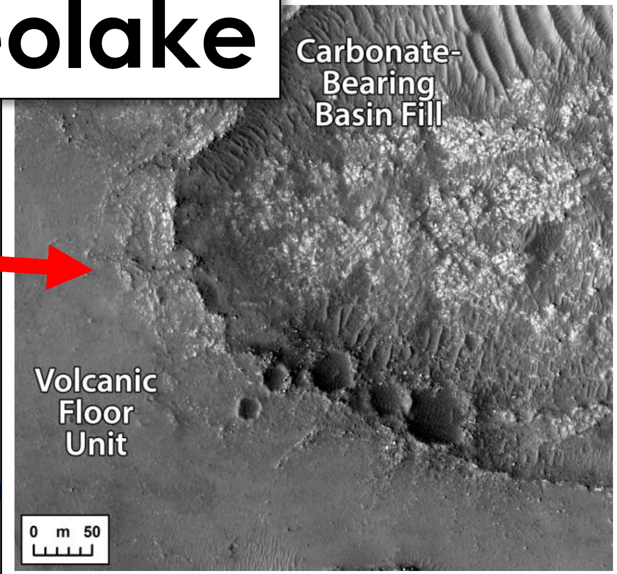
3 separate deposits of potentially igneous origin:
Floor: Early-Hesperian-aged, potentially dateable Hesperian lava flow
Ridge: Eroding out from under floor.
Likely to be a magmatic dyke of unknown age
Dark deposit: Thin, Amazonian-age, eroding layer that drapes underlying terrain and is regionally present. Hypothesized to be a tephra deposit

*Hauber et al, PSS, 57 (2009) 944-957

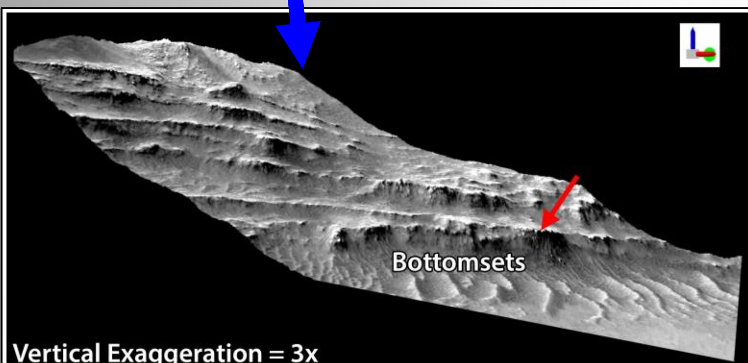
Jezero Crater Paleolake



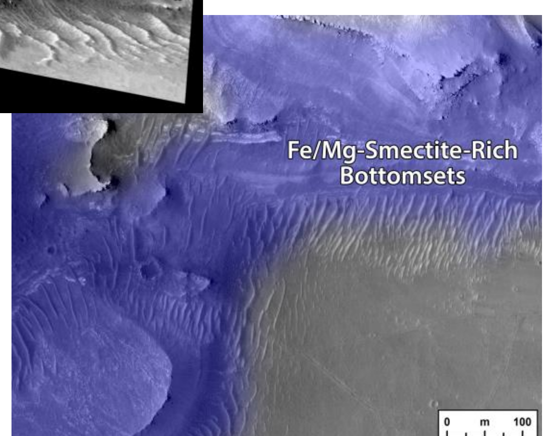
Open-basin lake; sink for alteration-mineral-rich terrain



Exposures of (1) regional carbonate-bearing material, and (2) dateable volcanic floor unit

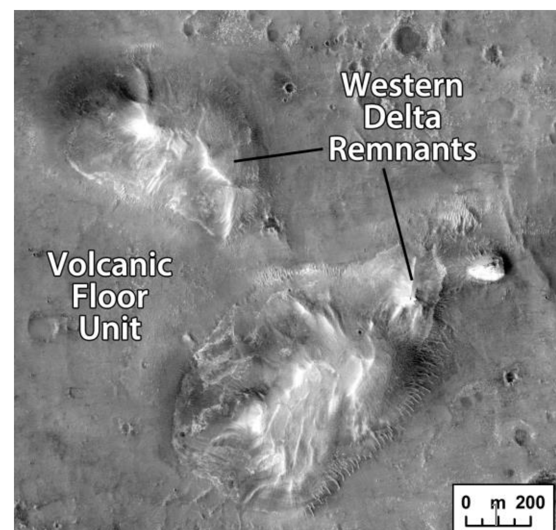


Exposed smectite-rich delta bottomsets



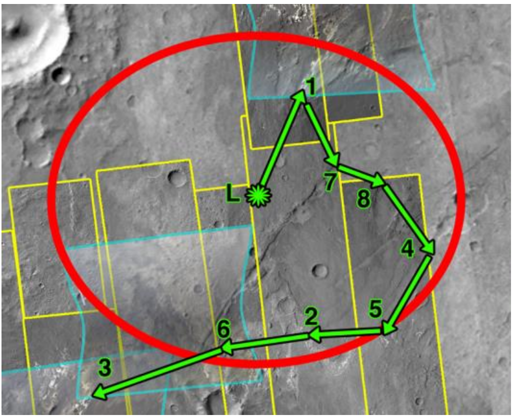
Delta bottomsets provide excellent accumulation and preservation potential for organics

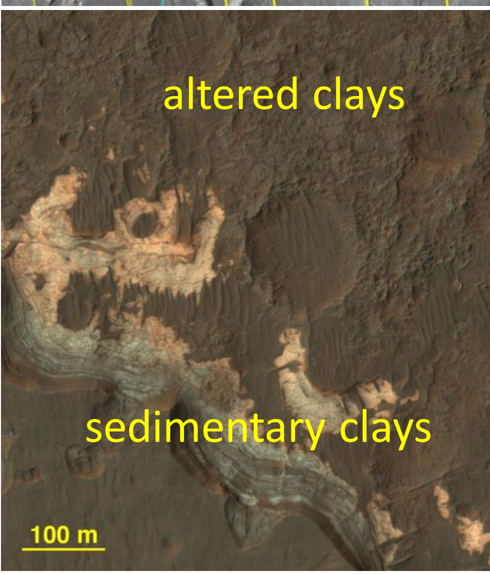
Delta remnants accessible in ellipse



Ladon Valles site

329.9° E, -20.06° N,
-2.069 km elevation





Land On Science

- Lacustrine conditions during the Late Noachian to Late Hesperian produced ~60 m thick & 100 km long clay-bearing finely layered sediments within northern Ladon Valles

  **Favorable conditions for preservation of biosignatures

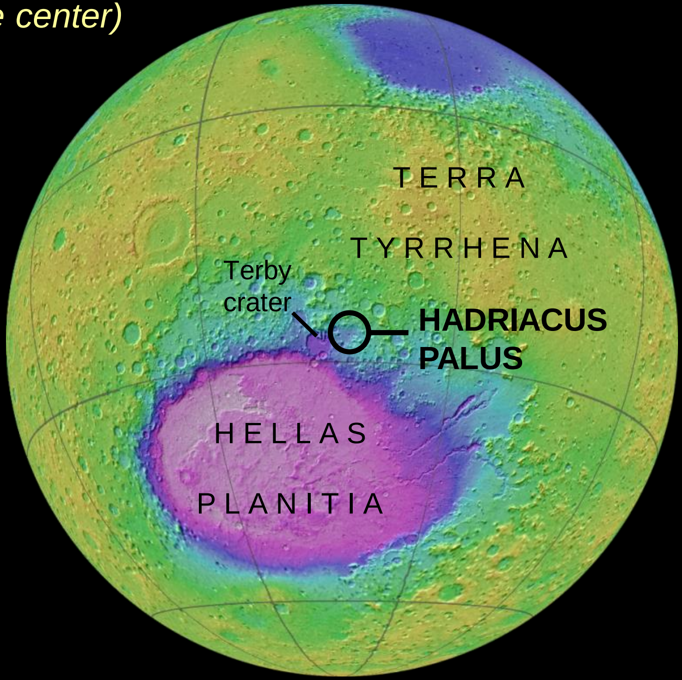
- Evidence for several kids of Fe/Mg-smectites and dehydrated clays, with possibility for many other minerals not resolvable in CRISM due to small areal extent within strata
- Stratigraphy of units is well defined
- Nearby volcanic cones and lava flows outside ellipse suggest dark units closer to ellipse could also be volcanic flows
- Etched surface and few craters on lacustrine sediments provides recent exposure
- Diversity of rock types transported through Ladon Valles and deposited in landing ellipse at distal end of Ladon Valles
- Sampling of older Noachian rocks and possible impact breccias exposed by Ladon basin formation in early-mid Noachian
- 10 km diameter Amazonian crater to NE of ellipse likely has ejecta within ellipse that could reveal rocks at depth
- Terrain Relative Navigation and Range Trigger are probably not required for this landing ellipse

Landing Site Factor	Mars 2020 Mission and Decadal Priority Science Factors																							
	Environmental Setting for Biosignature Preservation and Taphonomy of Organics								Type 1A & 1B Samples: Aqueous Geochemical Environments indicated by Mineral Assemblages									Type 2 Samples: Igneous		Context: Martian History Sampled, Timing Constraints				
	Deltaic or Lacustrine (perennial)	Lacustrine (evaporitic)	Hydrothermal (<100°C) surface	Hydrothermal (<100°C) subsurface	Pedogenic	Fluvial/Alluvial	No diagenetic overprinting	Recent exposure	Crustal phyllosilicates	Sedimentary clays	Al clays in stratigraphy	Carbonate units	Chloride sediments	Sulfate sediments	Acid sulfate units	Silica deposits	Ferric Ox./Ferrous clays	Igneous unit (e.g, lava flow, pyroclastic, intrusive)	2nd Igneous unit	Pre- or Early-Noachian Megabreccia	Oldest stratigraphic constraint	Youngest stratigraphic constraint	Stratigrapy of units well-defined	Dateable surface, volcanic (unmodified crater SFD)
Ladon Valles	●	●	~	?	~	●	?	●	?	●								○	?	?	EN	EA	●	○

Summary - Hadriacus Palus

Immediate access to diverse, contextual geological units

- **Representative section** of Martian intercrater plains
  - *Regional and local geology fairly well constrained (evolving)*
- **Land on Science**
  - *Basin formation and filling processes*
  - *Fluvial and lacustrine infill (~10-12 m within 6 km of ellipse center)*
  - *Diverse provenance (EN Hellas massifs, highland volcanics, dissected regolith)*
  - *Exhumation and infill (multiple times)*
  - *Mineralized fractures*
- **Go to Science**
  - *Traverse across Noachian-Hesperian boundary*
  - *Down basin → Down traverse (100 m section <15 km from ellipse center)*
- Important science issues to be resolved
  - *Lacustrine and fluvial environment (MN → H)*
  - *Crustal formation (bounding massifs)*
  - *Igneous processes (?)*
  - *Basin filling processes*
  - *Channel sequencing and inversion*
  - *Alteration processes (filled fractures)*
  - *Syn- and post-tectonic sedimentation*
- Satisfies Science and Engineering
- **Not well established**
  - Direct evidence of aqueous geochemistry
  - Volcanic units on palus surface
  - Diversity of bounding terrains



M2020
Coprates Chasma landing site

Landing Site Factor	Mars 2020 Mission and Decadal Priority Science Factors																							
	Environmental Setting for Biosignature Preservation and Taphonomy of Organics								Type 1A & 1B Samples: Aqueous Geochemical Environments indicated by Mineral Assemblages									Type 2 Samples: Igneous		Context: Martian History Sampled, Timing Constraints				
	Deltaic or Lacustrine (perennial)	Lacustrine (evaporitic)	Hydrothermal (<100°C) surface	Hydrothermal (<100°C) subsurface	Pedogenic	Fluvial/Alluvial	No diagenetic overprinting	Recent exposure	Crustal phyllosilicates	Sedimentary clays	Al clays in stratigraphy	Carbonate units	Chloride sediments	Sulfate sediments	Acid sulfate units	Silica deposits	Ferric Ox./Ferrous clays	Igneous unit (e.g, lava flow, pyroclastic, intrusive)	2nd Igneous unit	Pre- or Early-Noachian Megabreccia	Oldest stratigraphic constraint	Youngest stratigraphic constraint	Stratigrapy of units well-defined	Dateable surface, volcanic (unmodified crater SFD)
Coprates	~	~		●		●	●	●	●			~		●	?			●	?	●	eN ?	H	●	?

Why Coprates Chasma ?

-Primitive Martian crust

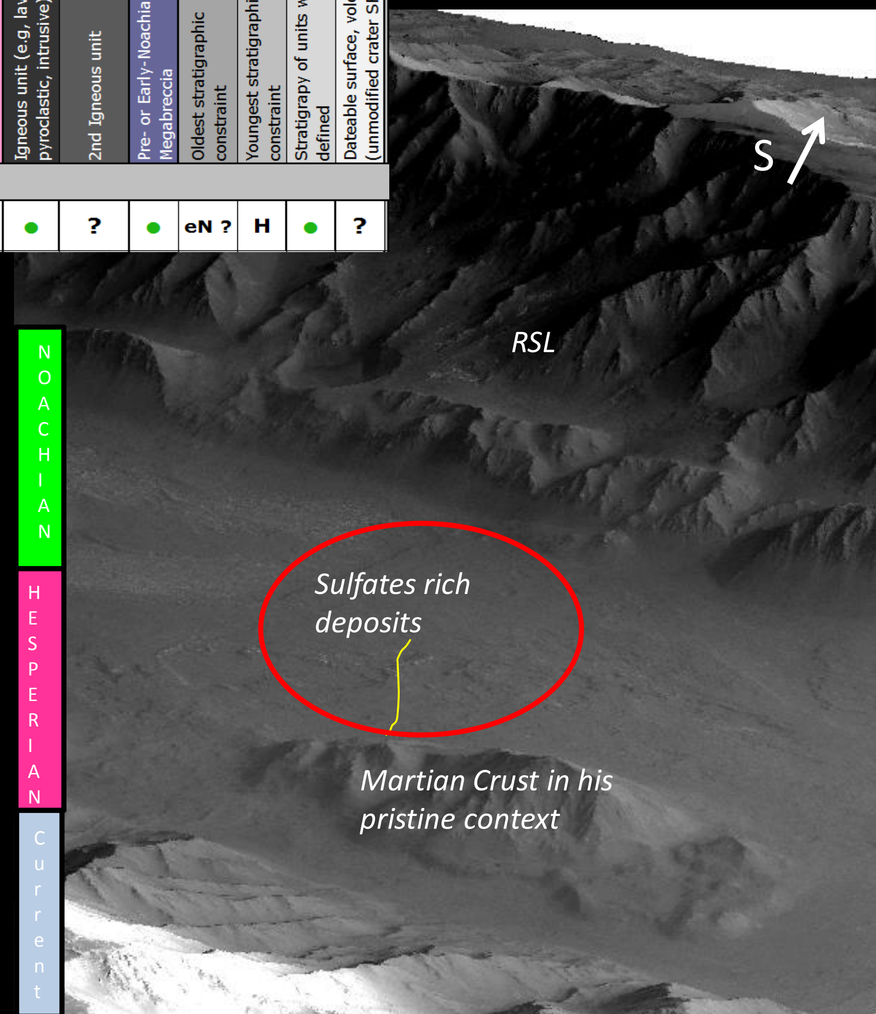
- Hydrothermal alteration of the martian crust (life emergence ?)

-Tectonics (VM opening)

-Sulfates rich floor deposit recently exhumed (conservation)

-Water -related morphologies (canyon floor+ alluvial fans)

-Active RSL (not too close but in a key place)



SW Melas Basin (Williams, Weitz, Grindrod, Davis, Quantin-Nataf & Dromart)

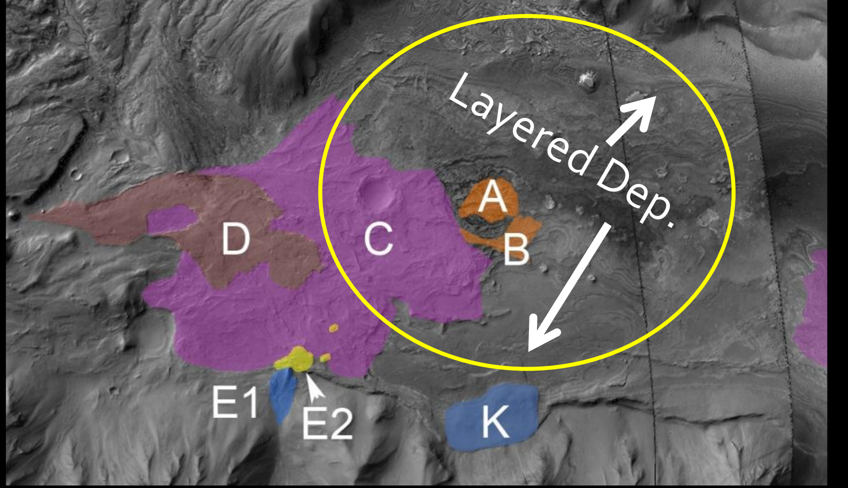
- Well-defined geologic context (dominantly lacustrine depositional environment in ellipse)
- Excellent stratigraphic exposure (explore layer by layer)
- Lacustrine setting is high BPP site (presence & preservation)
- Exhumed terrain (potential that basin deposits protected from irradiation) but timing of exposure is unconstrained.
- 90% of ellipse is high priority ROI targets and close proximity b/tw ROIs

→ Time spent on hypothesis testing using the scientific payload, rather than traversing

- Opportunity to traverse range of depositional environments within ~10 km

→deep to shallow subaqueous deposits to subaerial deposits.

- Diversity of source regions & rocks incl. likely ancient lava flows on canyonwalls transported into ellipse
- Engineering criteria met, and site is traversable.



Landing Site Factor	Mars 2020 Mission and Decadal Priority Science Factors																									
	Environmental Setting for Biosignature Preservation and Taphonomy of Organics								Type 1A & 1B Samples: Aqueous Geochemical Environments indicated by Mineral Assemblages									Type 2 Samples: Igneous		Context: Martian History Sampled, Timing Constraints					
	Deltaic or Lacustrine (perennial)	Lacustrine (evaporitic)	Hydrothermal (<100°C) surface	Hydrothermal (<100°C) subsurface	Pedogenic	Fluvial/Alluvial	No diagenetic overprinting	Recent exposure	Crustal phyllosilicates	Sedimentary clays	Al clays in stratigraphy	Carbonate units	Chloride sediments	Sulfate sediments	Acid sulfate units	Silica deposits	Ferric Ox./Ferrous clays	Igneous unit (e.g, lava flow, pyroclastic, intrusive)	2nd Igneous unit	Pre- or Early-Noachian Megabreccia	Oldest stratigraphic constraint	Youngest stratigraphic constraint	Stratigrapy of units well-defined	Dateable surface, volcanic (unmodified crater SFD)
SW Melas	●	~	~	~	~	●	[TBD]	●			?			○		●	?				?	EH	●	?

Key	
●	Yes (in-ellipse)
○	Yes (out of ellipse)
	No
~	Partial Support or Debated
?	Indeterminate
[grey]	TBD

Identified deltaic deposits; lacustrine activity over 100s—1000s years, potentially intermittent. Quantin et al., 2005; Metz et al., 2009; Williams & Weitz, 2014

Hydrated silica (opal) detection, potentially related to low temp. hydrothermal, but no morphological evidence; Williams & Weitz, 2014

Likely given fluctuating lake levels.

Scarp retreat, but exhumation age unconstrained.

Challenging to ascertain from orbital data

Authigenic clay formation **likely** in lacustrine setting

Jarosite in NW portion of basin; (Dromart et al., 2007)

Potential : Presumed lava flows in canyon walls transported via landslides/debris flows into ellipse

Unconstrained, but likely Noachian. Valles Marineris cany wall material

Excellent stratigraphic context with layered deposits

Crater count age date for basin of 3.6 Ga (Quantin et al., 2005); deposits post-date.

Nili Fossae Trough

Re-entrant exposes **unique window** into **mid-Noachian stratigraphy**, relative timing of events well constrained by cross-cutting relations.

Multiple **habitable environments** (not putting all eggs in one basket):

(1) Subsurface hydrothermal environments where crustal clays and carbonates **formed**.

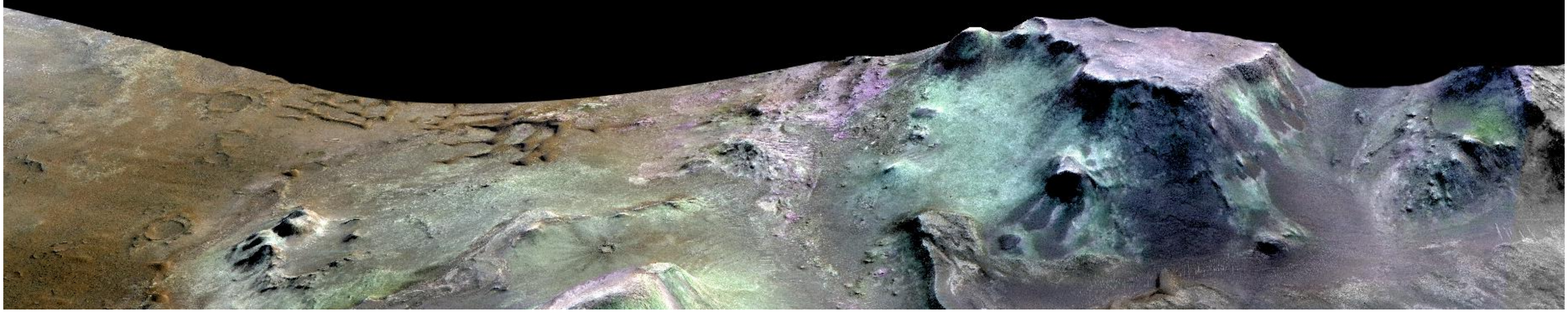
(2) Surface sedimentary system where trough fill clays were **deposited**.

Rocks for **preserving biosignatures** and of **astrobiological import**:

(1) Layered, clay-bearing rocks.
(2) Carbonates (e.g., isotopic).
(3) Mineral assemblage suggestive of serpentinization.

Returned samples can provide absolute ages for: (1) **Syrtis lavas**, (2) **Hargraves**, and possibly (3) **Isidis**.

Diverse samples: **Carbonates**, Fe/Mg clays, Al clays, intact **igneous rocks** of both **Noachian** and **Hesperian** age.



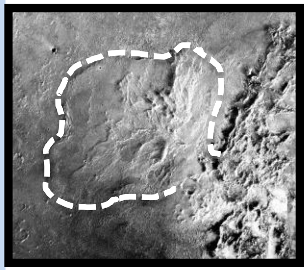
Southern Nili Fossae Trough Viviano-Beck et al.

diverse, eN-eH, strat. context., mult. potential habitable environs.

In ellipse

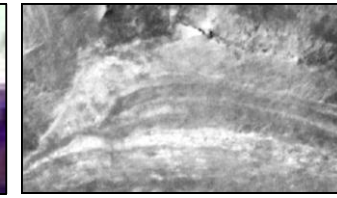
1
- -HCP Syrtis flow
- -**Age dating**

2
- -**Debris flow**/fan
- -Ancient Noachian
- -Phyllosilicates
- -Diverse sampling of wall



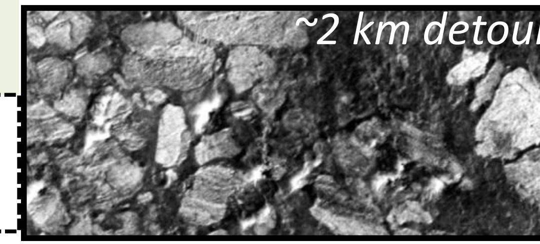
Just outside ellipse / wall

3
- -**Compositionally stratified** phyllo.



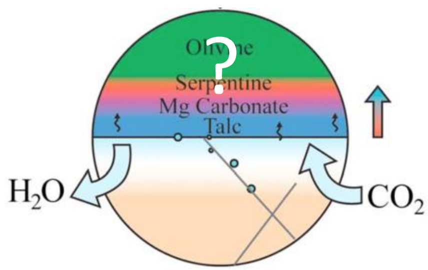
4
- -Phyllo. **Layers**
- -Sed? Habitability?

5
- -**Megabreccia**
- -Diversity



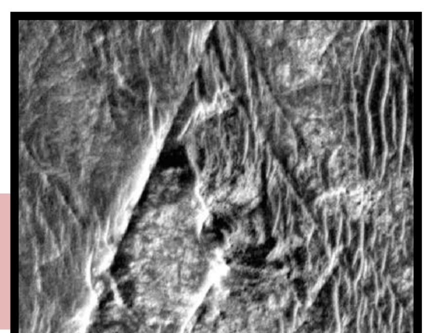
Plateau

6
- -Olivine-**carbonate**-(talc?)
- -Serpentinization
- -Habitability?

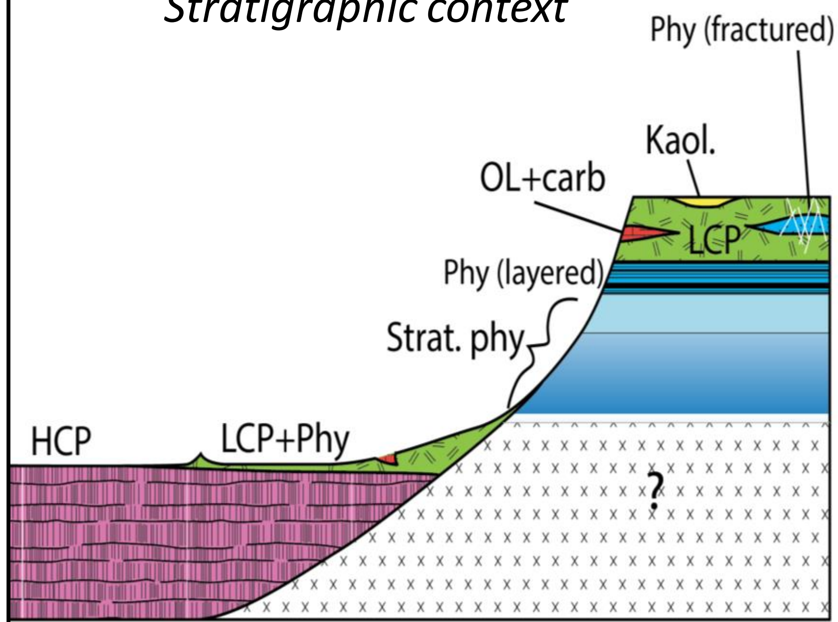


7
- -**Kaolinite**
- -Pedogenic?

8
- -Resistant **fractures**
- -Phyllo.

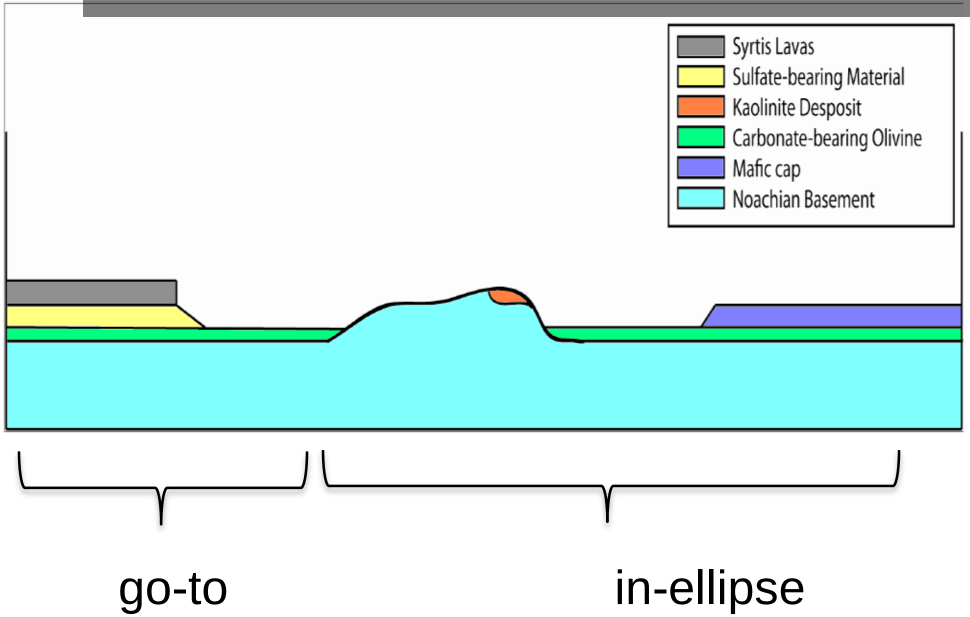


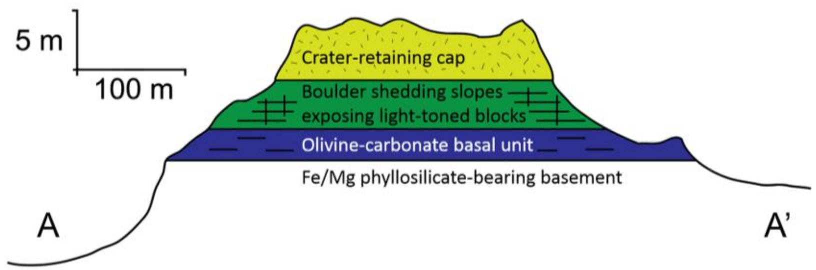
Stratigraphic context

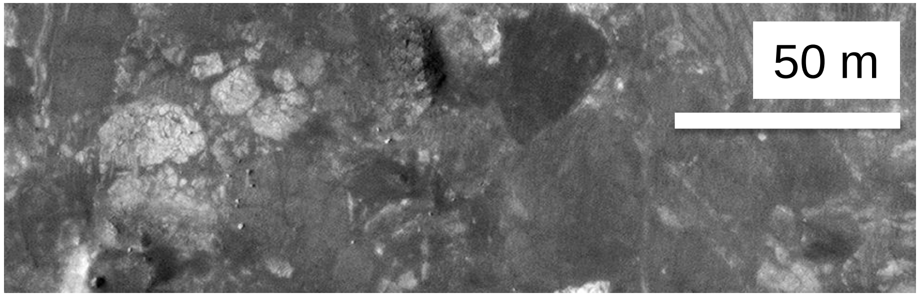


NE Syrtis: Rich Diversity of Habitability

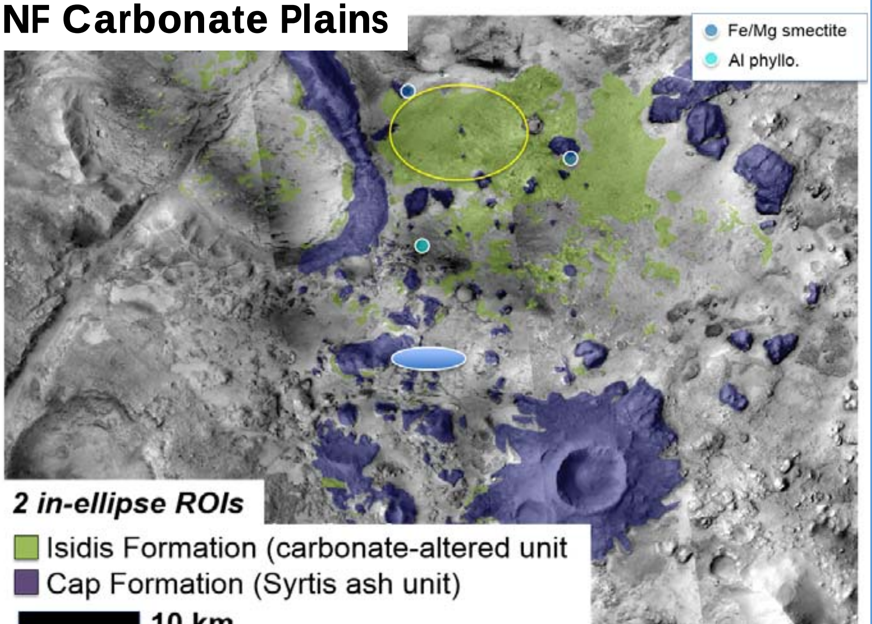
- Bedrock strata in-situ representing four distinct environments of aqueous alteration where reactants and products are together
  - early crustal megabreccia: Phyllosilicate formation; deep biosphere, Isidis basin formation, primary crust
  - carbonate/serpentine: surface alteration or hydrothermal?
  - layered phyllosilicates (Al- over Fe/Mg)
  - sedimentary sulfate formation
- A record of aqueous low-T geochemistry preserved in mineral-bearing strata, distinct in age, primary mineralogy, and geologic setting
- Well-suited for the M2020 measurements and caching
- Key stratigraphies from Noachian and Hesperian eras
- Hydrothermal, pedogenic and sedimentary environments
- Multiple igneous units of distinct age







NF Carbonate Plains



PROS

- Land On Primary Science*: two ROIs evenly distributed in ellipse for easy access
- Largest carbonate deposit formed by neutral to alkaline waters: key for Martian habitability and atmosph. Evolution
- Clear timing constraints: Early Noachian to Early Hesperian
- Immediate petrology to determine origin of Mars carbonate; measure in situ carbonate precipitates for organics
- Immediate petrology of one of Mars' key igneous units (olv.rich)
- Multiple igneous units (olivine fm., ash unit in cap fm.)
- Go to regional stratigraphy with Fe/Mg clays and Al clays; use petrology to determine origins
- Datableigneous units for CFD calibration
- Sample Early N. to Early Hesp. isotopic record of enviro change

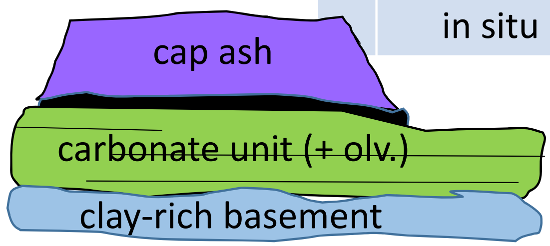
CONS

- Isotopic, mineralogical, chemical, morphological biosignatures can be present in multiple enviro settings; however, organics preservation potential of carbonate will not be knowable until in situ petrology establishes setting

__Geologic History & Stratigraphy__

1. Basement Formation (clays) disrupted by Isidis impact (EN)
2. Isidis Olivine Formation emplaced atop basement (EN/MN)
3. Carbonate Unit Forms (MN/LN)
4. Cap Formation ash emplaced atop Carb Unit (LN/EH)
5. Fluvial dissection (MN to EH)

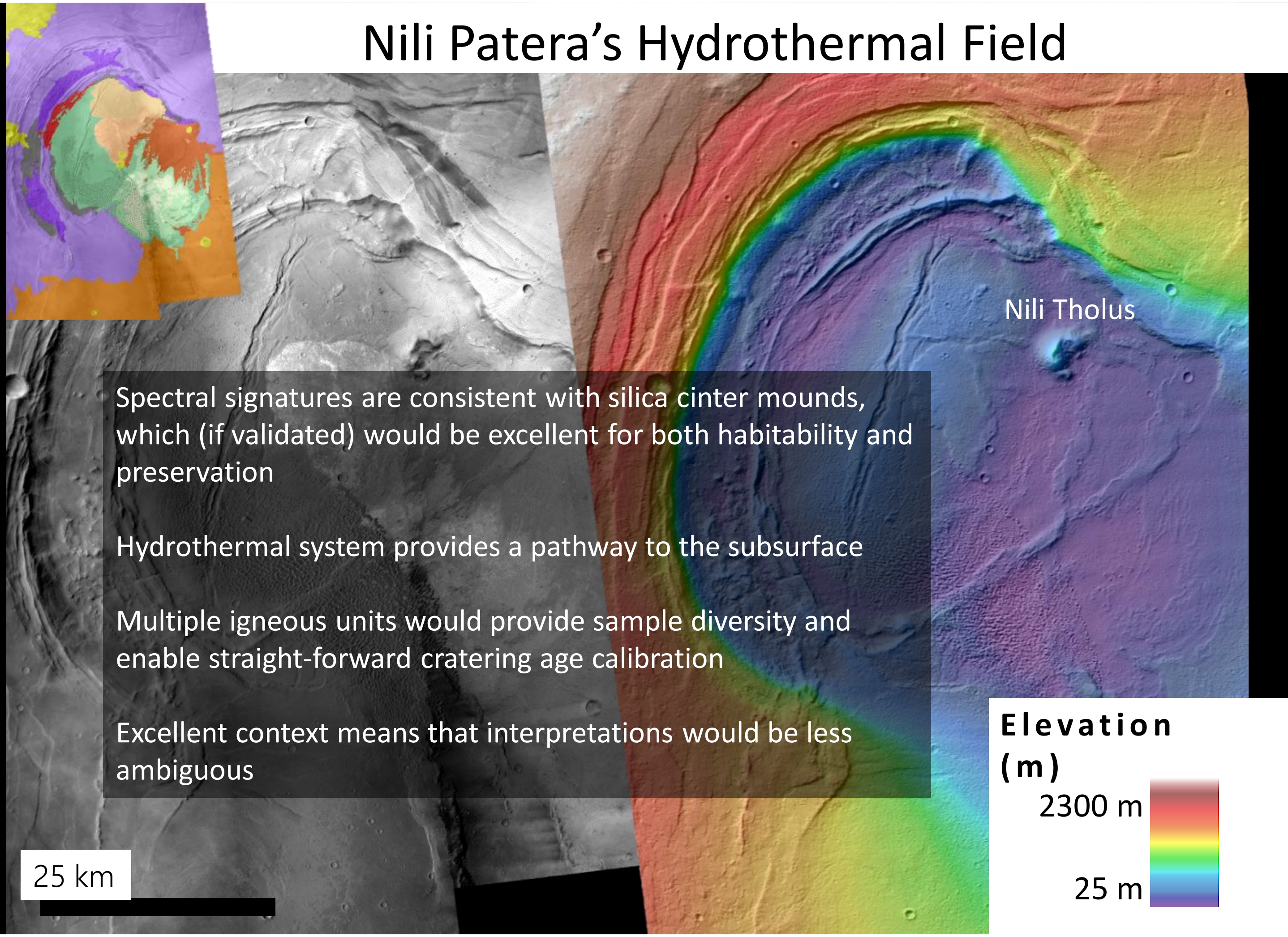
__NF Carbonates stratigraphy__



A	1. **Geo. History**	🟢
B	2a. **Ancient habitable enviro.**	🟢
	2b. **High biosig. preservation potential**	🟢/🟡
C	3a. **samples for astrobio.**	🟢
	3b. **samples for planetary evolution**	🟢

*IMPORTANT (based on bar conversations): New ellipse needs assessment. Traversability report of the old ellipse should not preclude a vote for this site if you support the science

Nili Patera’s Hydrothermal Field

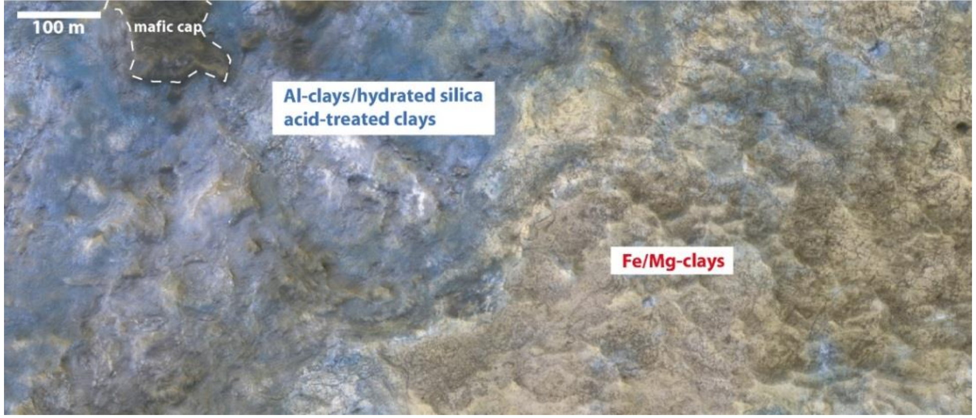


Spectral signatures are consistent with silica cinter mounds, which (if validated) would be excellent for both habitability and preservation

Hydrothermal system provides a pathway to the subsurface

Multiple igneous units would provide sample diversity and enable straight-forward cratering age calibration

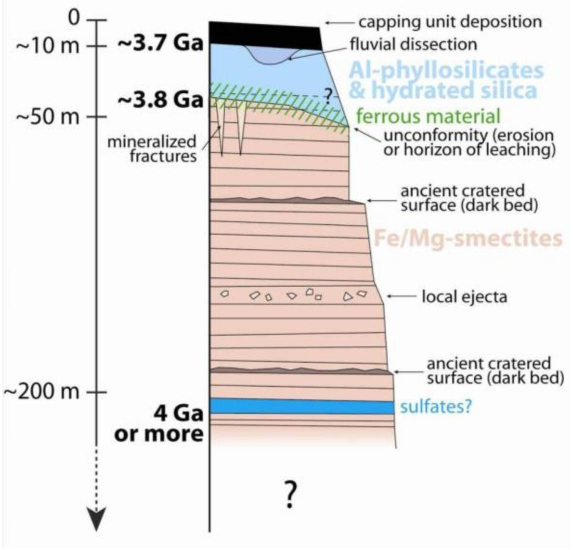
Excellent context means that interpretations would be less ambiguous



MAWRTH VALLIS PLATEAU

KEY ATTRIBUTES:

- **Possible paleosol sequence preserving diverse geochemical environments**
- **High preservation potential for biosignatures, locally high concentration**
- **Continuous stratigraphy provides unique window into Noachian climate**
- **Key ROI is land-on: instead of driving, maximized science and sampling**



Science objective	Observations in support
1. Geologic setting and history	Vertically extended exposed layered deposits; Multiple depositional, alteration and erosional environments
2a. Ancient habitable environment	Long-lived aqueous environment with geochemical gradients - most diverse hydrated phases & highest clay content on Mars (> 50%)
2b. High biosignature preservation	Locally high - reduced phases, hydrated silica, large clay content, recent exposures
3a. Sampling for astrobiology	Diverse habitable environments through all Noachian (clay transition, paleo-surfaces, veins, inverted valleys…)
3b. Sampling for planetary evolution	record extending from eN to eH, surface weathering, unique window into early Mars climate, mafic cap rock

McLaughlin Crater

Geology:

Deep crater that contained an ancient, groundwater-fed lake

Targets:

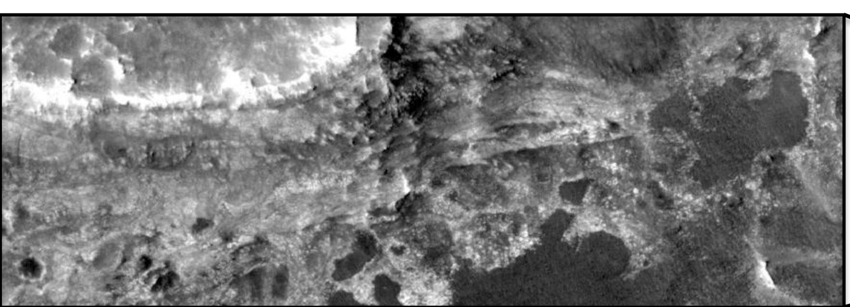
1. Layered, carbonate and Fe,Mg-clay bearing (rich?) lacustrine deposits with well constrained stratigraphic context
2. Ejecta from Keren Crater and/or debris flow from southern interior wall of McLaughlin containing clays, blocks of carbonates, likely serpentine, and very likely a large suite of igneous crustal rocks (breccia in debris flow/ejecta)
3. Dark-toned, cratered, dark datable surface (possibly airfall volcanic)
4. Alluvium, colluvium and possibly deltaic deposits in eastern crater

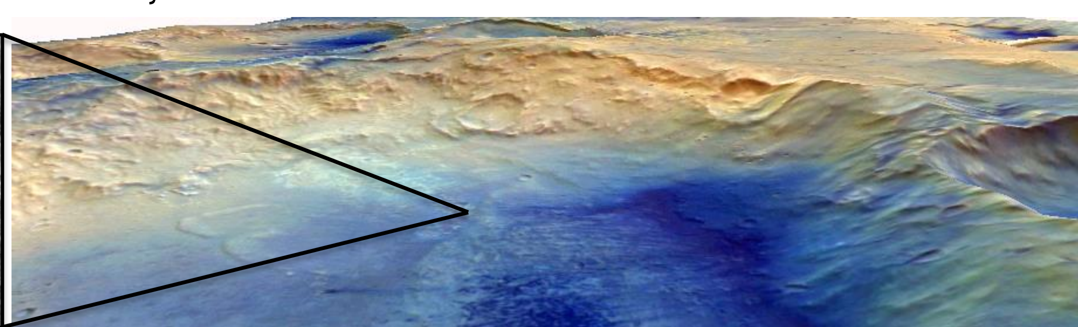
Weaknesses:

1. Cannot currently prove beyond a shadow of a doubt that layered, altered floor materials formed in a lake.
2. IS a DIVERSE site, but perhaps not as diverse as the most diverse sites (e.g. no sulfates or Al-clays)

Strengths:

1. Plenty of water, sustained, wet conditions in a Noachian site
2. Likely altered by subsurface fluids that could contain clues to subsurface habitability
3. High preservation potential in both lake sediments and debris flow/ejecta (rapid deposition!)
4. At least 50 meters of clay-carbonate subhorizontal floor deposits in context
5. Large suite of altered and unaltered igneous crustal materials in the ejecta/debris flow
6. Possibly contains deltaic deposits in eastern floor
7. Thick atm column for EDL margin
8. Different from anywhere we have visited

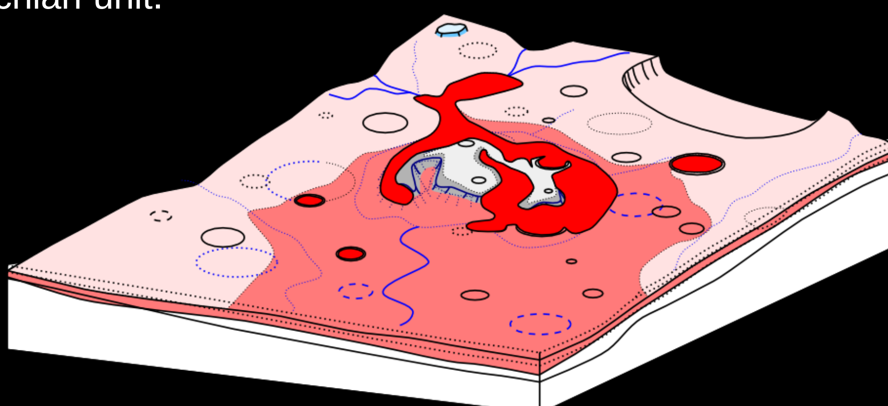




Oxia Planum Summary

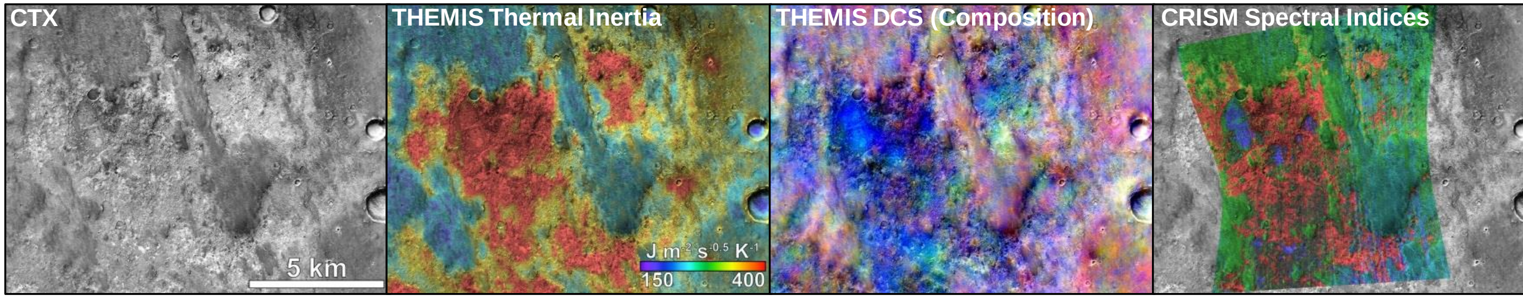
Landing Site Factor	Mars 2020 Mission and Decadal Priority Science Factors																						
	Environmental Setting for Biosignature Preservation and Taphonomy of Organics								Type 1A & 1B Samples: Aqueous Geochemical Environments indicated by Mineral Assemblages									Type 2 Samples: Igneous		Context: Martian History Sampled, Timing Constraints				
	Deltaic or Lacustrine (perennial)	Lacustrine (evaporitic)	Hydrothermal (<100°C) surface	Hydrothermal (<100°C) subsurface	Pedogenic	Fluvial/Alluvial	No diagenetic overprinting	Recent exposure	Crustal phyllosilicates	Sedimentary clays	Al clays in stratigraphy	Carbonate units	Chloride sediments	Sulfate sediments	Acid sulfate units	Silica deposits	Ferric Ox./Ferrous clays	Igneous unit (e.g, lava flow, pyroclastic, intrusive)	2nd Igneous unit	Pre- or Early-Noachian Megabreccia	Oldest stratigraphic constraint	Youngest stratigraphic constraint	Stratigrapy of units well-defined	Dateable surface, volcanic (unmodified crater SFD)
Oxia Planum	●		?		~	●	?	●		●	~	~				●	●	●	~		mN	eA	●	●

1. **Noachian** basement (4 Ga), layered (sedimentary or igneous) and altered
2. **Fluvial** valleys and channels on Noachian basement
3. **Delta-fan** likely lN/eH (3.8-3.6 Ga), synchronous with fluvial features
4. **Fe/Mg-phyllosilicates** (ferrous iron: Fe^{2+}) in late noachian unit.
5. Other alteration minerals include **Al-phyllosilicates** in delta-fan, **hydrated silica** on edge of igneous unit, possible **carbonates** with Fe/Mg-clays.
6. **Early Amazonian lava flow unit** (~ 2.6 Ga): igneous unit with crater count and precise age.
7. **Continuing erosion** during Amazonian: **renewing of surface outcrops** and **renewing of potential biosignatures**.
8. Impact craters forming natural cross-sections, also secondaries from large nearby craters.



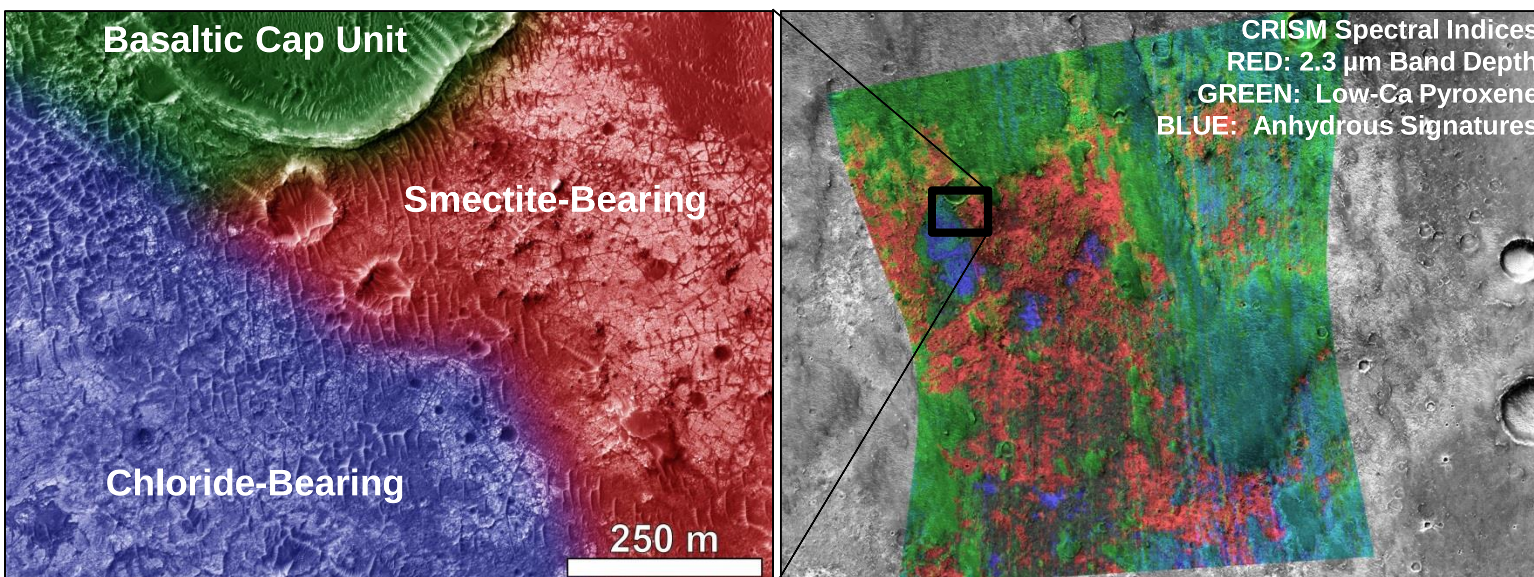
Deltaic or Lacustrine (perennial)	~
Lacustrine (evaporitic)	●
Hydrothermal (<100°C) surface	
Hydrothermal (<100°C) subsurface	
Pedogenic	
Fluvial/Alluvial	○
No diagenetic overprinting	●
Recent exposure	
Crustal phyllosilicates	
Sedimentary clays	●
Al clays in stratigraphy	
Carbonate units	
Chloride sediments	●
Sulfate sediments	
Acid sulfate units	
Silica deposits	
Ferric Ox./Ferrous clays	
Igneous unit	●
2nd Igneous unit	~
Pre- or Early-Noachian Rocks	
Oldest stratigraphic constraint	MN
Youngest stratigraphic constraint	?
Stratigrapy of units well-defined	●
Dateable surface(s)	●

E. Margaritifer Chloride Deposit



- **Land-on science** (easily traversable, short distances to primary targets).
- *In situ* and stratified smectites and chloride deposits, **pervasive aqueous weathering** and **terminal evaporitic environments**.
- Ejecta lobe within ellipse – **opportunity to sample deep crustal materials**.
- **Datable units** (ejecta, Noachian plains unit, nearby fluvial channel).

<u>**Sampling Priorities**</u>: (1) Evaporitic chloride deposits (**exceptional biosignature preservation!**), (2) stratified smectite-enriched sedimentary units (including contact with chloride units), (3) crustal materials emplaced within ejecta lobe, (4) Noachian highlands plains



HYPANIS: A large, enigmatic deltaic-lacustrine system

	Mars 2020 Mission and Decadal Priority Science Factors																							
	Environmental Setting for Biosignature Preservation and Taphonomy of Organics								Type 1A & 1B Samples: Aqueous Geochemical Environments indicated by Mineral Assemblages									Type 2 Samples: Igneous		Context: Martian History Sampled, Timing Constraints				
	Deltaic or Lacustrine (perennial)	Lacustrine (evaporitic)	Hydrothermal (<100°C) surface	Hydrothermal (<100°C) subsurface	Pedogenic	Fluvial/Alluvial	No diagenetic overprinting	Recent exposure	Crustal phyllosilicates	Sedimentary clays	Al clays in stratigraphy	Carbonate units	Chloride sediments	Sulfate sediments	Acid sulfate units	Silica deposits	Ferric Ox./Ferrous clays	Igneous unit (e.g, lava flow, pyroclastic, intrusive)	2nd Igneous unit	Pre- or Early-Noachian Megabreccia	Oldest stratigraphic constraint	Youngest stratigraphic constraint	Stratigraphy of units well-defined	Dateable surface, volcanic (unmodified crater SFD)
Hypanis	●	~	~			●		~		○								~			LN	EA?	●	~

Delta deposits in ellipses; likely pro-delta deposits cover ellipse

Hydrated mineral signatures from aqueously-altered materials or minerals precipitated when lake dried up?

Fluvio-deltaic deposits exposed in ellipse and at ellipse edge

Multiple retreating scarps suggest potentially-recent exposure

Hydration signature from CRISM nearby in deltaic sediments (1.9 micron water signature)

Igneous clasts in deltaic sediments ?

Based on Fluvio-deltaic deposit formed in early Hesperian

Based on crater retention ages

Well-defined stratigraphy mapped in basin

Possible ash beds outside ellipse?

- **TRN required? *No***