LOOSE SOIL PRESENCE AND CHARACTERISATION AT THE EXOMARS 2020 ROVER CANDIDATE LANDING SITES.

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Introduction: The 2020 ExoMars rover will be launched in 2020 to the surface of Mars [1]. Choosing the best landing site for the platform and the rover involves evaluating a safe place for landing, a safe place for driving, and the best place to find past signs of life.

The LSSWG (Landing Site Selection Working Group) for the ExoMars 2020 rover gathers scientists and engineers to make a recommendation for the best site for the ExoMars rover mission.

Three landing sites have been preselected and are under further study at the moment: Oxia Planum, Aram Dorsum and Mawrth Vallis. More exactly, Oxia Planum is one of the two final sites and a next landing site selection workshop will help selecting between Aram Dorsum and Mawrth Vallis as the second final site [2].

The nominal surface mission will imply driving few km on the surface to investigate a diversity of rock units and samples.

One of the concerns for the safety and the efficiency of the surface mission is the presence of loose soil in which the rover wheels could sink, and hence limit the driving capacity, or even stop the progress of the rover. The landing sites show the presence of aeolian bedforms, dunes and ripples, which can be easily recognized on HiRISE images, but loose soil can also be present as flatbeds, which appear as smooth, even surfaces on HiRISE images. For example, the Mars Exploration Rover Spirit sank into thick, flat, loose soil deposits, which presence was difficult to predict.

Mapping method:

Sample mapping. Loose soil deposits can be widespread, but as small as a few tens of cm wide. Hence, correctly quantifying their presence requires mapping them at the highest resolution. A landing site for ExoMars can be more than 3500 km² in surface area, as landing ellipses have a long axis between 100 and 124 km long, and a short axis around 20 km long. Few tens of HiRISE images are available for each site. Mapping such a large area at the highest resolution is perhaps too ambitious.

For this reason, we decided to map small-area samples (200 m x 200 m), located on a 5 km-spaced grid in the north-south and east-west directions. This resulted in about 60 to 80 samples for each site.

Mapping units: We defined five different surface type to classify any surface:

- bedrock: generally bright surface, with high frequency texture, where a rover should not sink at all,
- individual aeolian bedform: isolated dune or ripple that can be easily avoided by a rover,
- aeolian bedform field: adjacent ripples or dunes, can be a large obstacle for the rover,
- thick dust/sand cover: a homogeneous dust or sand cover that hides any underlying morphology or texture at the ten meters horizontal scale.
- thin dust/sand cover: a dust or sand cover that smooths the surface, hiding rocks but partly revealing underlying morphology or texture.

Figure 1 shows an example of a mapped sample at the Oxia Planum site.

Potential hazard for the rover. Aeolian bedforms are a hazard to drive through, as the thickness can easily reach few tens of cm; the thick dust/sand cover is expected to be few tens of cm as well, up to few meters or more, in craters for example. The thin dust/sand cover shows more uncertainty, with thickness probably from few cm to few tens of cm. The bedrock surfaces are generally the safest surfaces to drive, although float rocks and fractures can also be hazardous.

Mapping results:

Oxia Planum. Roughly one third of the surface of this landing site is made of bedrock, one third of thick sand deposits, comprising flat beds and aeolian bedforms, and one third is made of a thin dust or sand cover. The bedrock corresponds to both the clay-rich layered rocks and to the dark cap that was probably emplaced by lava flows [3]. At the outer limits of the site (to the north-west and to the south-east, the thin dust/sand cover is more prominent, and hides a possible larger extension of the clay-rich rocks. Thick sand deposits are widespread, although denser at the base of the delta/fan identified to the east of the site [3].

Aram Dorsum. A large majority of the surface of the site is covered by a thin layer of dust that smooths the underlying rocks. Thicker sand or dust deposits like flat beds or aeolian bedforms are also identified, but are also generally covered with dust. The bedrock unit is only present directly at the surface on steep surfaces, in cliffs or in groups of boulders. Thick deposits seem to be more prominent around the main inverted channel at the center of the site [4].

Mawrth Vallis. Around 15% of the surface of this site is made of bedrock directly at the surface; of the three sites, the bedrock is the flattest at this site. But half of the remaining surface is covered with thick sand deposits (flatbeds or aeolian bedforms), while the other half is covered with thin dust or sand deposits. The dark cap that covered the whole area is under erosion [5], and produces sand that feeds the thick deposits.

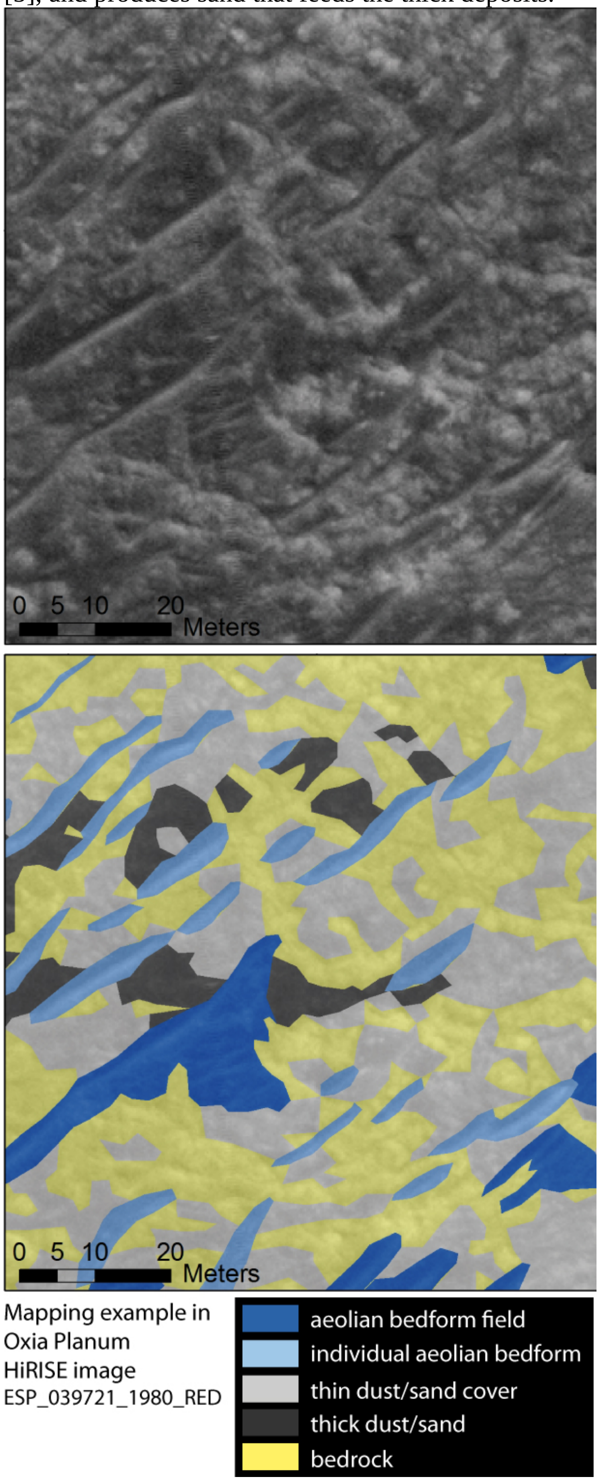

Figure 1: Image of the surface and corresponding mapping for an example at the Oxia Planum landing site.

Limits of the mapping method: From HiRISE images, from orbit, it is not possible to evaluate the grain size of the dust and sand deposits at the surface. It is merely possible to evaluate the thickness of these deposits. The behavior of the rover wheels (will they sink or not) will depend on this grain-size. Hence, the mapping method that we developed in this work cannot be directly transposed to a mapping of drivable surfaces.

In addition, mapping 200 m x 200 m boxes spaced every 5 km on the site covers only 0.1% of the site. The representativeness of the mapping can be questioned. However, when the units are large, this sample mapping can show good results and even reveal the lateral variations in loose deposits at the surface of the site.

Conclusion: From the mapping method developed in this study, and recognizing its limits, it emerges that among the three candidate sites, Oxia Planum has the largest surface made of bedrock, where driving may have the least uncertainty. Aram Dorsum is dominated by dust deposits of various thicknesses where driving capacities are less certain, and Mawrth Vallis has the largest surface area of the three sites occupied by thick sand deposits that should better be avoided.

References: [1] Vago J. et al. (2017) *Astrobiology*. [2] ExoMars 3rd Landing Site Selection Workshop Final Report, *EXM-RM-REP-ESA-00005, 18 December 2015*. [3] Quantin C. et al., (2015) ExoMars LSSW#3. [4] Balme M. et al., (2015) ExoMars LSSW#3. [5] Poulet F. et al., (2015) ExoMars LSSW#3.