
# Mawrth 2

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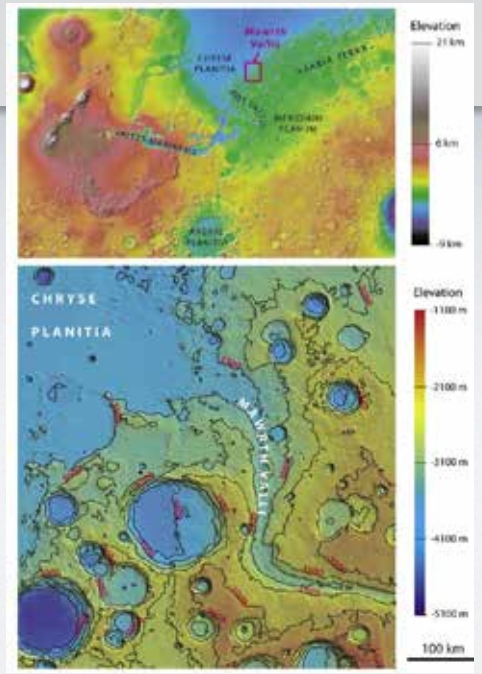
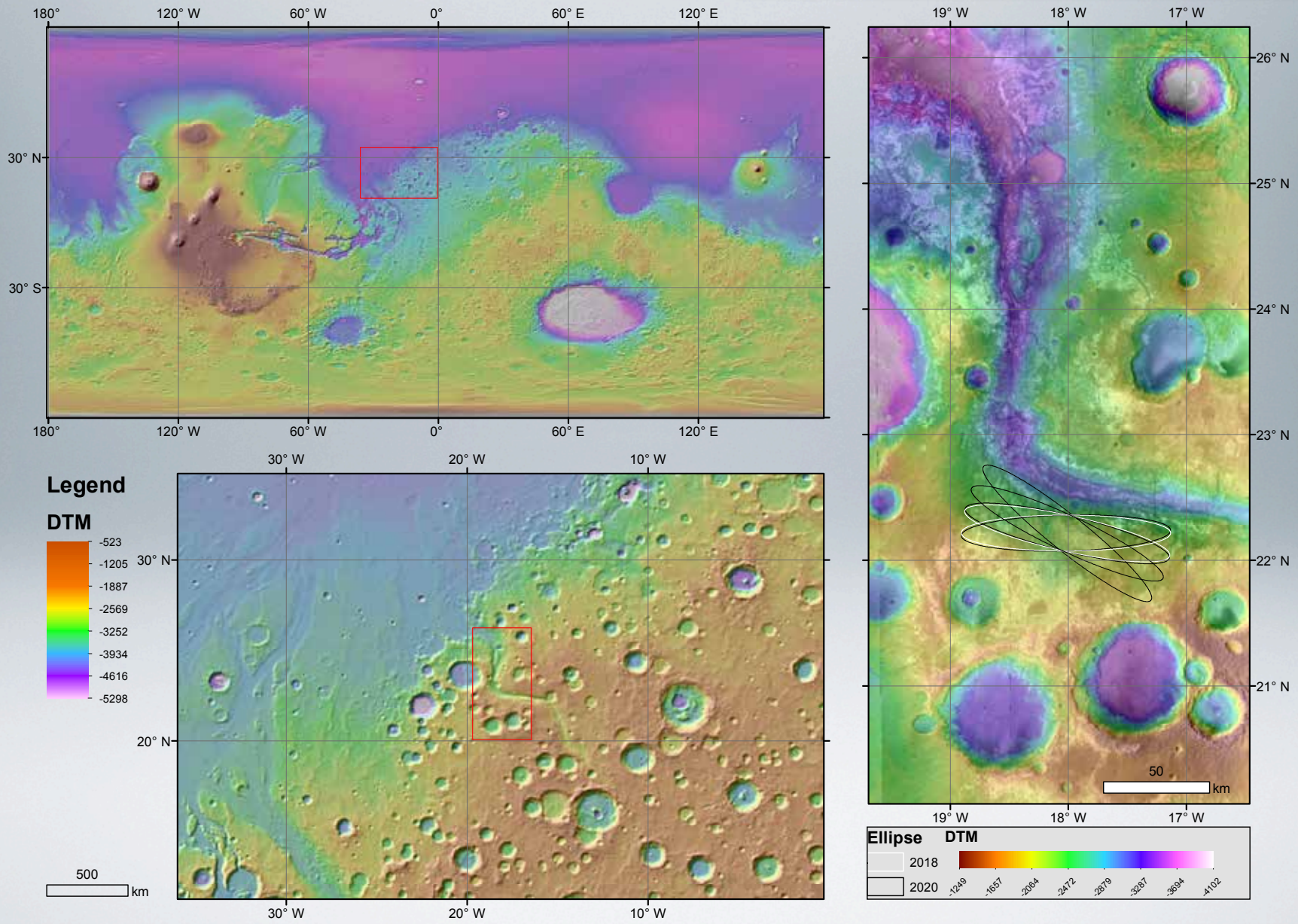
# Site presentation

**Mawrth Vallis** is the boundary between the southern highlands and northern lowlands of Mars. It is a place where the entire planet suddenly drops in elevation. In effect, Mars is lopsided. Its southern hemisphere is higher in elevation than its northern hemisphere. Mawrth Vallis itself is an **ancient channel carved by catastrophic floods**. "Mawrth" is the Welsh word for Mars and "Vallis" is Latin for valley. Layered cliffs are rich in clay minerals. Such minerals, called phyllosilicates, form in the presence of water. They could be a source of information about past environments that could have supported life. It is **one of the oldest preserved outflow** channels on the surface of Mars. This sinuous channel cuts across the western surface of the Arabia Terra plateau and is a possible manifestation of past catastrophic outflow of a subterranean aquifer. Few bed forms are preserved indicating the channel has undergone sifnificant modification since its formation.



# Site presentation



# Site Geological Context

Studies of the stratigraphy of Mawrth Vallis region made with OMEGA and HRSC data (Loizeau et al., 2010) indicate that the proposed site, located in the southern region Mawrth lies in a **sequence of materials that define a broad syncline** with a maximum dip of 3.3° ± 0.5° at both sides of the channel. This shallow dipping could favor the formation of outcrops across the landing ellipse and provide a window lo units located under the upper materials of the area. The sequence of materials present in the landing ellipse as determined by the authors include mostly an upper unit formed by Fe/Mg- clay rich and another unit mostly covered by a dark mantle. Stratigraphically lower materials that outcrop as we move down to the channel also include, from upper to lower units, a subunit unit formed by Fe/Mg- clay rich materials, an Al-rich sub-unit and an Fe/Mg-rich clay sub-unit. Most of the landing ellipse fall into the first two units.

The region surrounding Mawrth Vallis contains one of the largest exposures of phyllosilicates detected on the Martian surface (Poulet et al., 2005; Bibring et al., 2006). The phyllosilicates occur in light-toned layered deposits of possible sedimentary or volcanic/hydrothermal origin (Loizeau et al., 2007, 2010; Michalski and Noe Dobrea, 2007). The clay-rich rocks at Mawrth Vallis exhibit the highest degree of aqueous alteration identified on Mars from the orbit (Poulet et al., 2008), providing an intriguing and unique window into early Mars water history.

The proposed ellipse, located in the southern region of Mawrth Vallis, is located in Late to Middle Noachian materials of the Noachis Terra unit. This unit is composed of rocks of volcanic and sedimentary origin, that belong to the present distributed light toned deposits across the landing ellipse. Those bright deposits have been described as phyllosilicates in other areas surrounding

Mawrth Vallis suggesting that abundant water was present during Noachian period (e.g. Bishop et al., 2013 and references therein).

# Site presentation

- **Geomorphologic description**

- There are three primary units along and within Mawrth Vallis: the Noachian cratered terrain, Hesperian channel floor materials, and Amazonian deposits near the northwest boundary of the channel. In some locations along the walls of Mawrth Vallis, the Al-rich unit appears to lie stratigraphically between Fe or Mg- bearing smectite units (e.g., nontronite). A transitional unit with spectral signatures of both Al- bearing and Fe/Mg clays is also observed. Other dark-toned materials present throughout the region are identified as pyroxene-rich materials (i.e.,basaltic sand and dust) that mantle the surface (and clay-bearing units).

- **Mineralogy**

Three principal clay types are present: Fe, Mg and Al-rich smectites. Al-rich phyllosilicates in the form of montmorillonite clays are located in eroded light-toned outcrops along the flanks of Mawrth Vallis.

- **Sedimentary outcrops**

Mawrth exposed the strata in the edge of the channel but outcrops distributed.

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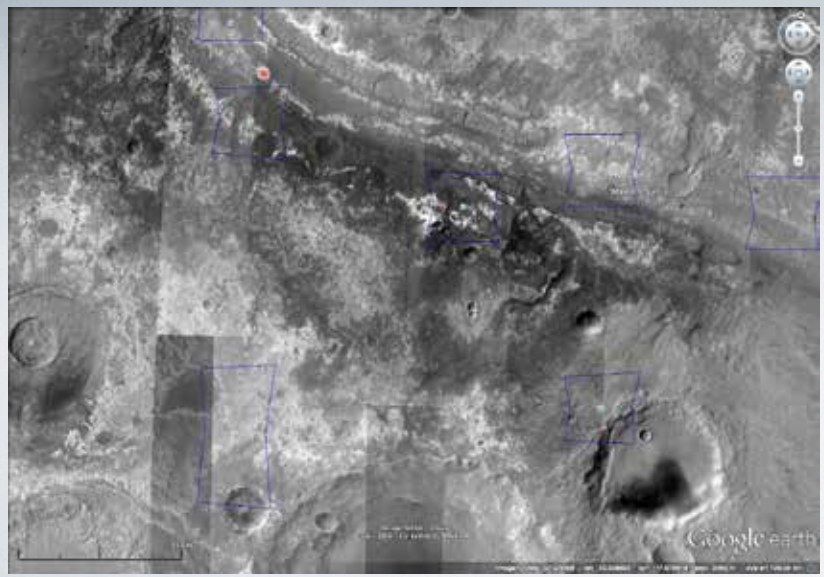
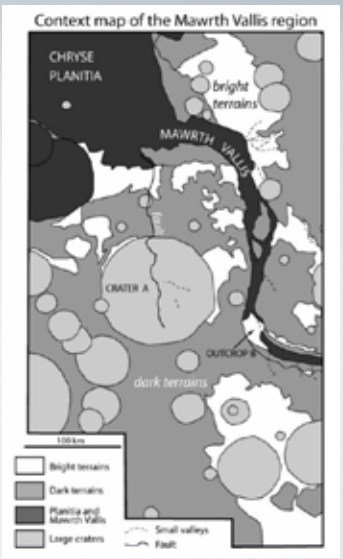


# General Site Presentation

- **What are the attractive points of this location**

- Prime science targets Layered
- high albedo materials
- Sedimentary materials
- Water flow features
- Distance of prime science targets from ellipse centre < 1 km
- Distance of other science targets from ellipse centre > 1.5 Km water flow features (flow channels)
- Overall distribution of science targets in ellipse In different locations around the ellipse center.
- No Occurrences of dark streaks
- No Occurrences of RSL

# Site's Geological Context

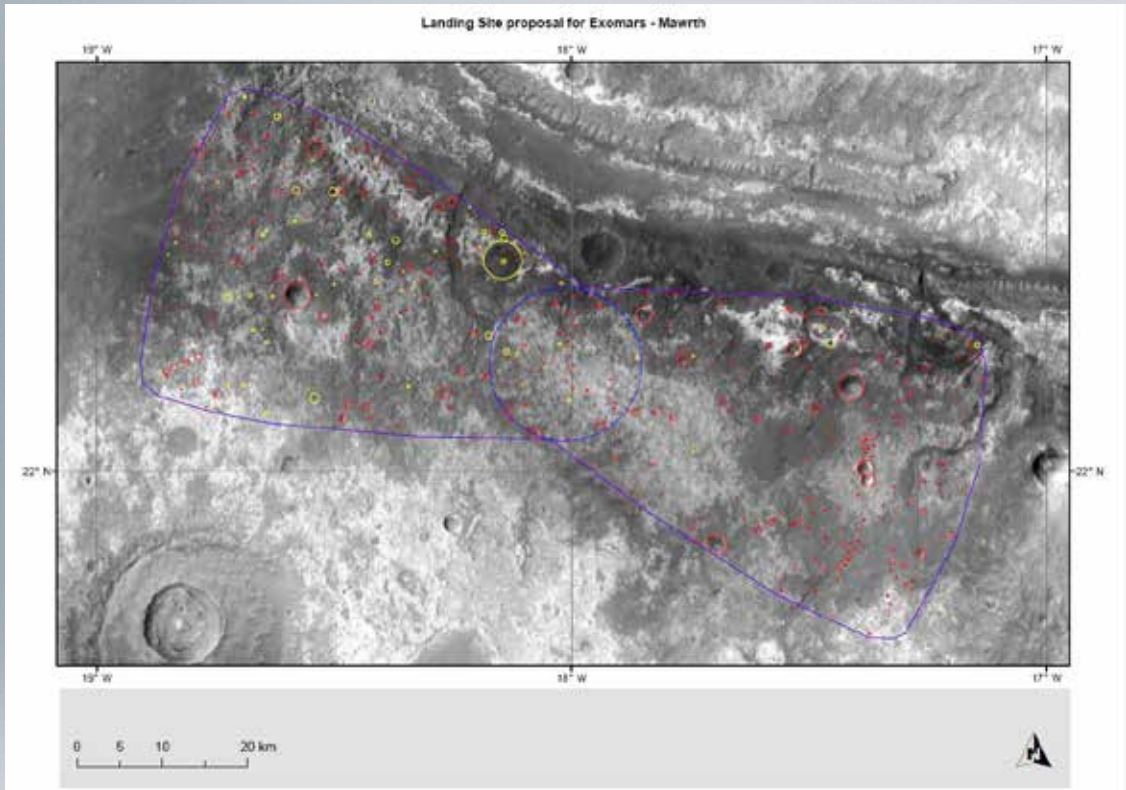
- site's age Age of the units of interest

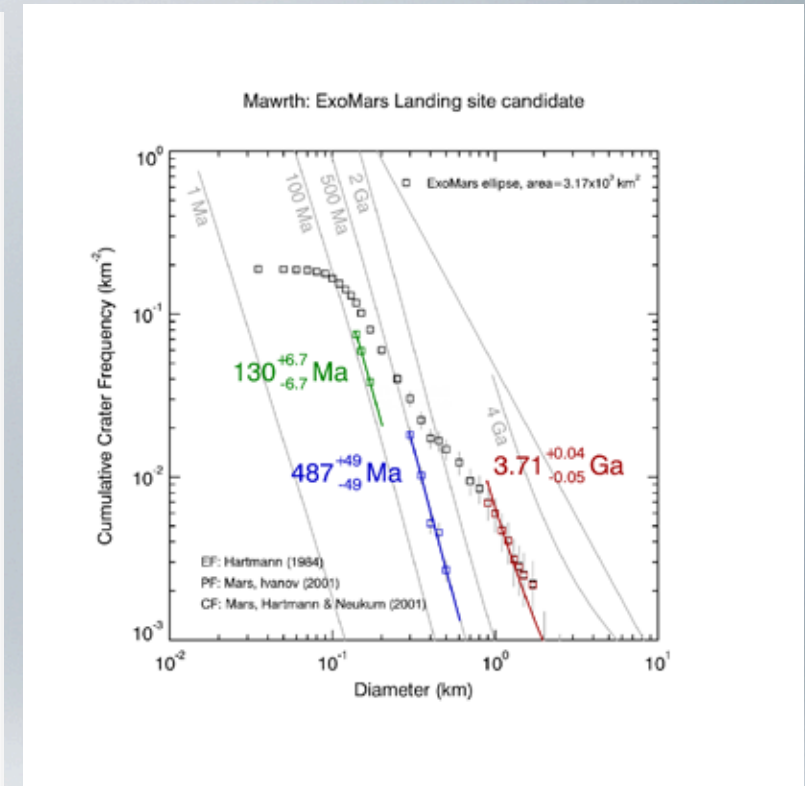
  Chronology determined for the area located to the north, and also located in the Mawrth "plateau" indicate a Noachian age for the layered clay rich materials that are the target of the proposal (Loizeau et al., 2012). According to this crater model results formation of the layered materials started ~ 4.0Ga ago, was largely deposited by ~ 3.9 Ga ago, and suffered erosion and redeposition up to ~ 3.8 Ga ago. The age of the dark discontinuous mantling materials is ~ 3.7–3.6 Ga.

- By crater counting we report 3.71 Ga, if we assume similarities on dark discontinuous materials this means that salt expose areas are older due to that they are stratigraphically below the dark mantle materials.

- We can report by crater counting data the presence of two events of exhumation (487 +/- 49 Ma and 130 +/- 6 Ma). It is important to coinstrain the age of the exhumation events but the processes as well.

- **Show crater counts (if available)**



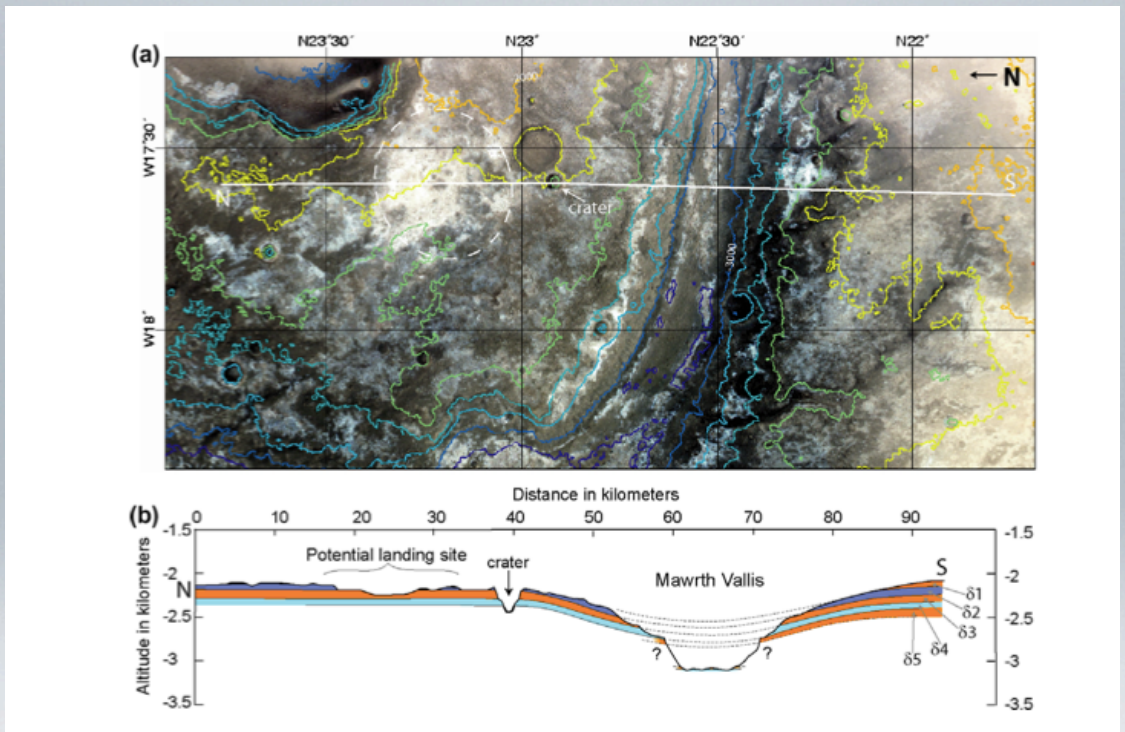




- **Show stratigraphic (or cross-cutting) relationships**

- No cross-cutting relationships observed due to the horizontal dispositon of beds. Lower materials outcrops due to variations in slope and topography.

- Geology description: Nature of substrata—rocks and sediments below the "more recent" cover.

- Stratigraphy of the proposed landing site was determined by Loizeau et al., 2010 by studying OMEGA and HRSC images and topographic data at both sides of the channel (Figure). According to the changes in the tone of the materials and their altitude Loizeau et al determined a sequence of materials that include form top to bottom al alternating sequence of Fe/Mg rich clay and Al rich clay materials.




- The norther part of our proposed landing site is located in the southern plateau illustrated in the Loizeau et al Figure. Partly mantled layered plaeau composed by Fe/Mg rich clays of unit 1 and the dark mantled materials of unit 2. The richness in Fe/Mg clays (smectite), indicates an aqueous environment that was more neutral to alkaline than for the formation of sulfate-rich rocks [Poulet et al., 2005; Bibring et al., 2006].all the sequence of clay rich materials is covered by dark deposits of aeolian origin (Loizeau et al., 2010) poorly indurated. This characteristic of the mantling material could be very important for the drilling.

# Mineralogical Description

- Please discuss the available mineralogy data (composition of rocks and sediments) in some detail and explain how they support your geological context interpretation.
  - Please identify any interesting water-related mineral locations (e.g. clays, evaporites, etc.) in the context of search for signs of life investigations.
  - Please show the availability, distribution, and type of sedimentary outcrops in the landing ellipse.
  - Please discuss the distribution of other interesting mineral targets.

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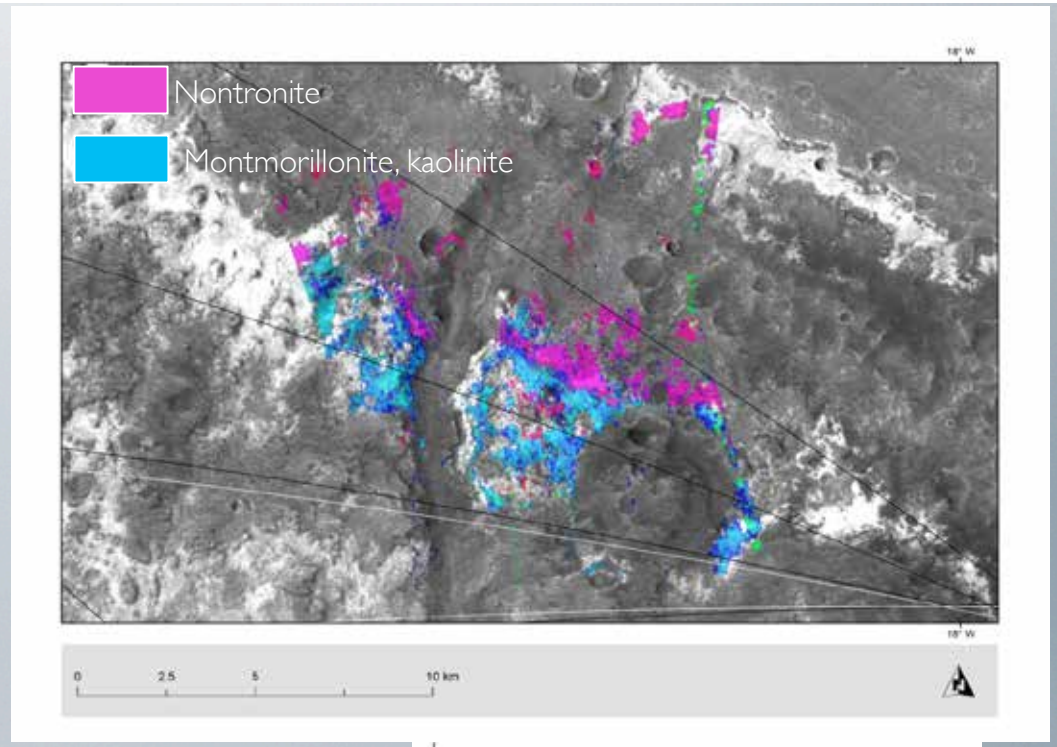


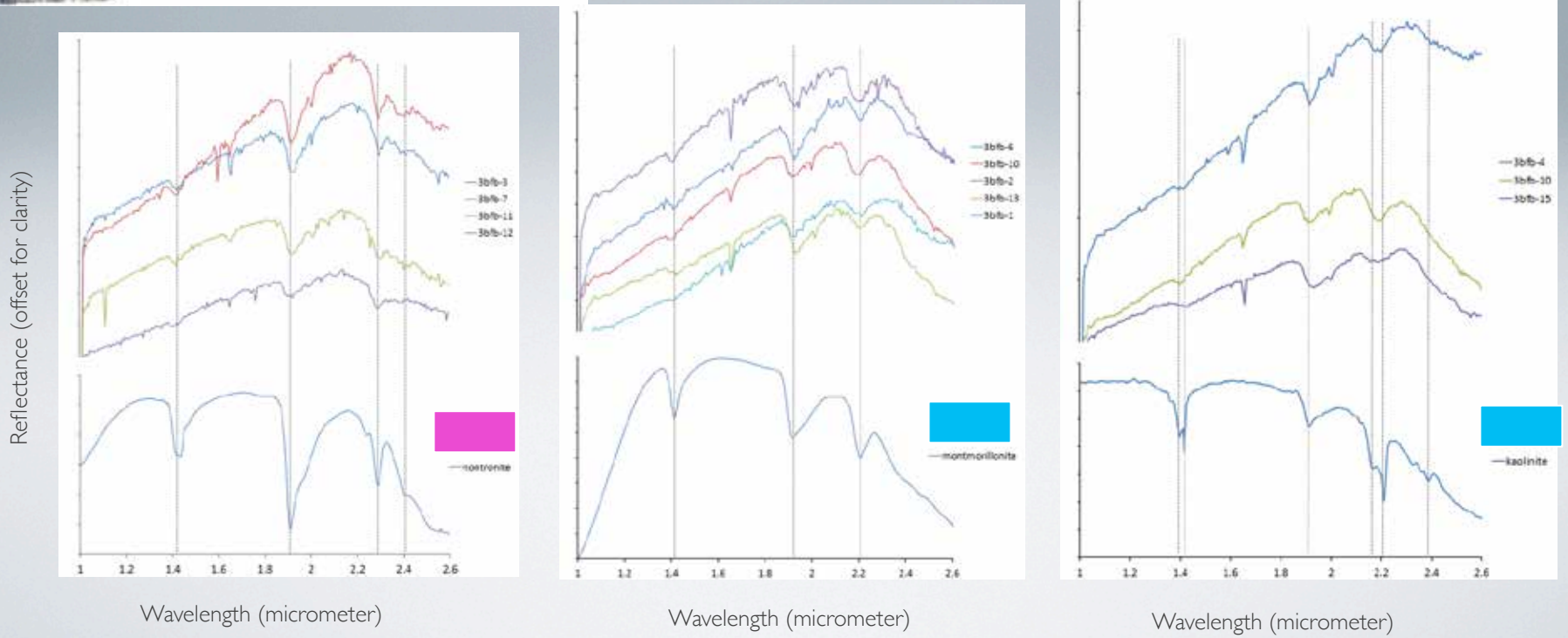

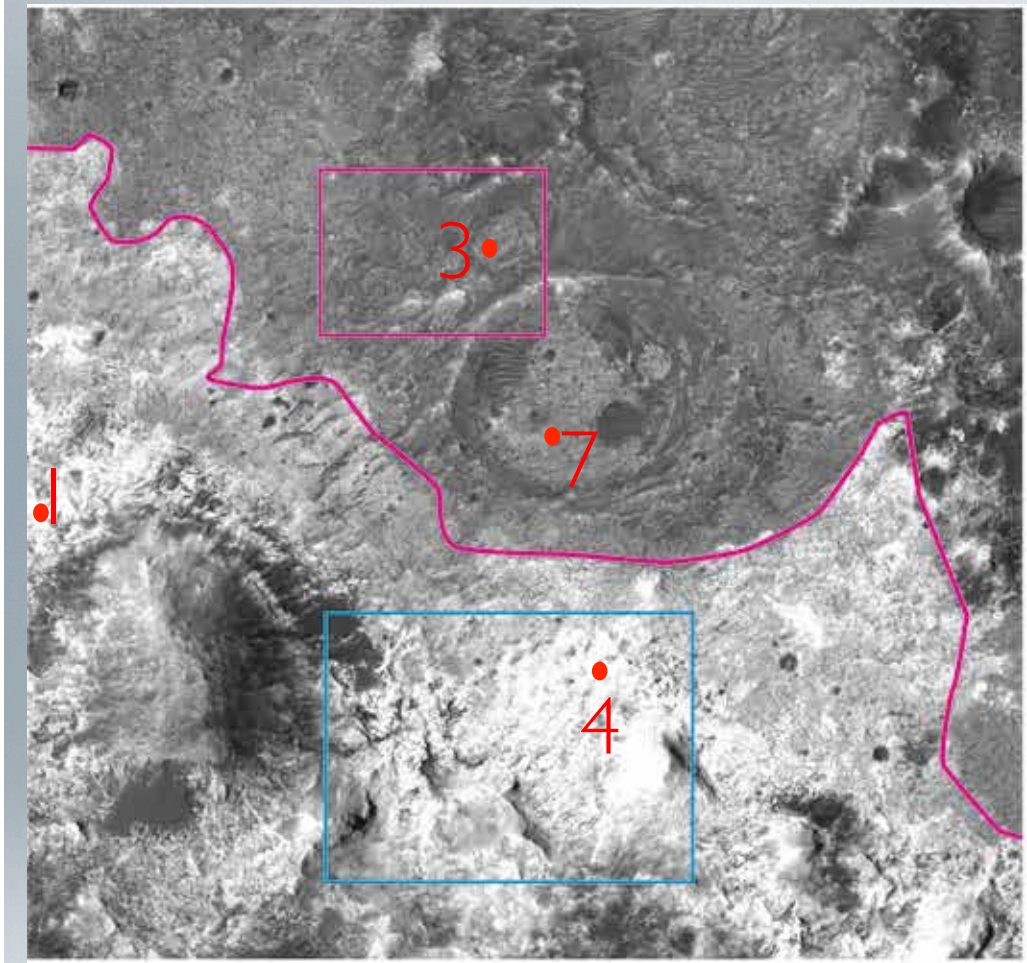


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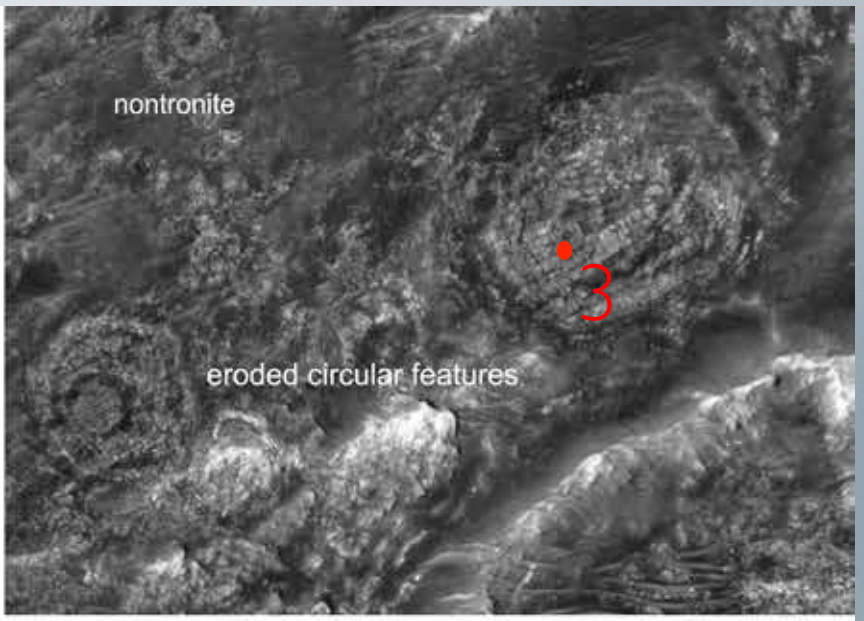
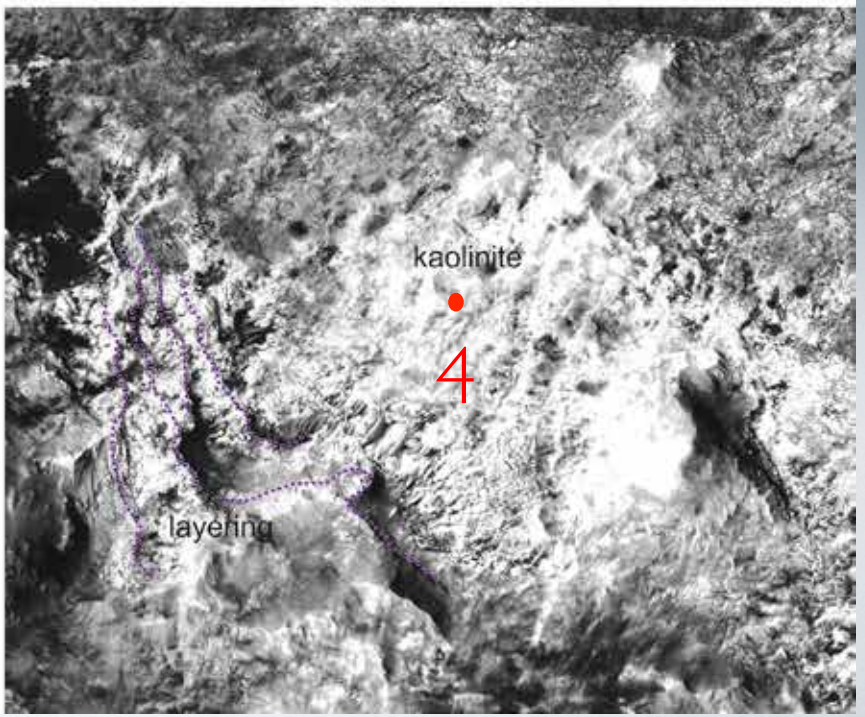
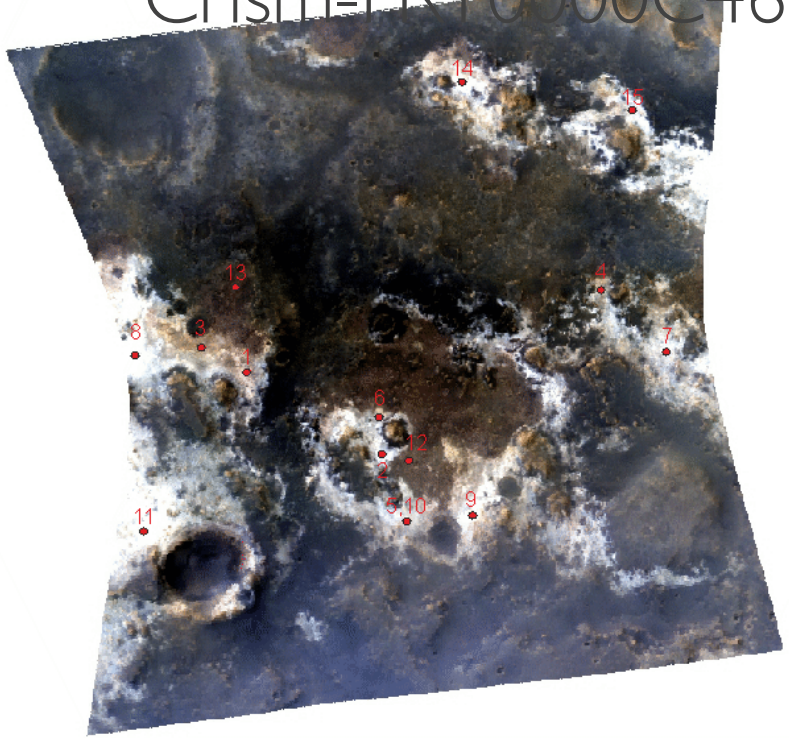
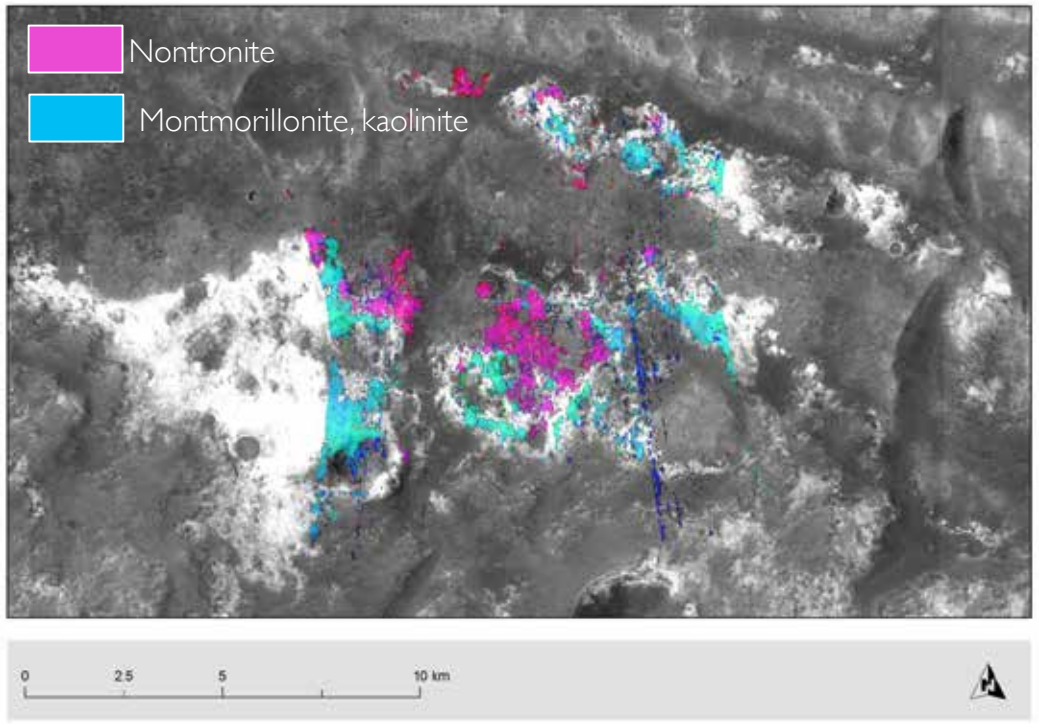


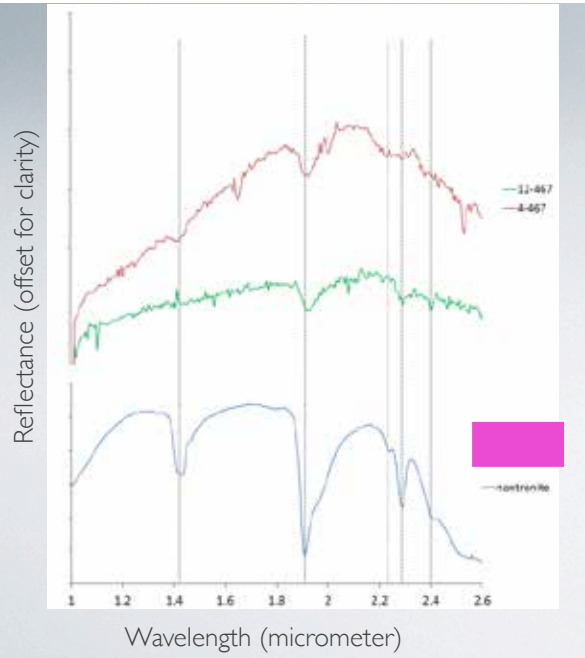



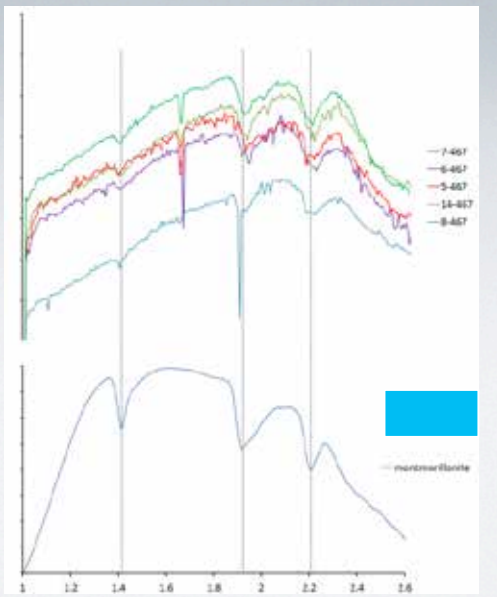

Spectra from CRISM 3bfb

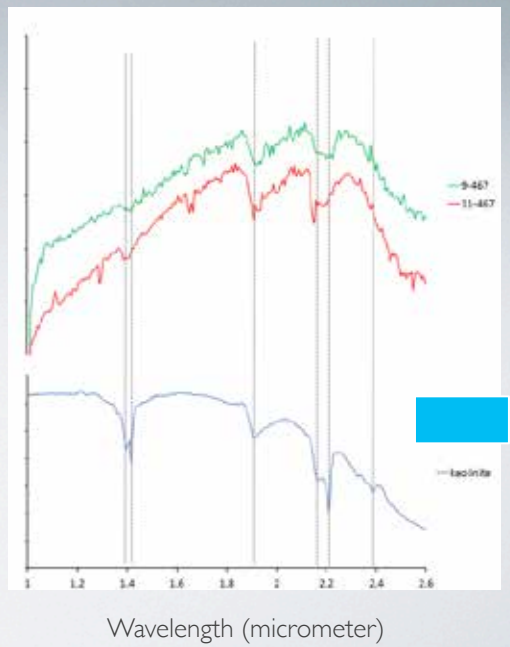
# Crism-FRT0000C467



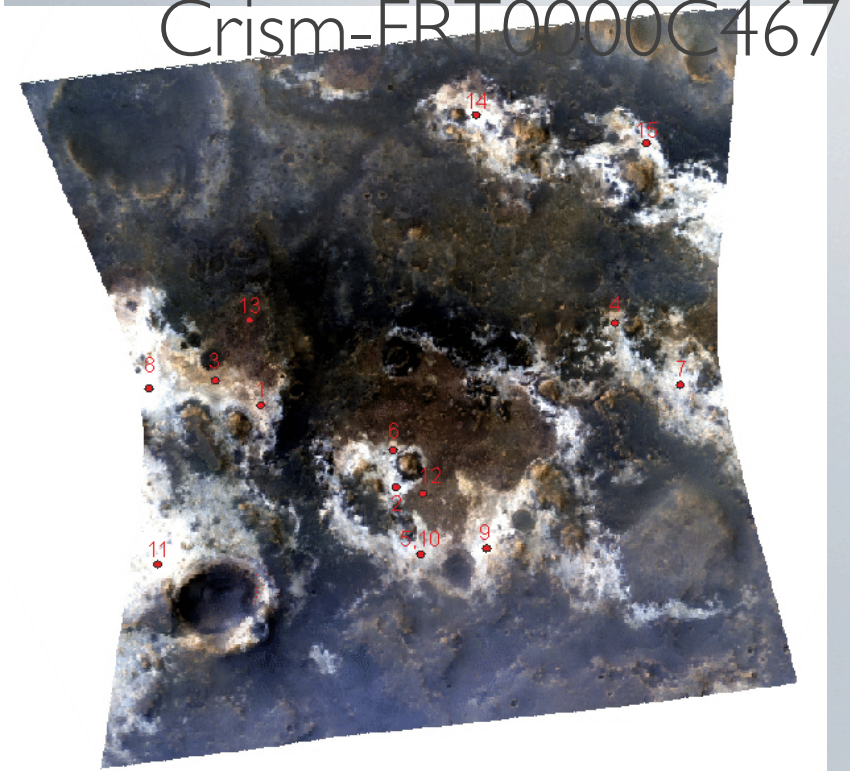




# HIRISE PSP_264

# Crism-FRT0000C467

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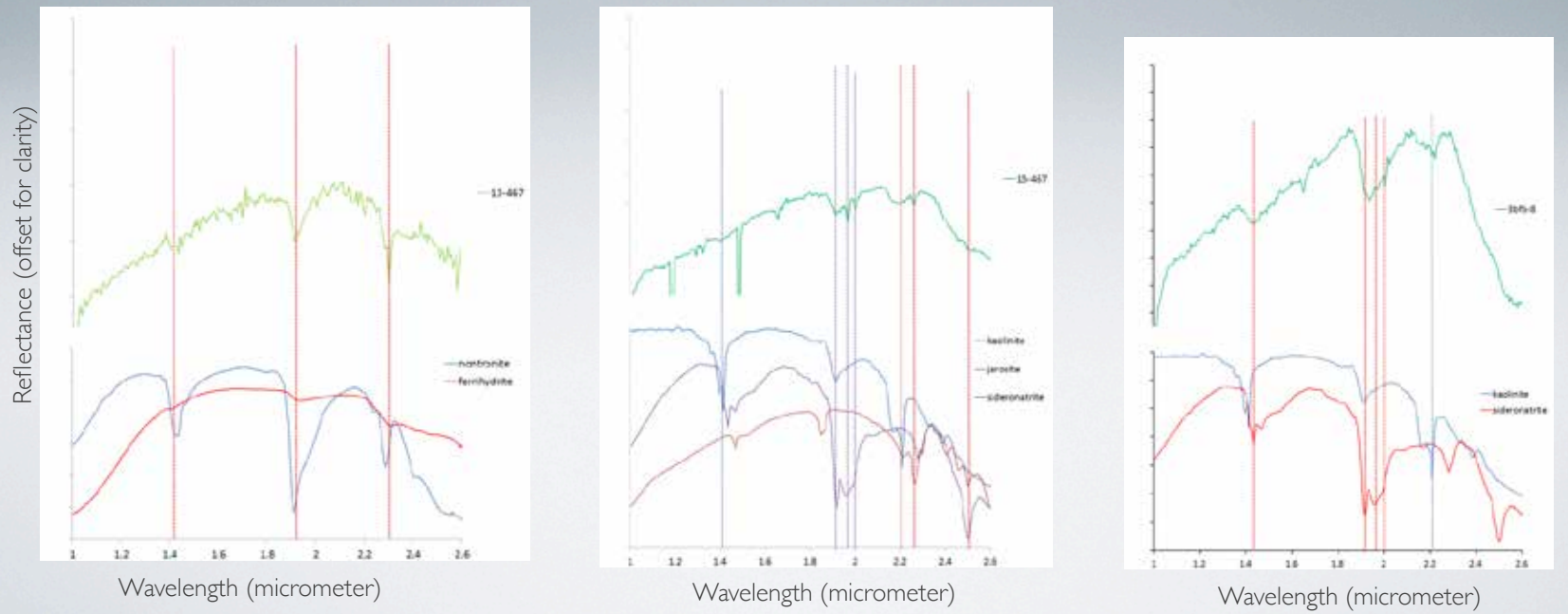



HIRISE ESP_019242_2025

# Preservation in Mawrth S (Clays)

- Maturation degree of clays is potentially low that suggests a good preservation for organics. Sedimentary load in the clay-rich unit of Mawrth, about 300 meters as maximal thickness (Michalski et al., 2010)

- Absence of tectonics plus an exposition to low temperature conditions (we should check geothermal gradient in Noachian) are favorable for a net preservation of organics. Assuming a low thermal activity affecting to a low thickness suggests that some degradation process (e.g. decarboxilation should have not occurred in Mawrth)

- The mineral association support an  early diagenesis of clays that is compatible with a high potential of organics, when other factors are not considered (e.g. UV and other cosmic radiations).

- The presence of kaolinite could also be an unfavorable factor for preservation, when formed as weathering of the underlaying montmorillonite-rich unit (Michalski et al., 2010).

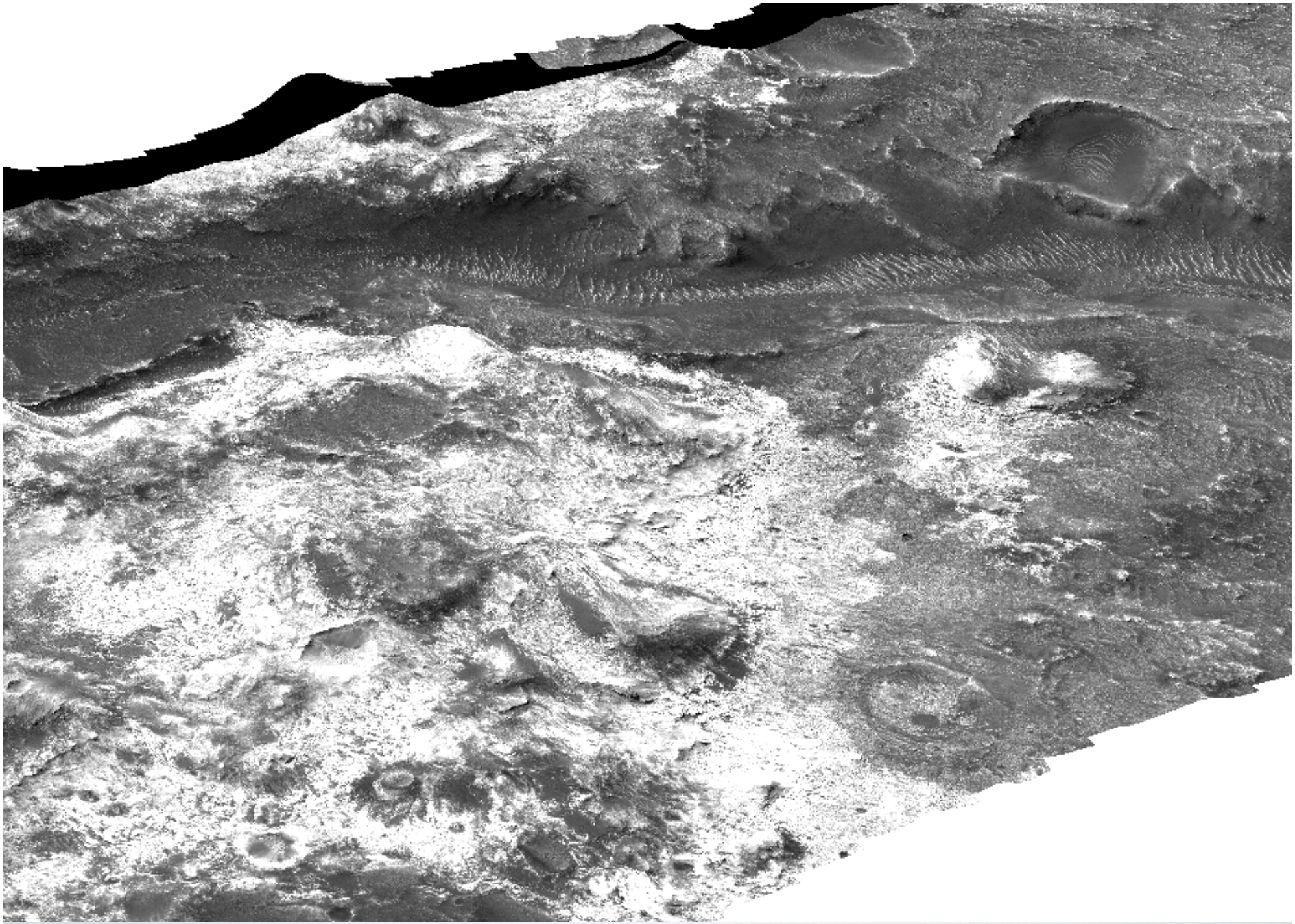
- Several unknown factors (e.g. nature of kaolinite) should be fixed to estimate the real potential for the preservation of organics in Mawrth.

# Preservation in Mawrth S (Sulfates)

- Presence of bassanite and other sulfates  like jarosite suggest fast mineralization, which is highly favorable with preservation (first step of lowering water activity)

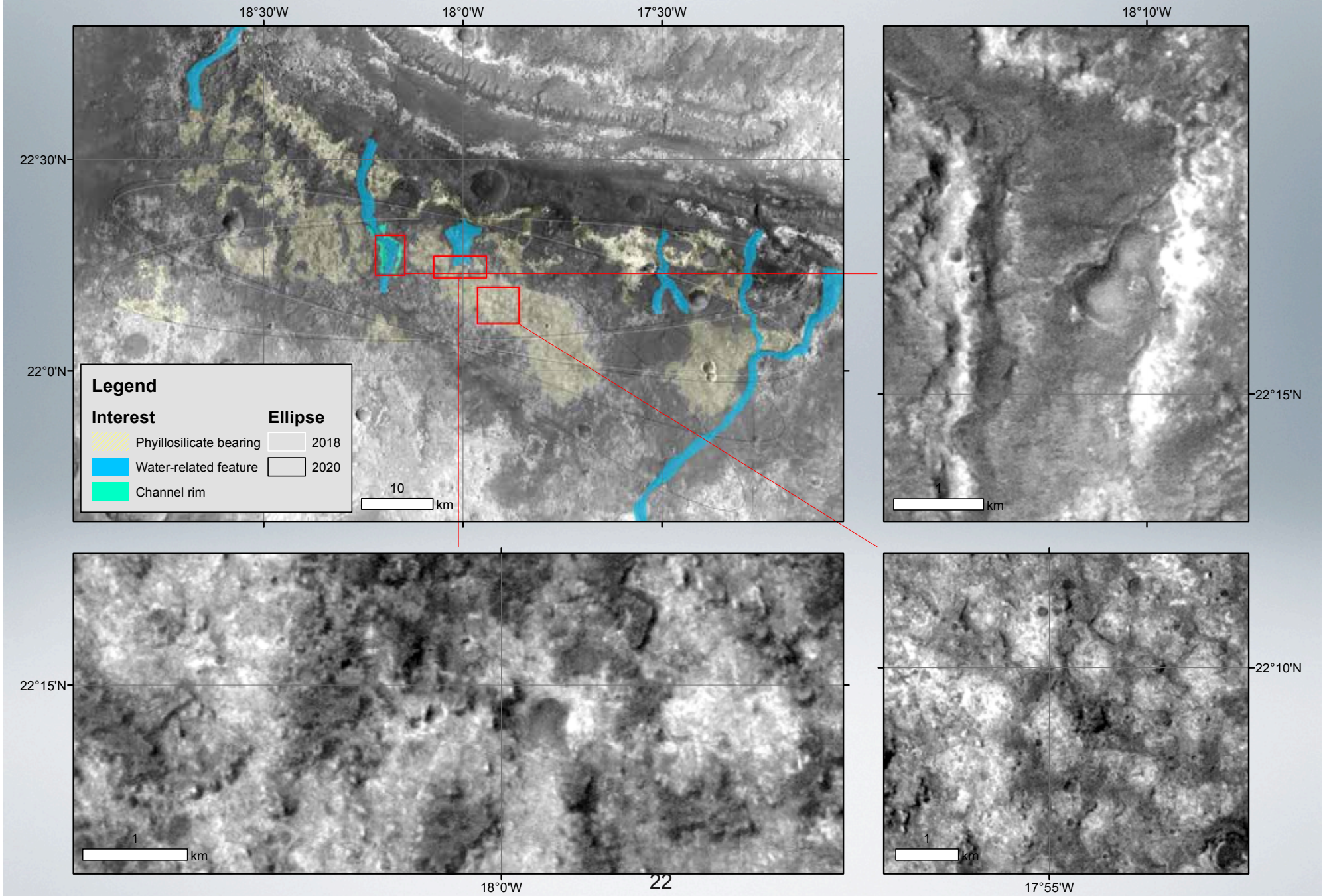
- Ocurrence of bassanite (and not gypsum) supports dehydration processes in sulfates dramatically decreasing the water activity and producing and anhydrous matrix.

- Presence of highly soluble salts as jarosite suggest that the area has not been exposed to a younger hydrological cycling preventing the exposition of organics potentially preserved in salts to solutions that could have degraded in a secondary phase of aqueous dissolution/alteration



# Target Accessibility and Dust

- Please provide an estimate of the accessibility—distance (in km) to primary target outcrops:
  - From landing ellipse centre;
  - In general, within the ellipse (since we cannot be sure where the touchdown point will be), i.e. provide 1) “typical” distances between targets, 2) the percentage of the ellipse covered by sedimentary outcrops, 3) the percentage of the ellipse having mineral signatures of interest.
  - Propose an example rover traverse, assuming we would land at the ellipse centre (2–5 km in length).
- Please describe the type and distribution of dust-and sand-related features from TI data and imagery :
  - General estimate of dust coverage;
  - Depth of dust layer (e.g. dusty outflow channels with lots of transported boulders and few outcrops are not good, thick dust is also not good);
  - Presence of dune and/or ripple systems.

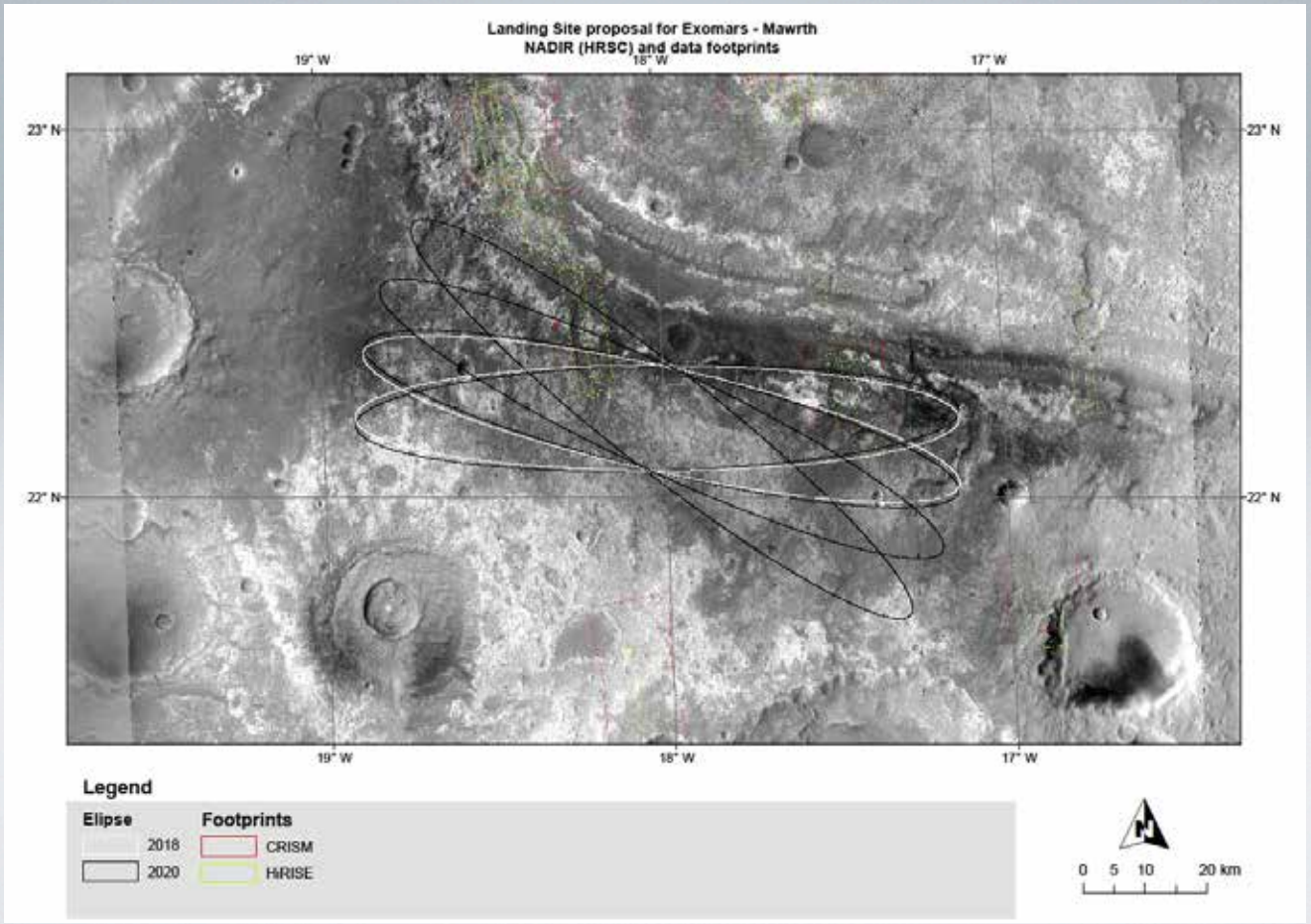

18°30'W
18°0'W
17°30'W
18°10'W
22°30'N
22°0'N
22°15'N
22°10'N
17°55'W
Legend
Interest
Phyllosilicate bearing
Water-related feature
Channel rim
Ellipse
2018
2020
10
km
1
km

# Site presentation

## Planetary Protection Requirements:

Due to the age of the location not expected present liquid water due to that not expected any protection planetary issue. Not recent features that could indicate any planetary protection issue.

## Engineering Requirements:



## Engineering Requirements:

- **Ellipse's slopes compliance**
  - Site Name Mawrth south Ellipse pattern centre's latitude, longitude, and size 22º13´5"N, 18º 0´12"W 104 km x 19 km (spanning 88° to 127° azimuth range)
  - Elevation (for centre, max, min)
  - -2241 m MOLA centre
  - -2500 m MOLA max
  - -2065 m MOLA min

- **The terrain relief and slopes in the proposal following the recommendations have been considered and included. Only in the scale of 2 km map some slope limitations can be identified.**

**Moving the ellipse a little bit to the South better slopes at 2 Km scale can be reach but a little bit far from the interesting identified features. A consensus could be reached if finally needed due to engineering constraints.**

- **≤ 3.0° slopes for length scales 2–10 km (resampled from MOLA MEGDR): Some slopes > 3 º in 2 km scale.**
- **≤ 8.6° at 330-m length scale (resampled from 75-length scale HRSC).**
- **Since we were not able to obtain DEMs for evaluate 7-m and 2-m length scale slopes (≤ 12.5° and ≤ 15.0°), 75-length scale HRSC slopes are showed in Figure 5 instead.**

- **Ellipse's rock abundance, thermal inertia, albedo, and wind compliance**
- **Ellipse's HiRISE, CTX, CRISM, HRSC, OMEGA coverage**
- **Prioritised proposals for new MRO, MEX pointings**

## Summary

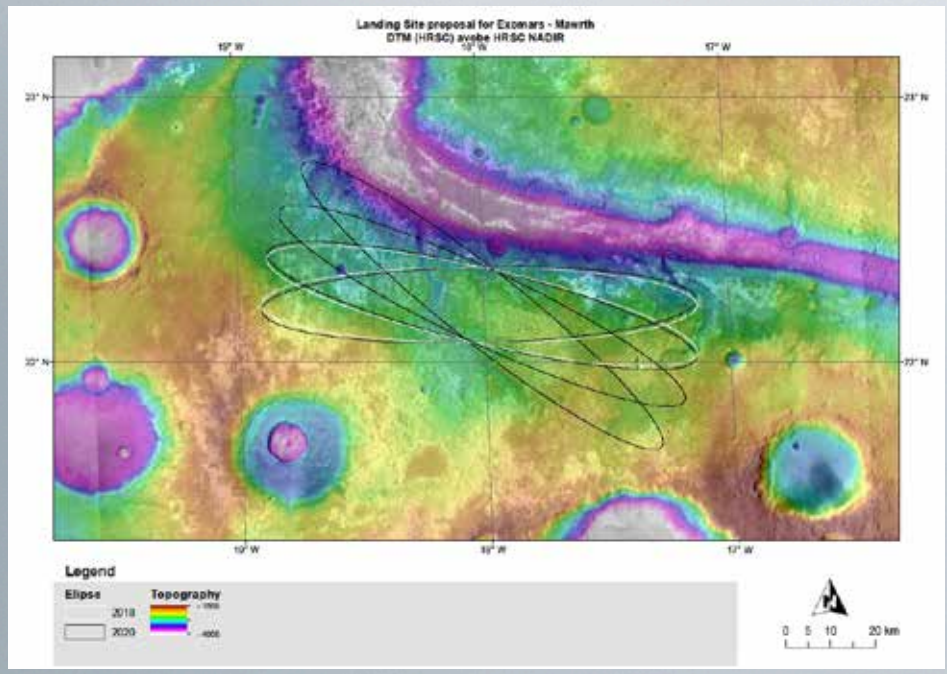



Fig. Topography map with the landing ellipse.

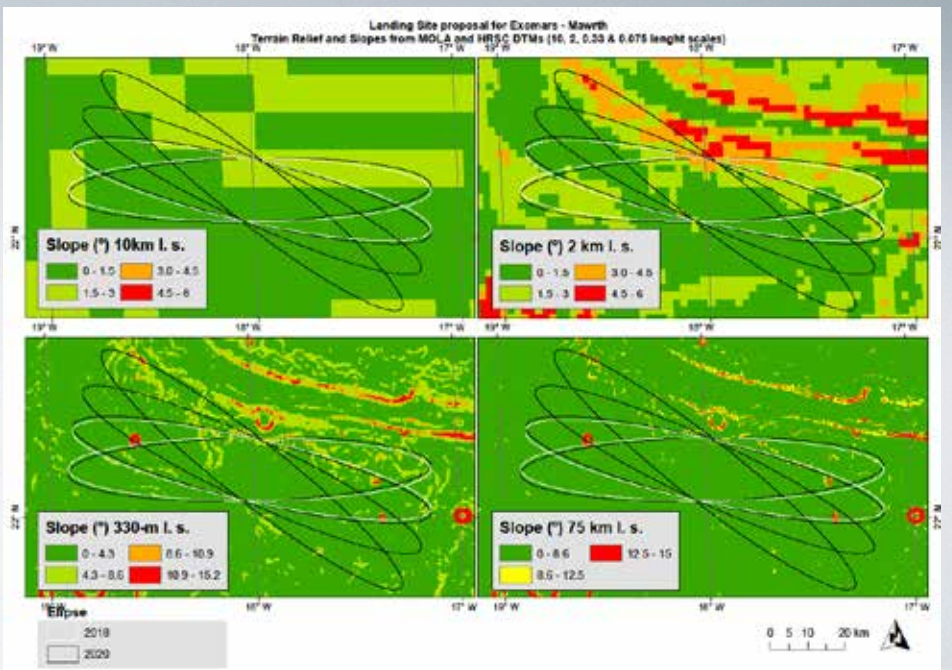
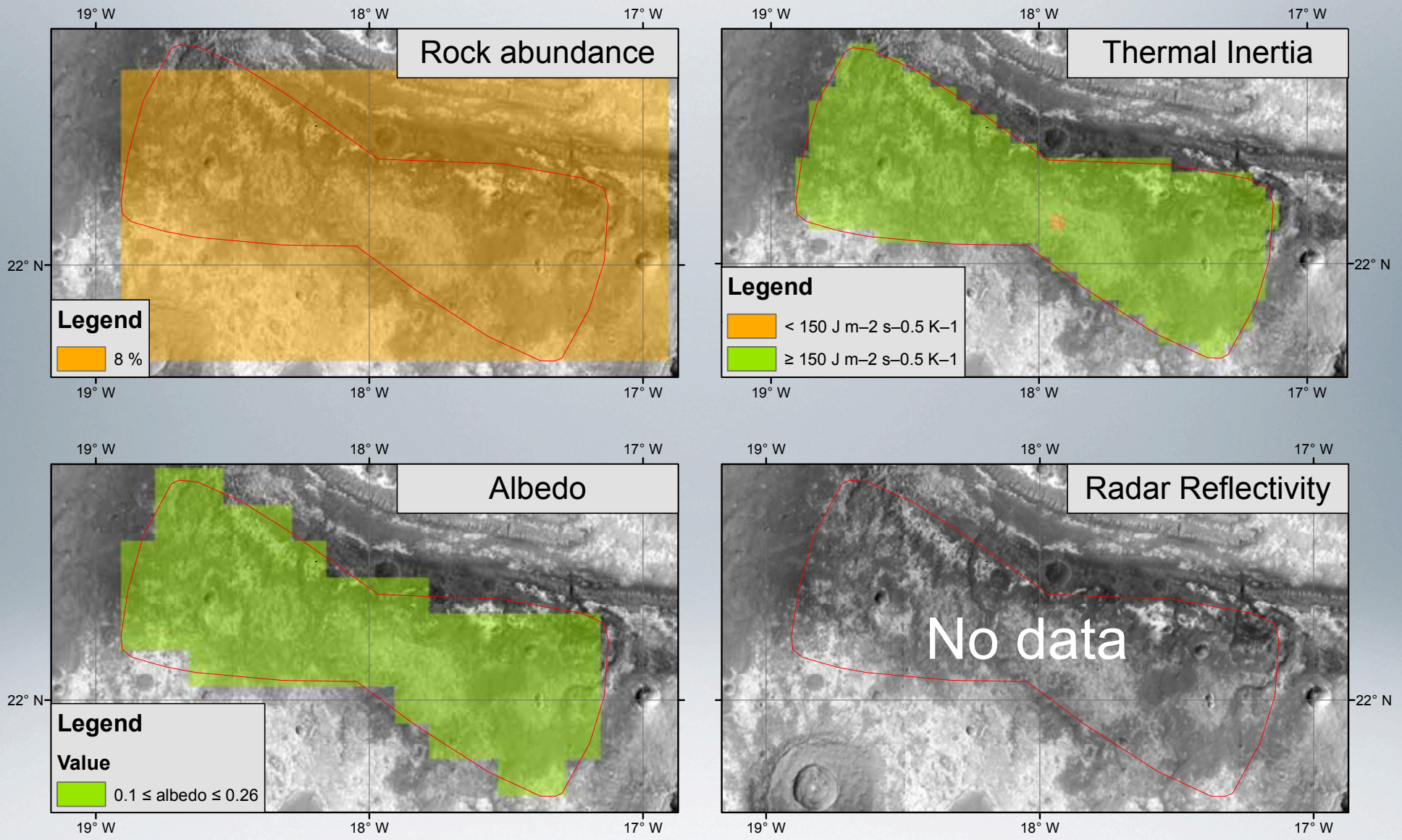
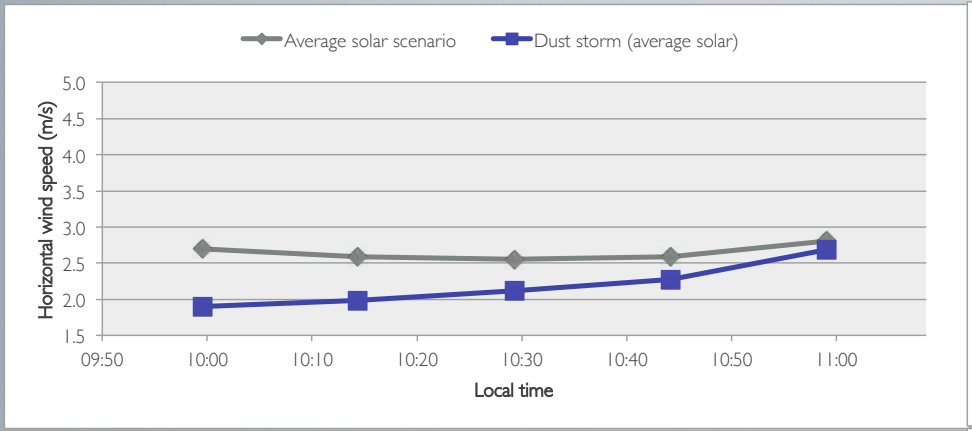
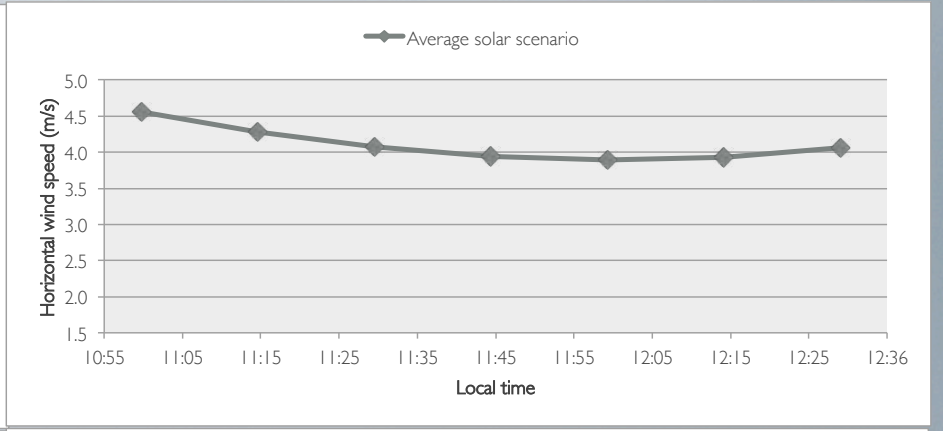


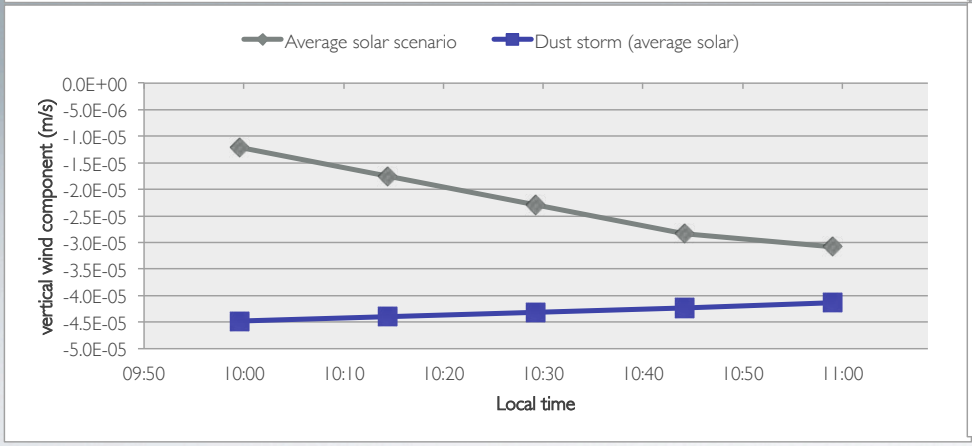

Fig. on Terrain relief and slopes.

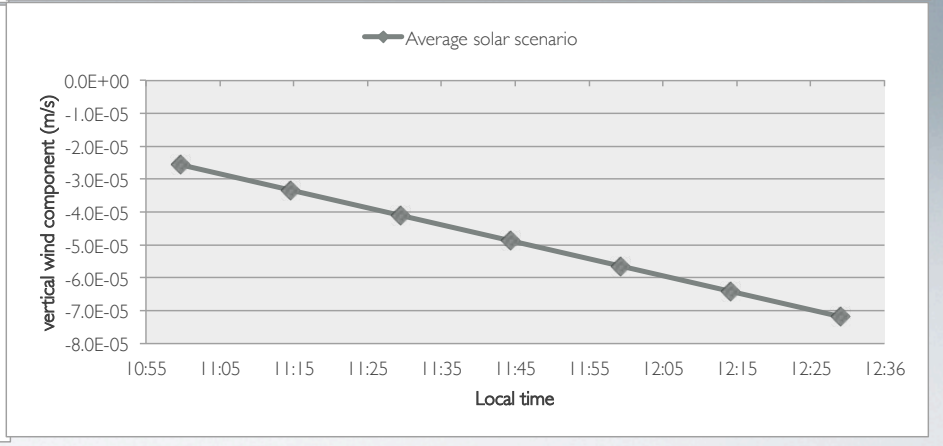

Rock abundance
Legend
8 %
Thermal Inertia
Legend
< 150 J m–2 s–0.5 K–1
≥ 150 J m–2 s–0.5 K–1
Albedo
Legend
Value
0.1 ≤ albedo ≤ 0.26
Radar Reflectivity
No data
19° W
18° W
17° W
22° N
0 10 20 40km

| | | Ls = 324º (Jan 2019) | | | | | Ls = 34º (Apr 2021) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 | 12:30 |
| Average solar scenario | Horizontal wind speed (m/s) | 2,69859 | 2,59330 | 2,55394 | 2,58295 | 2,80001 | 4,56385 | 4,28280 | 4,07009 | 3,93681 | 3,89073 | 3,93504 | 4,06651 |
| | vertical wind component (m/s) | -1,21E-05 | -1,75E-05 | -2,29E-05 | -2,83E-05 | -3,08E-05 | -2,57E-05 | -3,34E-05 | -4,11E-05 | -4,88E-05 | -5,64E-05 | -6,41E-05 | -7,18E-05 |
| Dust storm (average solar) | Horizontal wind speed (m/s) | 1,89765 | 1,98673 | 2,11437 | 2,27414 | 2,68166 | When a dust storm scenario is selected, available dates must be within the dust storm season (180 < Ls < 360). | | | | | | |
| | vertical wind component (m/s) | -4,49E-05 | -4,40E-05 | -4,31E-05 | -4,23E-05 | -4,13E-05 | | | | | | | |



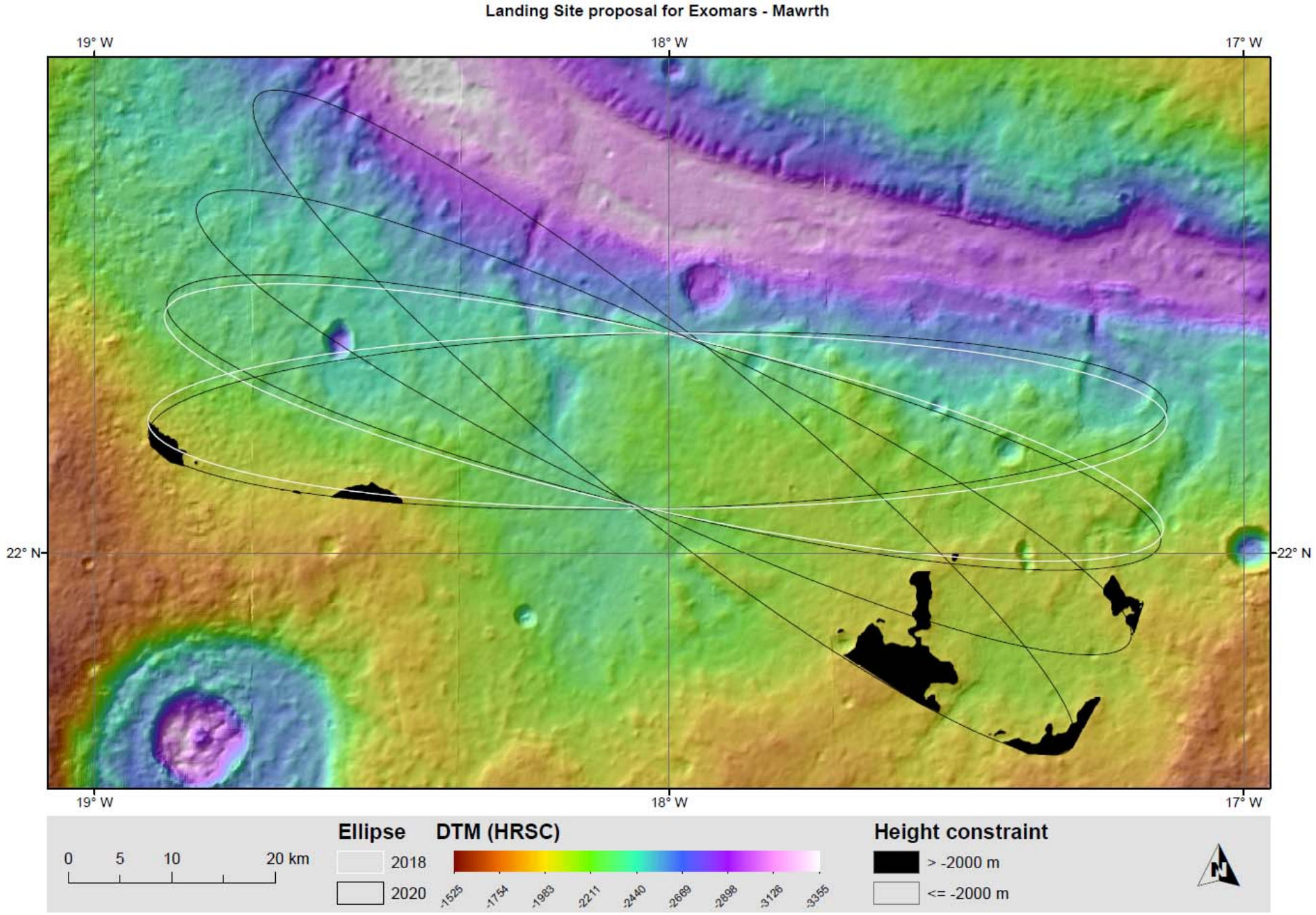



# Landing Ellipse Properties

- **Please present latitude, dimensions, orientation, and elevation compliance.**
  - **Percentage estimate of altitude compliance in your proposed ellipse**
  - Most of the ellipse locations are under altitude range, mainly in the centre of the ellipse.
  - Only 3 % of ellipse locations do not compliance the altitude but they are located in the edge of the ellipse. If necessary, this percentage could be reduced moving the ellipse location north-west.


Landing Site proposal for Exomars - Mawrth
19° W
18° W
17° W
22° N
Ellipse
2018
2020
DTM (HRSC)
-1525
-1754
-1983
-2211
-2440
-2669
-2898
-3126
-3355
Height constraint
> -2000 m
<= -2000 m
0
5
10
20 km
N

# Landing Ellipse Slopes

- **Compliance with landing ellipse slope requirements.**

  **Please explain how you have calculated slopes, e.g. include information about the baseline(s) along which slopes have been calculated.**

  ArcGIS: Identifies the slope (gradient, or rate of maximum change in z-value) from each cell of a resample (length scales) DTMs (MOLA and HRSC).

  - **Please provide a percentage estimate of slope compliance in your proposed ellipse for each of the requested length scales in a table;**

  (See figure) Histogram with all pixels values within the ellipse area distribution in the different DTMs.

  - **For each requested length scale, please include ellipse maps that clearly identify (with bright colours) areas of slope non-compliance (ideally, provide the ArcMap files to the LSSWG) .**

  We are aware that the 2-m scale slope compliance verification will require HiRISE DTMs, and that there will be limited data at this stage.

  - **Please discuss challenging areas that may be known, but not visible in available slope maps (e.g., presence of stair-stepped topography at layered outcrops).**

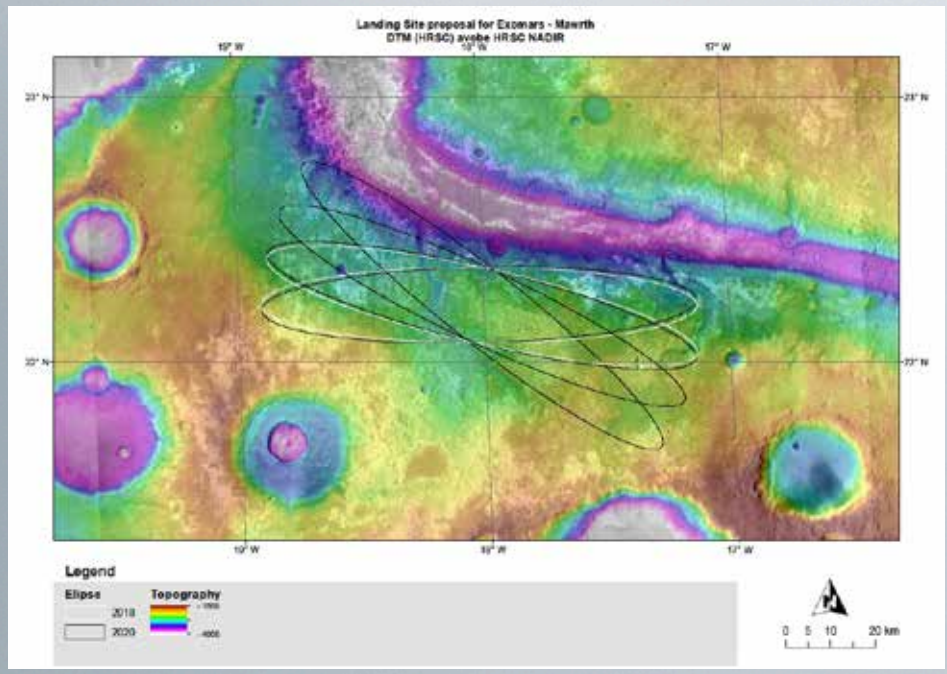



Fig. Topography map with the landing ellipse.

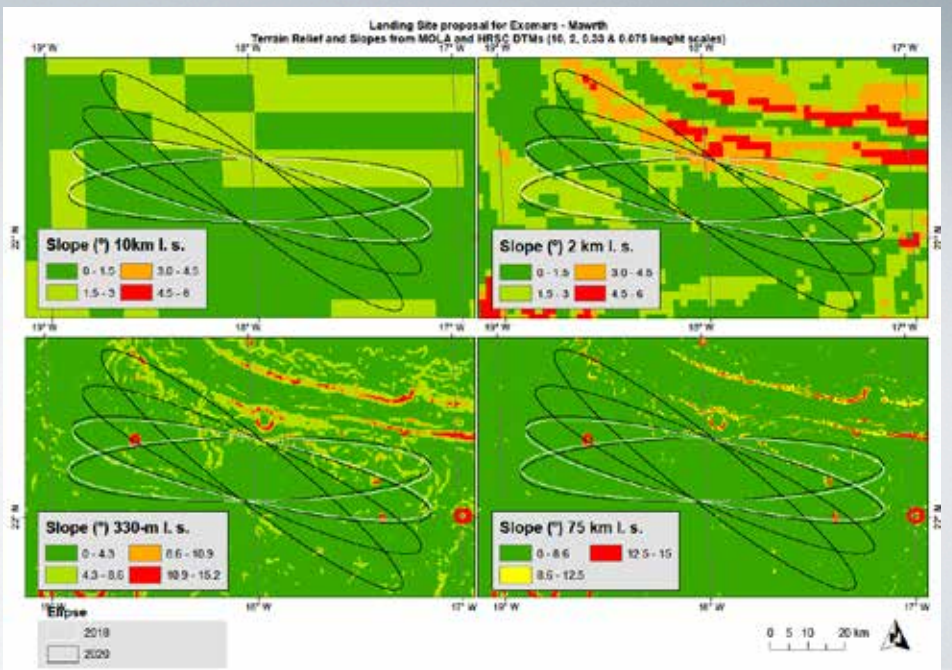
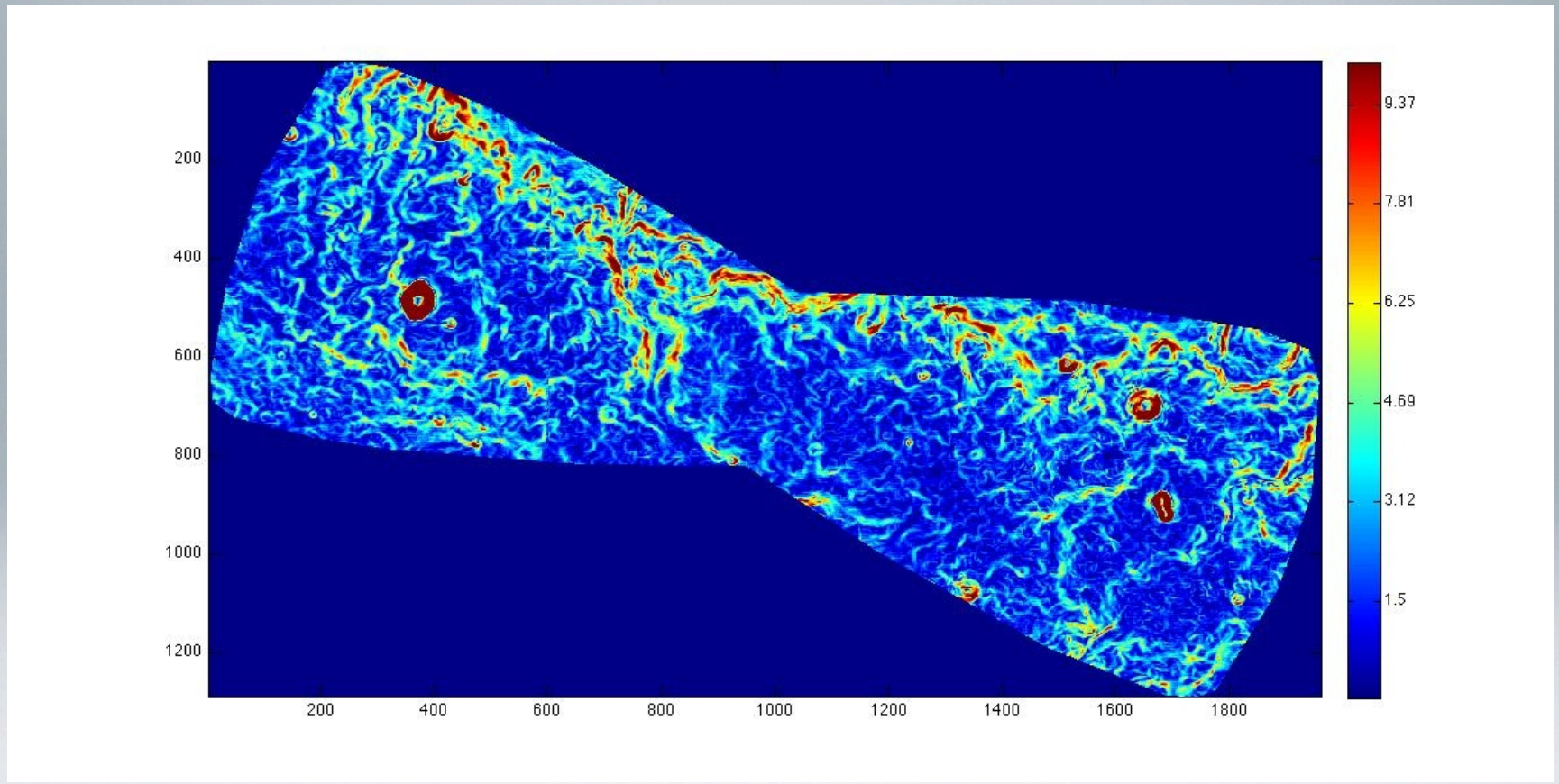
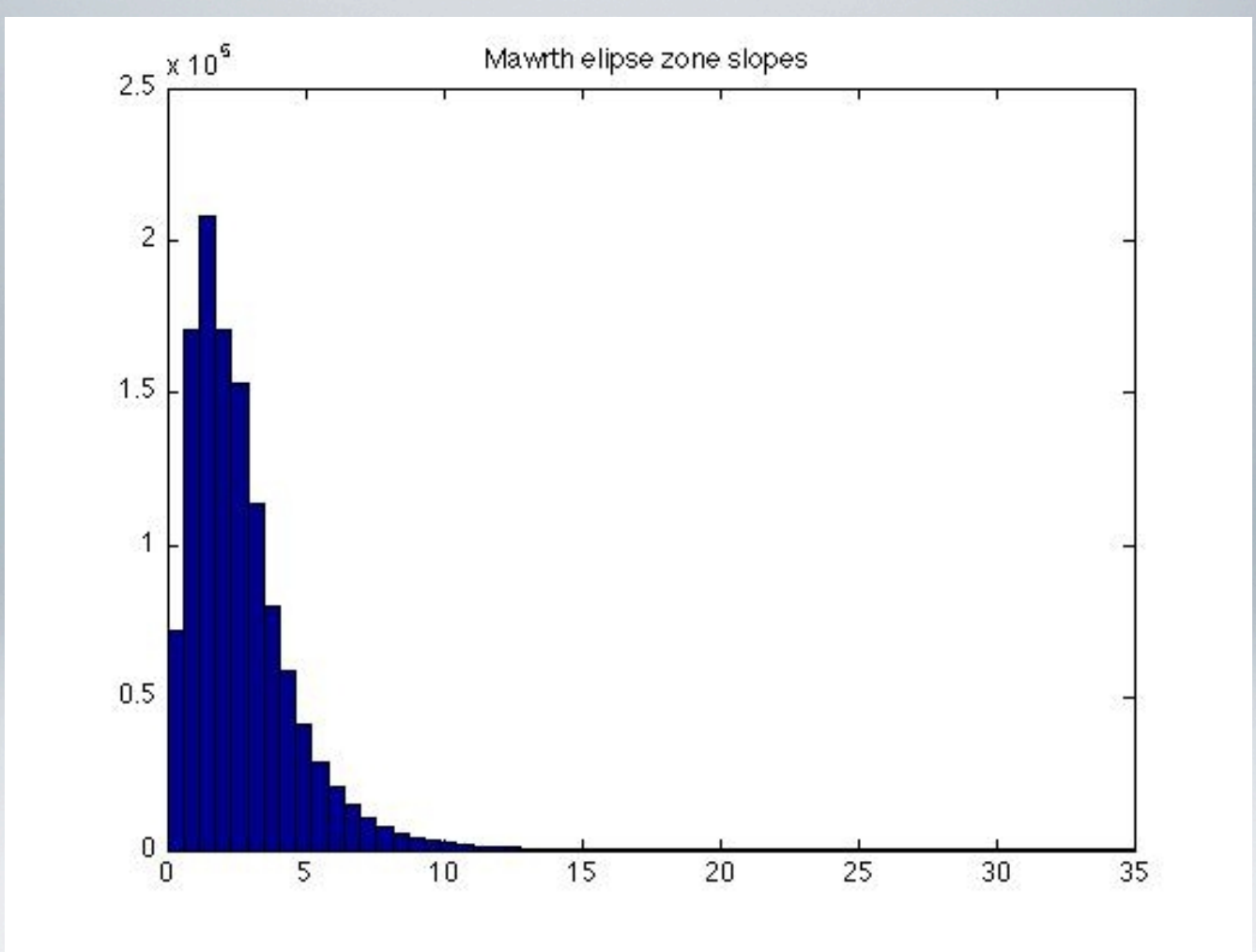



Fig. on Terrain relief and slopes.

# MAWRTH


200
400
600
800
1000
1200
200
400
600
800
1000
1200
1400
1600
1800
9.37
7.81
6.25
4.69
3.12
1.5

# MAWRTH



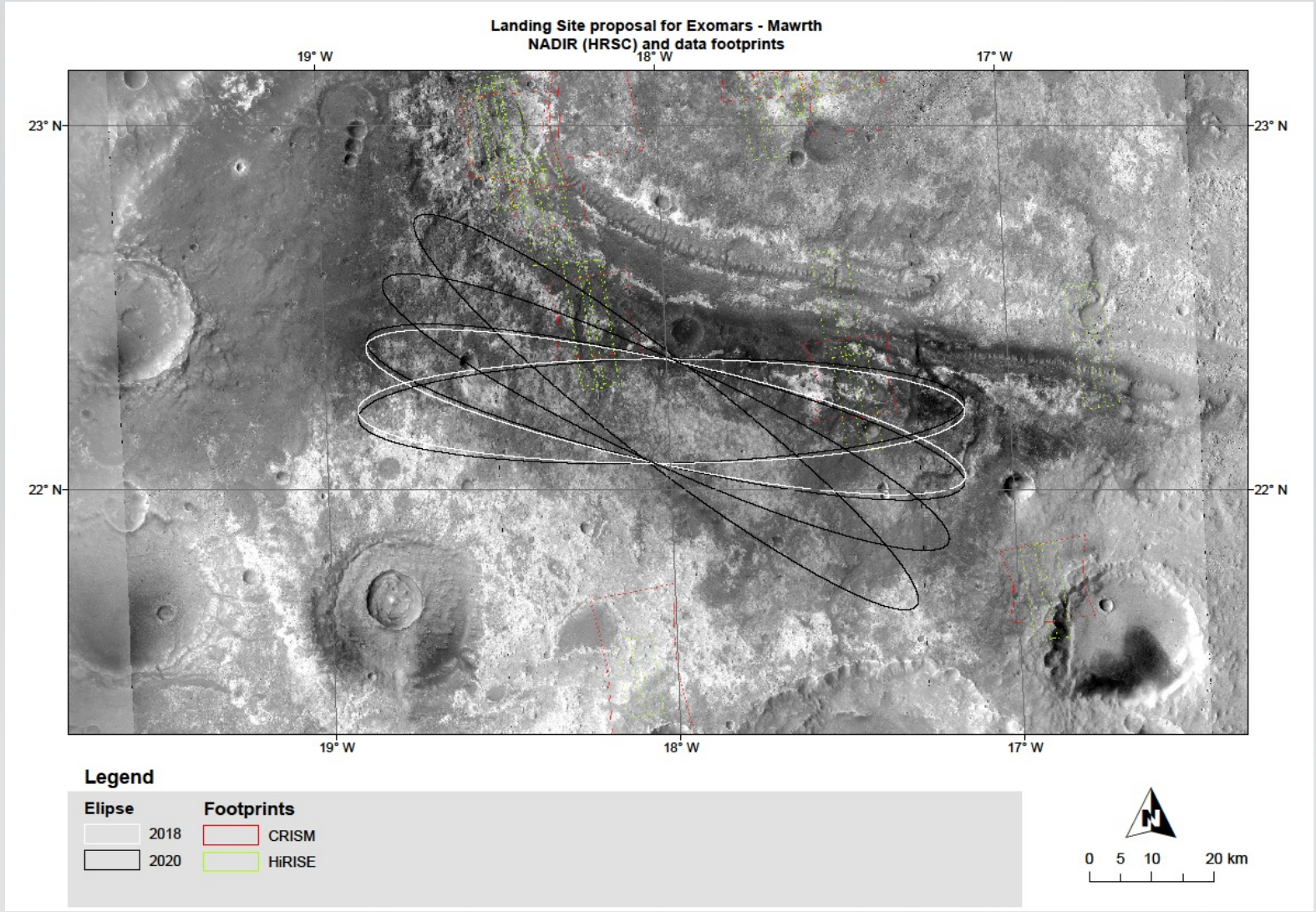
# Rocks, TI, Albedo, Radar, Winds

- **Please present compliance rock abundance, thermal inertia, albedo, and radar reflectivity.**
- **HiRISE to be requested we are in the limit in the 8 value**
  - **Please explain the method you have used to check compliance for each of the above requirements.**
  - **Please provide a percentage estimate of compliance in your proposed ellipse for each of the above requirements;**
  - **Please identify in dedicated maps any areas of non compliance.**
  - **For rocks, the presence of flat sedimentary outcrops is a good thing. Transported boulders and rocks on a dusty river bed are not (e.g. as in the large outflow channels). So, please try to differentiate good (flat) rocky terrain from rocks sticking out, which constitute a risk for the landing system.**

  Rock abundance data from TES and Viking IRTM are a useful way to begin the analysis. Ideally this work requires rock counting on HiRISE images.

  - **For winds, the LSSWG will perform a small GCM study (describing the global wind regimes at the planned landing times for different atmospheric dust loading scenarios) for all sites, which will be presented at the workshop.**

# HiRISE, CTX, CRISM, OMEGA, HRSC



# Geomorphologic Description

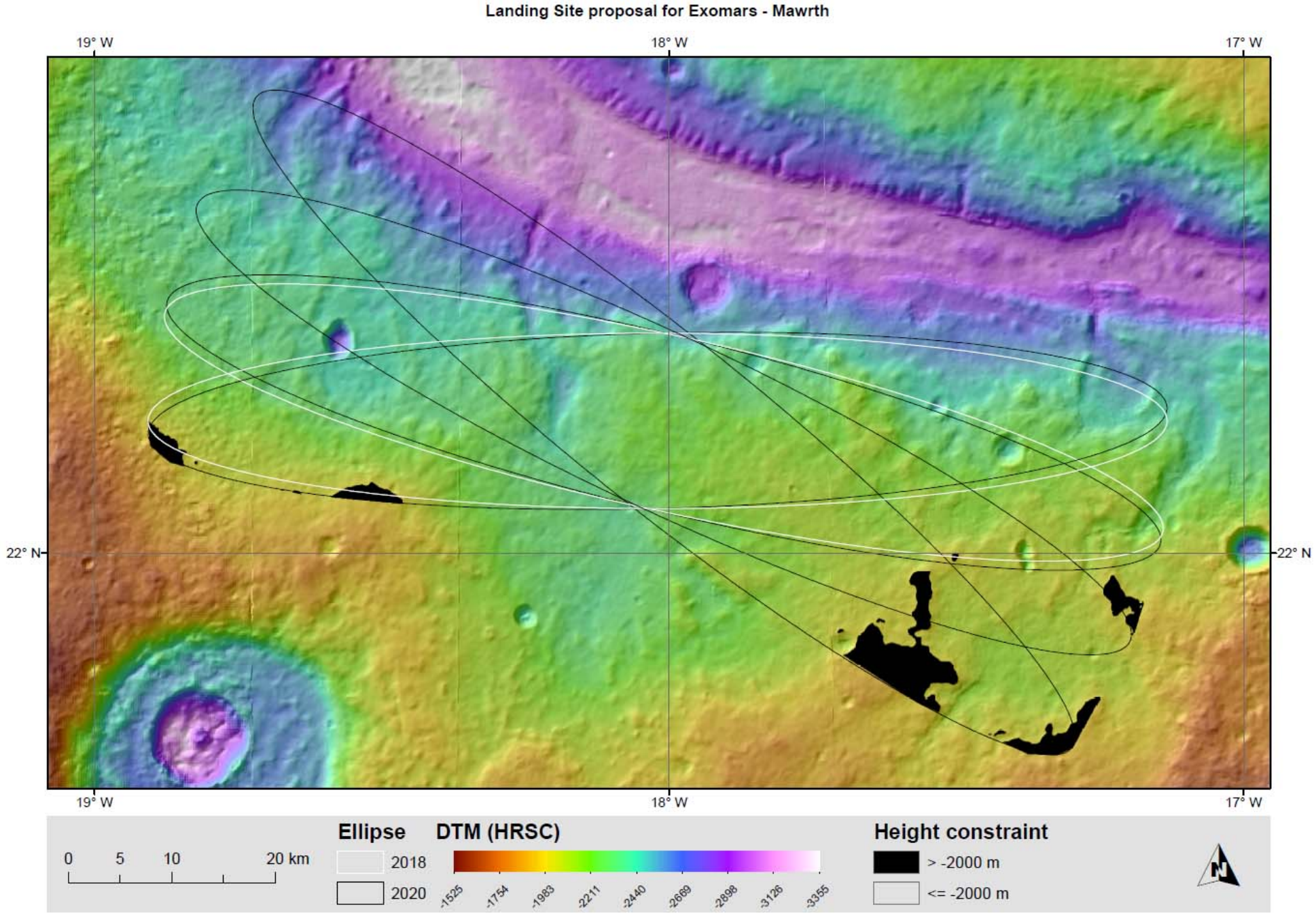


- **Summary**

- Site shows abundant morphological and mineralogical evidence for long-duration, or frequently reoccurring, aqueous activity, but also sedimentary rock outcrops in different locations of the ellipse were identified.
- Regular distribution of interesting features over de landing ellipse. Further studies are needed in order to measure real distance to those different features for final identification of the most proximal easy to reach from the ellipse centre.
- The site has little to nothing dust coverage.
- Recently exhumated white material on the centre of the ellipse (phyllosilicate)
- Water feature (to 4 km)
- Channel / Scarp to 9 km

# Summary 2

| Criterion | Specification | Data Used | This Landing Site |
|---|---|---|---|
| Latitude | 5 S to 25 N | MOLA | 22°13′5″N, 18° 0′12″W |
| Elevation | Below –2 km | MOLA | 96.28 % of ellipse is below, 3.02 % is above |
| Slopes (2–10 km) | ≤ 3.0° | MOLA | At 10 km, 100 % of ellipse is below, 0 % is above |
| Slopes (2–10 km) | ≤ 3.0° | MOLA | At 2 km, 93.06 % of ellipse is below, 6.94 % is above |
| Slopes (330 m) | ≤ 8.6° | HRSC | 99.12 % of ellipse is below, 0.88 % is above |
| Slopes (330 m) | ≤ 8.6° | CTX | ND |
| Slopes (7 m) | ≤ 12.5° | HiRISE | ND |
| Slopes (2 m) | ≤ 15.0° | No Data | No Data |
| Rock abundance | ≤ 7% | IRTM | 8 Poor coverage: 8–12 % is bedrock (flat + rocks) |
| Rock abundance | ≤ 7% | HiRISE | No Data |
| Thermal Inertia | ≥ 150 J m–2 s–0.5 K–1 | TES | 99.73 % of ellipse is above (night time data) |
| Albedo | 0.1 ≤ albedo ≤ 0.26 | TES | 100 % of ellipse is in spec |
| Radar Reflectivity | –15 dB ≤ Ka band backscatter cross section at nadir ≤ 27.5 dB | No Data | No Data |
| Horizontal Wind (1 m–10 km agl) | ≤ 0.25 m/s | GCM | Max speed: 35–45 m/s at 1–9 km agl (arrival season, arrival time) |
| Horizontal Wind (1 m above ground) | ≤ 0.30 m/s | GCM | No Data |


Landing Site proposal for Exomars - Mawrth
19° W
18° W
17° W
22° N
Ellipse
2018
2020
DTM (HRSC)
-1525
-1754
-1983
-2211
-2440
-2669
-2898
-3126
-3355
Height constraint
> -2000 m
<= -2000 m
0
5
10
20 km
N

# Summary 1

- **Summarise your site's main scientific attributes for the ExoMars mission's objectives.**

Proposed site is **ancient (older than 3.6 Ga)** — Noachian (Phyllosian) following the main requirement of ExoMars mission landing site selection process.

CRISM data analysis of the materials located in the north (in the limit of the plateau with Mawrth Vallis and to the south of the landing ellipse that display similar reflectivity in CTX images) indicate the presence of **hydrated sulfates, clays, glass or water ice and Al-rich phyllosilicate or hydrated glass** in a lower extent (restricted to the area closer to Mawrth Vallis)

Potential for habitability and preservation of the different mineral and rocks (Bishop et al) Clay-rich materials, like those present in the proposed site, do not show evidence of burial and diagenesis (Bishop et al., 2013) and are capable of preserving biosignatures (e.g. Farmer and Des Marais, 1999) as well as others salt deposits located on site. This make those materials a mayor target for the study with instruments aimed to detect biosignatures, thus this site is considered favorably for preservation, and providing easy access and not long distances to those locations from the ellipse center.

Site shows **abundant morphological and mineralogical evidence for long-duration, or frequently reoccurring, aqueous activity, but also sedimentary rock outcrops** in different locations of the ellipse were identified. Regular distribution of interesting features over de landing ellipse.

The site has little to nothing dust coverage.

Landing Site's Engineering Constraints have been considered and this site doesn´t violates any of mission requirements.