Melas Chasma	Location (lat,lon):	9°48'N, 283°30'E

Summary of observations and interpreted history, including unknowns:

Located on the margins of Valles Marineris, Melas Chasma is an enclosed basin containing diverse rock formations and minerals formed in multiple aqueous paleoenvironments over a sustained period. Timing of lacustrine activity is widely agreed to have been Late Hesperian or younger. Materials eroded from eastern and western ends of the basin formed a diverse array of subaqueous sedimentary deposits, including 11 fans. These sediments were deposited in lakes as deep as 400 m during as many as three different lacustrine episodes in the basin. Periods of subaerial exposure are indicated by megaripples in a distinctive stratigraphic marker bed of probable eolian origin. A variety of minerals occur in the Melas region, and includes Ca-sulfates, Fe-sulfates (jarosite), Fe/Mg-smectites and/or Al smectites (outside the basin), opaline silica, and possible other hydrated minerals.

The interpretation of geologic history at Melas is based on a robust assemblage of observations including landforms, mineralogy, stratigraphy, depositional architecture, field relationships and bedforms. A plethora of aqueous landforms includes the well-studied lacustrine assemblage with eleven different subaqueous fans, at least two of which were deposited in deep water. There are also layered lacustrine beds - an interpretation evidenced by their occurrence below the lake rim elevation as determined from fan elevation). Rough agreement in volume estimates of the eroded material from the eastern watershed and the layered beds in the basin indicates the beds comprise reworked material transported from the incised upland valleys (as opposed to airfall dust/eolian transport).

Potential for fundamental scientific discoveries: With different sedimentary materials being supplied from drainage/erosion from eastern and western source areas, and then being deposited in such diverse environments, there would have been a variety of potential habitats and pathways for recording the evolving basin chemistry, sedimentary processes, weathering processes, evolving atmosphere and climate, and potentially a microbial biosphere. The deposits within SW Melas are exhumed and the deep subaqueous fan deposits (ROI 1) are an erosional window into the strata, indicating protection from harmful irradiation. This attribute is a major contrast from other deltaic sites under consideration, which do not appear to have been formerly buried.

Key Unknowns: Presence/amount of igneous rock. A landslide from the south may have provided some igneous rock from the walls of Valles Marineris although it is unclear whether or how much igneous material is in the ellipse.

Land-on science: The ellipse is entirely made up of materials of interest. Layered deposits, inferred lacustrine deposits are pervasive in landing zone and would be sampled in any traverse. Therefore, these were not designated a separate ROI. The landing ellipse includes layered deposits believed to be emplaced in shallow to deep water conditions, reflecting a range of habitable environments. Geologic

context is clearly visible from orbit. Outcrop exposure is excellent. Superposition relationships exist between multiple layered deposits and fans within the basin, which can be used to better constrain the sequence of events that shaped this region.

Summary of key investigations

- Assess water depth variations. Identify shallow and deep water deposits, episodes/areas of subaerial exposure. Evaluate diagenetic history.

- Look for authigenic minerals, chemical sediments: possible sites for chemical, mineralogical, organic, micromorphological, macromorphological, isotopic biosignatures.

- Look for quiet water conditions.

- Determine mineralogy and depositional environment of the lacustrine sediments.

- Determine origin and environment of formation of the opaline silica and sulfate-bearing outcrops

Cognizant Individuals/Advocates:

Becky Williams, PSI

Link to JMARS session file | Link to Workshop 2 rubric summary

https://docs.google.com/spreadsheets/d/16Rmn2qHFQc6BKJtiyIeDLcyBxJqq8Oq4VO3etqrZ8lo/edit?invite=CNm8lqYF&pref=2&pli=1#gid=868597987

Key Publications list :

Dromart, G. et al., 2007. Stratigraphic architectures spotted in southern Melas Chasma, Valles Marineris, Mars. Geology 35, 363–366. http://dx.doi.org/10.1130/G23350A.1.

Liu, Y., and J. G. Catalano,2016. x Icarus, 271, 283-291.

Mangold, N. et al., 2004. Evidence for precipitation on Mars from dendritic valleys in the Valles Marineris area. Science 305, 78–81. http://dx.doi.org/10.1126/science.1097549.

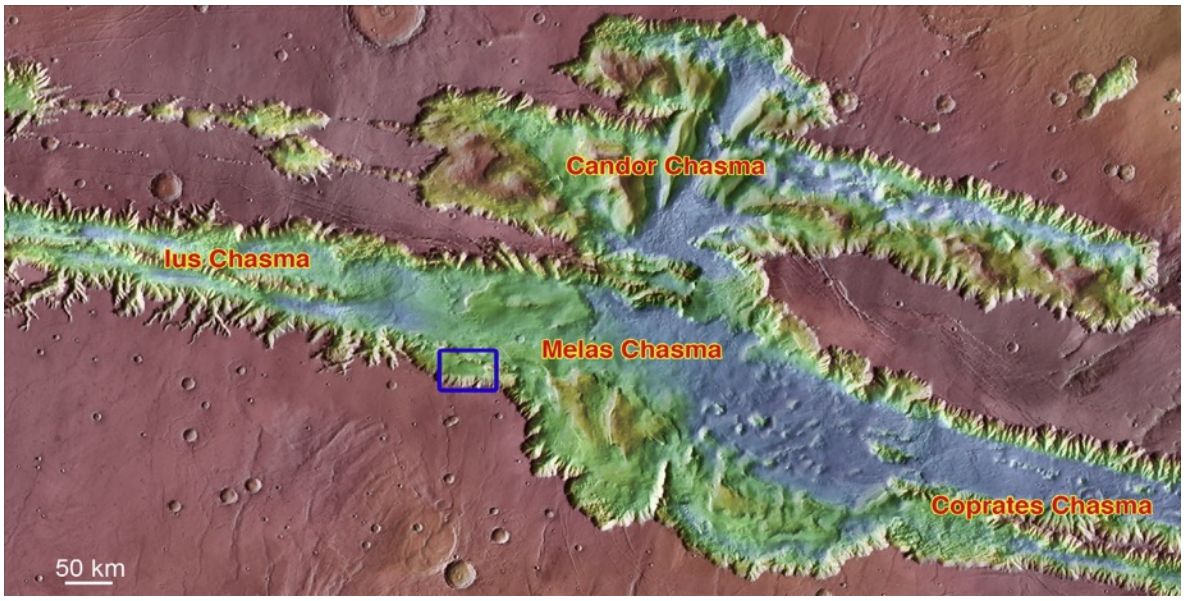
Metz, J.M. et al., 2009. Sublacustrine depositional fans in southwest Melas Chasma. J. Geophys. Res. 114, E10002. http://dx.doi.org/10.1029/2009JE003365.

Quantin, C. et al., 2005. Fluvial and lacustrine activity on layered deposits in Melas Chasma, Valles Marineris, Mars. J. Geophys. Res. 110, E12S19. http://dx.doi.org/10.1029/2005JE002440.

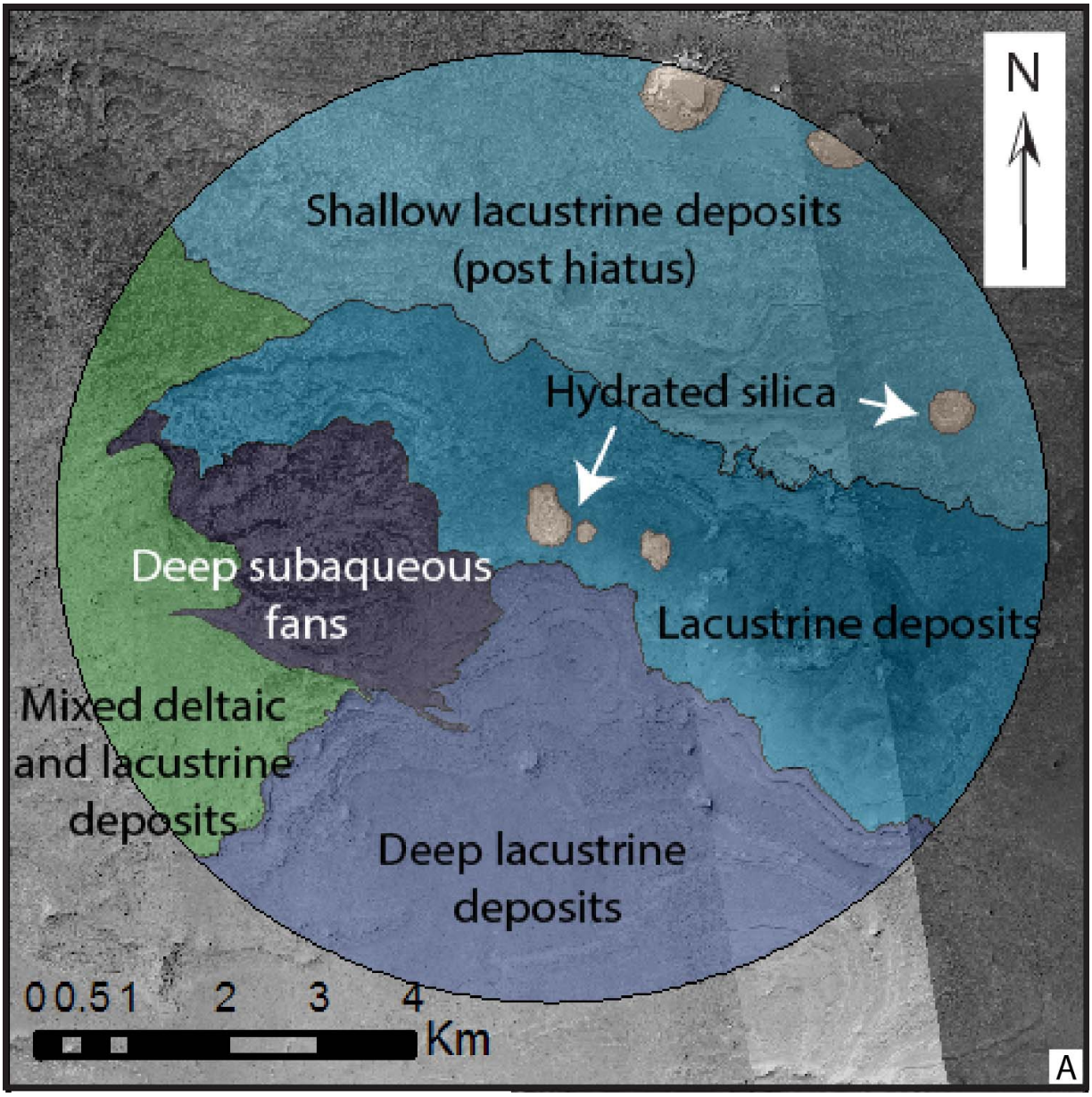
Weitz, C.M., Noe Dobrea, E., Wray, J.J., 2015. Mixtures of clays and sulfates within deposits in western Melas Chasma. Icarus 252, 291–314. doi: http://dx.doi.org/10.1016/j.icarus.2014.04.009

Williams, R.M.E., Weitz, C.M., 2014. Reconstructing the aqueous history within the southwestern Melas basin, Mars: Clues from stratigraphic and morphometric analyses of fans. Icarus 242, 19–37. http://dx.doi.org/10.1016/j.icarus.2014.06.030

Regional Context Figure (Williams & Weitz, 2014)

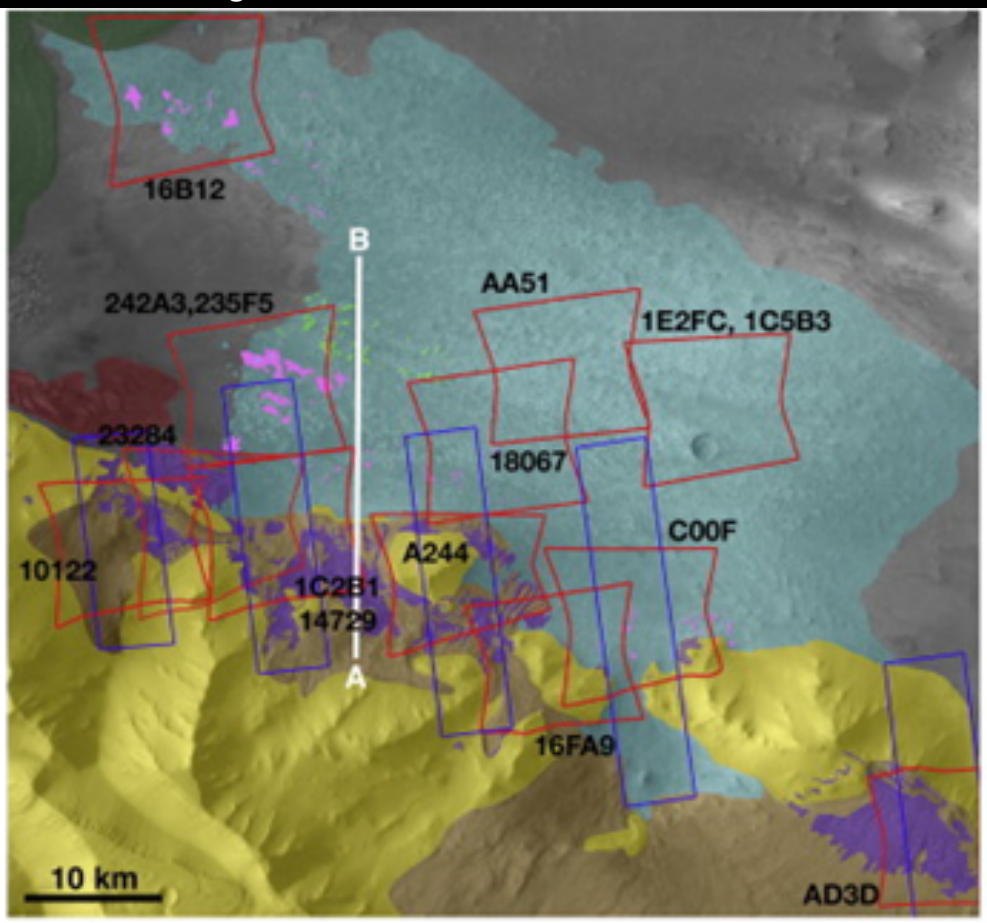


Ellipse ROI Map or Geologic Map Figure (Williams 2nd landing site workshop)



Layered deposits, inferred lacustrine deposits are pervasive in landing zone and would be sampled in any traverse. Therefore, these were not designated a separate ROI.

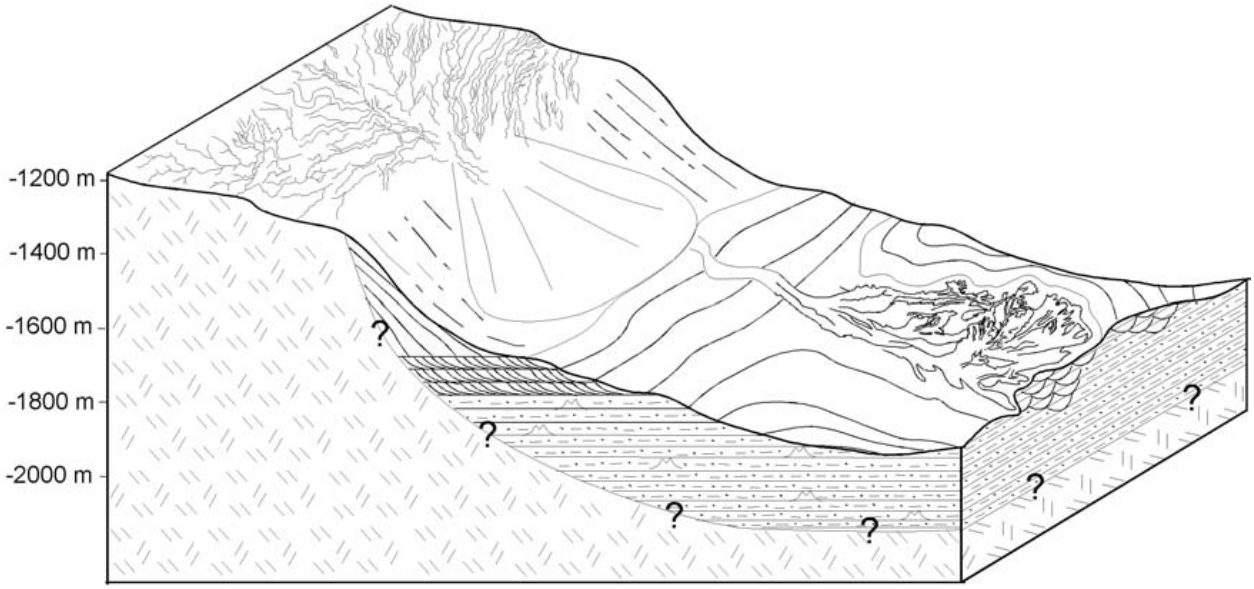
Mapped units and mineralogical observations



Legend

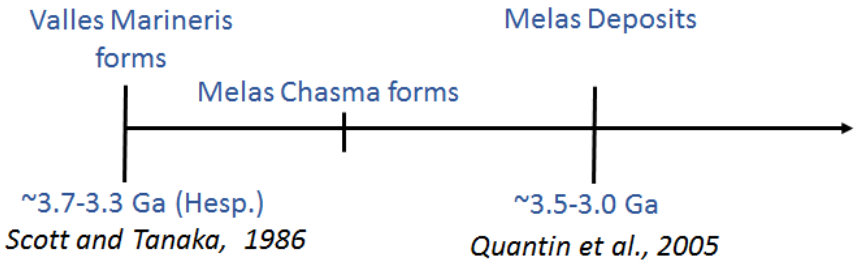
- dark dunes (DD)
- medium-toned blocks in BD (PHS signatures may be present) ← Polyhydrated sulfates
- light-toned blocks in BD (1.92, 2.21, and 2.28 μm features) ← Fe/Mg smectites, and/or Al-smectites, hydrated silica, jarosite
- light-toned layered mounds (LLM) (Ca-sulfates) ← Gypsum and/or bassanite
- landslides (L)
- light-toned draping deposit (LD) (1.92, 2.21 and 2.265 μm and/or PHS) ← Jarosite, and/or hydrated silica, pre-cursor clays, residue of acid-treated clay. PHS may also be present
- medium-toned layered deposit with valleys (ML) ← (may contain igneous float from valley walls)
- wallrock and talus debris (W)
- eolian debris and ripples (E)

Regional (~3x ellipse) Stratigraphic Column Figure (Metz et al, 2009)



Sketch of the paleolake deposits with an upper fan feed by the valley network upstream, and lower fans formed by subaqueous channel deposits.

Inferred Timeline Figure



Summary of Top 3-5 Units/ROIs

ROI	Aqueous or Igneous?	Environmental settings for biosignature preservation	Aqueous geochemical environments indicated by mineral assemblages or other evidence
1	Aqueous	Deep subaqueous fan for preserving biosignatures via clastic deposition and/or chemical sedimentation	Deep water fan is indicated by landforms, stratigraphic architecture, field relationships
2	Aqueous	Hydrothermal, chemical sedimentary or diagenetic alteration	Hydrated silica could indicate any of those environments
3	Aqueous	Layered lacustrine deposits	Opaline silica; nearby jarosite
4	Igneous?	Landslide front	No mineralogy, likely igneous float rocks from the walls of VM

Top 3-5 Units/ROIs Detailed Descriptions

Unit/ROI Name: Lakebeds

Aqueous

Description:

Horizontal layered deposits that are abundant in the ellipse

Interpretation(s):

- Layers interpreted as lacustrine because they are all below the paleolake level traced by fans and clinoforms

In Situ Investigations:

- map up-section and lateral variations in texture, bedforms, chemistry, mineralogy, organics.
- Study contacts: Channels? any signs of subaerial exposure? Could provide insights to ancient atmospheric composition etc. How did the environment above/below contact change? This could provide insight to evolution of surface processes, climate and habitability.
- Petrology with PIXL, SHERLOC, SUPERCAM: clastics – composition, shape, alteration rims, cements, matrix etc – for provenance studies, evolution of water chemistry, water depth, wave energy, sedimentation rate, benthic processes etc. over time

- Look for possible microbial textures and textural variations
- Look for possible microbial structures (stromatolites, bioherms, reefs), organics.
- Look for materials that could provide insights to the processes affecting isotope fractionation (e.g. crusts, interstitial cements)
- Look for unusual distiributions of elements of minerals that could reflect microbial activity
- Look for precipitated mineral deposits that may preserve microfossils, organics, gas or fluid inclusions, isotopic proxies for paleoenvironment, atmosphere and climate
- Look for veins to compare and contrast with sedimentary materials and provide experimental controls on analyses in situ or returned samples
- Look for igneous clasts or ash deposits, spherules or other volcanic "event deposits" for possible geochronology studies
- Look for ooids and other accretionary features from the sedimentary environment
- Look for organics in fine clastic sediments
- Look for possible chemical bioisignatures such as reduction spots
- Look for alteration features and compare those related to modern weathering to alteration caused by paleosurface processes or burial diagenetic processes.
- RIMFAX: map subsurface layers, including spatial changes. Search for subsurface boundary between proposed lake layers and basal terrain to assess thickness, map contacts between other units including, if possible, spatial changes in thickness. Search for buried channels.

Returned Sample Analyses:

- Analyze a well characterized suite of samples representing the key facies and microfacies. Continue the investigations as outlined above, but at smaller scales and with different techniques.
- Study any authigenic minerals – do they preserve microfossils, organics, gas or fluid inclusions? Analyze these, measure isotopic compositions etc – yield proxies for paleoenvironment, atmosphere and climate
- Fine scale (eg synchrotron XRF/XRD, TEM, SIMS, nanoSIMS) analysis of any organics to characterize morphology, chemistry, isotopic composition, mineral association, assemblage characteristics.
- Geochronology studies of mineral grains (authigenic, volcanic, clastic)
- Provenance studies of grains
- Look for possible biominerals
- Look for possible chemical biosignatures such as reduction spots

Unit/ROI Name:
Subaqueous channel deposits

Aqueous

Description: Digitated fans present on the western margin below the paleolake level

Interpretation(s):

- Subaqueous channels and fans, as determined from their morphology similar to terrestrial subaqueous fans
-

In Situ Investigations:

- In addition to investigations outlined for ROI 1, also observe channel and overbank deposits for detailed insights to the sedimentary environment, including any changes that would be relevant for habitability (e.g. sedimentation rate, type) and preservation. Look for shallow water parts or sediments deposited in low energy environment: these would provide ideal loci for benthic organisms. Look for possible microbial sedimentary textures, structures, authigenic mineral deposits (rationale as above)

Returned Sample Analyses:

As above

Unit/ROI Name: Opaline silica outcrops

Description:

Local layered outcrops that present opaline silica signature

Interpretation(s):

- **Specific alteration with authigenic silica, location to understand better the lacustrine environment**

In Situ Investigations:

- Determine the origin of the siliceous deposits:
- Study mineralogy in detail: what, if anything, is the silica mixed with? Is it deposited in layers or massive? What textures and fabrics does it exhibit? How do they vary? What is the nature of the contact with adjacent rock units?
- Identify facies and microfacies. Map contacts and spatial variations in facies.
- Look for microcrystalline occurrences – possible preservation site for cellular structures.
- Search for organics
- RIMFAX: Map stratigraphic relationship of these deposits to other units, as well as internal layering within the deposit.

Returned Sample Analyses:

- Microtexture – insights to origin of silica
- Entrained organics – any microfossils
- Gas or fluid inclusions studies etc

Unit/ROI Name: Landslide margin

Description: Landslide tongue at the southern margin of the ellipse

Interpretation(s):

- Igneous rock from Valles Marineris walls may be accessible for exploration and sampling in this landslide

In Situ Investigations:

- Study the composition of boulders in the landslide – especially for variations in igneous boulder characteristics (grain size, mineralogy, chemistry, alteration), to inform sample selection
- RIMFAX: If possible, map basal boundary of landslide and internal structure. Map contact between this and surrounding deposits.

Returned Sample Analyses:

- Age dating of igneous rocks

Biosignatures (M2020 Objective B and Objective C + e2e-iSAG Type 1A, 1B samples)

Biosignature Category	Inferred Location at Site	Biosig. Formation & Preservation Potential
Organic materials	Quiet water (e.g. fine grained, finely layered) deep or shallow lacustrine deposits in any of the fans or layered lacustrine units could contain either transported organics that have been hydraulically sorted, pelagic organics, or in situ organics formed at benthic boundary layer	Formation: Transported organics that have been hydraulically sorted may be deposited in deep water. Abundance depends on productivity in source region. Pelagic organics: Benthic organics Preservation requires burial and absence of oxidizing diagenetic processes etc.
Chemical	Anywhere in the lacustrine deposits or opaline siica – texture-specific chemistry can reveal a variaety of potential clues to past microbial activity in a variety of subaqueous facies that would occur at the site	High
Isotopic	Authigenic minerals and/or organics in the lacustrine deposits.	High
Mineralogical	Authigenic minerals in lacustrine deposits, silica deposits	High
Micro-morphological	Authigenic minerals in lacustrine deposits, opaline silica, chemical sediments, any evaporative sedimentarya deposits. Also possible endolithic microborings in clastics in lacustrine deposits	High
Macro-morphological	Lacustrine deposits	High

Dateable Unit(s) for Cratering Chronology Establishment

Unit Name	Total Area (km^2)	Time Period	Geologic Interpretation and uncertainties	What constraints would the unit provide on crater chronology?

Key Uncertainties/Unknowns about the Site

No igneous units with well-established crater density

Duration of lacustrine deposition.