RADAR INVESTIGATIONS OF THE MARS 2020 ROVER LANDING SITES.

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Introduction: We have used a combination of orbital and Earth-based radar data to investigate the surface and shallow subsurface (0–5 m and > 10–100 m) of the eight original candidate landing sites for the Mars 2020 (M2020) rover. Radar data provides information on a range of properties including, surface roughness, rock distributions, surface composition and subsurface structure, all of which are beneficial to landing-site assessment studies and planning for surface science operations. Building upon strategies adopted for characterization of the InSight landing site in Elysium Planitia [1-2], we have used sounding radar data from the Shallow Radar (SHARAD) instrument on Mars Reconnaissance Orbiter and S-band (12.6 cm) Arecibo Earth-based radar imaging data. **We will present the results of our analysis of all eight sites,** with particular attention paid to the remaining three candidates: **Columbia Hills, Jezero Crater and Northeast Syrtis [citation?].**

SHARAD Data: SHARAD has a center frequency of 20 MHz (15 m wavelength) and can penetrate through tens to hundreds of meters of rock to reveal buried subsurface interfaces. The M2020 mission has a ground penetrating radar instrument, RIMFAX, that will operate at a higher range of frequencies (150 MHz to 1.2 GHz) relative to SHARAD [3]. Nevertheless, the two instruments could potentially detect the same shallow interfaces. Hence, we have searched for subsurface reflectors below the sites in all the available SHARAD coverage. In addition, the strength of the SHARAD surface echo along each profile can be used to assess roughness relative to the wavelength scale [4]. We have taken full advantage of this property to constrain the slope distributions over horizontal scales of 10–100 m.

Subsurface Reflectors: SHARAD data are presented as radargrams (Figure 1), displaying round-trip delay time on the vertical axis and along-track distance on the horizontal axis. The radar has a free-space vertical resolution of 15 m, yielding a 5–10 m vertical resolution within common silicic geological materials [5]. Reflectors recorded at a greater time delay relative to surface reflections may be considered subsurface interfaces, but clutter (reflections from topographic variations of the surface within the radar beam that have a longer direct path to MRO relative to the nadir return) can interfere with or be indistinguishable from real subsurface returns. To account for the origin of delayed returns, we have employed cluttergrams, which simulate the expected SHARAD echoes using surface-elevation data (Fig. 1).

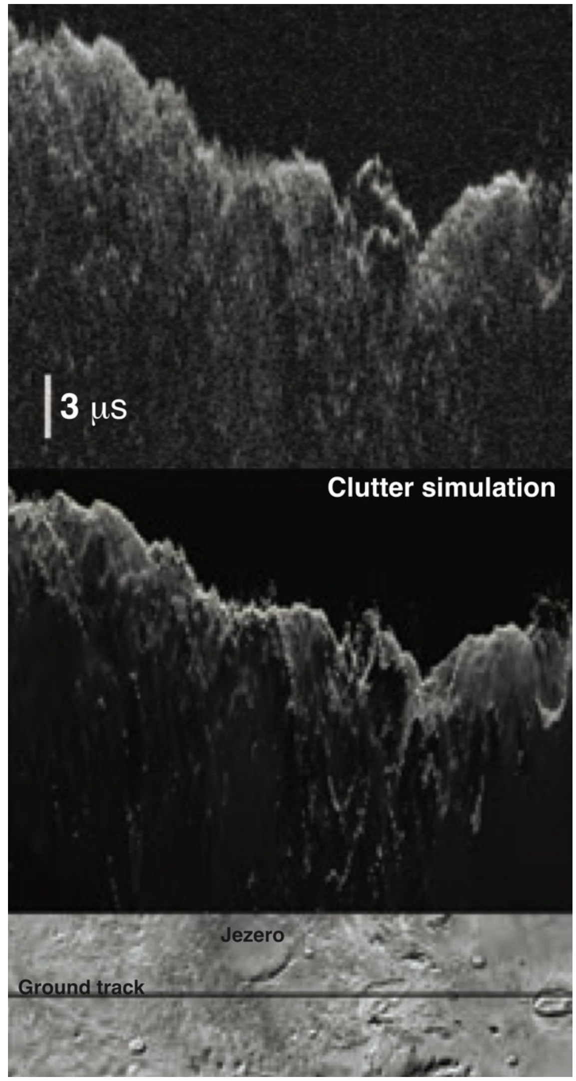

***Figure 1**. (Top) Northeast Syrtis Radargram (1826901) and (Middle) accompanying cluttergram. Due to the size of the SHARAD footprint (500 m along track, >3 km across track, (Bottom) the topographic variations present in Northeast Syrtis generates a lot of clutter, making the search for subsurface reflectors problematic.*

Surface Roughness: Although designed primarily to provide information about the subsurface of Mars, SHARAD echoes also contain a range of additional information including Fresnel reflectivity and surface physical properties. [4] developed a methodology to extract a parameter for surface roughness from SHARAD data that is complimentary to that of the two MOLA derived roughness measurements [6-7] (Fig. 2).

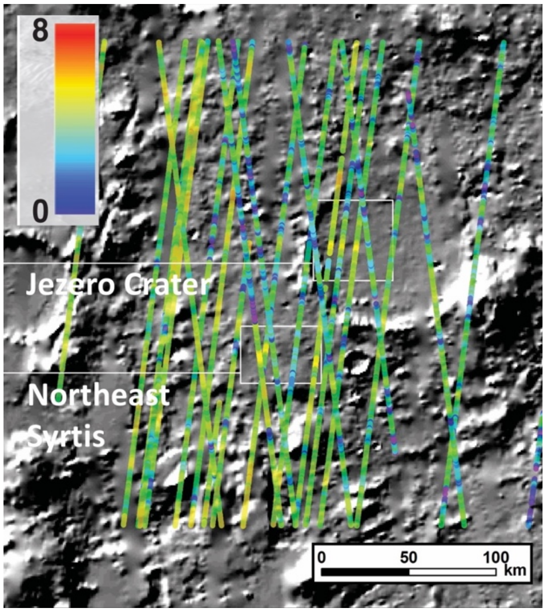

Figure 2. *SHARAD roughness parameter [4] data over Northeastern Syrtis and Jezero crater. Both sites exhibit similar roughness distributions. Since these sites were not considered for previous missions, SHARAD coverage is sparse relative to that of the six other sites.*

SHARAD data are sensitive to horizontal scales that range from the scale of the radar wavelength to scales comparable to the illuminated footprint: ~10–100 m. These scales are considerably finer than the shortest baseline of MOLA derived roughness of [6], which is 600 m. The SHARAD roughness scale lengths are equivalent to that of MOLA pulse-width measurements [7]. However, there are significant gaps in the coverage of the latter dataset due to a large number of the MOLA pulses being oversaturated.

Arecibo Earth Based Data: The Arecibo S-Band (12.6 cm) radar dataset collected by [8] is sensitive to the roughness and dielectric properties of the surface/shallow subsurface, and can provide unique information regarding near-surface rock distributions (at the same scale as the transmitted wavelength and longer). Critical to the M2020 mission, the Arecibo data provides a means to characterize the microwave reflectivity of the surface over wavelength scales comparable to the descent radar altimeter. Accurately establishing the rover's altitude during descent is of course essential to a successful landing. Evaluating the Arecibo data therefore ensures there are no surface units with anomalously low reflectivity properties (i.e. stealth-like terrain [citation needed]), which could cause erroneous altimetry readings.

The histograms in Fig. 3 show the radar reflectivity for three surface unit types: Late Amazonian volcanics, Hesperian volcanics, and Medusae Fossae Formation material, where the latter is associated with stealth-like terrain. The Mars2020 sites can be compared to these unit type distributions and with other landing sites.

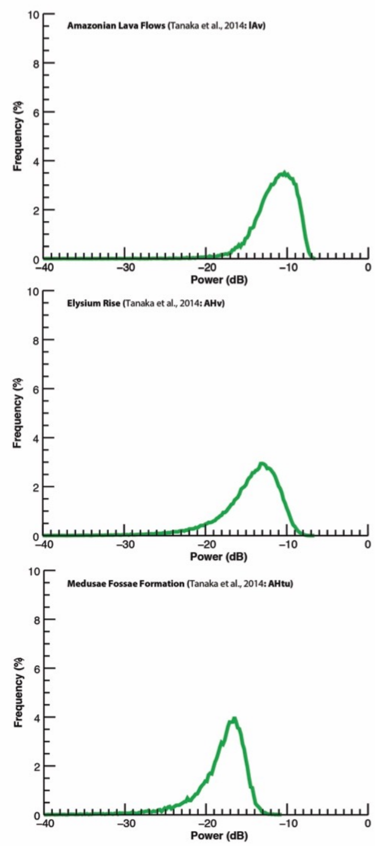

Figure 3. *Arecibo radar reflectivity for three Tanaka et al [2014] surface-unit types. Such distributions provide a 'library' of martian terrain backscatter response which can be compared to the M2020 candidate landing sites.*

LPSC Presentation: For each of the sites we will present (1) a full survey of all available SHARAD radargrams to search for subsurface reflectors, (2) a comparison of the SHARAD roughness statistics for each site with previous landing sites and distinct martian terrain types, and (3) an assessment of whether any of the sites exhibit anomalously low radar reflectivity. In the mean time we will continue to target the three remaining landing sites with new SHARAD observations to improve coverage density.

References: [1] Golombek et al., 2017, Spac. Sci. Rev. 211, 5-95; [2] Putzig et al., 2017, Spac. Sci. Rev. 211, 135-146; [3] Hamram et al., 2016, 3rd Int. Workshop Instrumentation Planetary Mission. 4031 [4] Campbell et al., 2013, JGR, doi: 10.1002/jgre.20050; [5] Seu, et al., 2007, JGR., doi:10.1029/2006JE002475; [6] Kreslavsky & Head., 2000, JGR, 105, 695; [7] Neumann, G. et al., 2003, GRL, 30, 1561; [8] Harmon, et al., 2012, Icarus, 220, 990–1030.