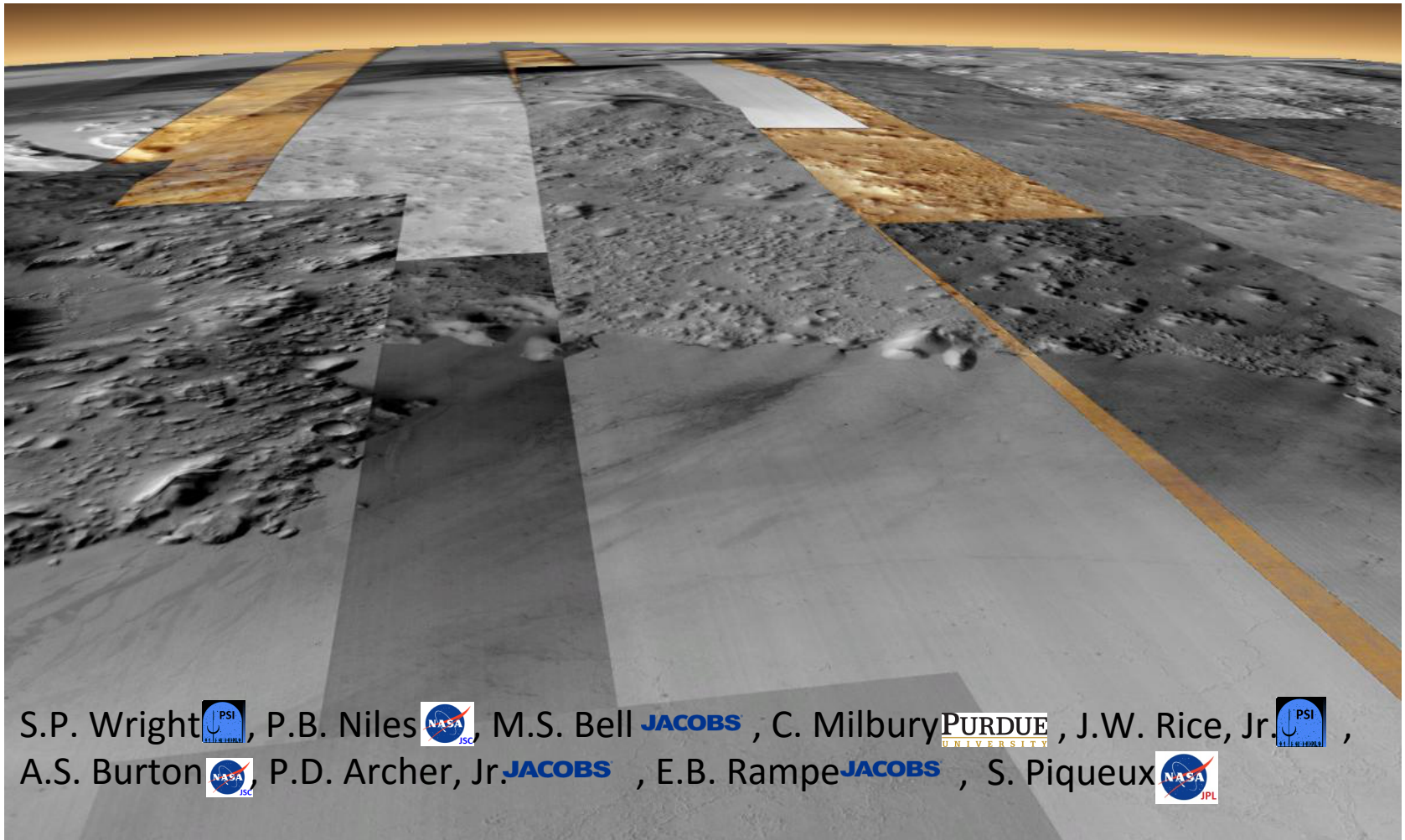
# An Exploration Zone in Cerberus Containing Young and Old Terrains, Including Fossae/Faults and Shergottite Distal Ejecta (abstract #1017)



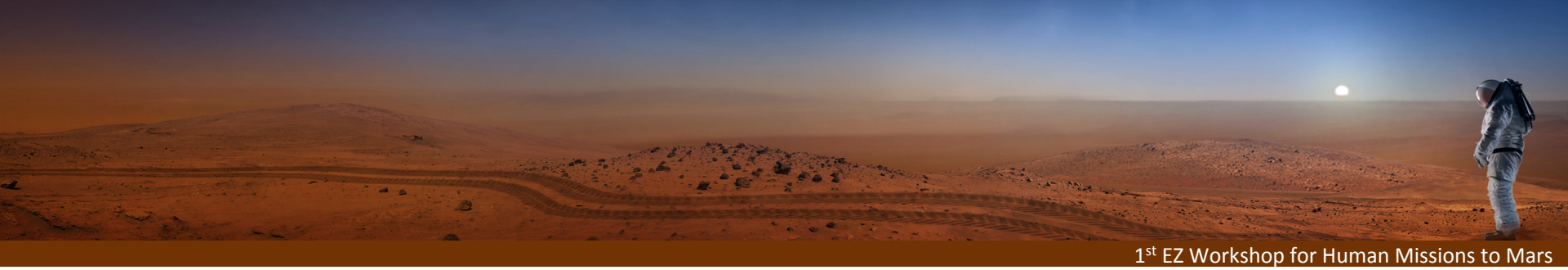
S.P. Wright, P.B. Niles, M.S. Bell, C. Milbury, J.W. Rice, Jr., A.S. Burton, P.D. Archer, Jr., E.B. Rampe, S. Piqueux

# E2E-iSAG Mars Sample Return

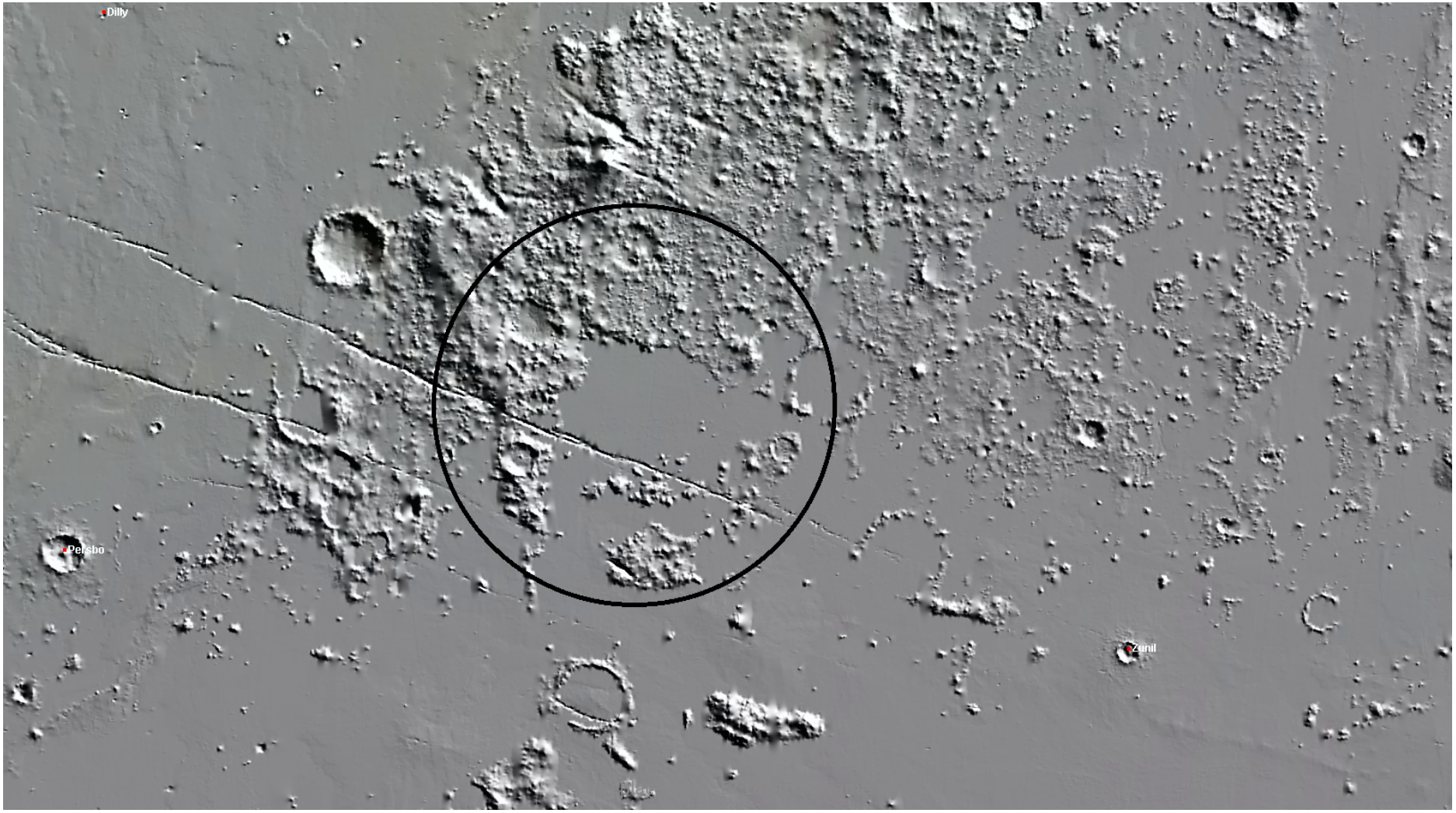


**MEPAG report of the End-to-End international Science Analyses Group suggests:**

- Noachian – igneous and/or sedimentary
- igneous rocks – pristine and altered
- impactites and ejecta
- aeolian sediments
- soils / regolith
- airfall dust
- aqueously altered rocks
- hydrothermally altered rocks



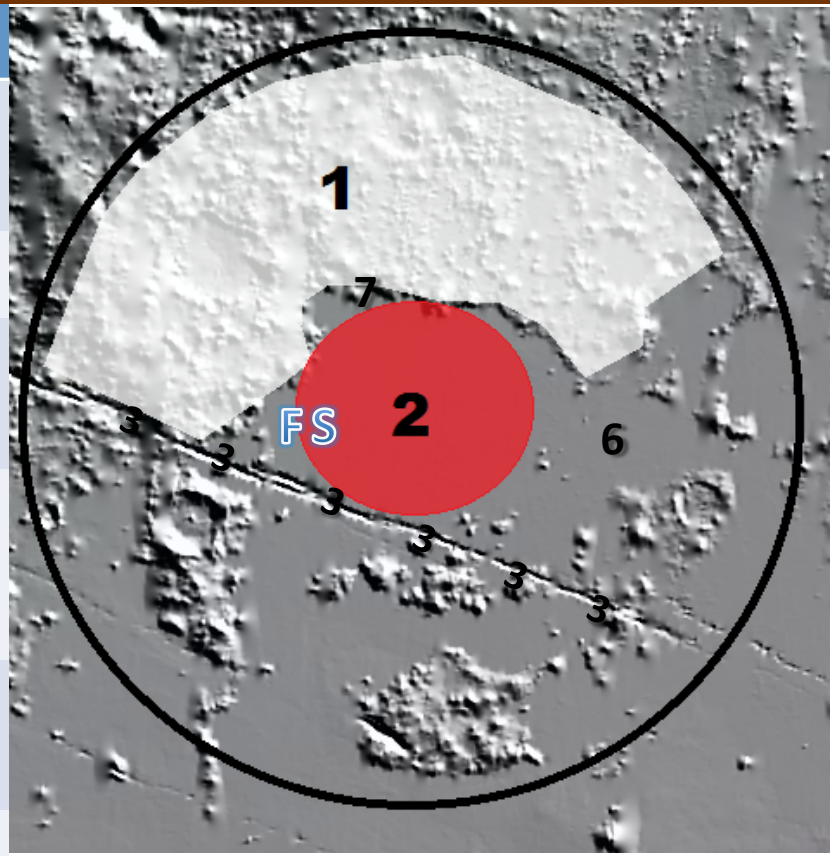



Dilly
Persbo
Zunil

# Exploration Zone Map



| SROI | Label | Brief description |
|---|---|---|
| 1 | Noachian terrains | Knobbed, ridged – sedimentary rocks? |
| 2 | young flood basalts | For dating purposes |
| 3 | Fossae | Tectonic rifting? Subsidence? |
| 4 | ancient crater rims embayed; young craters | For geomorphology, mapping, context |
| 5 | Zunil rays / ejecta (throughout EZ) | Is Zunil 1 of 4 shergottite source craters? |
| 6 | (aqueous) flood features, deposits | Several authors |
| 7 | hydrated salts (RSL's) | contact/border of 1 & 2? |



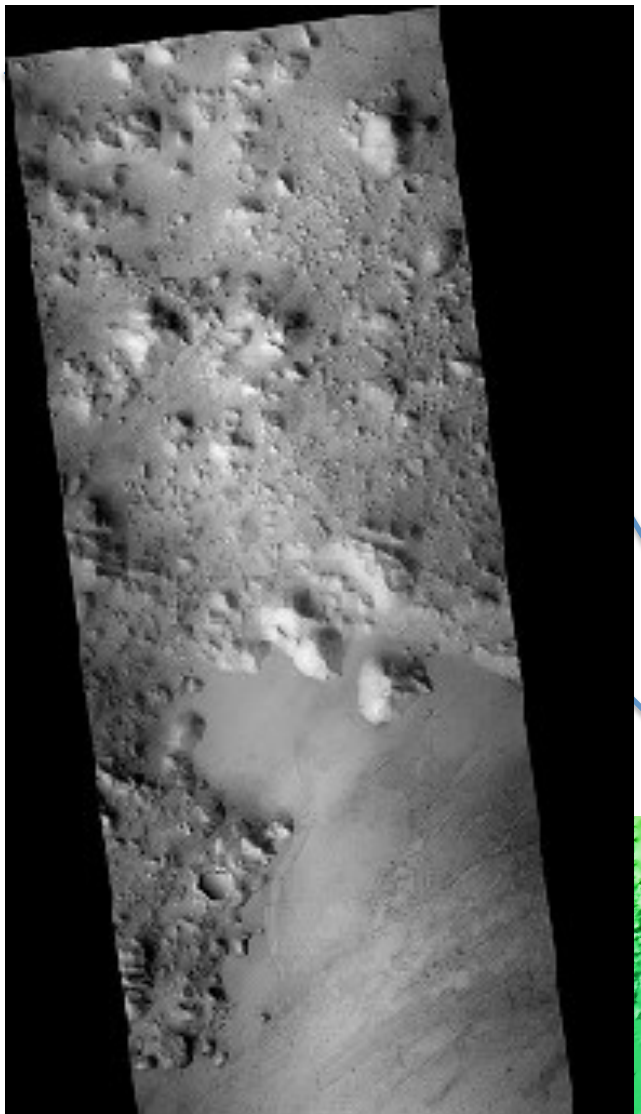

center: 161.9 E, 9.7 N, -2700 m

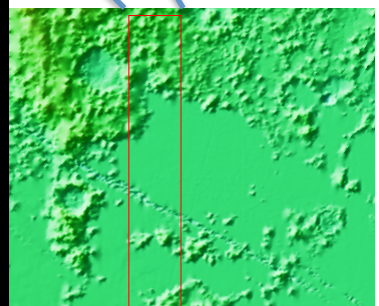
RROI1 – ice

RROI2 – materials

# Science ROI 1: knobby terrain



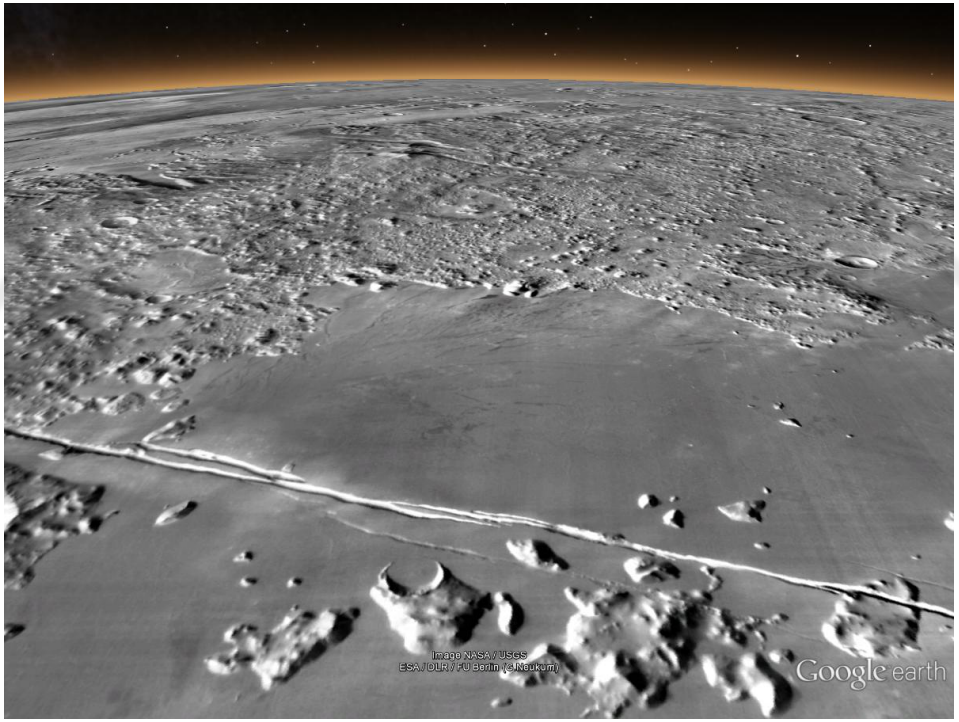




- Surrounds EZ; primarily N &W
- Early or Late Noachian
- A long history of geologic and atmospheric processes:
  - Original emplacement
  - Climate change
  - Hesperian/Amazonian volcanics
    - Hydrothermal alteration?
    - Ashes/tephras?

# Science ROI 2

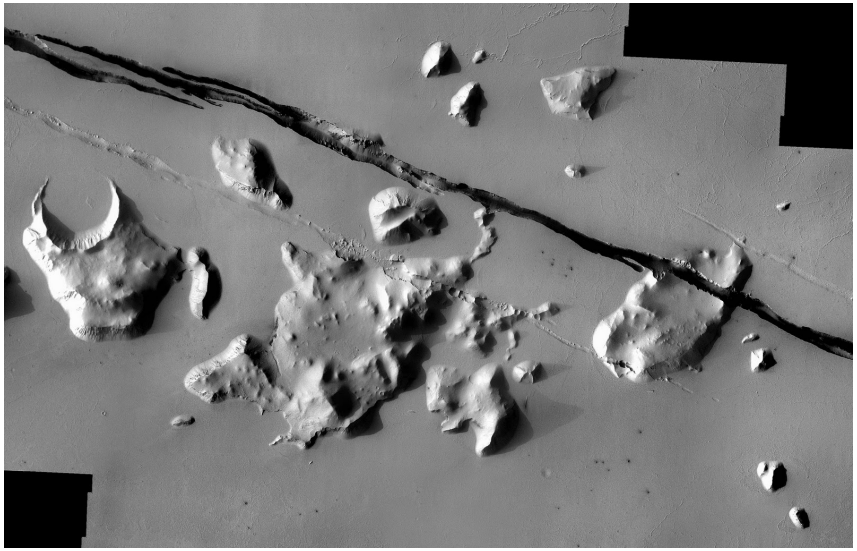


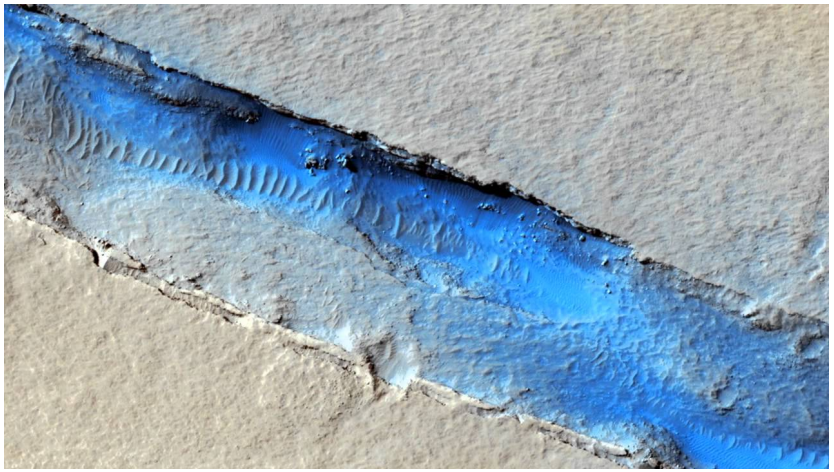



- Center of EZ at 9.9°N, 162° E; “mini-EZ” or “bullseye” w/ ~70 km diameter
- Igneous rock can be dated and compared to global crater counts of surfaces

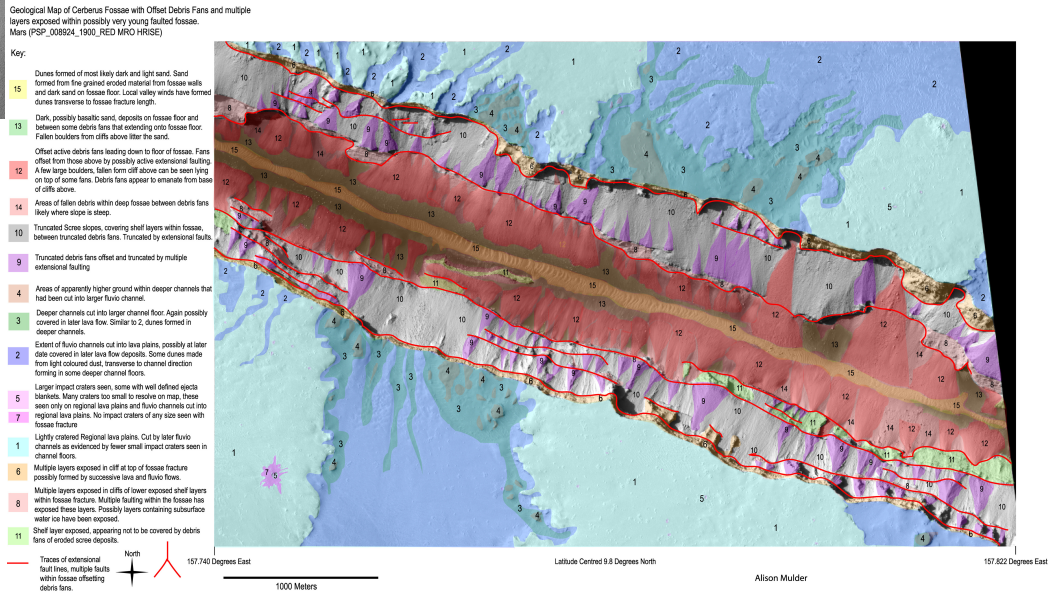
# Science ROI 3: Fossae





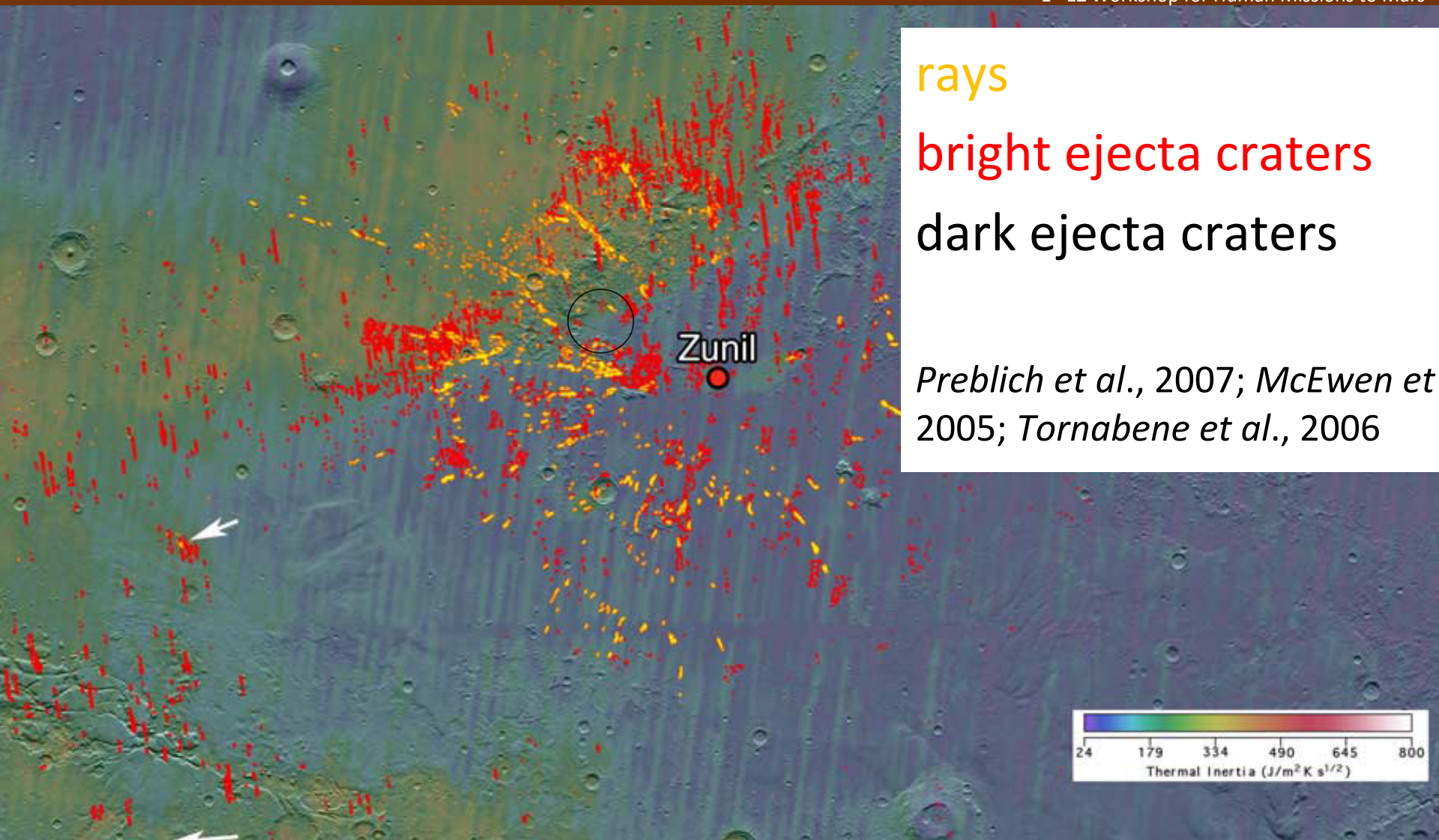


- Cause of Fossae can be investigated
  - tectonics or subsidence?
  - global implications
- Subsurface can be examined



# Science ROI 5: Zunil ejecta/rays






rays

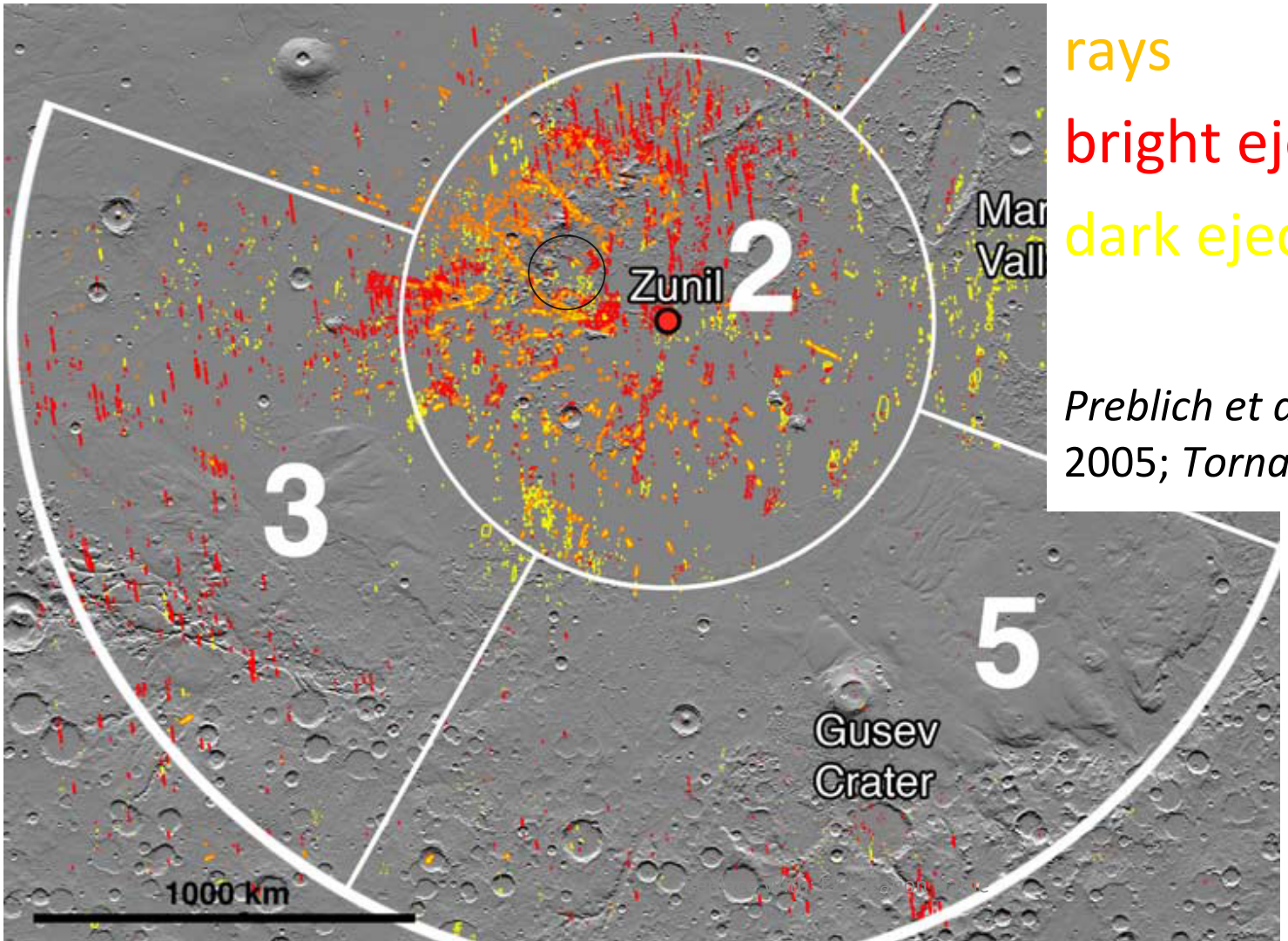
bright ejecta craters

dark ejecta craters

*Preblich et al.*, 2007; *McEwen et al.* 2005; *Tornabene et al.*, 2006

# Science ROI 5: Zunil ejecta/rays






rays

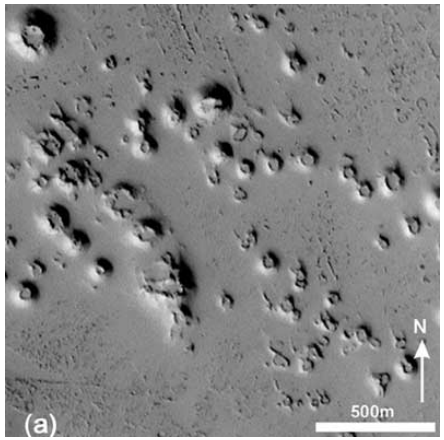
bright ejecta craters

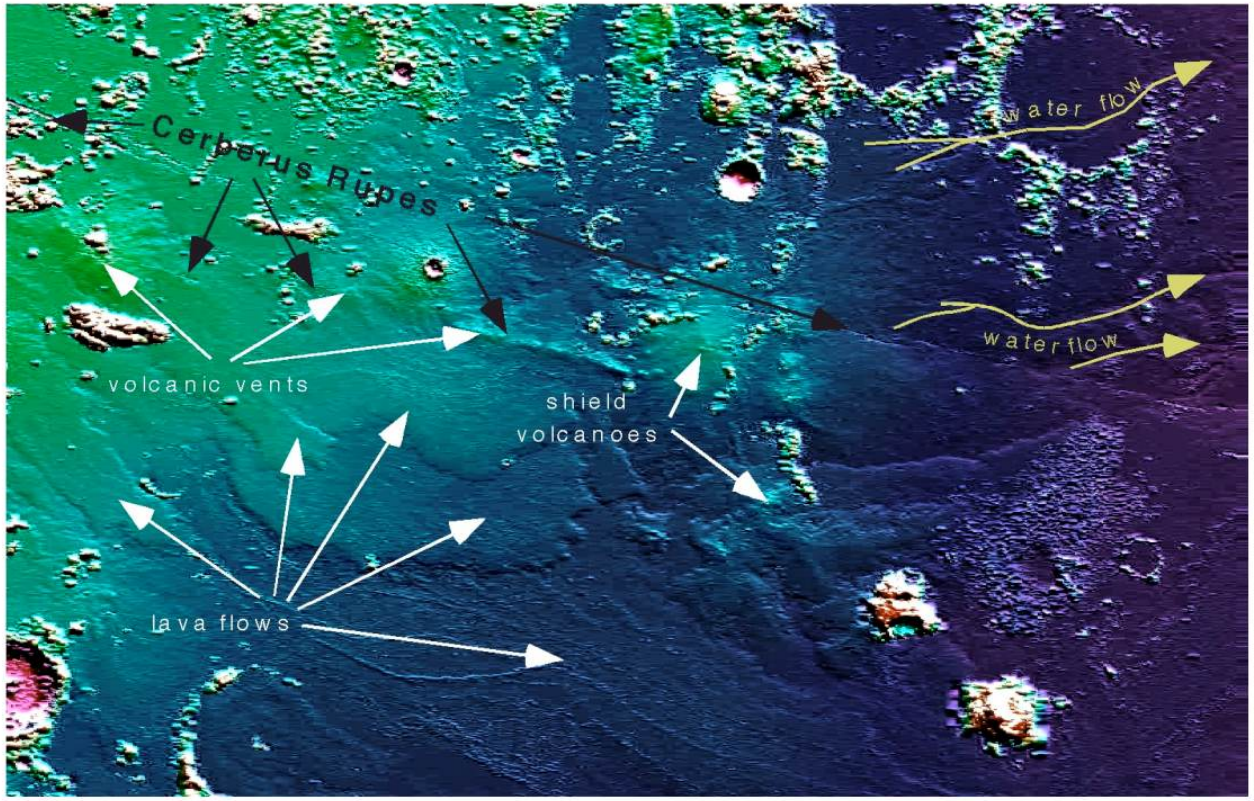
dark ejecta craters

*Preblich et al.*, 2007; *McEwen et al.*, 2005; *Tornabene et al.*, 2006

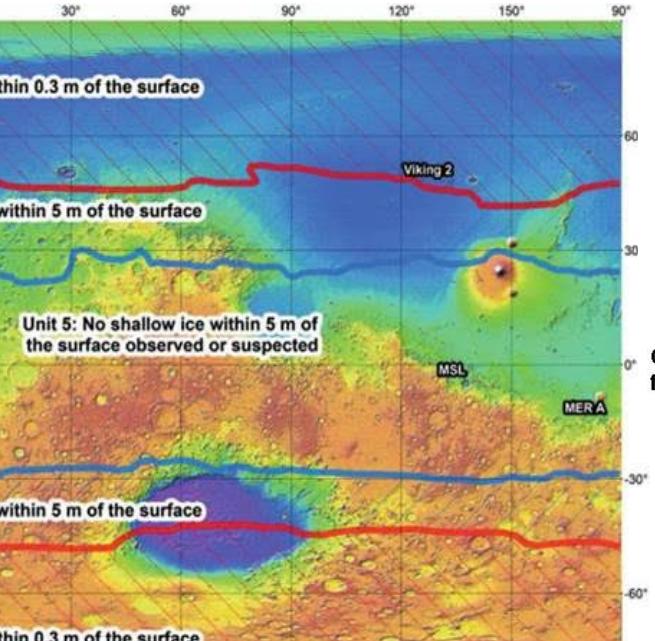
# Science ROI 6: aqueous flooding





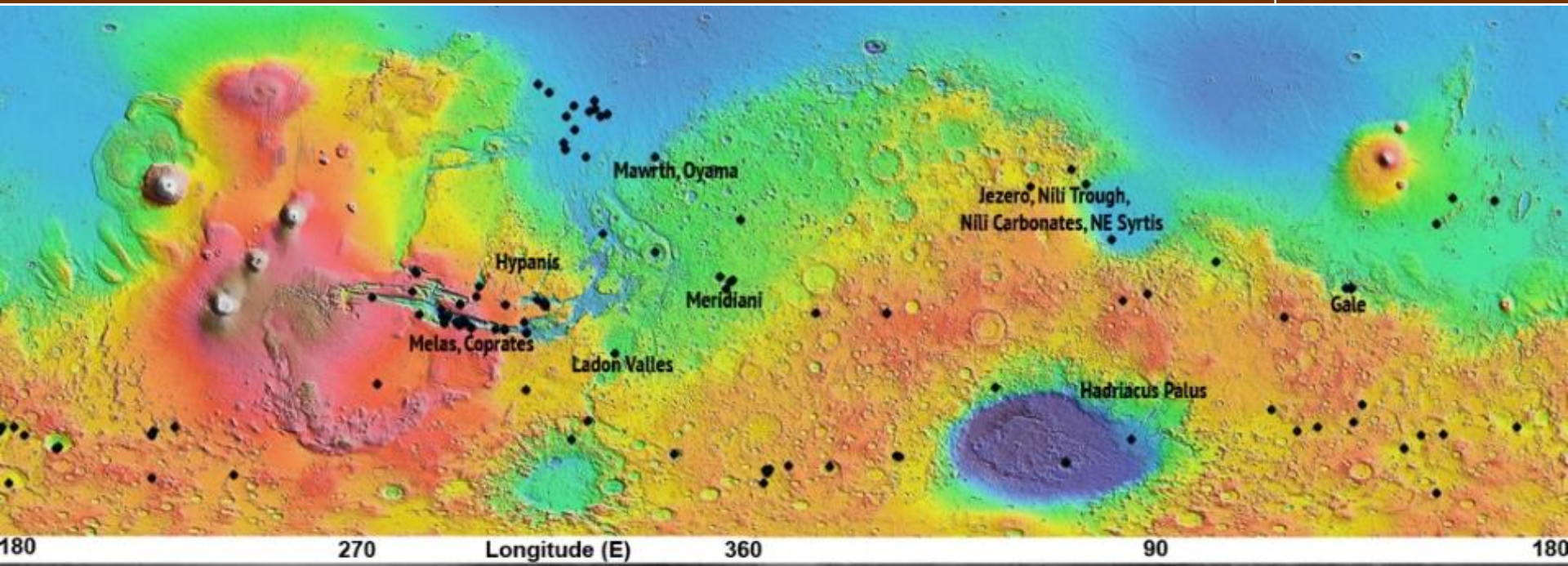



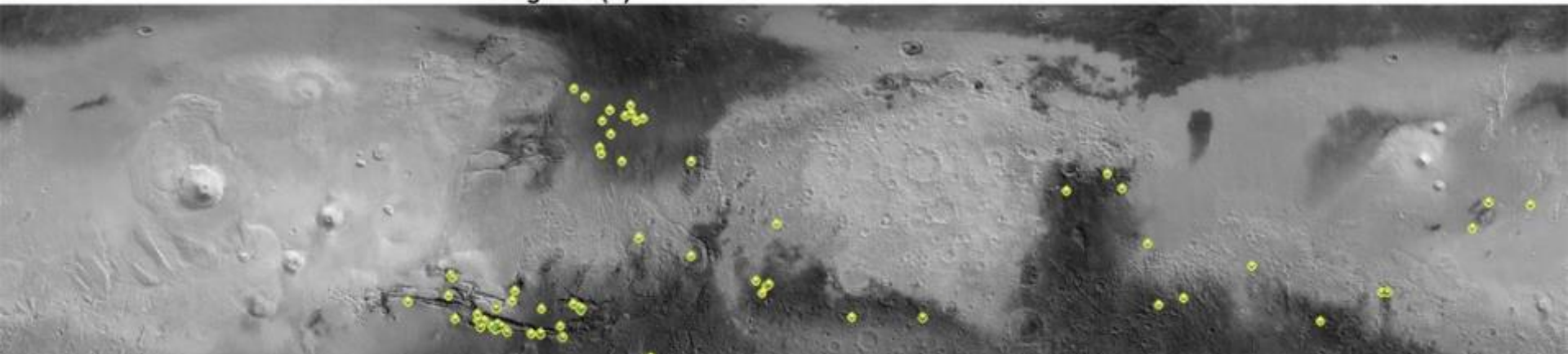

Cerberus Plains on Mars, showing fissures, vents, shield volcanoes, lava flows, fluvial channels and inferred directions of flows of both water and lava. Elevation shown by color (dark blues and purples are lows; greens are higher elevations).

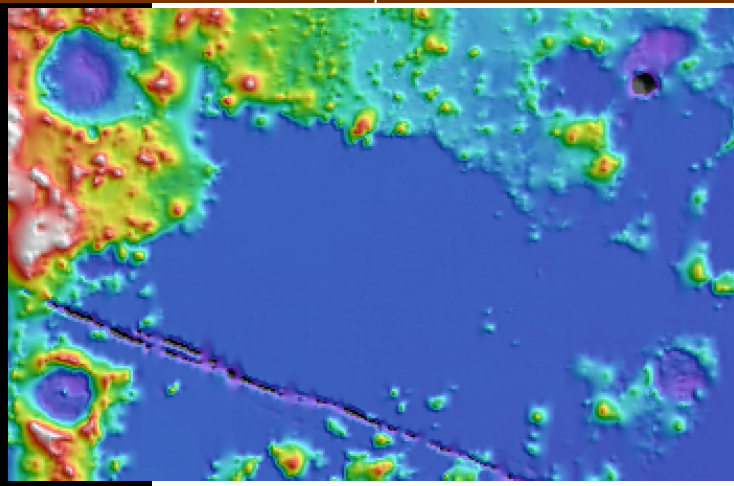



# Science ROI 7: ~~RSL's~~ hydrated salts







MOLA -1500 to -3000

CTX image of knobs-plains contact

# Science ROI(s) Rubric

1st EZ Workshop for Human Missions to Mars

| Science Site Criteria | | | AND/OR | Site Factors | SROI1 | SROI2 | SROI3 | SROI4 | SROI5 | SROI6 | SROI7 | RROI1 | RROI2 | RROI3 | EZ SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Astrobio | **Threshold** | | **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 | ● | | | | ● | | | | | | |

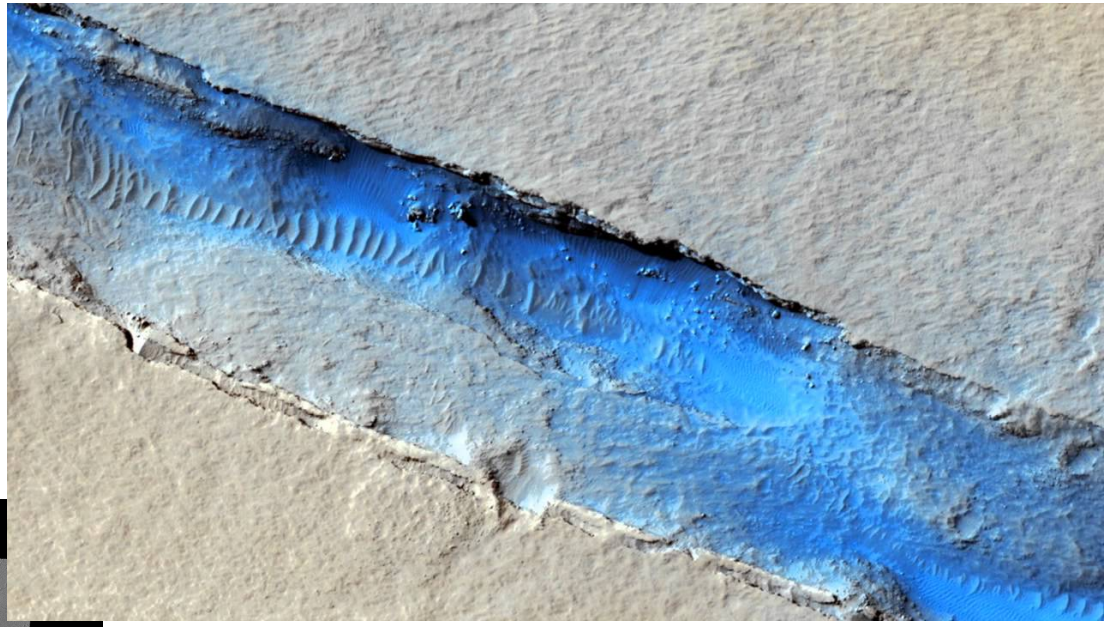
| Key | |
|---|---|
| ● | **Yes** |
| ○ | **Partial Support or Debated** |
| | **No** |
| ? | **Indeterminate** |

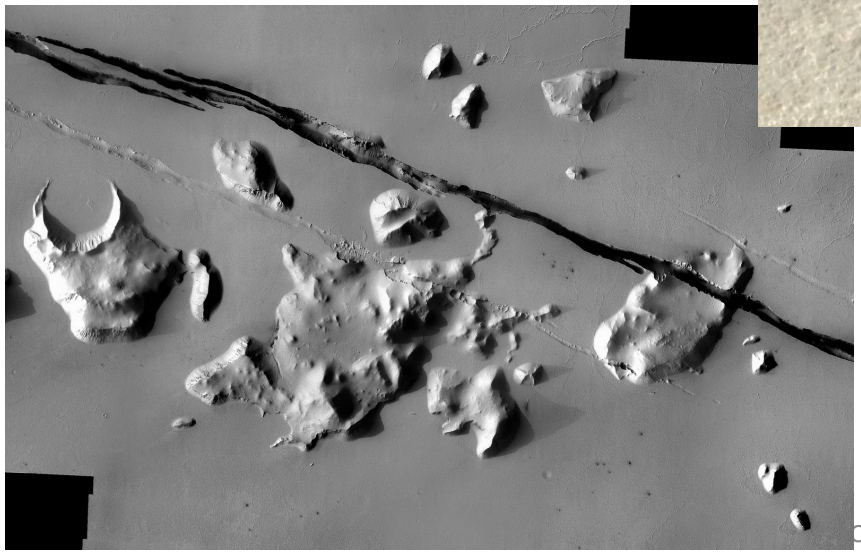
# Resource ROI 1: ice



**Fossae and aqueous flooding – contemperaneous**

**at 2-10 Ma ?**





# Resource ROI 2: materials



- dust
- cobbles of basalt
- sedimentary rocks – “cherty” silica?

# Resource ROI(s) Rubric

1st EZ Workshop for Human Missions to Mars

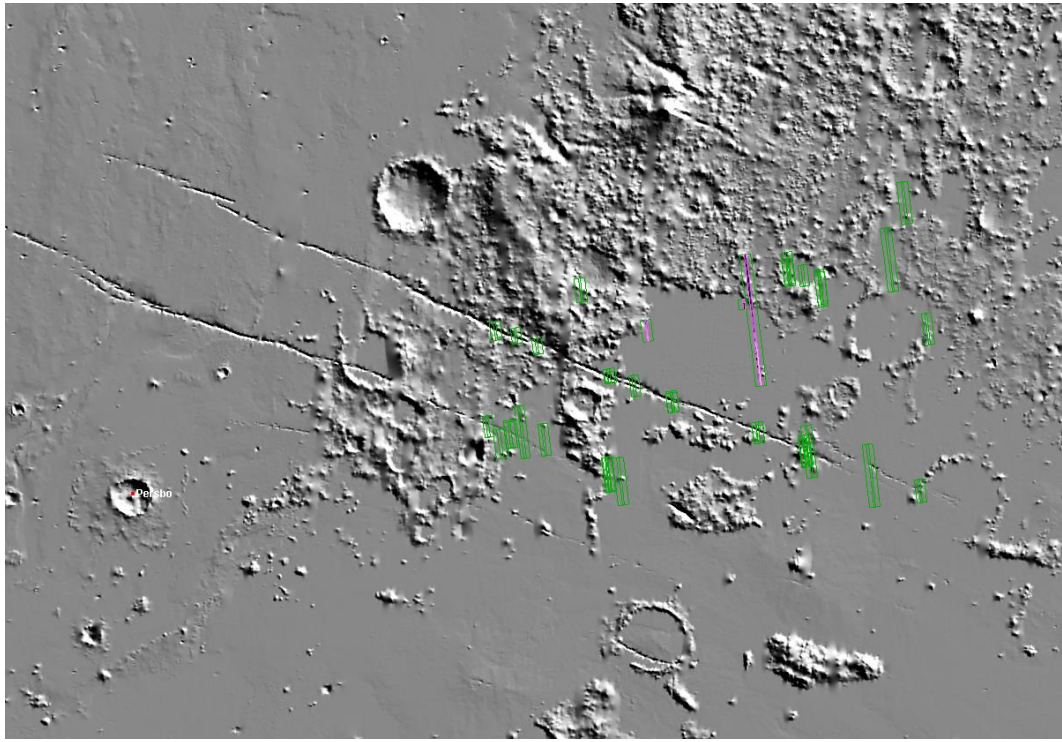
| ISRU and Civil Engineering Criteria | | | Site Factors | SROI1 | SROI2 | SROI3 | SROI4 | SROI6 | SROI7 | | RROI1 | RROI2 | | EZ SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering | | Meets First Order Criteria (Latitude, Elevation, Thermal Inertia) | ○ | ○ | | | | | | | | | |
| | Water Resource | Threshold | AND/OR **Potential for ice or ice/regolith mix** | | | | | | | | ● | | | |
| | | | AND/OR **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°** | | ● | X | | | | | | | | |
| | | | **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 |

# Prioritization List of EZ Data Needs



- Science:
  - Instrument: HiRISE
  - Lat/Long: 10.5° N, 161.3° to 162.1° E
  - ~40 km embayment contact between lava plains and Noachian knobby terrain … hydrated salts/RSL's?



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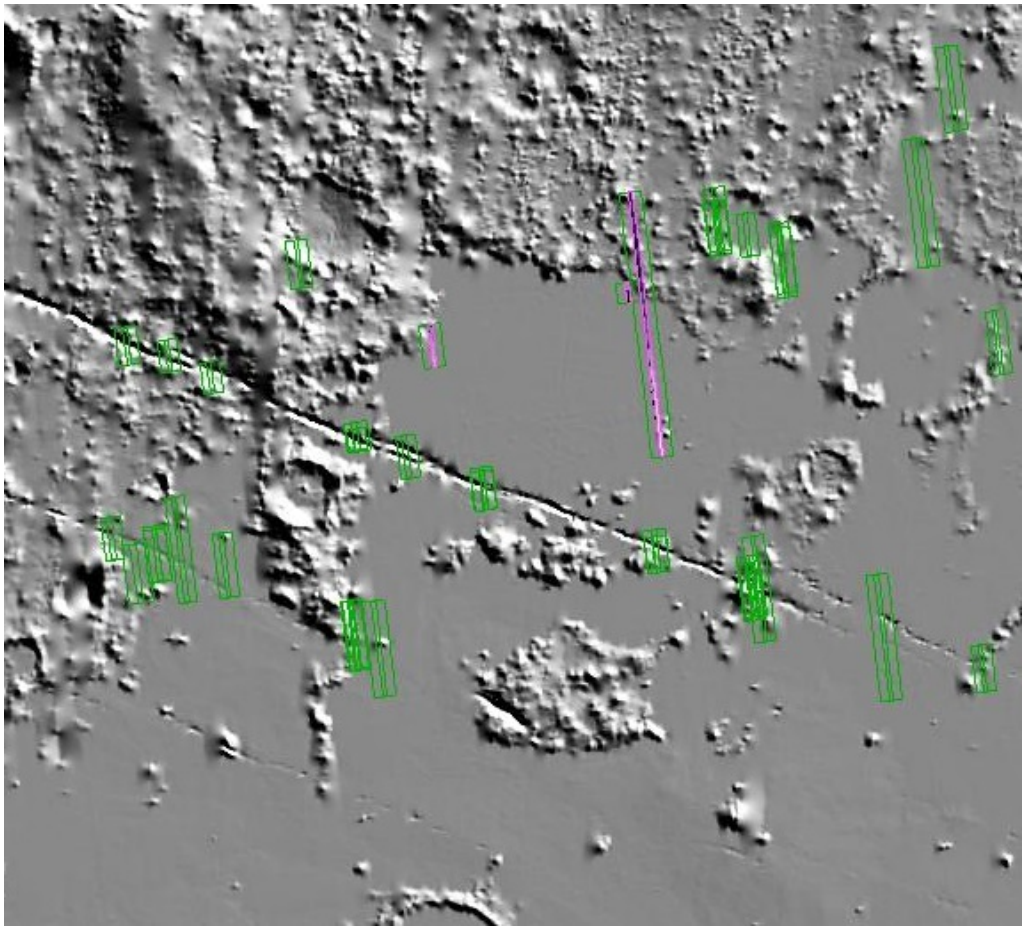
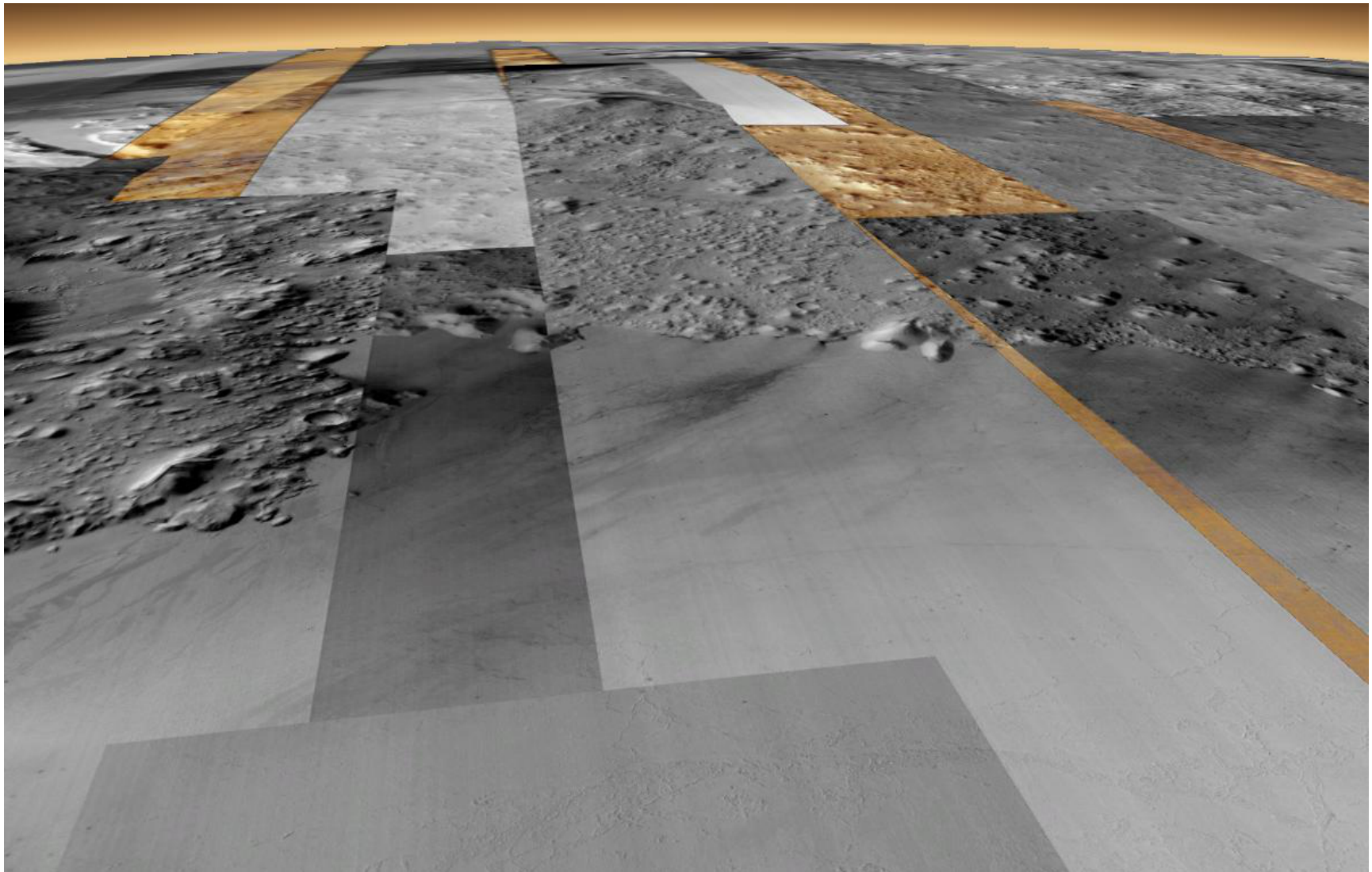


# Priority: HiRISE of contact





# Conclusions

- Science
  - Old Noachian, younger Hesp-Amaz lava flows
  - 2-10 Ma Fossae faults
  - ~1 Ma distal ejecta/rays from 500+ km
  - Evidence of aqueous flooding 2-10 Ma
  - *Nearby* Formations: Medusa Fossae, southern Highlands
- Resources
  - Ice?
  - Safe, flat landing site on basalt flood plains
    - caves or skylights?
  - Materials: dust, basalt in plains (silica in knobs?)

# Available orbital datasets

| Dataset | Instrument | Coverage | Spatial Res./Footprint | Where to look at |
|---|---|---|---|---|
| Surface images | HiRISE | 2.4% | Res- 0.25-1 m/px<br>Width- Red: 6km wide, Color: 1.2 km wide, Nominal length- 35km; | http://hirise.lpl.arizona.edu/ |
| | CTX | 95% | Res- 5 m/px<br>Width- 30 km | http://global-data.mars.asu.edu/ bin/ctx.pl |
| | MOC (-2006) | 6% | Res- <12 m/px | http://www.msss.com/moc_gallery/ |
| | HRSC | >90% | Res- 10-60 m/px<br>Swath width- 60 km | http://www.rssd.esa.int/PSA, http://ode.rsl.wustl.edu/mars/ |
| NIR spectral data (e.g., composition) | CRISM | 97% msp VNIR, to 36% hsp IR | Res- 20-200 (msp) m/px<br>msp Footprint: 10 km x 45-540 km | http://crism.jhuapl.edu/gallery/featuredImage/index.php |
| TIR spectral data (e.g, thermal inertia for rock counting, surface texture/ type, subsurface cavities) | TES (-2006) | Near global | Res- 3 km<br>Width- 5.3,<br>Length- 8.3 km | http://tes.asu.edu/data_archive.html |
| | THEMIS | Near global | Res- 100 m<br>Width- 20 km | https://themis.asu.edu/gallery |
| Digital Terrain Models/slope maps | HiRISE | 274 (there are more stereo images) | Meter-scale | http://www.uahirise.org/dtm/ |
| | HRSC | 75% | ~50 m/px | http://hrscview.fu-berlin.de/ |
| | MOLA (-2001 as altimeter) | global | 100s m spacing of points | http://mola.gsfc.nasa.gov/ |
| Radar | SHARAD | 40% | Swath width- 3km, Depth res.- 10m, Depth pen.- 300m | http://pds-geosciences.wustl.edu/missions/mro/sharad.htm |
| | MARSIS | 80% | Swath width- 10km, Depth res.- 100m, Depth pen.- 1km | http://pds-geosciences.wustl.edu/missions/mars_express/marsis.htm |

***Notes***: Rows in orange are those that can be requested. Atmospheric datasets (not listed) are also available. Global maps can be found at: http://www.mars.asu.edu/data/. A useful tool for looking at and analyzing multiple datasets: http://jmars.asu.edu/