Candidate landing sites in Valles Marineris: Ancient and Modern habitability

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Summary

- Mars 2020 objective is to study ancient habitability
- Valles Marineris provides the best exposures of the ancient geologic history of Mars
  - Interior Layered Deposits (ILDs) show various sulfates deposits, suggesting existence of abundant past water
  - The canyons may also have the best sites to investigate present-day habitability: Recurring Slope Lineae (RSL)
  - Due to planetary protection rules, we expect to observe RSL remotely on nearby slopes, but not directly visit with rover
- Difficult to find acceptable landing sites due to steep slopes and winds
  - We think there are possibilities in Melas Chasma, and maybe elsewhere (Capri Chasma and Juventae Chasma)
Juventae Chasma

- In the context of the Valles Marineris system
- Connected to Maja Vallis outflow channel
- Low point: -4.5km (>6km below surrounding plateau)
ILDs; Results of ancient aqueous history

Absence of small craters and high thermal inertia indicate that the ILDs are composed of sedimentary rock (Catling et al., 2006). Gypsum, Juventae Chasma LLO material, forms only at low temperatures (<60 °C) and thus excludes a volcanic origin. (Catling et al., 2006)

Monohydrated sulfate and polyhydrated Ca sulfate (Bishop et al., 2009) 50 wt% of kieserite (Clark et al., 2008)
“Confirmed” RSL at the top of the knob
RSL: Most easily explained by aqueous origin(s)

- Incremental growths during warm seasons. Fading in cold seasons
- Appear only on warm slopes when surface temperature is >250K
- Liquid brine near the surface might explain this activity
- But the source of water and mechanism behind its motion are not understood (e.g., McEwen et al., 2011; 2013)

Strength of absorptions at 920 and 530 nm (ferric iron) varies seasonally -- weaker when the RSL are inactive and stronger when the RSL are active (Ojha et al., 2014)
Many RSL found

Most in southern hemisphere (summer in southern hemisphere is warmer than northern hemisphere)

Many to be explored:
What time of day are RSL active?
What is the salt composition and concentration?
Where does the water come from?
No dry phenomena?
Is the water activity high enough for life?
Do RSL sample water from subsurface habitats?
Special Region?

Lengths of RSL and associated slope phenomena are expectable

Observing RSL remotely but not visiting with rover may be possible without violating planetary protection rules
Valles Marineris is a unique place holding evidence of ancient and current aqueous activities.

We propose Juventae, Melas, and Capri Chasmata as possible landing sites.
**Site Name**: Juventae

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Juventae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Coordinates</td>
<td>61.58W 4.39S</td>
</tr>
<tr>
<td>Elevation</td>
<td>-3100</td>
</tr>
<tr>
<td>Prime Science and distance</td>
<td>ILD 17 km</td>
</tr>
<tr>
<td></td>
<td>Volcanic rock 19 km</td>
</tr>
<tr>
<td></td>
<td>RSL 34 km</td>
</tr>
</tbody>
</table>

- **Sulfate mounds**
- **Confirmed RSL**
- **Deep Noachian wall rock**
- **maybe Noachian volcanics**
This area is covered by sand, providing fairly smooth surface. However may suffer poor Ka-band radar reflectance.
Valles Marineris is a unique place holding evidence of ancient and current aqueous activities.

We propose **Juventae, Melas, and Capri Chasmata** as possible landing sites.
Melas Chasma:
Widest and deepest part of the Valles Marineris

Outflow channels are 0.03 degree slope upward to the northern plains; would have a lake with a depth of one kilometer before flow out to the northern plains (e.g., Golombeck 1989)

Hydrated sulfates and various phyllosilicates detected among canyon units, suggesting existence of abundant past water (e.g., Gendrin et al., 2005, Murchie et al., 2009, Roach et al., 2010; Weitz et al., 2012, 2014)

Deepest part near the equator; may be useful for future manned mission/base
Red: kieserite type
Green: polyhydrated sulfate
(Gendrin et al., 2005; OMEGA)
Sulfate-bearing Layered Deposits

Candidate RSL
<table>
<thead>
<tr>
<th>Site Name</th>
<th>Melas Chasma</th>
</tr>
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<tbody>
<tr>
<td>Center Coordinates</td>
<td>68.52W 11.47S</td>
</tr>
<tr>
<td>Elevation</td>
<td>-4800</td>
</tr>
<tr>
<td>Prime Science</td>
<td>ILD 7.5 km, RSL 25 km</td>
</tr>
</tbody>
</table>

- **Landslide deposits**
- **Confirmed RSL**
- **Candidate RSL**
- **Hydrated sulfates**

The Site Name Melas Chasma has the following characteristics:

- **Center Coordinates**: 68.52W 11.47S
- **Elevation**: -4800
- **Prime Science**: ILD 7.5 km, RSL 25 km

The image shows a map with various geological features labeled, including landslide deposits, confirmed RSL, candidate RSL, and hydrated sulfates.
Melas Chasma

MOLA Topography (463 m/pix)

HRSC Elevation (75 m/pix)

MOLA

HRSC

CTX

CTX DEM (20 m/pix)

•H0334_0001_DT4 •H0515_0000_DT4 •H2028_0000_DT4 •H2039_0000_DT4 •H3195_0000_DT4

HRSC
Valles Marineris is a unique place holding evidence of ancient and current aqueous activities

We propose Juventae, Melas, and Capri Chasmata as possible landing sites
Candidate landing sites in Capri Chasma

Landing site mostly flat with 1-meter scale ripples
ESP_036069_1645

HiRISE images

More work needed to study mineralogy of this region.

Abundant RSL

20k m

clays

Signs of flowing water on Mars?
Floor of eastern Coprates Chasma to Capri is covered by lava (and thin sand cover)? Probably Hesperian in age, whereas most of the deep outer wall rock is Noachian.
<table>
<thead>
<tr>
<th>Site Name</th>
<th>Capri Chasma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Coordinates</td>
<td>50.50W 15.23S</td>
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<tr>
<td>Elevation</td>
<td>-4450</td>
</tr>
<tr>
<td>Prime Science</td>
<td>RSL 12 km</td>
</tr>
<tr>
<td></td>
<td>Volcanic rock &lt;1 km?</td>
</tr>
<tr>
<td></td>
<td>Outer Noachian rock 6km</td>
</tr>
</tbody>
</table>

Abundant RSL

clays

20k m

20k m

20k m

Abundant RSL
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