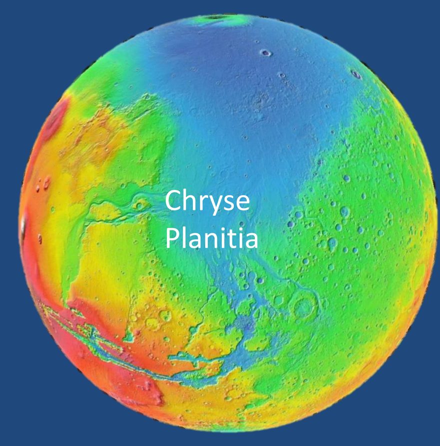

Selection and Characterisation of the ExoMars 2020 Rover Landing Sites

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Introduction

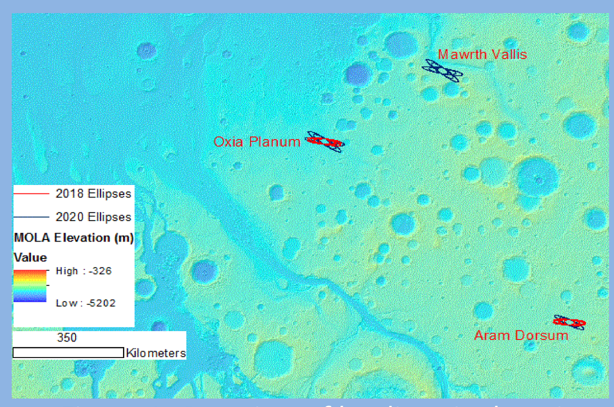
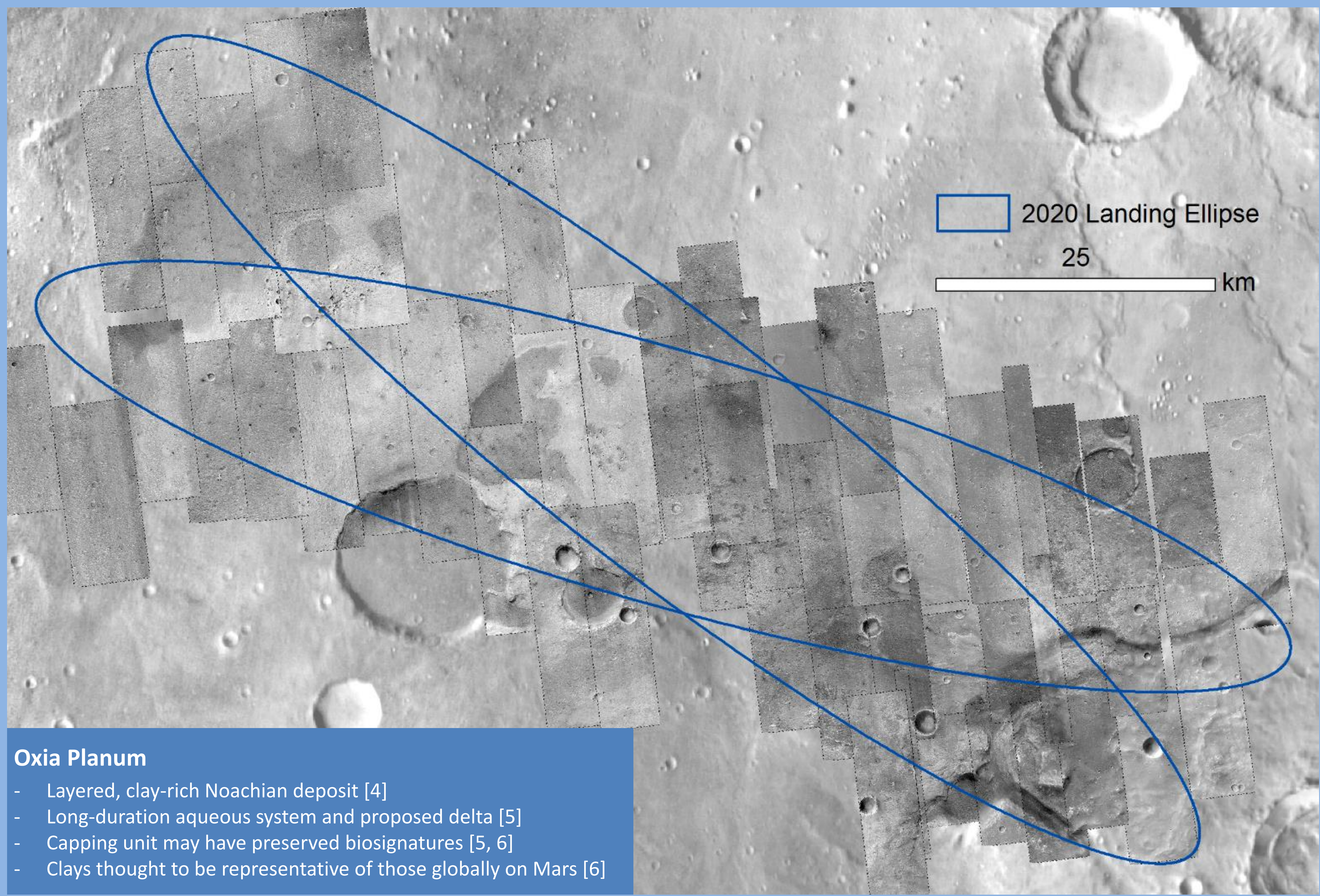


Figure 1: Overview of landing site locations.

Due for launch in 2020, the ExoMars rover currently has three candidate landing sites in the Chryse Planitia region of Mars: Oxia Planum (Fig. 2), Aram Dorsum (Fig. 3) and Mawrth Vallis (Fig. 5). Site selection and characterisation is beingundertaken through workshops and a Landing Site Selection Working Group (LSSWG). The characterisation of the landing sites requires a large number of observations by HiRISE, including DTM analysis to calculate slopes over different scales [1], and CRISM to determine the surface mineralogy [2]. Here we present the current HiRISE image coverage of the landing sites, along with analysis of transverse aeolian ridges (TARs) and rock abundance. Mapping has been conducted, led by the LSSWG, to evaluate the risk of encountering rocks that would be too large for the rover, and identify the area covered by aeolian bedforms and other types of loose material at the surface [3]. A summary of the sites' characteristics are shown in table 1.

	Oxia Planum	Aram Dorsum	Mawrth Vallis
Lat, Long	18.14 N, 335.76 E	7.869 N, 348.8 E	22.16 N, 342.05 E
Azimuth Range	100 - 125°	93 - 116°	102 - 129°
Semi-Major Axis	60 km	50 km	60 km
Elevation	100% <-2 km -3.6 km to -2.66 km	≥ 93% <-2 km -2.57 km to -1.88 km	≥ 89% <-2 km -3.02 km to -1.46 km
Slopes (baseline)	**% Compliant**	**% Compliant**	**% Compliant**
2-10 km	>99	>99	>98
330 m	98	99	98
7 m	94	95	88
2 m	95	95	92
Thermal Inertia	100% ≥ 150 J m^{-2} $s^{-0.5}$ K^{-1}	99% ≥ 150 J m^{-2} $s^{-0.5}$ K^{-1}	99.5% ≥ 150 J m^{-2} $s^{-0.5}$ K^{-1}
Albedo	100% 0.1 - 0.26	100% 0.1 - 0.26	100% 0.1 - 0.26
TAR Coverage	4.1 %	1.4 %	20.3 %
Rock Abundance (d≥18, 35 cm)	8.2, 5%	10.9, 6.9%	7.1, 4.2%

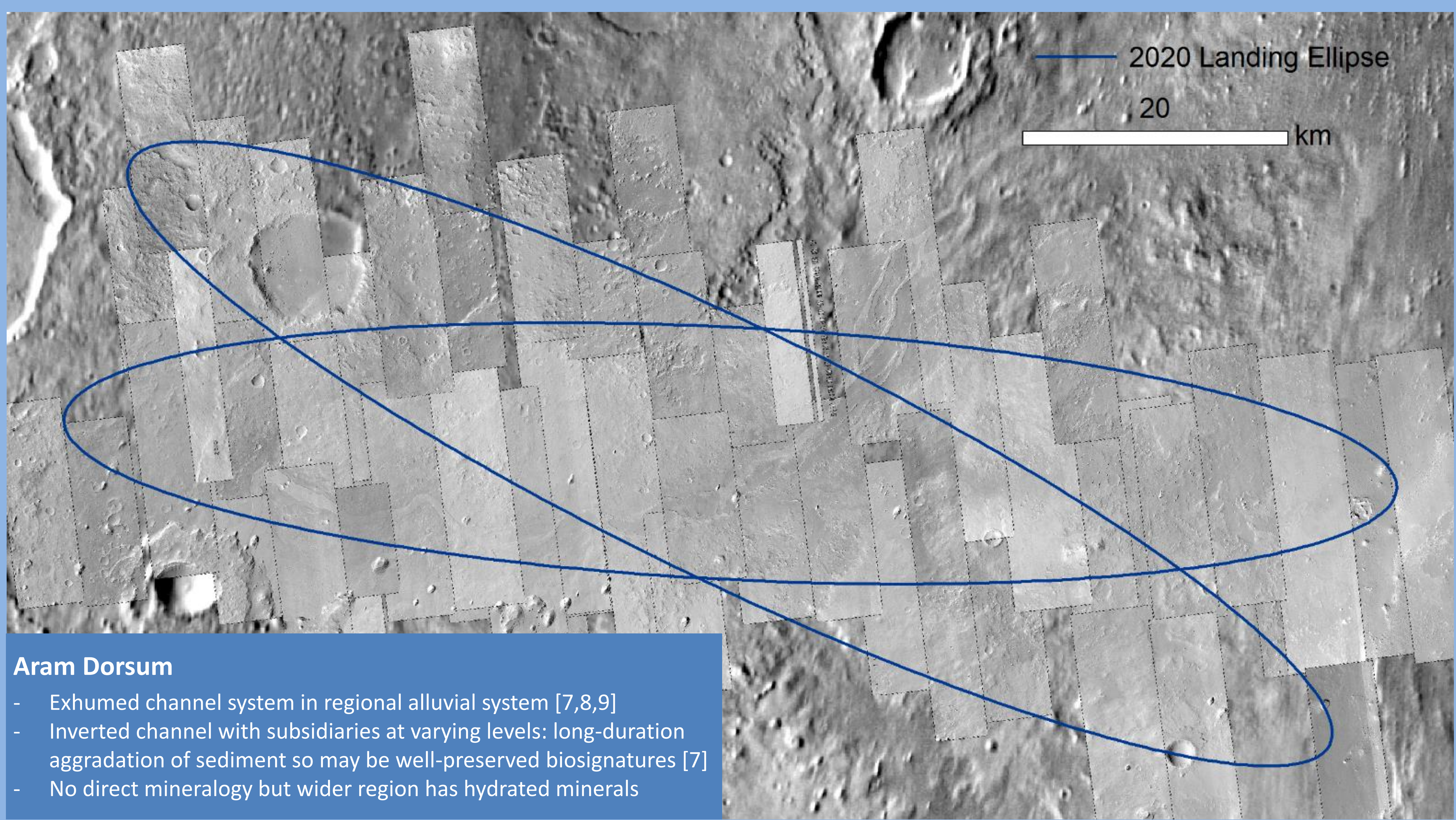
Table 1: Summary of landing site characteristics. Each location has been analysed as a region encapsulating all possible azimuth ranges, and percentages therefore represent these regions.



Oxia Planum

- Layered, clay-rich Noachian deposit [4]
- Long-duration aqueous system and proposed delta [5]
- Capping unit may have preserved biosignatures [5, 6]
- Clays thought to be representative of those globally on Mars [6]

Figure 2:HiRISE coverage of Oxia Planum.



Aram Dorsum

- Exhumed channel system in regional alluvial system [7,8,9]
- Inverted channel with subsidiaries at varying levels: long-duration aggradation of sediment so may be well-preserved biosignatures [7]
- No direct mineralogy but wider region has hydrated minerals

Figure 3: HiRISE coverage of Aram Dorsum.

The ExoMars Rover

The ExoMars rover will search for traces of past or present life, and ideally will land at an ancient site with good biosignature preservation potential. It will be equipped with a drill for obtaining sub-surface samples up to a depth of 2 m, and a suite of instruments for investigating the surface, including PanCam and ISEM for identification of targets and MicrOmega and RLS to carry out mineralogical studies.

Figure 4: Transverse Aeolian Ridges (TARs) in crater located near the Oxia Planum landing ellipse.

TARs

Transverse Aeolian Ridges (TARs) have been found to be widespread across Oxia Planum. They vary in size and density as can be seen from Fig. 5. Approximately 1.8 × 10^8 m^2, 7.2 × 10^8 m^2 and 1.4 × 10^8 m^2 of Oxia Planum, Aram Dorsum and Mawrth Vallis, respectively, have been mapped at 1:2000 scale with the results shown in table 1. The mapped TARs are generally ~10 m scale in their traverse dimension, but bedforms 2 – 3 m across could still be a major hazard for ExoMars [10]. The results of a complementary mapping programme to determine the coverage of loose soil are summarised in [3].

Rock Abundance

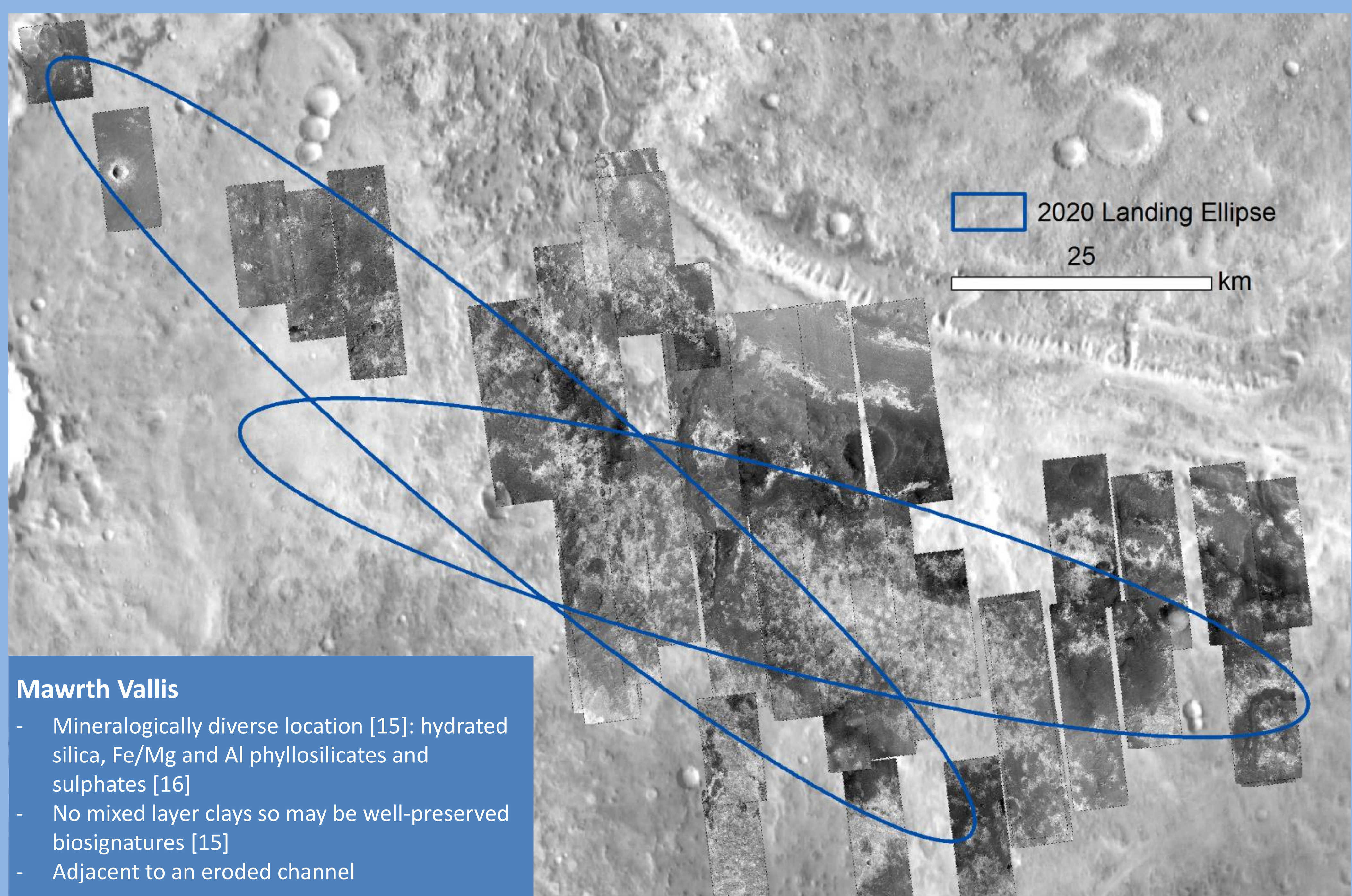
Cumulative size frequency distributions of rocks resolved in HiRISE images were used to infer abundance of unresolved small rocks, based on the model of [11]. The model defines the cumulative fractional area, $f_k(d)$ that is covered by float rocks with a minimum diameter, d. The rock abundance factor, k governs the distribution of diameters. The model does not account for other shadow-casting features such as rocky outcrop. Manual counts contain some non-rock features, and consequently our retrievals of rock abundance factors for each site probably over-estimates float rock abundance. However, this 'apparent' rock prevalence of short-baseline slopes is relevant to lander safety and rover traversibility. Geologically representative areas within landing ellipses were selected to sample rock abundance [12], though accounting for ≲1% of the total ellipse area. Coverage will be improved in future results from automated counts.

To minimize contributions from ambiguous features near the resolution limit, and from large non-float rock features, which disproportionally inflate cumulative distributions, we find optimal least squares best-fits to the model occur when constraining diameters such that $1.5 \le d \le 2.25$ m, in agreement with [13].

If $d = 0$ then $f_k(d) = k$, yielding apparent rock abundance factors of 0.138, 0.176 and 0.122 for Oxia Planum, Aram Dorsum and Mawrth Vallis, respectively. We also calculate $f_k(d \ge 0.18)$ to evaluate the abundance of only hazardous-sized features (where 0.18 m is the surface platform clearance [12Abs]), giving the far lower abundances shown in table 1. Features relevant to rover traversibility (i.e. larger than the rover's clearance of 0.35 m) are also shown in table 1, all lower than the 7% areal coverage nominal safety limit.

Conclusions

The ExoMars rover will investigate the Martian surface to search for past or present life. Oxia Planum is the leading candidate landing site.



Mawrth Vallis

- Mineralogically diverse location [15]: hydrated silica, Fe/Mg and Al phyllosilicates and sulphates [16]
- No mixed layer clays so may be well-preserved biosignatures [15]
- Adjacent to an eroded channel

Figure 5:HiRISE coverage of Mawrth Vallis.

References: [1] Fawdon, P., et al., (2017) LPSC 48, *this conference*. [2] Turner, S.M.R., and Bridges, J.C., (2017) LPSC 48, *this conference*. [3] Loizieau, D., et al., (2017) LPSC 48, *this conference*.[4] Quantin C. et al. (2014) ExoMars LSSW#1. [5] Quantin C. et al. (2015) EPSC2015-704. [6] Quantin C. et al. (2015) ExoMars LSSW#3. [7] Balme, M., et al. (2016) LPSC 47, 2633. [8] Balme M. et al. (2015) ExoMars LSSW#3. [9] Davis, J.M., et al., (2016) *Geology*, *44*(10), pp.847-850. [10] Balme, M., et al., (2017) LPSC 48, *this conference*. [11] Golombek, M., and Rapp, D., (1997) *J. Geophys. Res.* 102(E2) p. 4117-4129. [12] Sefton-Nash, E., et al., (2016) LPSC 47, 1918. [13] Golombek, M., et al., (2012) *Mars Journal* 7, p.1-22. [14] ExoMars 2018 Landing Site Selection User's Manual (2013), ESA (EXM-SCI-LSS-ESA/IKI-003). [15] Poulet, F., et al. (2015) ExoMars LSSW#3. [16] Carter J. et al. (2015) EPSC2015-661.