FRACTURED REGIONS OF EXOMARS 2022 LANDING SITE : MAPPING OF THE FRACTURED REGIONS

A. Apuzzo[1,2], A. Frigeri[2], F. Salvini[1], J. Brossier[2], M.C. De Sanctis[2], G.W. Schmidt[1] and the Ma_MISS team[2] Dip. Scienze, Università Roma Tre, L.go S.L. Murialdo 1, I-00146 Roma, Italy (andrea.apuzzo@uniroma3.it),[2] Istituto di Astrofisica e Planetologia Spaziali, INAF, Roma INAF Via del Fosso del Cavaliere, 100

Introduction: On November 2015, the European Space Agency (ESA) and the Russian Space Agency (Roscosmos) announced the landing site of the ExoMars rover in 2022, Oxia Planum, Mars, located southwest of Mawrth Vallis, to the east of the Chryse Planitia Lowlands (Fig. 1).

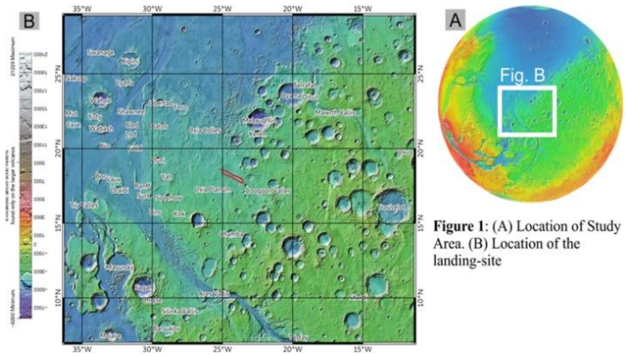

Figure 1: *(A) Location of Study Area. (B) Location of the landing-site ellipse in red at the center of the map.*

The aim of the mission is to investigate traces of past and present life on Mars [1]. The spectral and hyperspectral data of the Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA) and the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) show the presence of olivine and phyllosilicates enriched in Fe/Mg [2]. The high resolution images of HiRISE show that terrains on Oxia are often characterized by the presence of pervasive fractures at the meter scale [2]. The trend of fracturing over the landing ellipse may reveal some patterns useful to better understand the geology of the area. In our previous work we have started mapping the fracture patterns at 500x500m and 200x200m survey stations evenly distributed within the ~1400 squared kilometers landing ellipse and analyzed them both from a directional and a dimensional point of view [3]. In this work, we present the mapping of areas of fracture patterns over the whole landing ellipse.

Data and Softwares: The data used in this work comes from the HiRISE camera onboard the Mars Reconnaissance Orbiter (MRO) spacecraft [4]. The HiRISE camera produces the highest resolution imagery of the Martian surface currently available from orbit, with a spatial scale ranging from 25 to 60 cm/pixel [4]. We imported 33 HiRISE frames into QGIS version 3.20.2. The thematic mapping has been done by digitizing area boundaries, and processing them through the Mappy plugin, producing a GIS layer with polygonal areas associated accordingly with the interpretation of the state of fracturing [5].

Method: We chose to map fractures which are visible in HiRISE images at a 1:5000 scale. We mapped the terrain into two main categories: "Fractured" and "Non Fractured". Fractured areas have been further subdivided in subclasses (see below). It is important to note that the 'Not Fractured' category does not necessarily represent terrain without fractures, but terrains in which fractures are not detectable at the mapping scale. This way, we mapped the entire Exomars 2022 landing ellipse at Oxia Planum (Fig. 2, Major-Axis≈87km, Minor Axes≈10 km, Area≈1400 km^2).

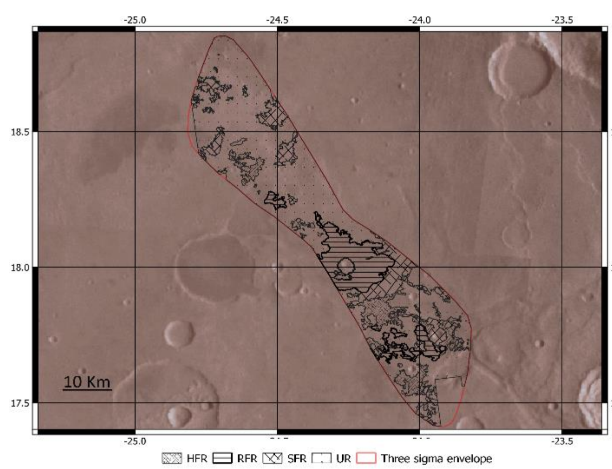

Figure 2: *Map of the fractured regions of Oxia Planum landing ellipse. Geospatial data is in simple cylindrical projection, considering Mars Sphere (IAU2018:49910) .*

The mapping process consists of two main steps: 1) mapping the fractured areas boundaries (i.e. discontinuity contacts) as lines and 2) generating category areas from the boundaries of mapped areas. The fracture boundaries have been mapped as 'certain', where the change between fractures and not fractured terrain was sharp and well defined, and 'approximate' where it was not possible to identify an exact position for the transition between fractured and not fractured terrain.

The fractured areas have been divided into four different categories: "Highly Fractured Regions" (HFR), “Ridge and Fracture Regions " (RFR), "Sand and Fracture Regions" (SFR), and the “Unfractured Regions” (UR) . The first category is characterized mainly by fractured terrain. The second category refers to fractured areas associated with the presence of linear topographic rises (ridges). The third category represents fractured areas with an abundance of sand and dunes.

Analysis and Results: The map of Figure 2 shows the spatial distribution of the terrain categorized as described above. The fractured terrains (HFR, RFR, and SFR) are located in the central and south-eastern portion of the landing ellipse (cross-hatch pattern and linear pattern areas in Fig.2). The RFR are mostly concentrated in the central-lower portion of the landing ellipse (linear pattern areas of Fig. 2). The SFR and HFR (cross-hatch pattern in Fig. 2) are more scattered along the entire landing ellipse. According to Quantin et. al. [6], clays in the landing area are always associated to fractured terrains.

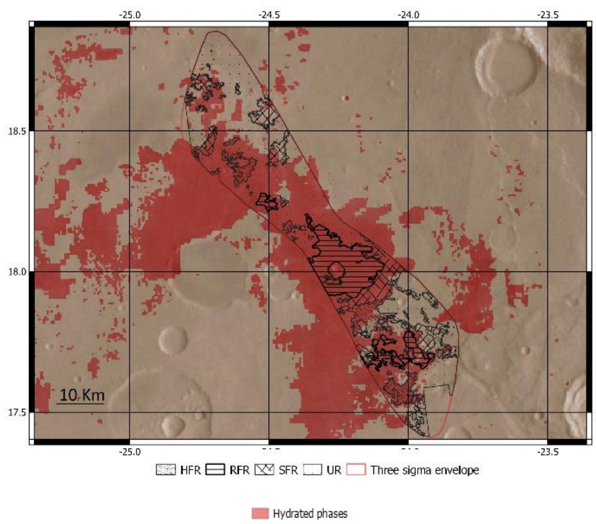

Figure 3 : *Oxia Planum hydrated phases (red) by Carter et.al (2016) [3] compared with the map of fractures.*

The map of Figure 3 indicates the spatial distribution of the hydrated phases in the Oxia Planum landing ellipse (red areas, [7]) compared with the map of fractured terrain distribution described above. There is a good spatial correlation between hydrated phases and fractured areas. Only small fractured areas are not reported as hydrated minerals on the map presented in [7]. However, in the northwestern sector of the ellipse, hydrated phases do not match with fractured terrain categories.

The lack of spatial correlation in the upper portion of the landing ellipse with the hydrated phase map does not imply the absence of fracturing. It may be simply related to the mapping scale adopted for this work, which aims at mapping small fractures over a very large area. In this way, the areas lacking spatial correlation with the Carter Map may indicate the presence of clays characterized by a different (smaller) fracturing style, which can address more localized and detailed surveys, as for example placing survey stations in key areas.

Conclusions: We develop a map of fractured areas over the whole ExoMars 2022 landing site ellipse. The combination of the qualitative *small-scale* and quantitative *big-scale* analysis of [3] offer a multi-scale view over the fracturing state of terrains at Oxia Planum, which helps to constrain the aspects of the geology of Oxia related to fracturing. We are producing the map in an open GIS digital format, enabling interoperability with other compatible mapping products such as the geologic map of Oxia currently in development [8]. Knowing the physical and spatial properties of the fractures is important to constrain the processes that led to their formation, improving our knowledge of the geologic context where ExoMars 2022 rover will operate and explore the subsurface of Mars down to 2 meters [9].

Acknowledgements: The map has been developed at the Planetary Cartography and GIS Laboratory of IAPS INAF in Rome, Italy.

References: [1] Vago et al. (2017) Astrobiology 17, 471. [2] Mandon et al. (2021) Astrobiology 21, 464 [3] Apuzzo et al. (2021) 52nd *LPSC Abstracts, 2082* . [4] McEwen et al. (2007) JGR 112 E05S02. [5] Penasa et al. (2020) 14th EPSC Abstracts, 1057. [6] Quantin-Nataf et al. (2021) Astrobiology 21, 345. [7] Carter et al. (2016) 47th *LPSC Abstracts*, 2064. [8] Fawdon et al., this conference. [9] De Sanctis et al. (2017) Astrobiology 17, 612.