The Ultimate Goal: Refining Constraints for Human Landing Site Selection

47 Exploration Zone Candidates proposed at the 2015 NASA Mars Human Landing Site Workshop
### Overview of Mars Water ISRU Planning (M-WIP) Study Results

**May 15, 2019 Pre-Decisional Information -- For Planning and Discussion Purposes Only**

The ranked value of information for assessing potential for engineering viability

<table>
<thead>
<tr>
<th>CASE</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 (Ice+open pit)</td>
<td>Thickness of overburden</td>
<td>Mechanical properties of overburden</td>
<td>Mechanical consistency of ore deposit</td>
</tr>
<tr>
<td>A2 (Ice+subsurface)</td>
<td>Mechanical consistency of ore deposit</td>
<td>Thickness of overburden</td>
<td>Mechanical properties of overburden</td>
</tr>
<tr>
<td>B (hydrated sulfate)</td>
<td>2D geometry/size of ore deposit</td>
<td>Mechanical consistency of ore deposit</td>
<td>Distance to processing plant</td>
</tr>
<tr>
<td>C (clay)</td>
<td>2D geometry/size of ore deposit</td>
<td>Mechanical consistency of ore deposit</td>
<td>Distance to processing plant</td>
</tr>
<tr>
<td>D (regolith)</td>
<td>Water concentration of ore deposit</td>
<td>Mechanical consistency of ore deposit</td>
<td>Chemical properties of ore deposit</td>
</tr>
</tbody>
</table>

**Source:** M-WIP (2016)

**Purple:** Data can be measured from orbit

**Green:** Data needs to be measured on the ground, *in situ*
Subsurface Ice
Survey of locations with geomorphological features that are indicative of subsurface ice

Hydrated Minerals
Survey of detections of spectral signatures of major classes of hydrated minerals

From: Dickson et al., 2012

From Ehlmann and Edwards (2014)
### Mars Water Mapping Project Teams

#### Task A – Subsurface Ice Mapping

<table>
<thead>
<tr>
<th>Team 1</th>
<th>Team 2</th>
</tr>
</thead>
</table>
| Putzig et al. (PSI)  
*Mapping Buried Water Ice in Arcadia & Beyond with Radar & Thermal Data* | Morgan et al. (PSI)  
*Local Subsurface Ice Mapping Through the Integration of SHARAD Derived Data Products with Other Datasets* |

**Depth of shallow subsurface reflectors over Arcadia Planitia, (color = depth, yellow symbols = features used to constrain dielectric constant) [Putzig et al.]**

**SHARAD Corrected Power (dB)**

**SHARAD Power Return Map over Arcadia Planitia. Blue areas indicate potential ice within the top ~5m of the surface. Left to right is 0-60°N latitude [Morgan et al.]**

#### Task B – Hydrated Minerals Mapping

<table>
<thead>
<tr>
<th>Team 1</th>
<th>Team 2</th>
</tr>
</thead>
</table>
| Carter et al. (Paris-Sud Univ.)  
*A Global Aqueous Mineral Abundance Catalog for Mars* | Seelos et al. (APL)  
*CRISM-Derived Global Map of Hydrated Mineral Bearing Units* |

**Global Map of Areal Extent of Hydrated Mineral Detections [Carter et al.]**

**Map of two types of hydrated minerals and bound water over the Mars 2020 Nili Site Candidates [Seelos et al.]**
Subsurface Water Ice – Preliminary Northern Hemisphere Map

Datasets used: MONS, TES, THEMIS, SHARAD, Geomorphology (imagery and elevation data)

Multiple datasets show indications of ice within 0-100m of surface

Region not mapped due to high elevation (not landable by human-class vehicles)

Arcadia Study Region

White dots = Fresh ice exposing impacts mapped by Dundas et al. [2014] showing good agreement between this map and observed data

Map of boundaries of thickness of ice-rich deposits over the Arcadia study region, indicating a subsurface ice-rich deposit of 15-60m thickness throughout the region
A pilot study performed by the SWIM team over the Arcadia Planitia region improved the previous state of the art by:

1. Extending reflector mapping coverage over region
2. Detecting more equatorward ice at \( \sim 35.6^\circ \text{N} \) (compared to \( \sim 39^\circ \text{N} \) previously)
   - Eases thermal design requirements landed ice exploration missions
3. Incorporating 19 additional topographic features to better refine the dielectric constant and hence estimate of material composition
   - Updated results indicate a larger fraction of non-ice material in the subsurface

Previous state of the art over Arcadia Planitia:
Bramson et al. 2015

SWIM Project:
- Increased coverage
- Refined dielectric constants (material composition)
- More-equatorward detections
Hydrated Minerals Mapping Preliminary Results

[Preliminary] Global map of mineral detections compiled from the entire OMEGA dataset by Carter et al.

[Preliminary] Map of the strength of the D2300 spectral feature (corresponding to the presence of Fe/Mg phyllosilicates and Mg-carbonate) over Jezero Crater and the Nili Fossae Region by Seelos et al.

Perspective view of Jezero delta

- Mg Carbonate + Brucite (Mg)
- Fe/Mg clay, serpentine
- Kaolins & silica
- Akaganeite (Fe,Cl)
- Sulfate
Potential Future Uses of Mars Water Maps

**Informing Future Orbital Science / Reconnaissance**
Provide targets and requirements for potential future orbiter mission(s) carrying new instruments to better characterize the distribution and depth of hydrated minerals and subsurface water ice deposits.

**Guiding Future Surface Science / Reconnaissance**
Revealing landing site options for a potential future landed ground truthing mission that will validate orbital measurements and further characterize possible water feedstocks.

**Selecting Humans Landing Sites / Exploration Zones**
Supporting human landing site selection activities and ongoing architecture studies for future human surface systems.
Thank You!

For more information on the water maps, visit:
https://www.nasa.gov/journeytomars/mars-exploration-zones and https://swim.psi.edu

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