WHERE TO LAND WITH EXOMARS 2018: THE CANDIDATE LANDING SITES. J. Flahaut[1], D. Loizeau[2], J. L. Vago[3], the LSSWG[4] and the ExoMars team. [1]VU University Amsterdam, The Netherlands (jessica.flahaut@ens-lyon.org), [2]Université de Lyon, France (damien.loizeau@univ-lyon1.fr), [3]ESA-ESTEC, The Netherlands.

[4]*Landing Site Selection Working Group (LSSWG): F. Westall, H. G. Edwards, L. Whyte, A. G. Fairén, J.-P. Bibring, J. Bridges, E. Hauber, G. G. Ori, S. Werner, D. Loizeau, R. Kuzmin, R. M. E. Williams, J. Flahaut, F. Forget, J. L. Vago, D. Rodionov, O. Korablev, O. Witasse, G. Kminek, L. Lorenzoni, O. Bayle, L. Joudrier, V. Mikhailov, A. Zashirinsky, S. Alexashkin, F. Calantropio, and A. Merlo.*

Introduction: The ExoMars Programme consists of two missions, scheduled in 2016 and 2018. The 2018 mission will land a rover, provided by ESA, making use of a Descent Module contributed by Roscosmos. The rover scientific objectives are to search for signs of past and present life on Mars and to investigate the water/geochemical environment as a function of depth in the shallow subsurface. On this purpose, the rover will carry a comprehensive suite of instruments (the Pasteur payload) dedicated to geology and exobiology research. The rover will be able to travel several kilometres, analysing surface and subsurface samples, down to a 2-meter depth. The very powerful combination of mobility with the ability to access in-depth locations, where organic molecules can be well preserved, is unique to this mission. The rover will also perform numerous investigations on rocks and soils, also contributing to the mission objective of characterizing the surface environment [1,2].

Landing site constrains: An invitation has been launched to the community to propose scientifically compelling sites for the mission [3], which respect the main engineering constraints for landing and operation, among which: a landing ellipse of 19 km x 104 km (with varying azimuth between 90°-127° depending on the launch date), an altitude < -2 km, a latitude between 5°S and 25°N, a thermal inertia > 150 J m^{-2} $s^{-0.5}$ K^{-1}.

Scientifically interesting sites include locations with evidence for long duration or frequently recurring aqueous activity, low energy transport and deposition, fined-grained, recently exposed sediments, and/or hydrated minerals such as clays or evaporites. The outcrops of interest must be distributed over the landing ellipse to ensure that the rover can access some over a short distance. The site must also compel with planetary protection requirements: It must not contain features currently considered as Mars Special Regions (gullies, bright streaks, recurrent slope lineae…) [3].

Eight proposed sites: The received proposals have been reviewed by the Landing Site Selection Working Group (LSSWG) and eight sites were found to be compliant with the science, engineering, and planetary protection requirements [4]. These sites were presented by their proposers and discussed at the first Landing Site Selection Workshop (LSSW) that took place in ESAC, Spain, 26-28 March 2014. Presentations are available at http://exploration.esa.int/mars/53944-proposed-landing-sites-for-exomars-2018-mission/.

Given the strict engineering constrains of the mission, three large areas of the martian surface have been identified as potentially accessible: Chryse Planitia, Isidis Planitia, and southern Elysium. Eight landing sites have been proposed by different teams: one site is located in Isidis Planitia, whereas the other seven sites are spread over the Chryse Planitia area (Figure 1).

We describe hereafter (from South to North) the geology of the landing sites as they were presented at the 1st LSSW.

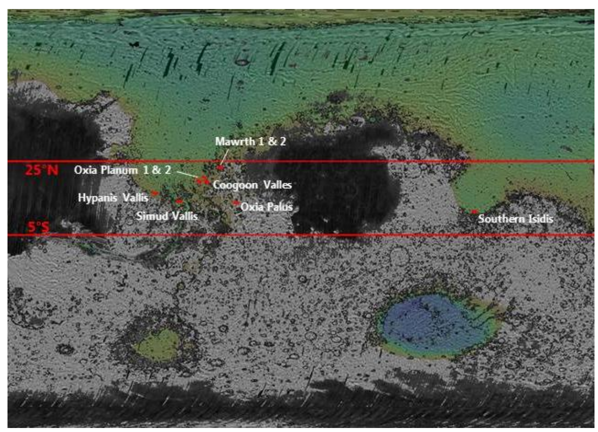

Figure 1: Accessible areas are in colour between the two latitude limits, light grey shows altitudes too high, and dark grey shows slopes too steep and surfaces with thermal inertia too low.

Isidis Planitia (4.35°N, 86.2°E) [5]. The proposed ellipse lies on the early Hesperian plains of southern Isidis Planitia, just north of the boundary with the Noachian highlands of Libya Montes. Potential science targets: 1) exhumed Noachian fluvial deposits, valleys, and ridges (inverted valleys or eskers); 2) Noachian highland remnants and deposits rich in Fe/Mg and Al-rich phyllosilicates; and 3) the Deuteronilus and Arabia contacts, which were interpreted as putative paleoshorelines [6,7].

Coogoon Valles (6º29´N, 23º 28´W) [8]. The proposed ellipse lies at the end of the Coogoon Valles system, between Mawrth Vallis and Ares Vallis. Coogoon Valles is an understudied Mars feature although it shows clear indications of past water activity, including flow channels, scablands, layered sedimentary deposits, craters with fluidized ejecta and high albedo materials of special interest because of their associate origin with aqueous solutions. In the proposed ellipse, layered deposits show the presence of phyllosilicates, with a similar mineralogical sequence than at Mawrth Vallis.

Oxia Palus (7.9°N, 348.8°E) [9]. The proposed ellipse lies ~100 km north of Crommelin crater in Oxia Palus. The site comprises layered sedimentary rocks with distinct development of a prominent inverted channel ridge (>80 km long). The superposing materials that comprise the rest of the site appear to be a mixture of sedimentary deposits and suggest that the inverted channel system has only relatively recently been exhumed.

Simud Vallis (8.49°N, 325.24°E) [10]. The proposed ellipse lies at the junction of Simud Valles and Tiu Valles, two outflow channels connected to the north with the Chryse Basin, and just west of the Mojave crater. Crater counts suggest an age of 3.55 Gy, belonging to the early-late Hesperian epoch. The considered area is characterized by a complex geomorphological evolution, as evidenced by many structures, which have been recognized and mapped inside and in the proximity of the landing ellipse, including fluvial channels and ridges [11].

Hypanis Vallis (11.8°N, 314.96°E) [12]. The proposed ellipse lies on one of the many exhumed fluvial fan/deltaic systems at the termination of Hypanis Vallis. This site contains fan-like deposits that were interpreted to be the remnants of a prograding delta. Although very few CRISM observations are available within the ellipse, the lower strata of this delta might be enriched in Fe/Mg-rich phyllosilicates as suggested by detections in other fans in the vicinity of the ellipse.

Mawrth Vallis (22.16°N, 342.05°E) [13,14]. The proposed ellipse lies in middle to late-Noachian terrains Southwest of the Mawrth Vallis channel and was suggested as a landing site by two independent teams. The region surrounding Mawrth Vallis contains one of the largest exposures of phyllosilicates detected on the Martian surface [15]. These phyllosilicates occur in light-toned layered deposits of unknown origin (possibly aqueous or aeolian sediments, pyroclastic deposits, or deposits from an ancient ice cap [16-18]). Outcrops in Mawrth Vallis are compositionally diverse, with a generally observed sequence of Al-phyllosilicates on top of Fe-smectites over large surfaces, and local outcrops of sulfates, indicating multiple wet environments. The rocks show the highest degree of alteration identified on Mars. The deposition and alteration are ancient (mostly > 3.8 Ga), and the rocks are well preserved.

Oxia Planum (EL1: 24,55°E; 18,2°N. EL2: -26,81°E; 16,63°N) [19]. Two ellipses were proposed in the Oxia Planum area, west of the Coogoon Valles system. These ellipses were chosen to overlap the extended exposures rich in Fe/Mg-phyllosilicates detected on both OMEGA and CRISM multispectral data, which represent the largest clays detections in the Chryse Planitia region. These detections are associated to layered rocks and may represent the Southwestern expansion of the Mawrth Vallis clay-rich deposits, pointing to an extended alteration process. The crust there is ancient (> 4 Ga) and have undergone intense erosion > 3.6 Ga ago, although the phyllosilicate bearing rocks have been exposed recently (< 100 Ma ago). Both ellipses have fluvial-related morphologies such as valleys and a fan or delta (EL1).

Preliminary assessment and future work: Following the 1st LSSW, the LSSWG will produce a ranked list narrowed down to four final candidate landing sites, and should make a recommendation in time for the mission's System Preliminary Design Review (S-PDR), planned for June 2014. Further imaging for terrain characterisation is taking place by agreement with HiRISE (25 cm/pixel and stereo) and near IR observations with CRISM. The four final sites will be presented at the time of the conference.

Acknowledgments: The LSSWG wishes to thank all the proposers and workshop participants, as well as the HiRISE, CRISM, HRSC and OMEGA instrument teams, for their insightful contribution to the landing site selection process of the ExoMars 2018 mission.

References: [1] Vago J.L. et al. (2013), ESA Bulletin 155. [2] http://exploration.esa.int/mars/48088-mission-overview/ [3] http://exploration.esa.int/mars/53462-call-for-exomars-2018-landing-site-selection/ [4] Vago J.L. et al. this meeting [5] Erkeling G. et al., 1st Exomars 2018 LSSW. [6] Clifford, S. M., & Parker, T. J. (2001), Icarus, 154(1), 40-79. [7] Parker, T. J. et al. (1993) JGR 98(E6), 11061-11078. [8] Gómez F. et al., 1st Exomars 2018 LSSW. [9] Balme M. et al., 1st ExoMars 2018 LSSW. [10] Pajola M. et al., 1st Exomars 2018 LSSW. [11] Pajola M. et al., this meeting [12] Gupta S. et al., 1st ExoMars 2018 LSSW. [13] Gómez F. et al., 1st ExoMars 2018 LSSW. [14] Poulet F. et al., 1st ExoMars 2018 LSSW. [15] Poulet, F., et al. (2005), Nature 438(7068), 623-627. [16] Loizeau, D., et al. (2007), JGR 112,E8. [17] Loizeau, D., et al. (2010), Icarus 205(2), 396-418. [18] Michalski, J. R., and E.Z. Noe Dobrea (2007), Geology 35(10), 951-954. [19] Quantin C. et al., 1st Exomars 2018 LSSW.