# East Melas Chasm Exploration Zone

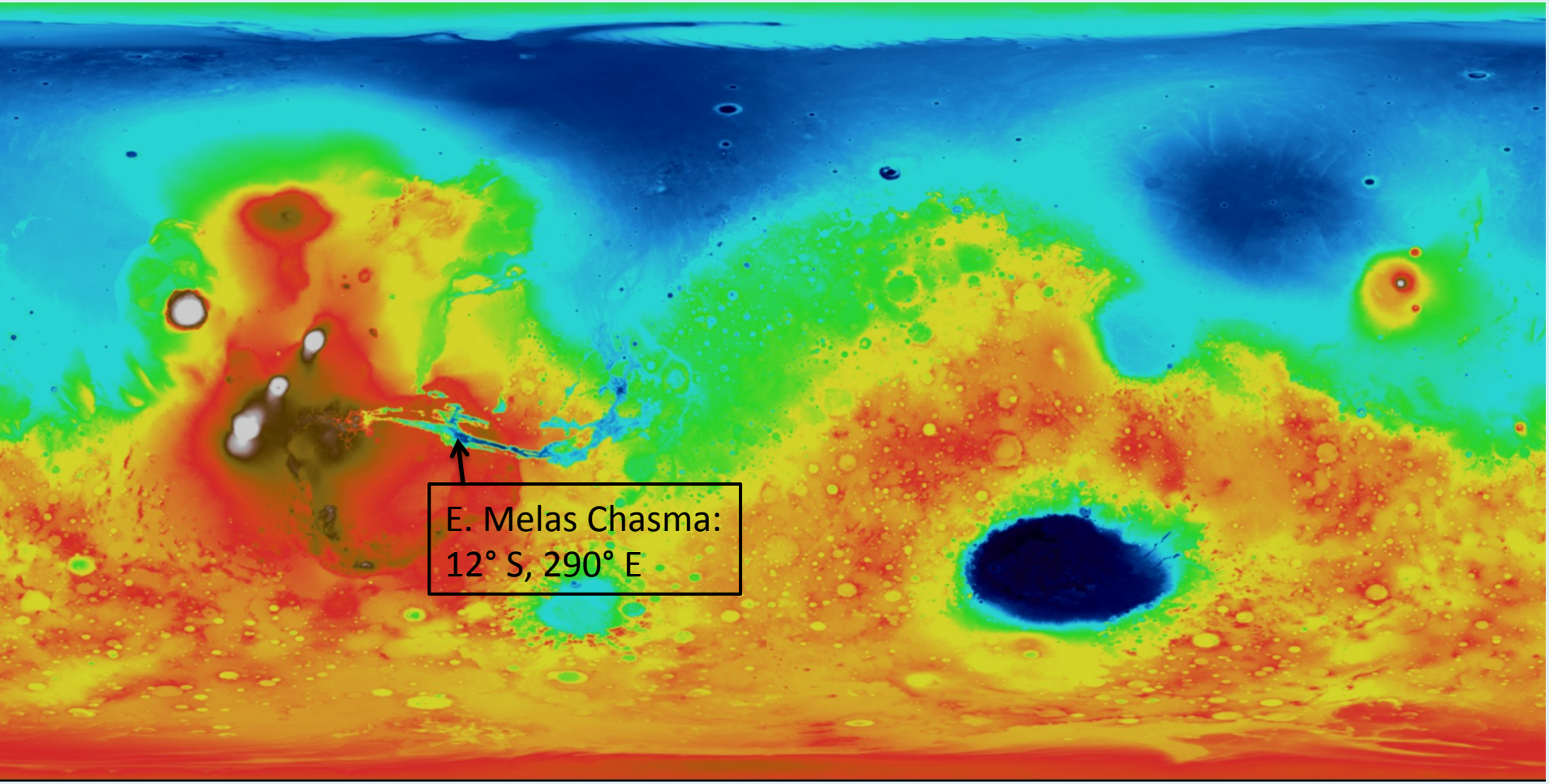
**First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars**

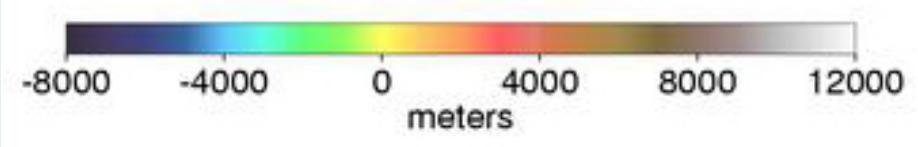
A. McEwen, M. Chojnacki, H. Miyamoto, R. Hemmi, C. Weitz, R. Williams, C. Quantin, J. Flahaut, J. Wray , S. Turner, J. Bridges, S. Grebby, C. Leung, S. Rafkin

ESP_034962_1670, Recurring Slope Lineae in Melas Chasma

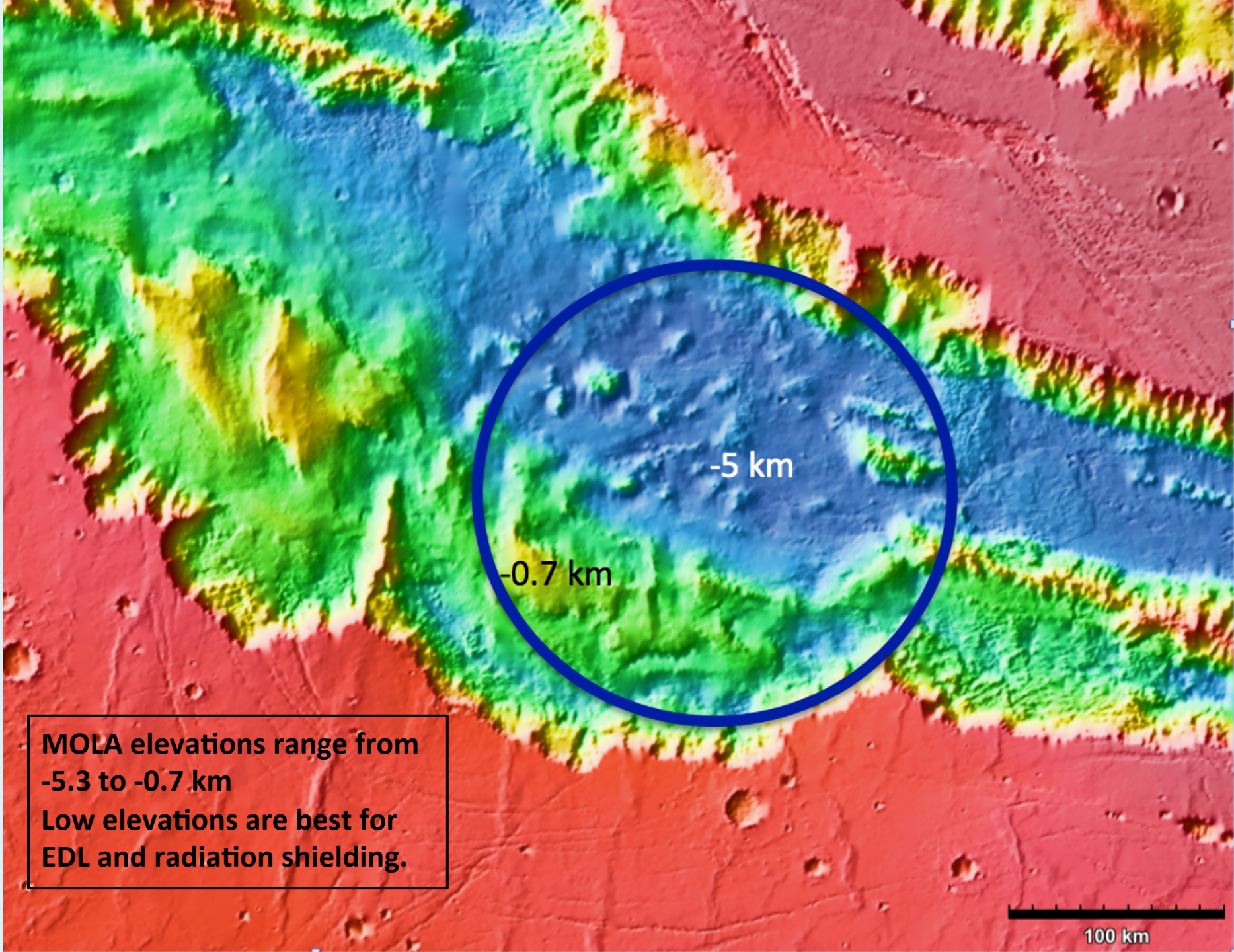
# Global Setting

- E Melas Chasm is the lowest-elevation spot near the equator of Mars




E. Melas Chasma




**MOLA elevations range from -5.3 to -0.7 km**
**Low elevations are best for EDL and radiation shielding.**

# E Melas EZ meets all Threshold requirements:

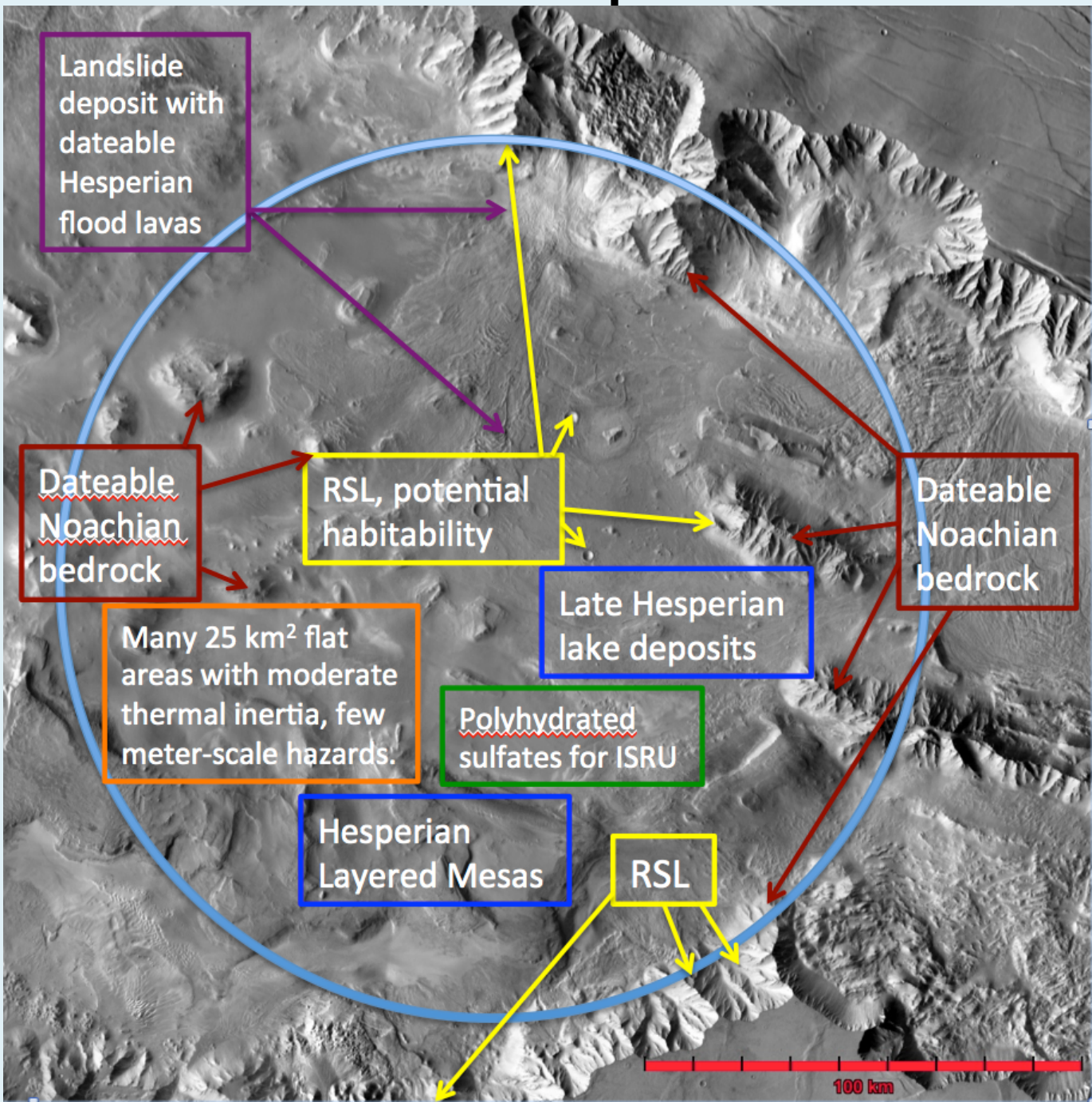
- Meets all landing site and rover constraints
- Easy access to raw materials for ISRU
  - >>100 MT water
- Other raw materials (loose materials, metals and silicon)
- Infrastructure ≤5 km from landing site (TBD)

**Science Threshold:**

- High preservation potential for past habitability
  - Hydrothermally altered Noachian bedrock, Hesperian lake deposits, and phyllosilicates

*and*

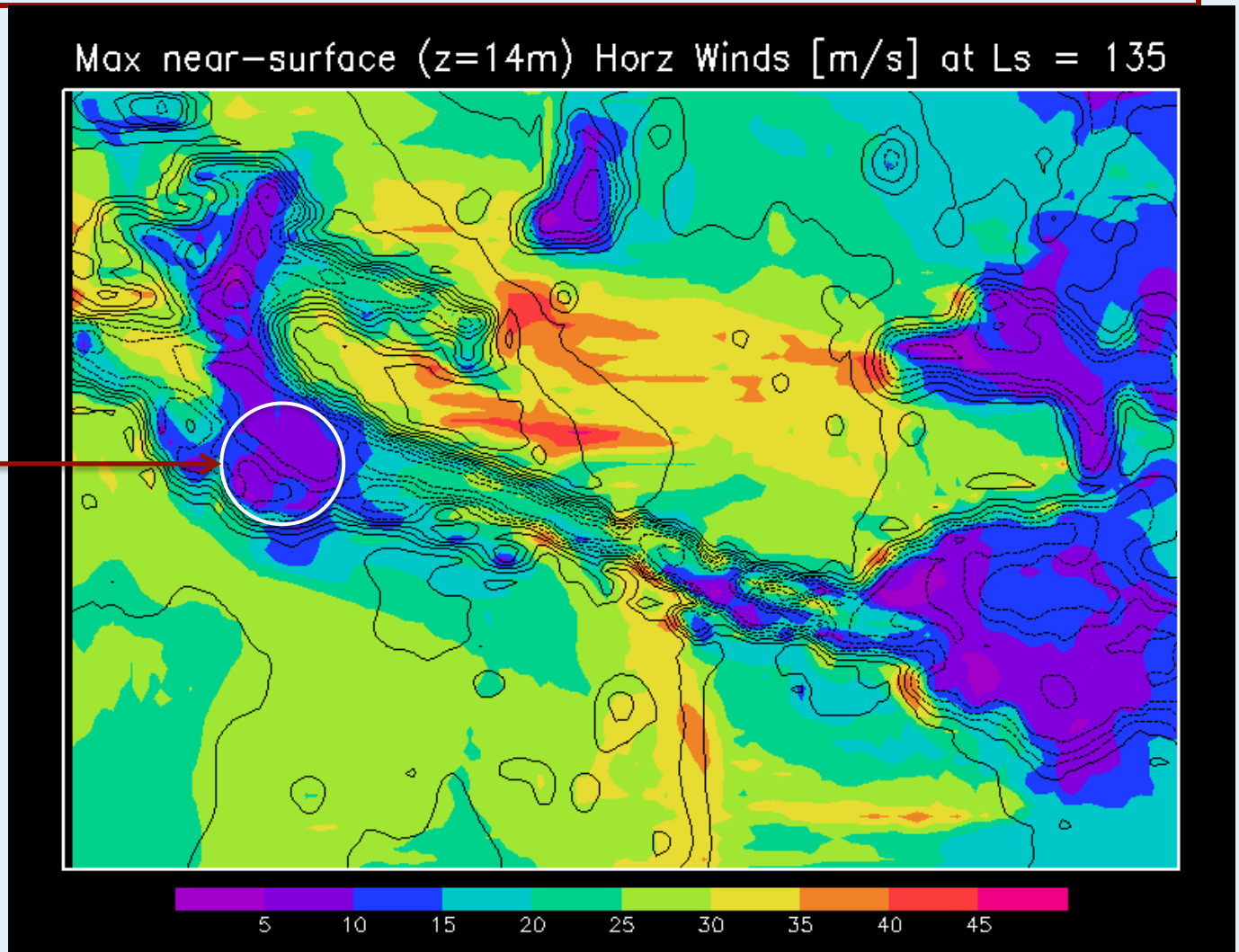
- Promising sites for present habitability--RSL
- Noachian and Hesperian dateable crustal units with regional extents
- Aqueous and groundwater processes
- Stratigraphic contacts and cross-cutting relations:
  - It doesn't get any better than Valles Marineris



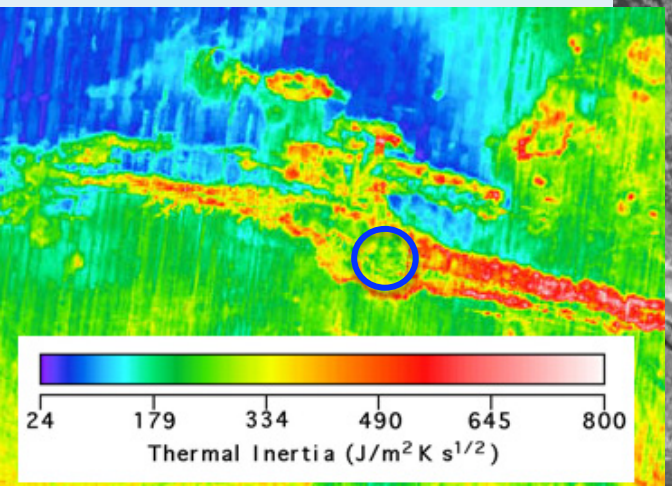
# Are high winds in Valles Marineris a concern for EDL?

- This concern eliminated the Melas landing site for MER
- At the 2020 landing site workshop in August, it was reported that the latest wind model did not pose a problem for the SW Melas site
- Studies indicate that high winds are close to canyon walls (Spiga and Forget 2009)

Mars Regional Atmospheric Modeling System (MRAMS) runs by C. Leung and S. Rafkin show Central Melas Chasm to be relatively calm at all times of day.

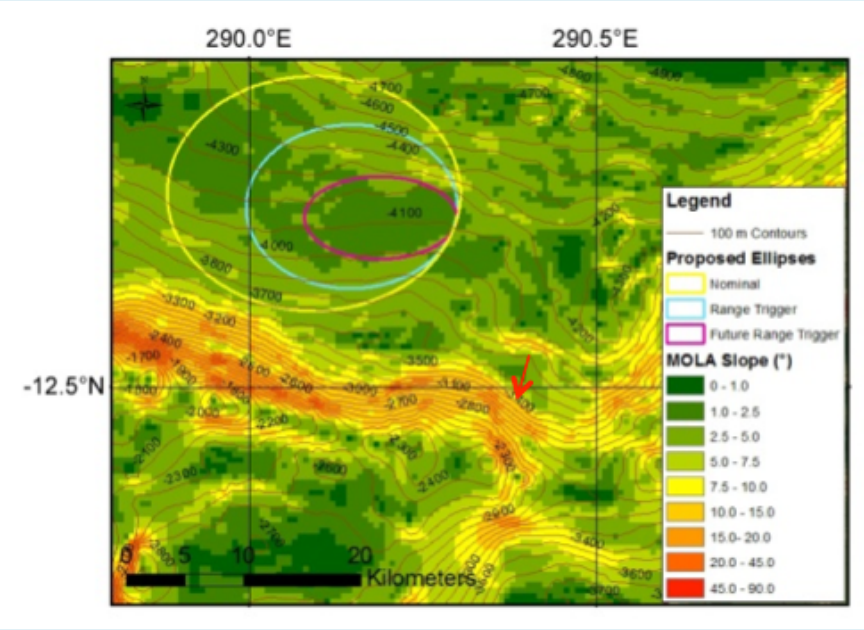


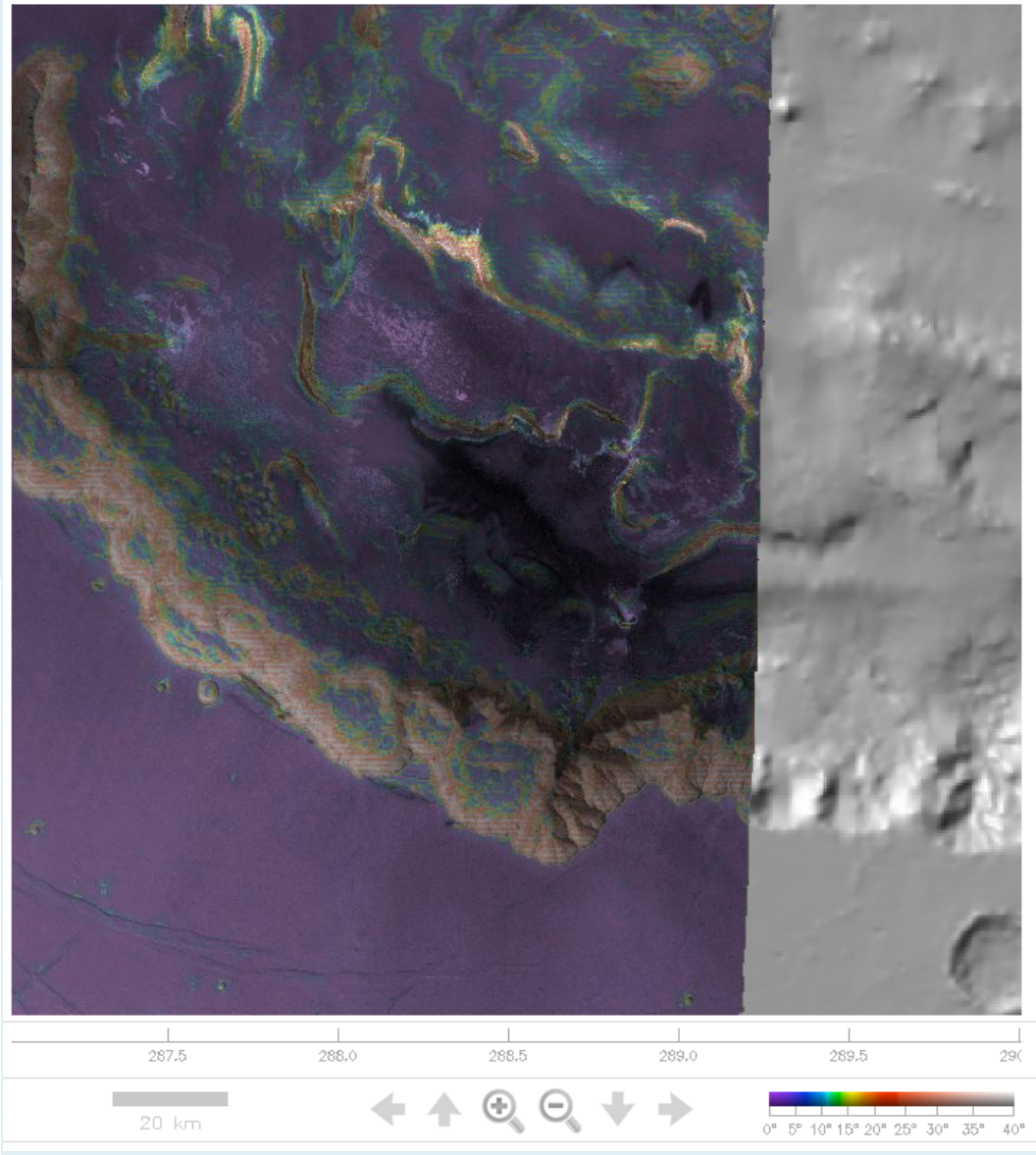
Dust is not a problem; fine-grained basaltic sand is plentiful



# Slopes are < 10° except for isolated areas

- HRSC covers western end of EZ (right)
  - Except for small areas, slopes are less than 10°
- MOLA slopes in SE region also <10° except small areas (Turner et al.; see below)

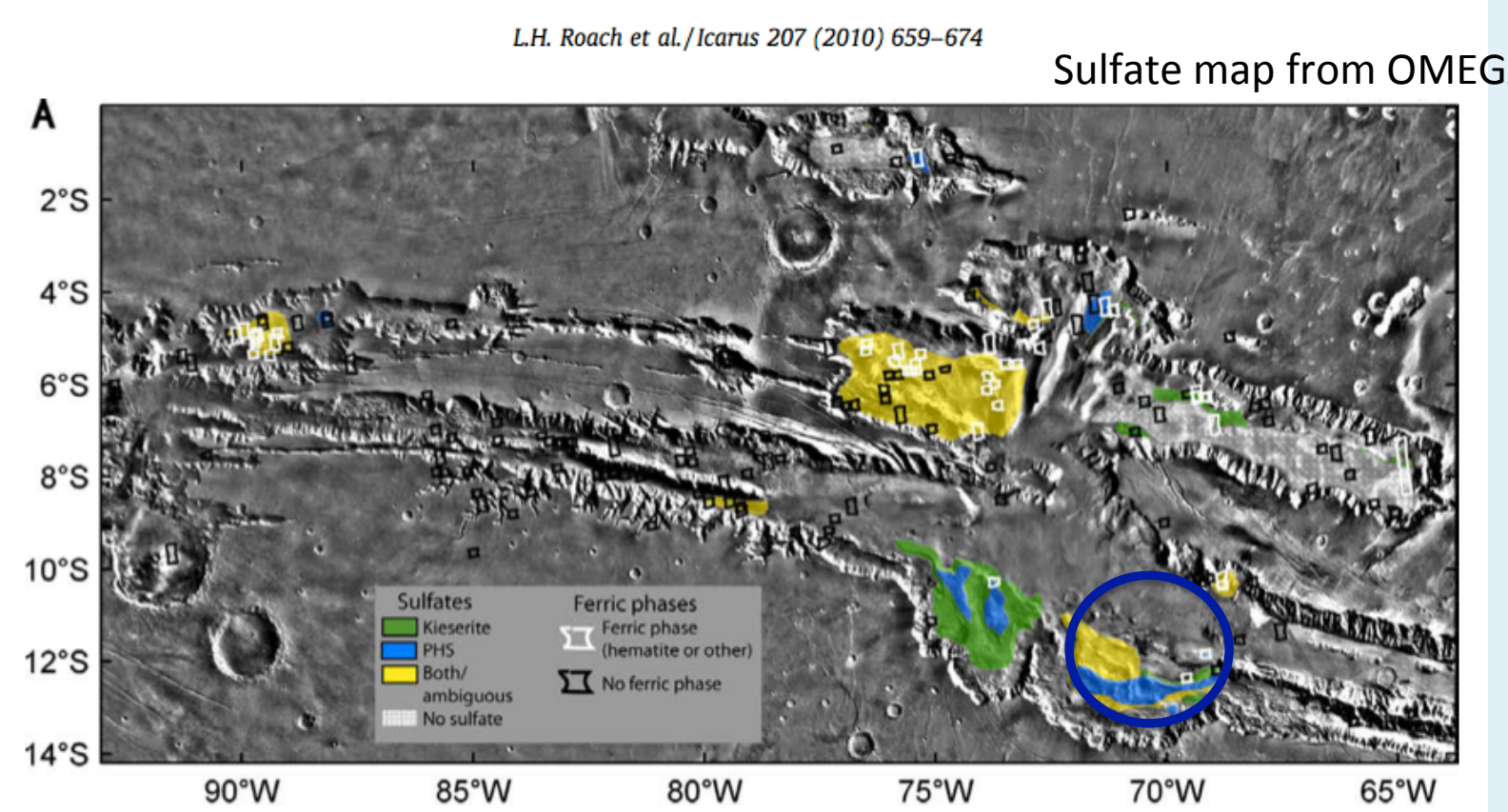


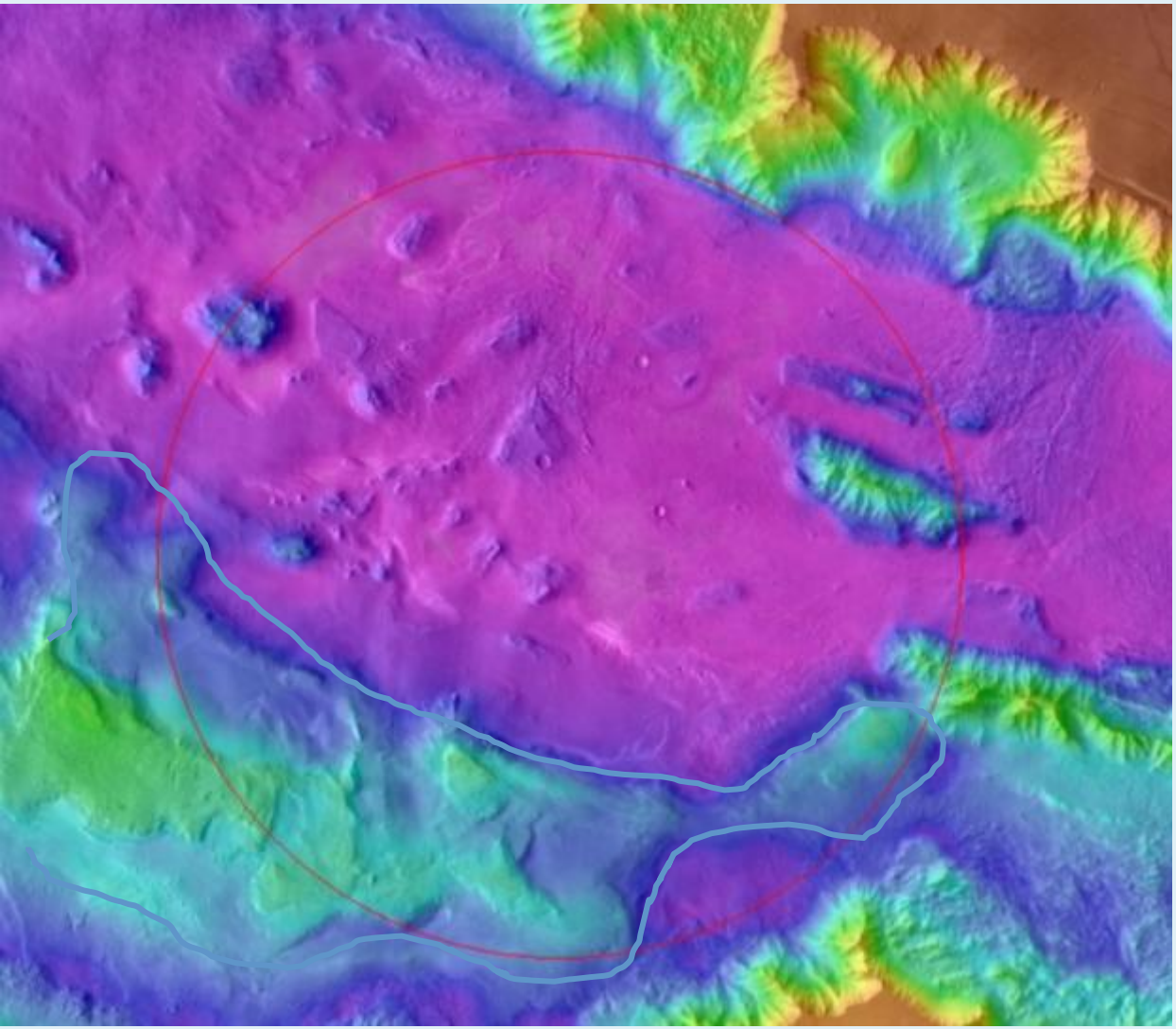

E. Melas Chasma

# ISRU: Water from polyhydrated sulfates

- Kms-thick stack of layered deposits in southern Melas Chasma is rich in sulfates.
- Hydrated magnesium sulfate ($MgSO_4 \bullet 7H_2O$) matches the spectra of some of these deposits, and ***consists of 51% water.***
- Water extraction: just heat to >150°C
  - See Clarke et al., 2006, Proceedings of the 6th Australian Mars Exploration Conference

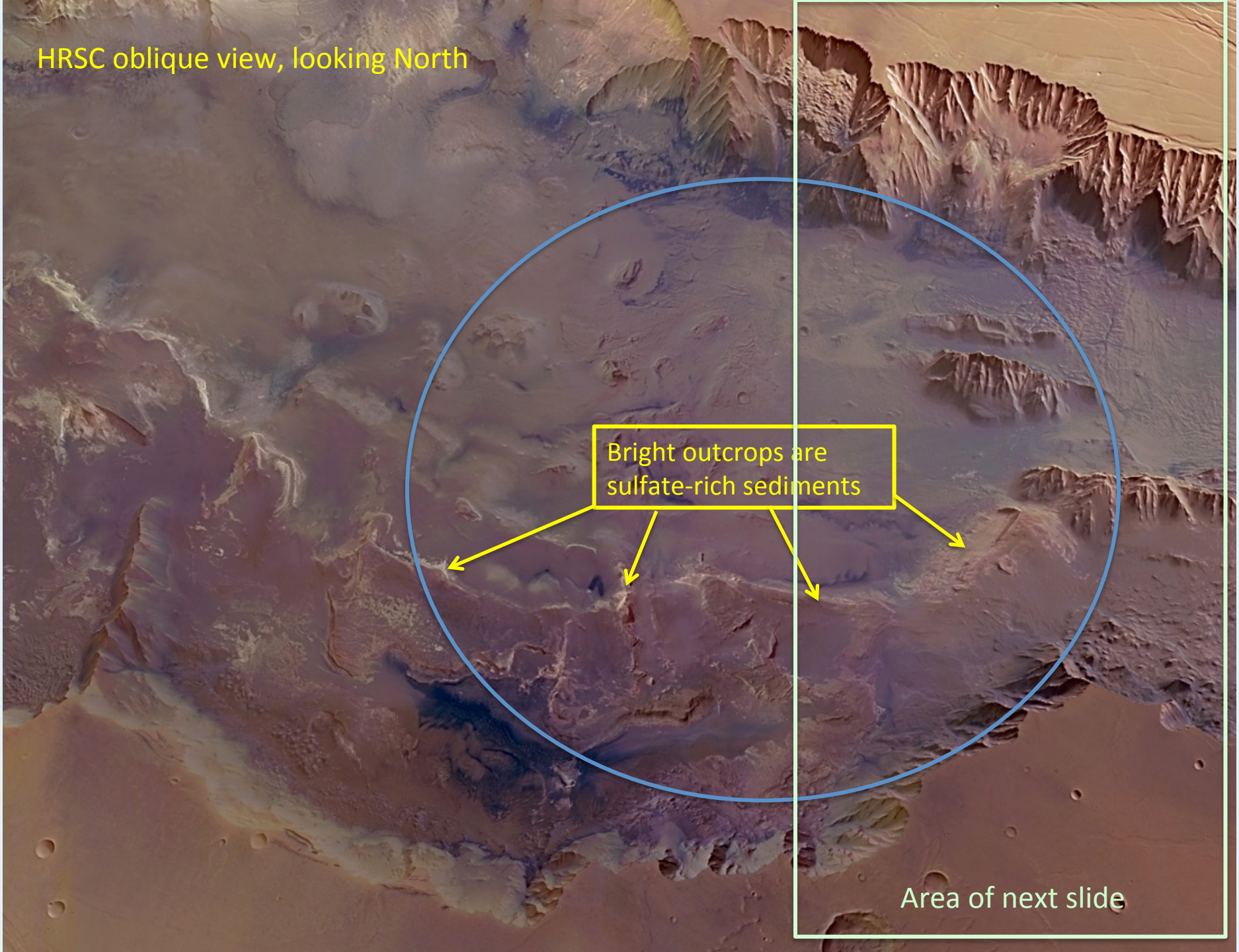


# Volume of water in E. Melas Interior Layered Deposits (IDL)



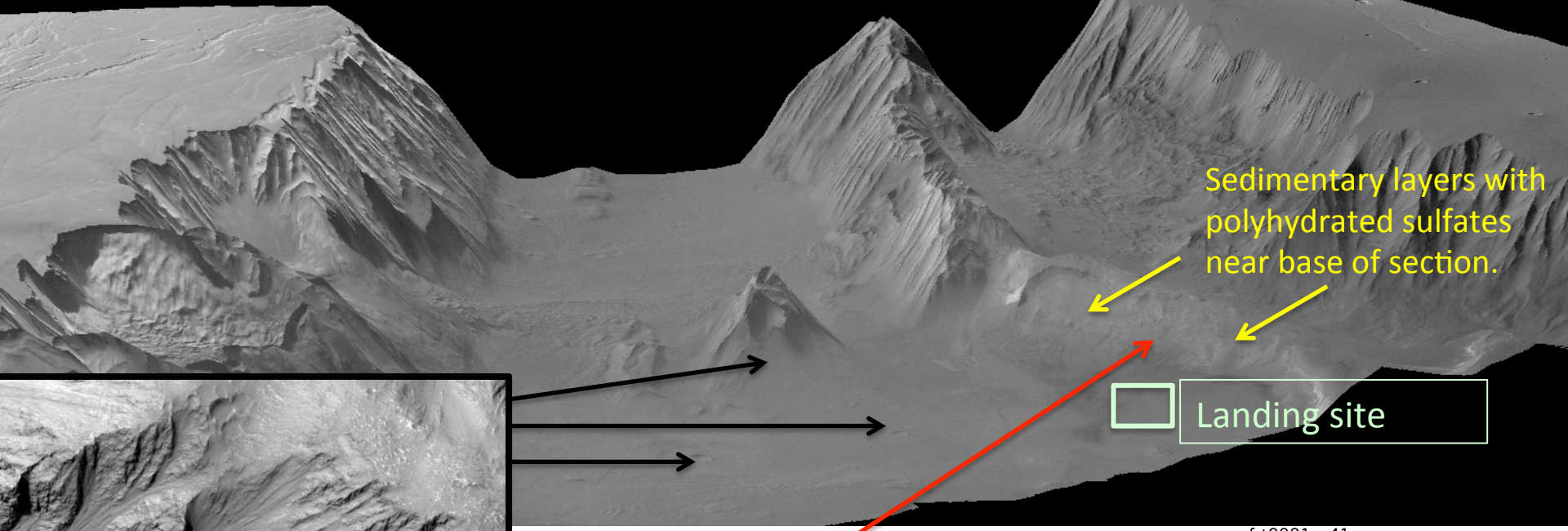
E. Melas Chasma

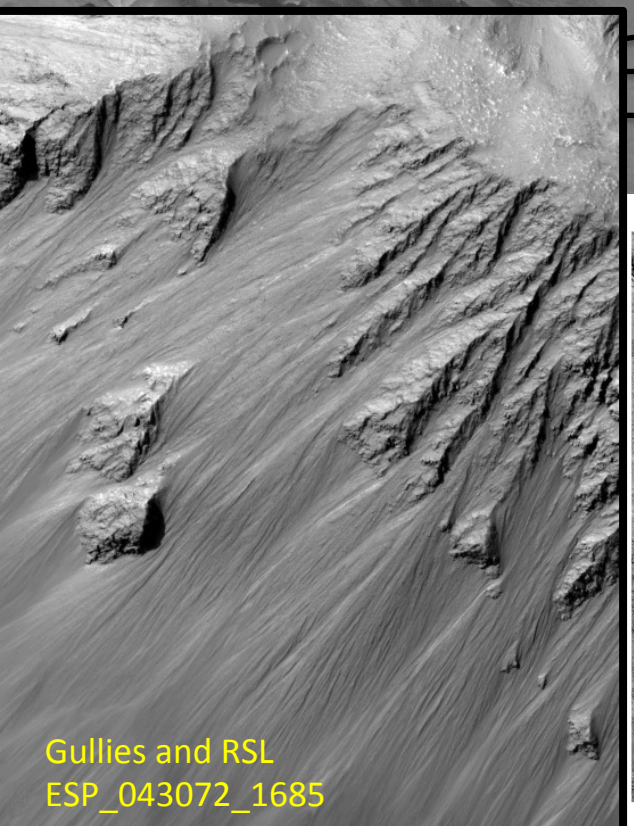
- ILD volume (MOLA): ~40,000 $km^3$
- Band depths indicate that sulfates represent ~10% of the ILD
  - $4 \times 10^{12}$ $m^3$
- Polyhydrated sulfate such as hexahydrite ($MgSO_4 \bullet 6 H_2O$) is 47% water
- Kieserite ($MgSO_4 \bullet H_2O$) is 13% water
  - Total ILD water: ~$10^{12}$ $m^3$ (1000 $km^3$ , 2x Lake Erie)
- >>100 MT ($10^2$ $m^3$) requirement
- Assuming we can find a spot with 20% polyhydrated sulfate (10% water overall), 80% efficiency, need to process 1200 $m^3$
  - 24 x 25 m area, 2 m deep

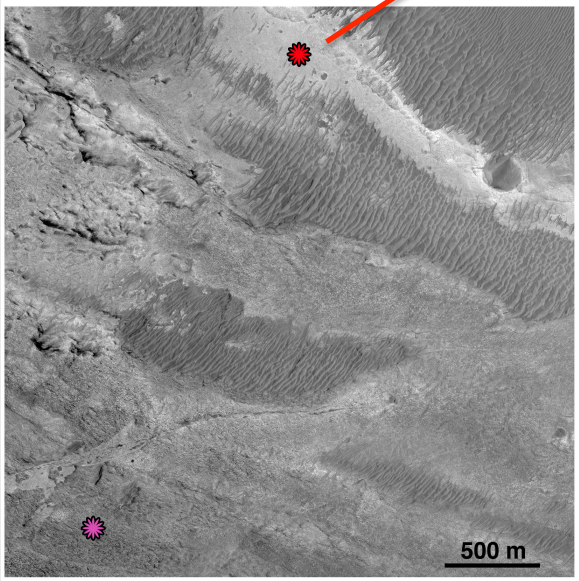

HRSC oblique view, looking North
Bright outcrops are sulfate-rich sediments
Area of next slide

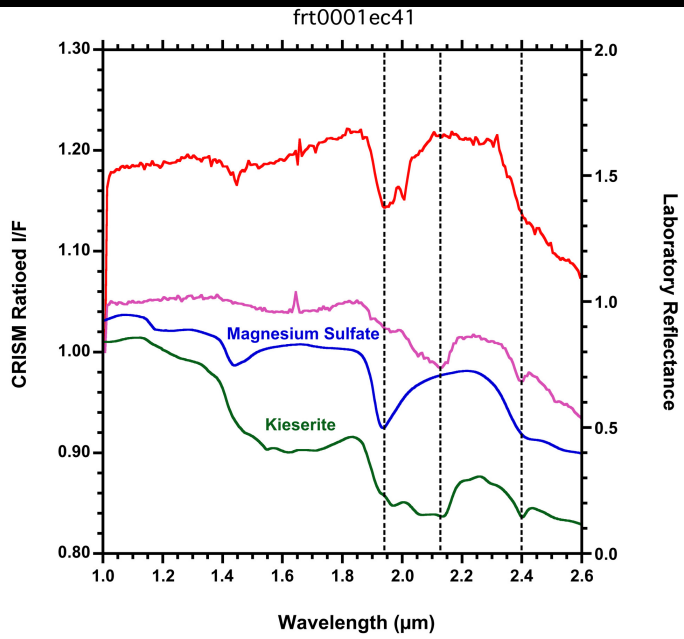
# Polyhydrated suflates for ISRU and base of RSL slopes are accessible

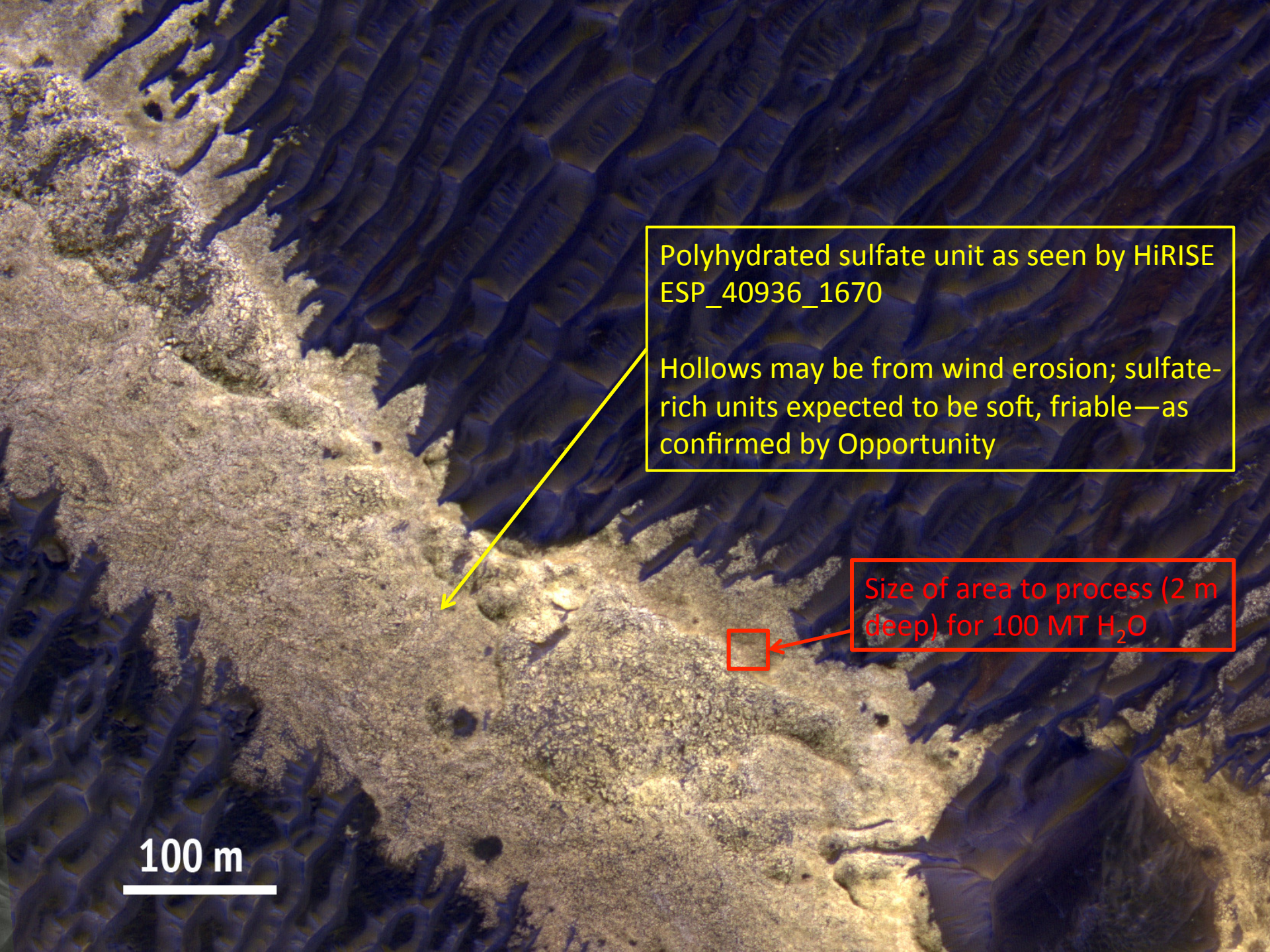
HRSC perspective view, looking East, 5x vertical exaggeration

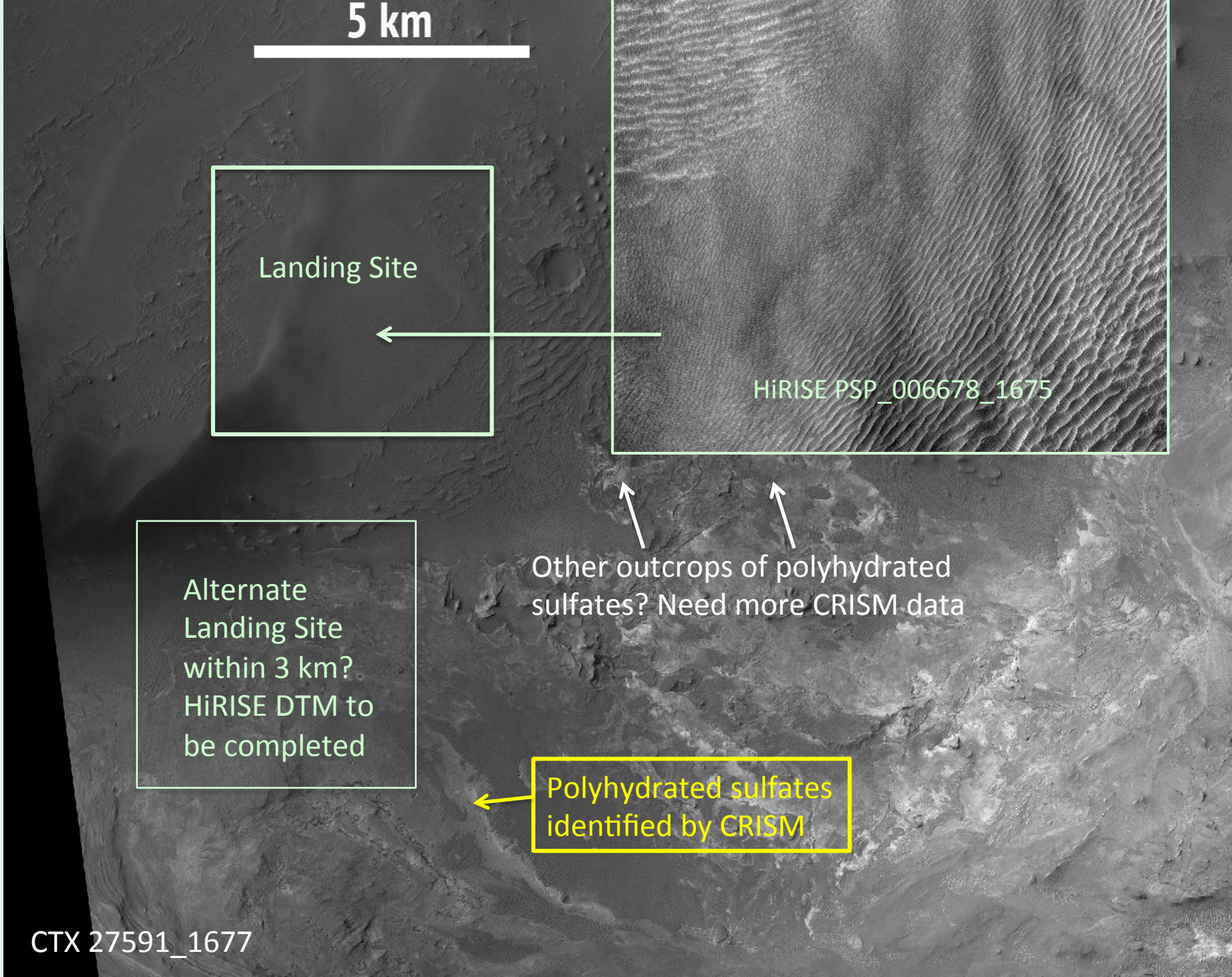



Polyhydrated sulfate unit as seen by HiRISE ESP_40936_1670
Hollows may be from wind erosion; sulfate-rich units expected to be soft, friable—as confirmed by Opportunity
Size of area to process (2 m deep) for 100 MT $H_2O$
100 m


5 km
Landing Site
HiRISE PSP_006678_1675
Other outcrops of polyhydrated sulfates? Need more CRISM data
Alternate Landing Site within 3 km? HiRISE DTM to be completed
Polyhydrated sulfates identified by CRISM
CTX 27591_1677

# Resource ROI Rubric

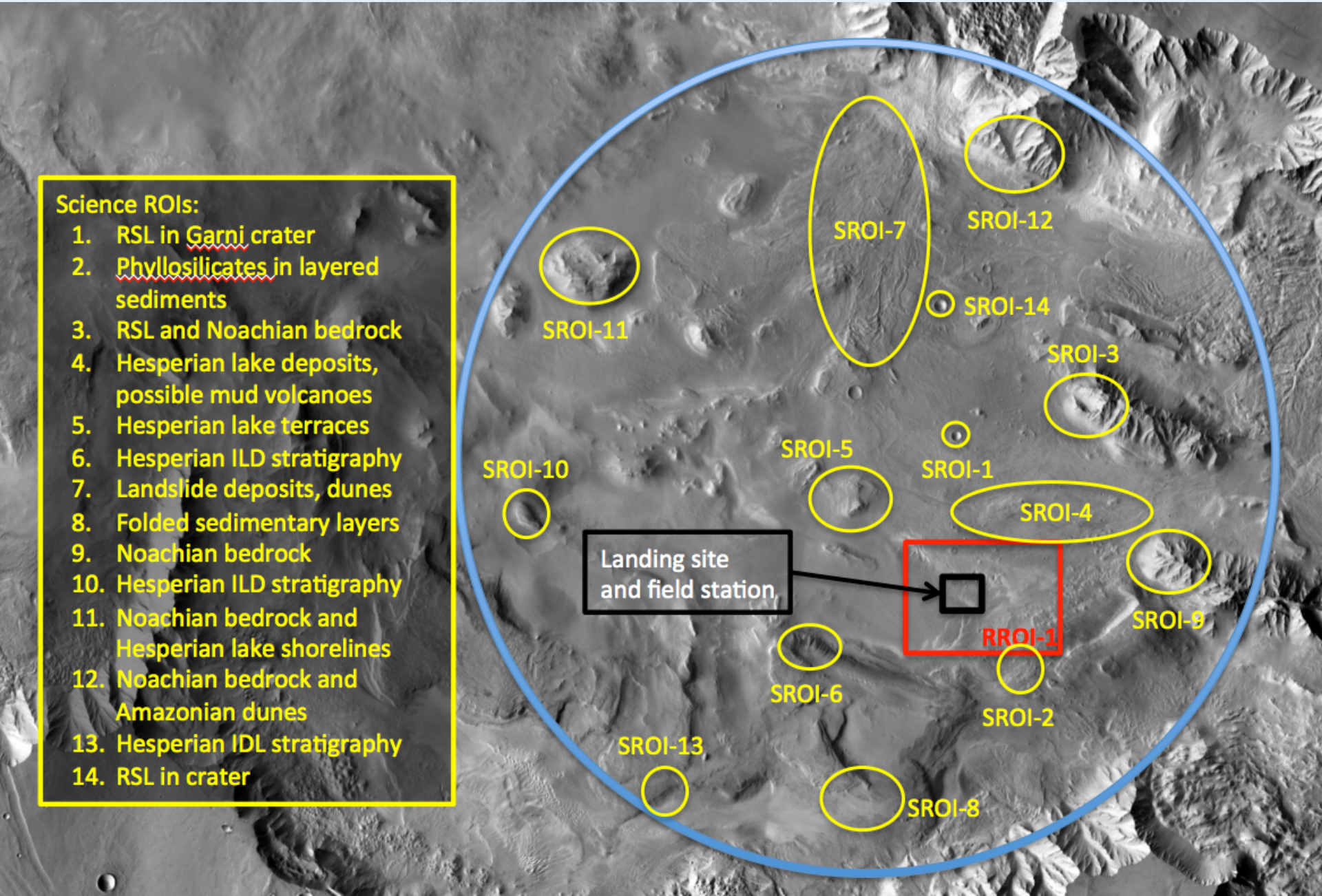
| ISRU and Civil Engineering Criteria | | | Site Factors | RROI-1 | EZ SUM |
|---|---|---|---|---|---|
| | Engineering | | Meets First Order Criteria (Latitude, Elevation, Thermal Inertia) | ● | ● |
| | Water Resource | **Threshold** | AND/OR **Potential for ice or ice/regolith mix** | | |
| | | | **Potential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

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

All Green except:

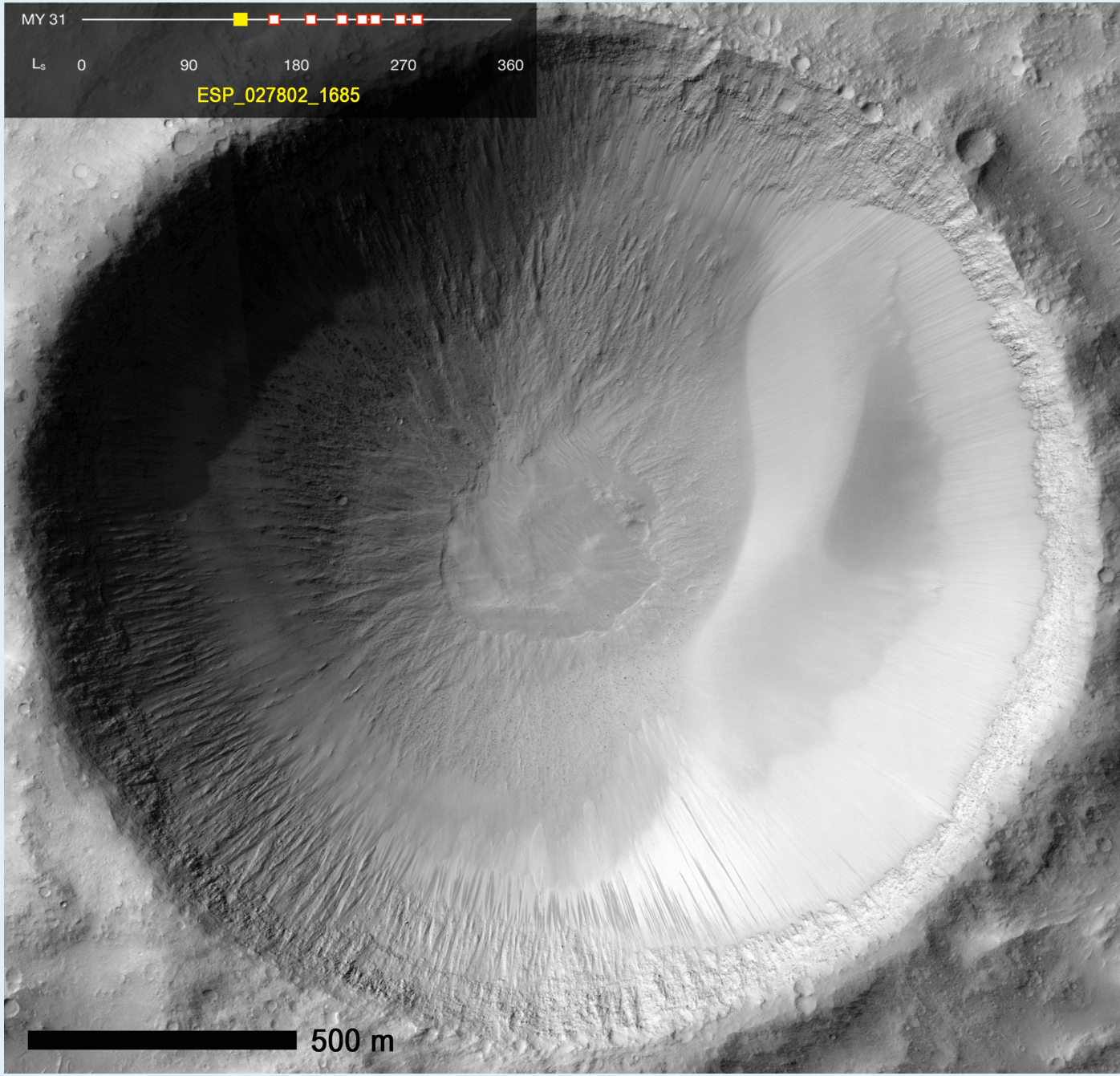
- No ice
- Not in N hemisphere
- Not clear if landing site can be <3 km
- Not sure about utilitarian terrain features

# 1 Resource ROI, 14 Science ROIs



# SROI-1, 3, 14: RSL

- RSL in Valles Marineris often follow the sun: growth occurs on south-facing slopes in southern summer and north-facing slopes in northern summer.
- Potentially useful for ISRU, but steep slopes and Planetary protection issues
- Special equipment needed to explore *in-situ*

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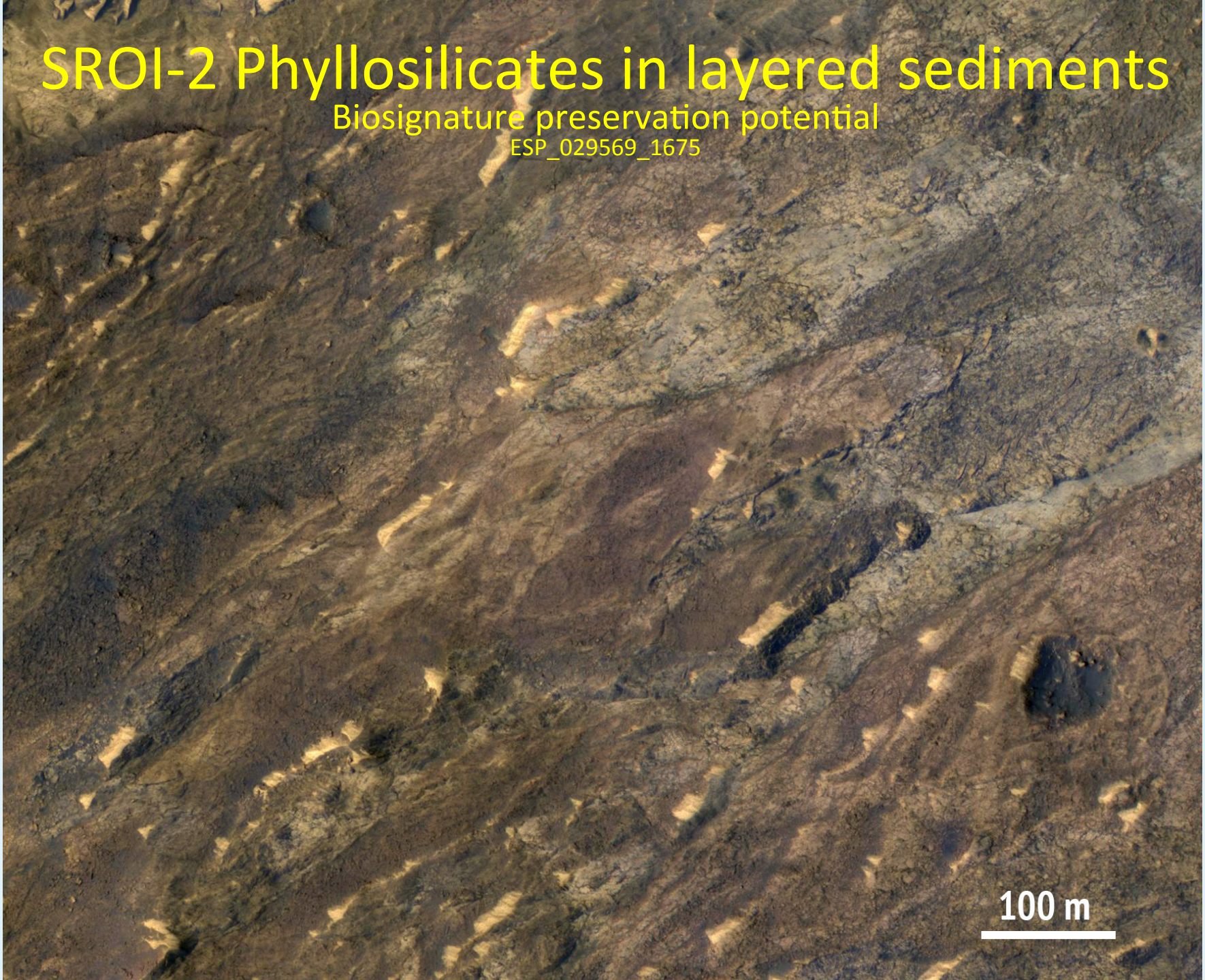
Garni Crater

# SROI-2 Phyllosilicates in layered sediments

## Biosignature preservation potential

ESP_029569_1675



# SROI-3, 9, 11, 12: Noachian Crust

- From Flahaut et al. 2012:
  - Valles Marineris is a unique vertical section through the uppermost kilometers of the martian crust.
  - Its location, east of the Tharsis bulge, and its water-related history, fuel a great diversity of rock types in this area.
  - Low-calcium pyroxene and olivine are detected in the lower portion of the walls--pristine Noachian or pre-Noachian crust might be exposed.
  - Phyllosilicates are commonly present within the walls; appear to be alteration products.

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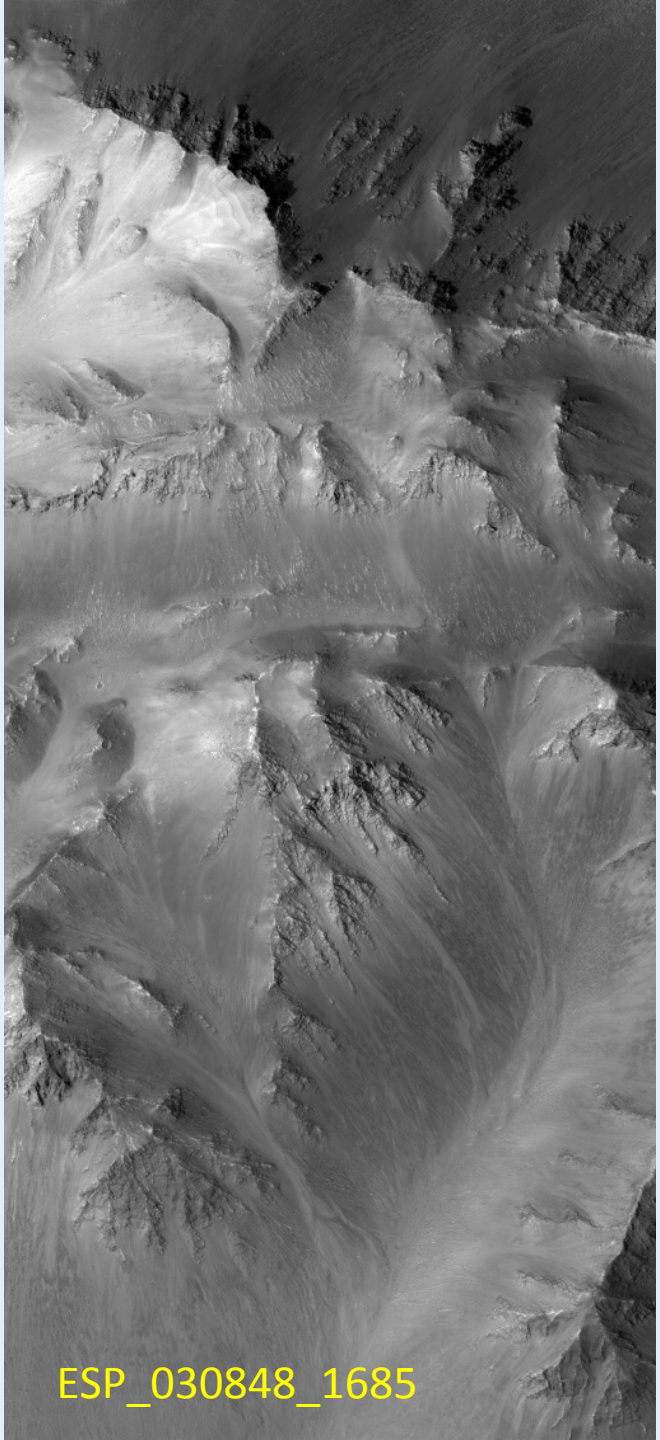
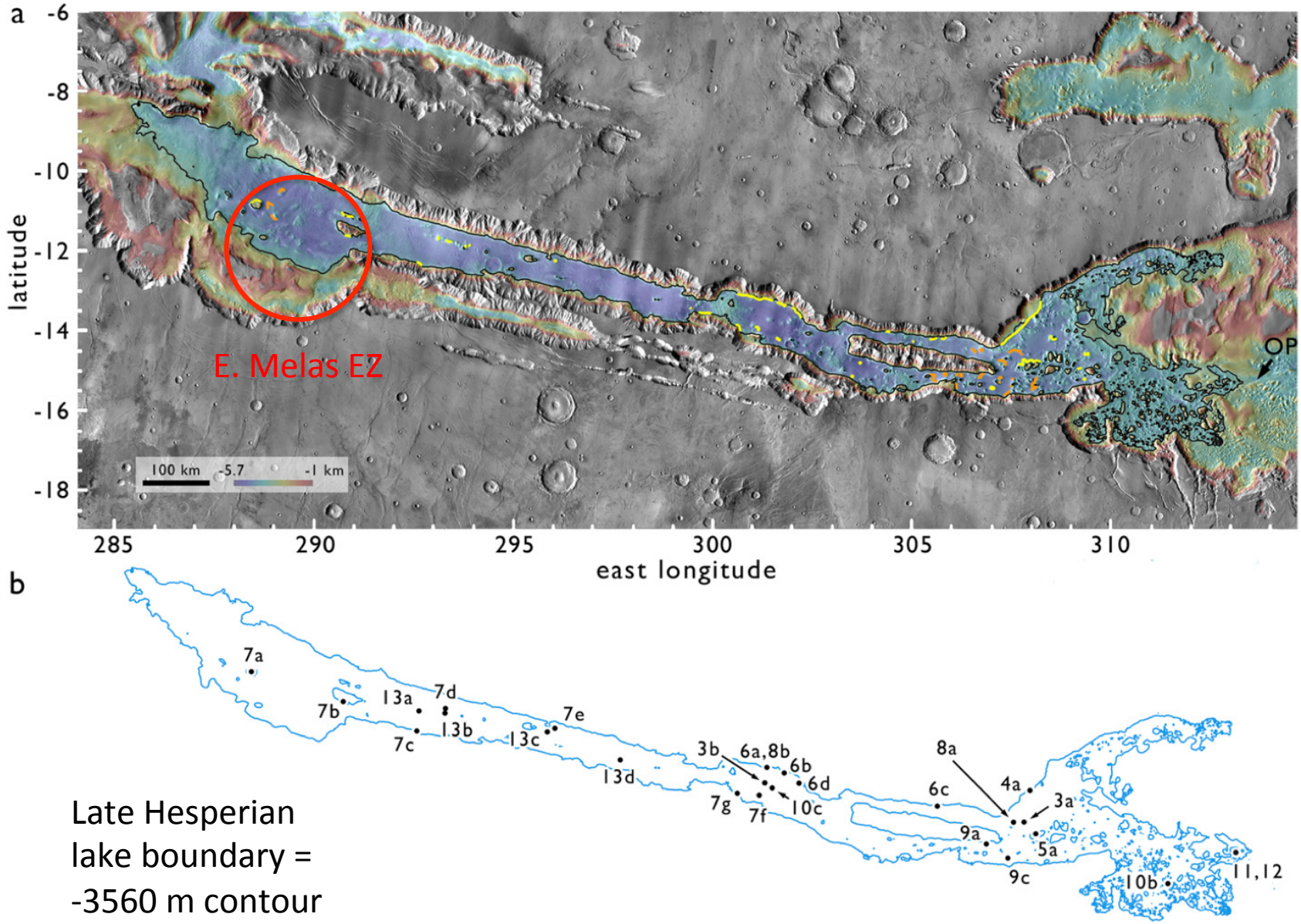


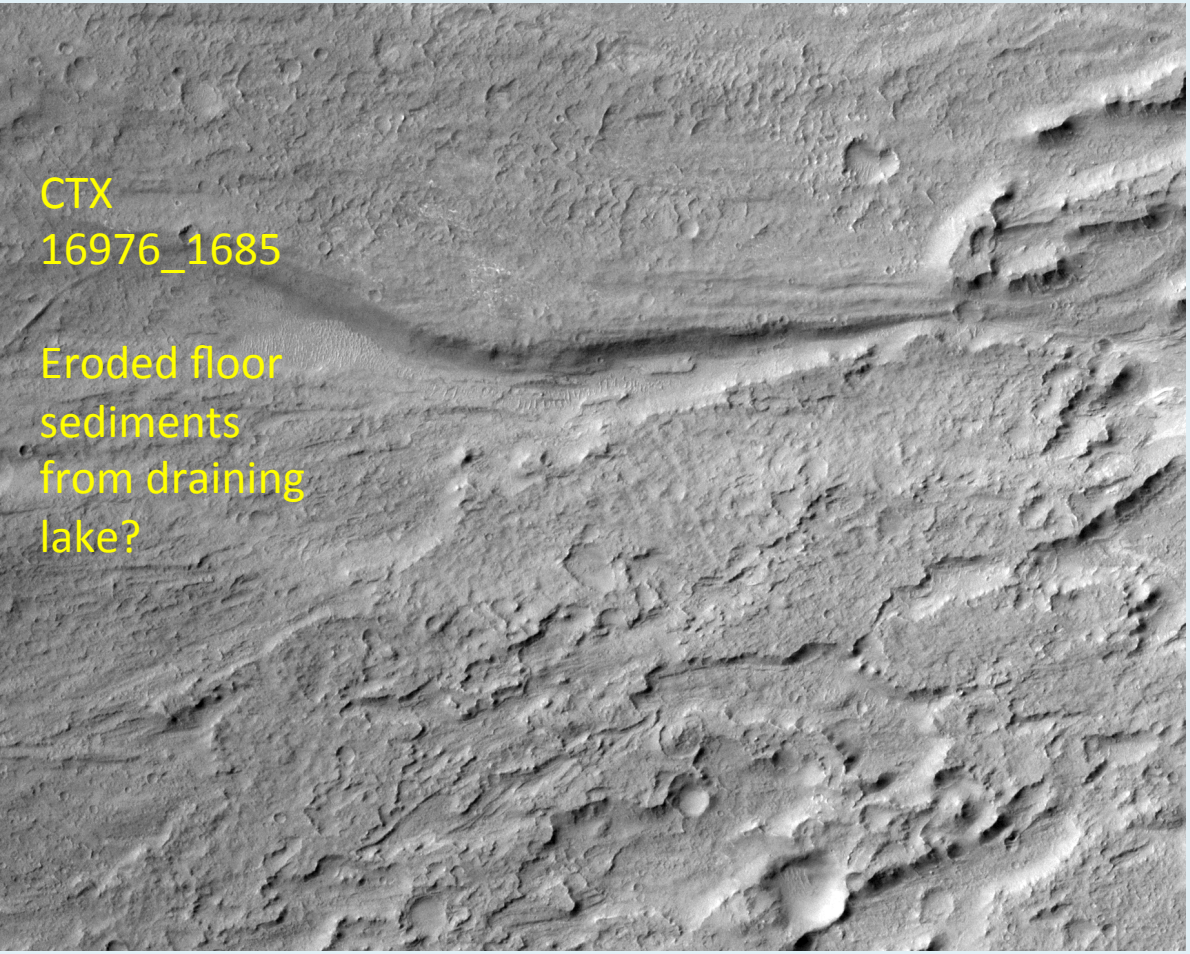


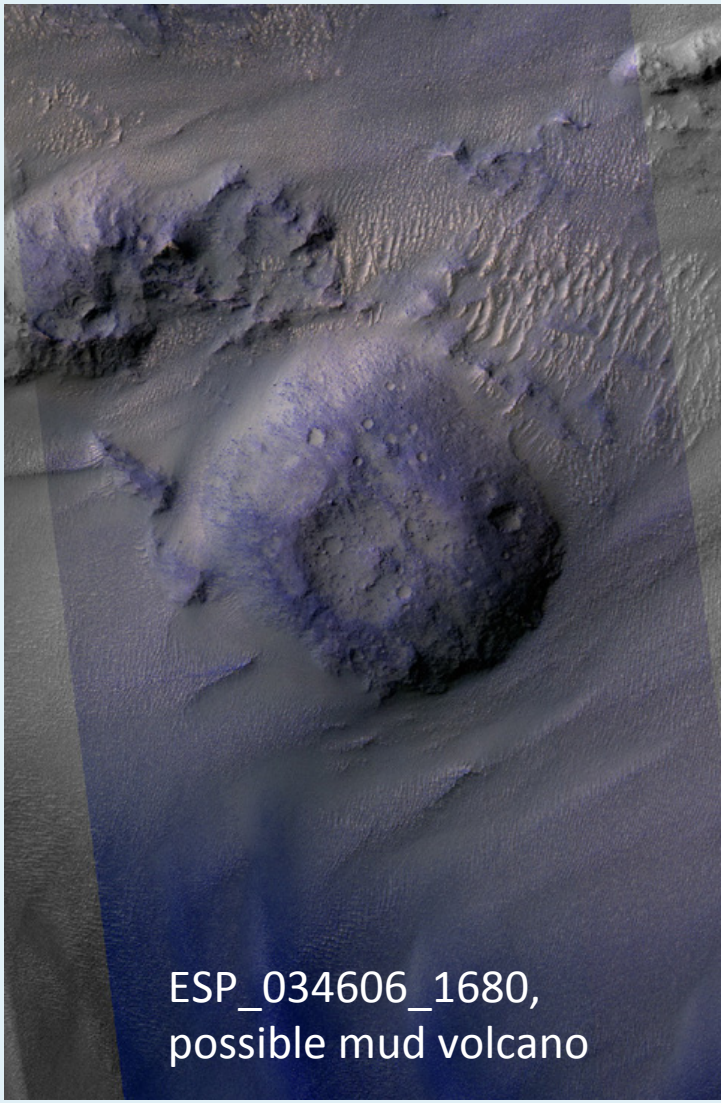

Late Hesperian
lake boundary =
-3560 m contour

**Fig. 1.** (a) Location of putative paleolake in the central Valles Marineris. Black contour defines the maximum ponding elevation, with overflow point indicated by "OP." Yellow and orange marks indicate possible lacustrine features described in the text as bench types *I* and *II* respectively. The underlying image is a THEMIS daytime IR mosaic with gridded MOLA data at elevations below −1 km shown in color. (b) The maximum ponding level contour provides context for other figures in this work. Dots correspond to the centers of figure images.

# SROI-4: Late Hesperian Lake deposits

biosignature preservation potential

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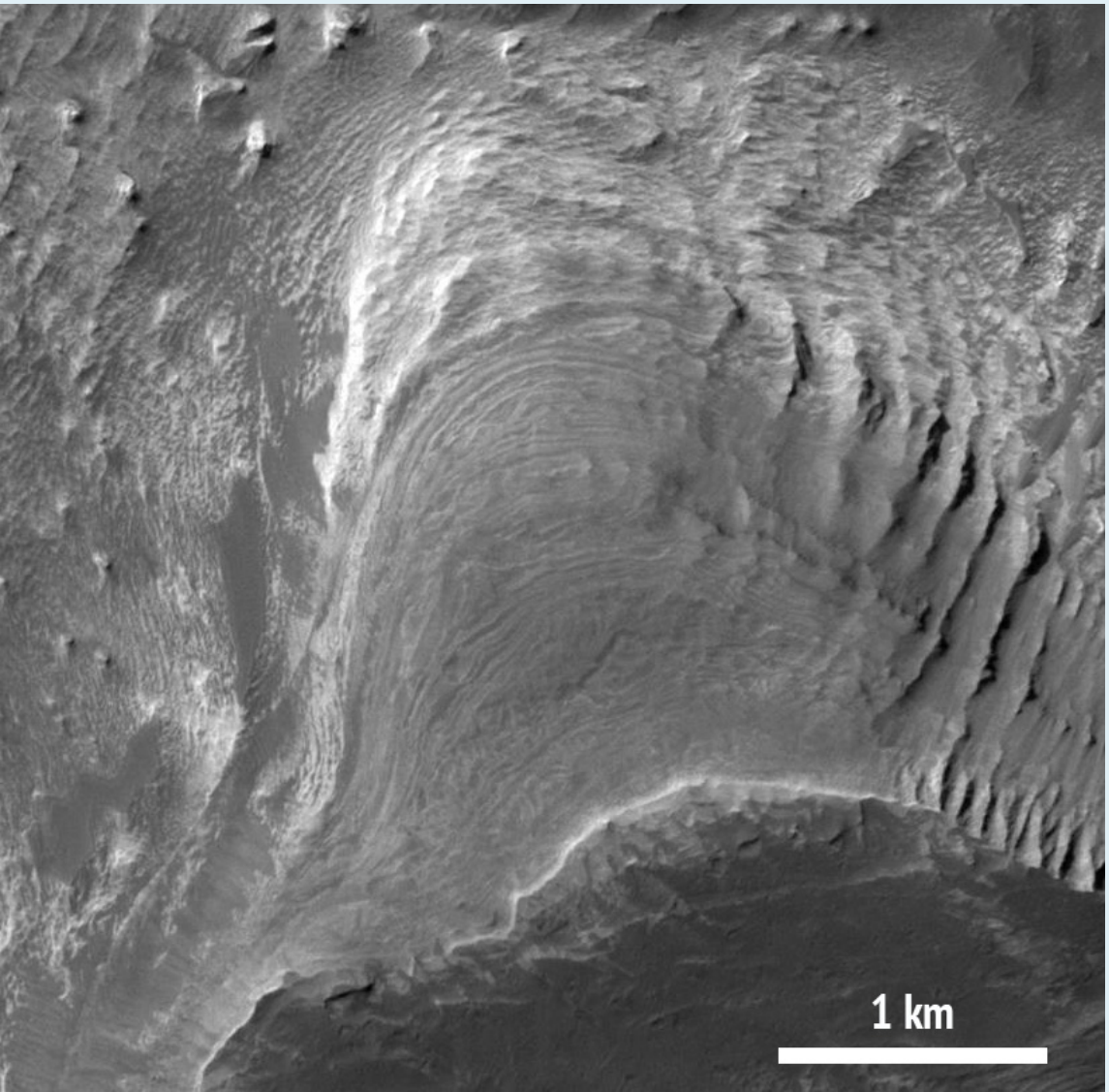
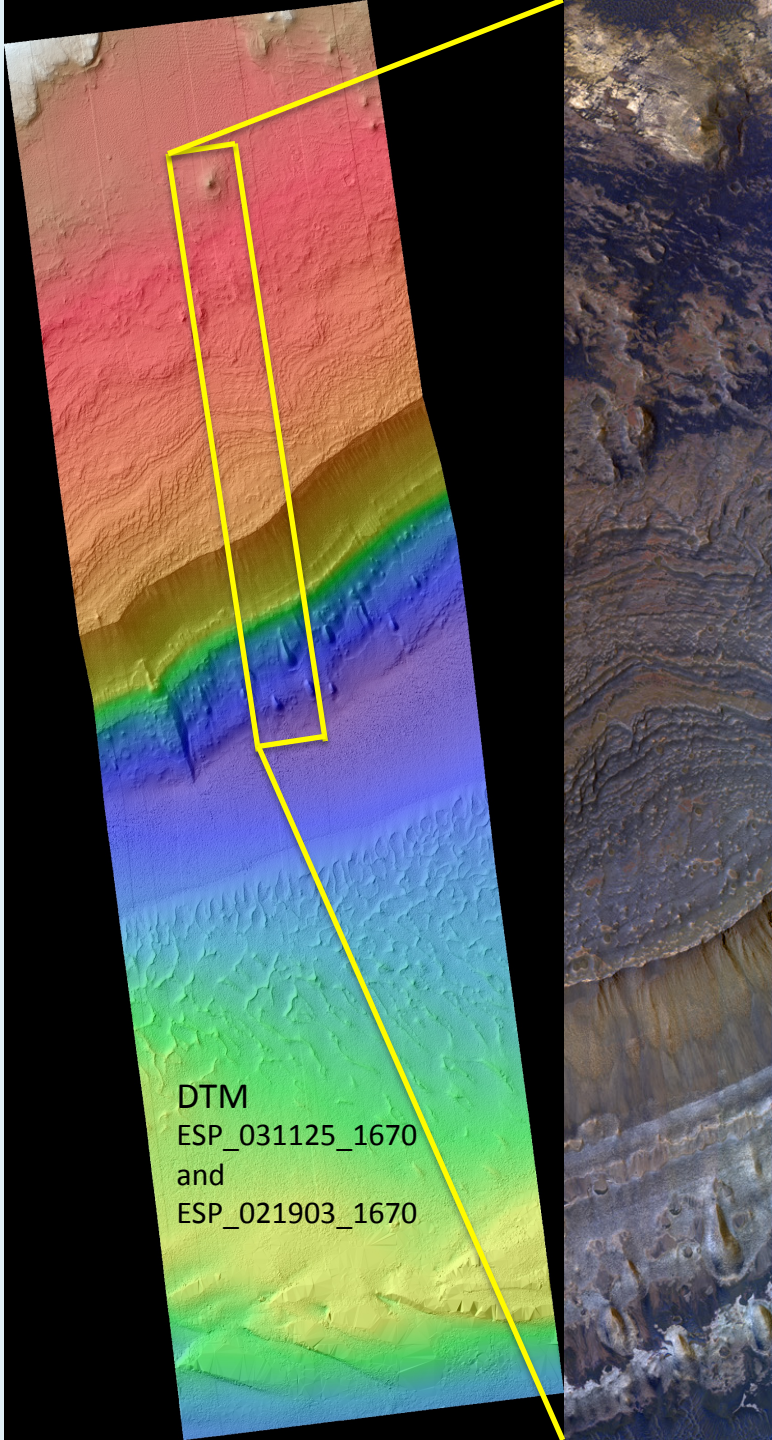
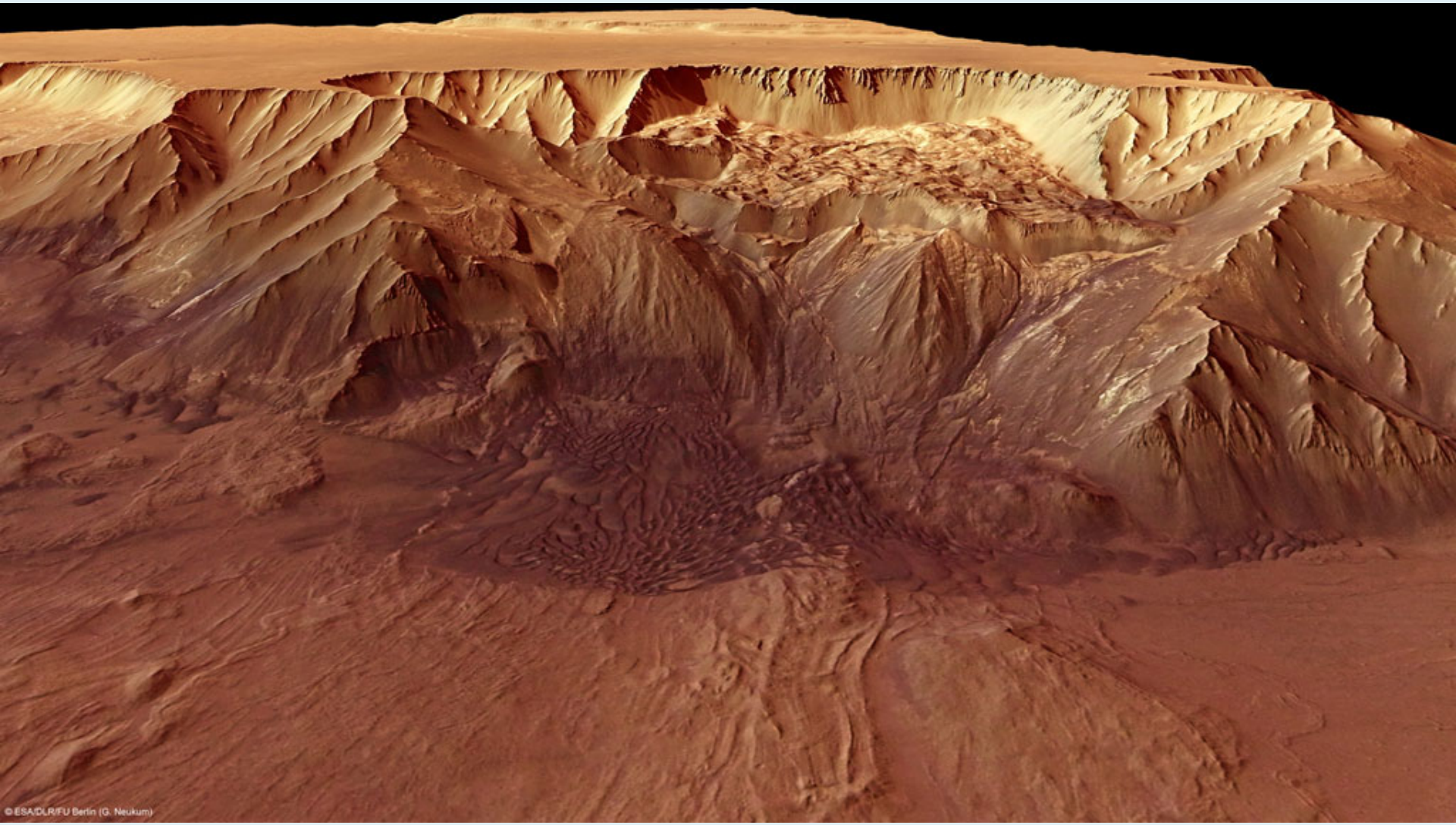
# SROI-5, 11: Hesperian lake terraces and shorelines

# SROI-6, 10, 13 Hesperian ILD Stratigraphy



# SROI-7: Landslides, dunes




HRSC oblique view looking North

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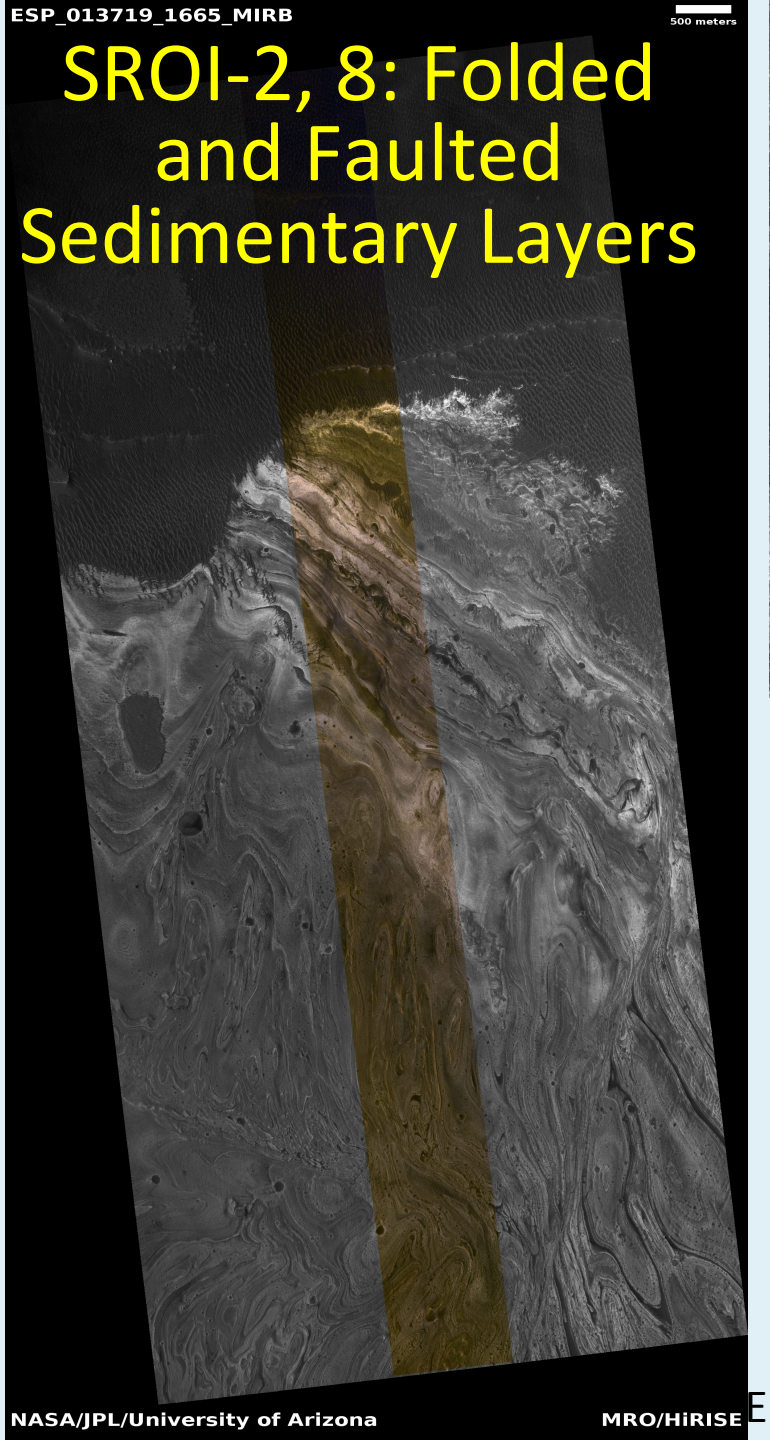
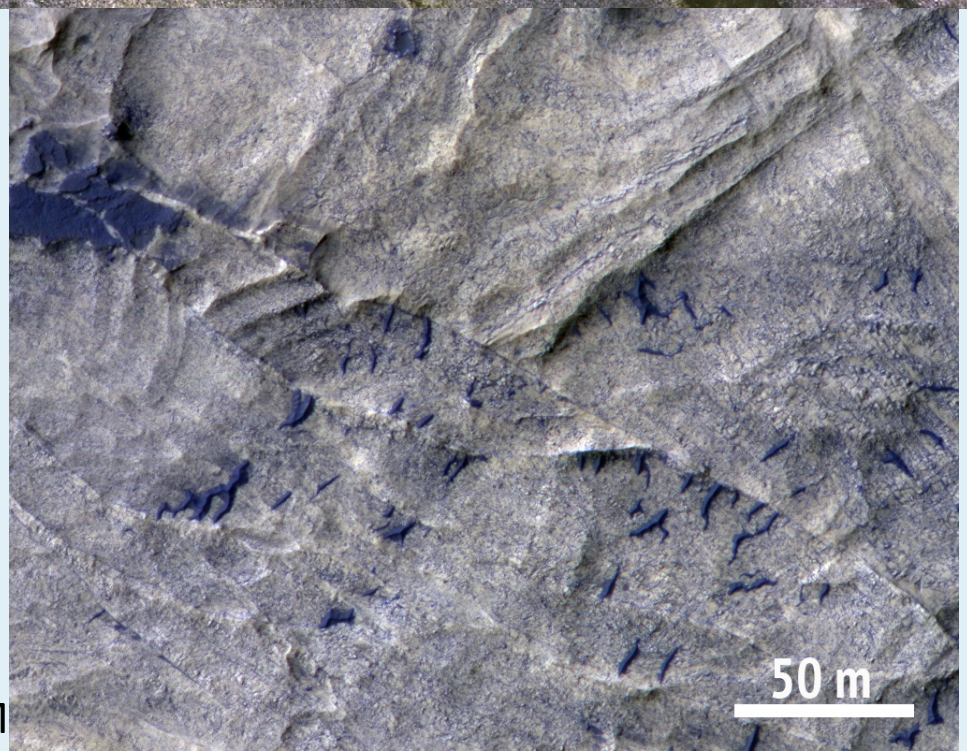
# SROI-2, 8: Folded and Faulted Sedimentary Layers



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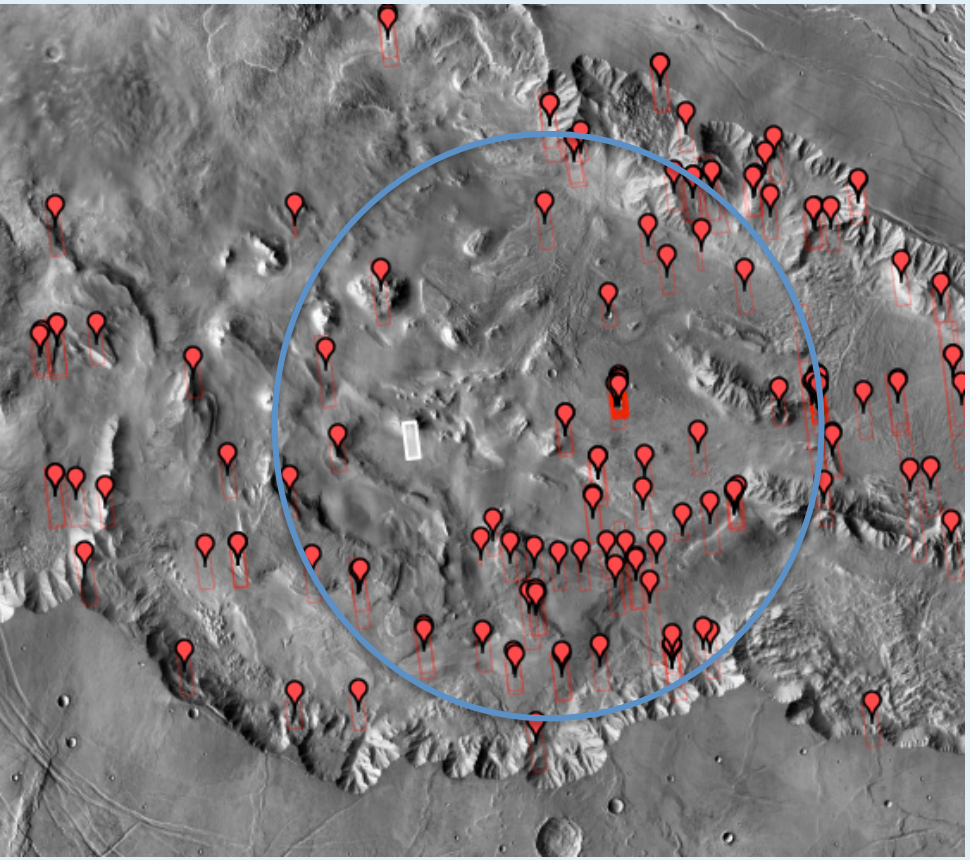
# Science ROIs Rubric

| Site Factors | | | | | SROI-1, 3, 14 | SROI-2 | SROI-3, 9, 11,12 | SROI-4 | SROI-5, 11 | SROI-6, 10, 13 | SROI-7 | SROI-8 | EZ SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Science Site Criteria | Astrobio | Threshold | AND/OR | **Potential for past habitability** | ● | ● | ● | ● | ● | ● | | ● | ● |
| | | | | **Potential for present habitability/refugia** | ● | | | | | | | | ● |
| | | Qualifying | | Potential for organic matter, w/ surface exposure | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ |
| | Atmospheric Science | Threshold | | **Noachian/Hesperian rocks w/ trapped atmospheric gases** | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | | Qualifying | | Meteorological diversity in space and time | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | | | | High likelihood of surface-atmosphere exchange | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | | | | Amazonian subsurface or high-latitude ice or sediment | | | | | | | | | |
| | | | | High likelihood of active trace gas sources | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| | Geoscience | Threshold | | **Range of martian geologic time; datable surfaces** | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | | | | **Evidence of aqueous processes** | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | | | | **Potential for interpreting relative ages** | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | | Qualifying | | Igneous Rocks tied to 1+ provinces or different times | | | ● | | | | ● | | ● |
| | | | | Near-surface ice, glacial or permafrost | | | | | | | | | |
| | | | | Noachian or pre-Noachian bedrock units | | ● | | | | | | | ● |
| | | | | Outcrops with remnant magnetization | | | ○ | | | | | | ○ |
| | | | | Primary, secondary, and basin-forming impact deposits | ● | | ○ | | | | | | ○ |
| | | | | Structural features with regional or global context | | ● | ● | | | ● | ○ | ● | ● |
| | | | | Diversity of aeolian sediments and/or landforms | ● | ● | ● | ● | ● | ● | ● | ● | ● |

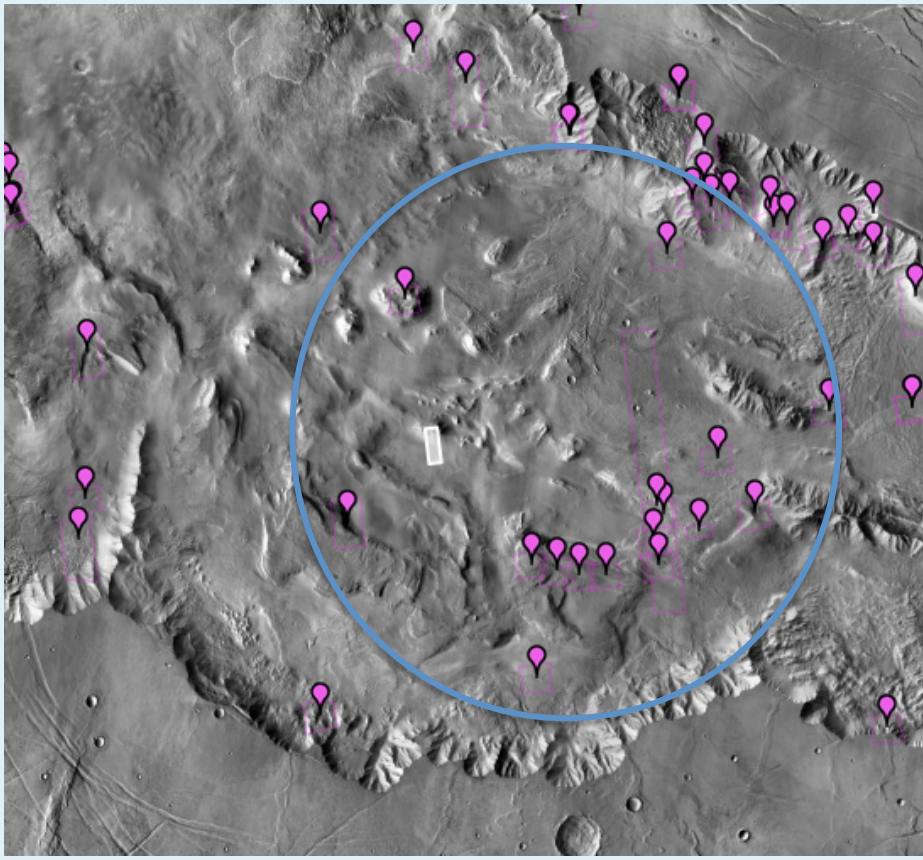
| Key | |
|---|---|
| ● | Yes |
| ○ | Partial Support or Debated |
| | No |
| ? | Indeterminate |

# HIRISE and CRISM (full-res) coverage is a few % of EZ

HiRISE



CRISM (incomplete)



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# Prioritized Data Needs

- 1. CRISM: Find best polyhydrated sulfates for ISRU within RROI
- 2. HiRISE stereo: Find best landing sites within RROI
  - combine with 1. above
- 3. CRISM: Search for additional hydrated minerals, especially in Noachian bedrock
- 4. HiRISE: Stratigraphic and other studies of science ROIs

  HiRISE targets will be entered (including those for CRISM) into HiRISE database; suggestion numbers will be sent to HLS$^2$ Steering Committee

- Continue HiRISE + CRISM monitoring of RSL
  - To be done outside HLS$^2$ process

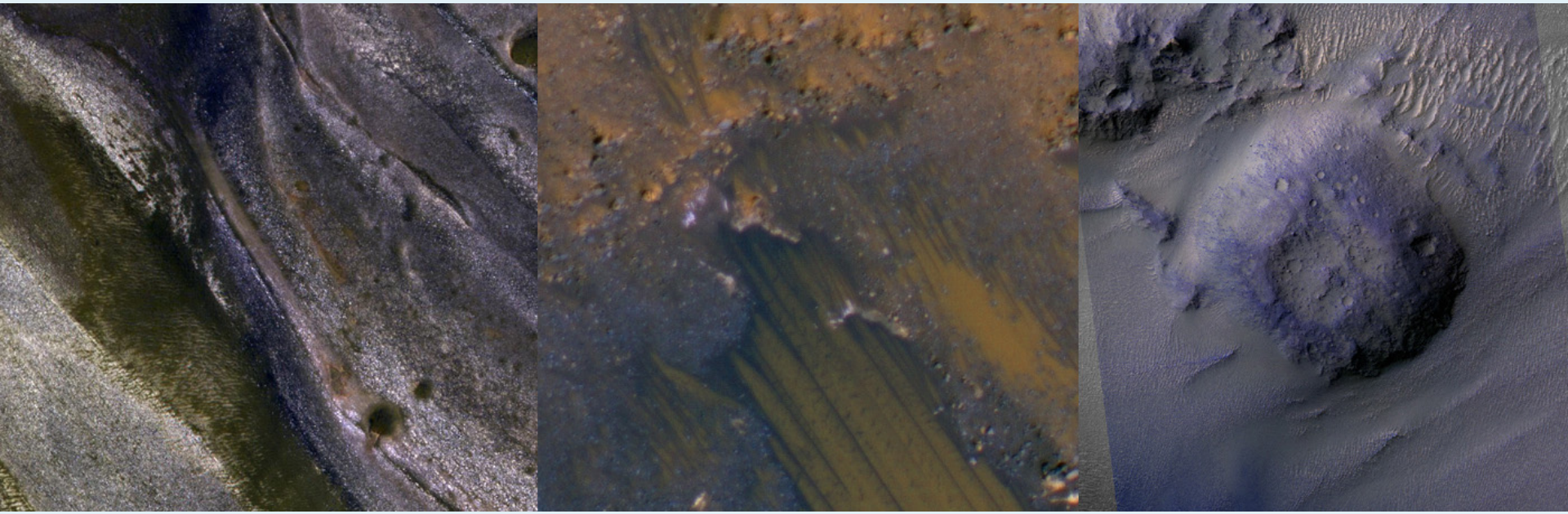
- TGO/CaSSIS: 4.6 m/pixel stereo/color coverage of entire EZ

- Future rover to locate best polyhydrated sulfates in ~24 x 25 m area and to understand its physical and chemical properties, prior to autonomous ISRU.
  - JAXA proposed MELOS mission could send a rover this area (see mepag.nasa.gov, meetings, 08_MEPAG_Miyamoto_Final.pdf)

# Conclusions

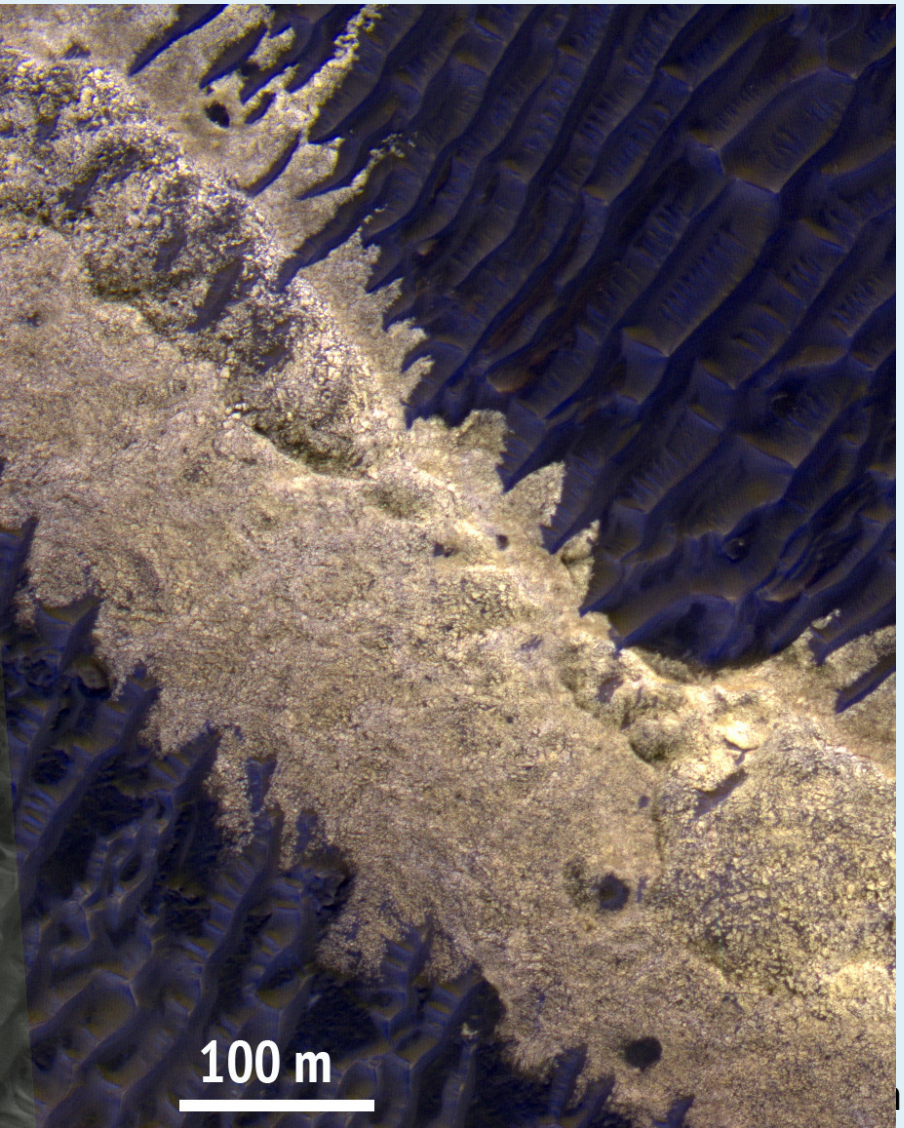
- **E. Melas EZ has it all**
  - Water for ISRU, low latitudes and elevations, safe landing site
  - Diverse science targets
    - Modern *and* ancient habitability
- Need to develop engineering systems for ISRU
  - Terrestrial polyhydrated sulfate deposits in western US, Australia can be used an analog materials
- More research and future exploration needed to understand RSL, ISRU potential, and special regions for Planetary Protection

**REMINDER: You can enter HiRISE image suggestions here: http://www.uahirise.org/hiwish/**



E. Melas Chasma

# Resource ROI 1




ıs Chasma

- 15.52°S, 290.36 E, -3.668 km
- Landing site within 5 km, maybe closer
- Polyhydrated sulfates:
  - Up to 50% water
  - Easy to excavate
  - Also contains basaltic sand for silica and metal resources

# Science ROI Data

| SROI | Latitude | Longitude | Altitude | HiRISE | CRISM | Characteristics |
|---|---|---|---|---|---|---|
| 1 | -11.52 | 290.32 E | -5.23 | many | many | Garni crater RSL (present-day habitability) |
| 2 | -12.52 | 290.56 | -3.69 | 29569_1675 | 276A4 | Phyllosilicates in layered sediments |
| 3 | -11.37 | 280.81 | -3.88 | 43072_1685 43573_1685 (stereo) | | Noachian bedrock (ancient habitability, radiometric dates) and RSL |
| 4 | -11.84 | 290.82 | -5.15 | 3843_1689, 34606_1680 | 5D59, 25276 | Late Hesperian lake sediments (ancient habitability) |
| 5 | -11.73 | 289.99 | -4.77 | 41292_1680 | 36F82 | Hesperian lake terraces (fluvial processes) |
| 6 | -12.5 | 289.6 | -1.9 | 24057_1675 | 203B6 | Hesperian ILD stratigraphy |
| 7 | -10.4 | 289.85 | -5.3 | 27169_1695 | 2C887 | Landslide deposits, dunes, phyllosilicates? |
| 8 | -13.2 | 289.95 | -2.85 | 14141_1665, 13719_1665 | 136D3 | Folded and faulted sedimentary layers |
| 9 | -12.1 | 291 | -2.98 | none | | Noachian bedrock, RSL? |
| 10 | -11.86 | 288.53 | -2.11 | 19310_1680 | | Layered mesa Hesperian stratigraphy |
| 11 | -10.83 | 288.8 | -3.25 | 26391_1690 | 23A6C | Noachian bedrock and Hesperian shorelines |
| 12 | -10.3 | 290.6 | -1 | 5866_1695 | | Noachian bedrock, dunes, phyllosilicates?, RSL? |
| 13 | -13.05 | 289.08 | -2.87 | 31125_1670, 31903_1670, DTM | | Hesperian IDL stratigraphy, phyllosilicates? |
| 14 | -10.98 | 290.25 | -5.34 | 33472_1690 | 2B663 | RSL in a crater |

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