SPATIAL DISTRIBUTION AND ORIENTATIONAL TRENDS OF FRACTURES ON OXIA PLANUM

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Introduction: Fractured terrains are common features on Mars that provide insights into the geologic history and tectonic activity of the planet. Optical orbital imagery captured over Oxia Planum reveals the presence of fractured rock volumes and terrains [1].

In this study, we aim to map and analyze the distribution and orientation of fractured terrains in the surroundings of the landing site of the Rosalind Franklin mission [2], which is located in the Oxia Planum region. The plain is located on the eastern border of Chryse Planitia, between the outflow channels of Mawrth Vallis and Ares Vallis. The landing site featuring extensive exposures of hydrated minerals [3], hosts some of the oldest (Noachian-aged) fractured terrains [3,4] covering approximately 60% of the landing site and exhibiting fractures aligned in east-west (E-W) direction [5, 6].

In our study, we conducted a grid-mapping analysis over high resolution images to document the distribution of fractured terrains in the surroundings of the Rosalind Franklin landing site. We systematically mapped metric and decametric fractures across various scan areas and examined the directional statistics of these fractures as we moved away from the landing area. We discuss the possible implications of our findings for the formation and evolution of Oxia Planum and its surroundings.

Methods: To record the locations of the finely fractured terrains over a large area such as Oxia Planum and its surroundings (about 500 km by 500 km) we used a grid-based mapping approach in QGIS [7]: we create a grid of 1 by 1 km squares over the areas surrounding the Rosalind Franklin landing site.

For each square we record the presence/absence of the fractures through visual inspection of HiRISE images [8] at 1:5.000 scale. Fractures in each grid-square were recorded as being either “present”, “absent” or “possible.” The “possible” grid-square classification was used in case of uncertainty in identification.

We then selected the squares more suitable to place measurement station, where fracturing is well evident. We placed a total of 14 200x200m squared SAs (colored quadrangle, Fig. 1) to examine the directional analysis of fractures as we moved away from the landing area. For this purpose, we arbitrarily chose a distance of 500 km to the east and west as the regional boundary within which to conduct the analysis.

Statistical software R (ver. 4.2.1) has been used to compute the orientation statistics [9] like the mean direction (θ) and the mean resultant length (R) of fractures traced in each SA.

Results: Circular statistics for each SA are presented in Figure 1, and specific values can be found in Table 1. Figure 1 illustrates the SAs located at east (E) and west (W) from the Rosalind Franklin landing site. Notably, the Western SA (Number# 1, see Fig. 1 and Tab. 1) is situated in the Chrise Planitia Basin and Eastern SA (Number# 14, see Fig. 1 and Tab. 1) is located in close proximity to Mawrth Vallis.

The statistical analysis revealed a higher degree of variability (see table 1) in the orientation of the fractures compared to the analysis conducted at the Rosalind Franklin landing site [10]. Specifically, SAs 6, 7, 8, and 10 (Fig. 1 and Tab. 1), which are located closer to the Rosalind Franklin landing site, exhibit θ values that closely align with the ≈90° (96.29°, 85.83°, 94.33° and 84.52°, respectively). In contrast, SAs further away from the Rosalind Franklin landing site show different orientations that deviate from the east-west (E-W) trend found in the landing site. SAs 1, 2, 3, 4 and 5 on the western side and 9, 11, 12, 13 and 14 on the eastern side show specific orientation at northeast (NE) and southeast (SE) (Fig. 1 and Tab. 1).

The deviation from the east-west (E-W) trend becomes more pronounced as one moves away from the Rosalind Franklin landing site (Fig. 1).

Number#	Location	SA	θ	v	R
1	W	sa_061724_1	93.71	53.63	0.61
2	W	sa_009577_1	99.95	45.00	0.67
3	W	sa_046499_1	95.76	93.76	0.64
4	W	sa_076685_1	83.49	49.69	0.66
5	W	sa_072518_1	85.83	52.10	0.63
6	W	sa_053540_1	96.29	40.13	0.78
7	W	sa_058881_1	85.83	37.71	0.80
8	E	sa_012214_1	94.33	50.74	0.65
9	E	sa_062916_1	73.89	50.84	0.65
10	E	sa_035580_1	84.52	48.92	0.68
11	E	sa_062982_1	68.09	49.35	0.68
12	E	sa_025611_1	82.63	47.86	0.68
13	E	sa_076988_1	108.92	45.00	0.70
14	E	sa_005832_1	95.26	53.16	0.61

Table 1 - *Computation of the circular frequency distribution parameters for the 14 Scan Areas (SAs). The column named "Location" refers to the SAs east and west of the Rosalind Franklinn landing site. Circular frequency distribution parameters computed with R are: circular mean direction (θ), variance (v), and mean resultant length (R).*

Discussion: The prevailing orientation of the fractures at the western stations aligns with the north-

northeast (N-NE) orientations observed in previous studies in the Chryse Planitia Basin [11]. The north-northeast (N-NE) and southeast (SE) trends tend to disappear completely about 200 km west of the landing site (SAs 6 and 7, Fig. 1), giving way to an east-west (E-W) trend.

While Marth Vallis studies do not show consistent trends in fracture orientation [12], it is noteworthy that the SAs east of the Rosalind Franklin landing site (SAs 8, 9, 11, 12, 13 and 14) show northeast (NE) and southeast (SE) trends. The east-west (E-W) trend appears to diminish at station 8 (≈ 70 km east of the Rosalind Franklin landing site), reappears at station 10, (≈100 km east of the landing site), and finally gives way to the northeast-southeast (NE-SE) trend near Mawrth Vallis. Consequently, the analysis of the 14 SAs indicates that the east-west (E-W) trend observed within the Rosalind Franklin landing site is sustained for a distance of approximately 200 kilometers to the west (W) and about 100 kilometers to the east (E), thus remaining confined within a few hundred kilometres. The geology at Oxia is complex due to its age, the low topographic relief leaves little to morpho-stratigraphical interpretations, and fractured terrain constitutes an important percentage of the landing site ellipse.

Subsequent analyses conducted to the north (N) and south (S) of the Rosalind Franklin landing site will provide additional constraints on the trend of fractures in the Oxia Planum region. Our study wants to support the understanding of the area where Rosalind Franklin will search for evidence of life on Mars.

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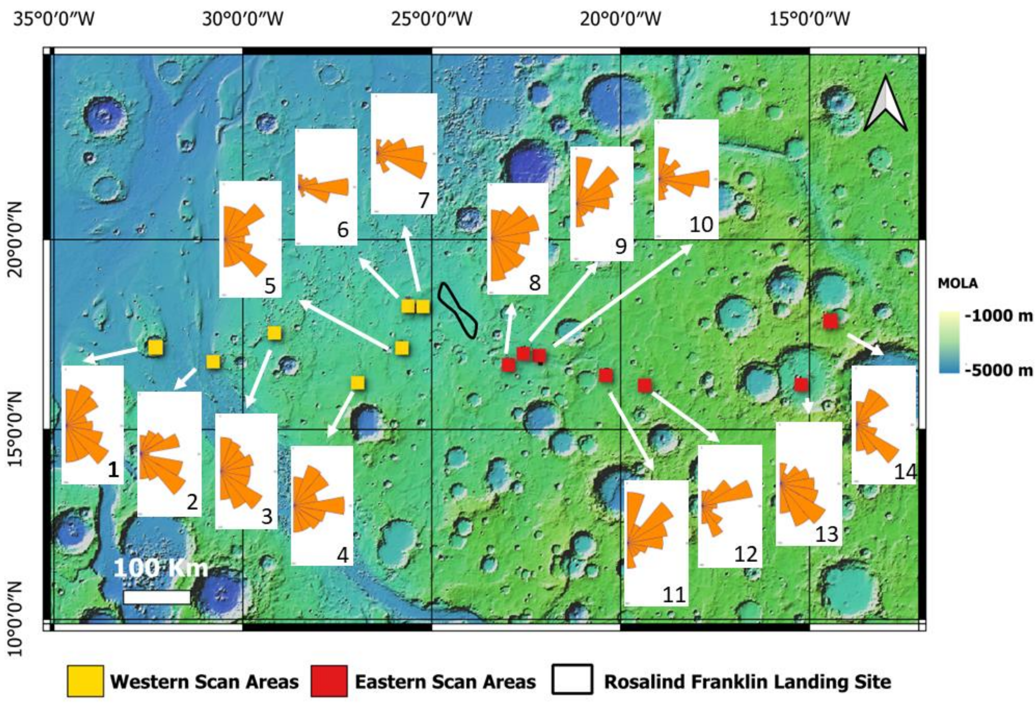

Figure 1 – *Fractures direction trend on Oxia Planum at the regional scale. The map shows the spatial distribution of the orientation (orange wind-roses) of the fractures for each 200x200m Scan Area (SA) located west (yellow squares) and east (red squares) of the Rosalind Franklin Landing site (black ellipse). The numbers at the bottom-right of each wind roses refer to the number associated with the SAs listed in table 1. The prevalence of NE and SE orientations increases towards the east or west. Topographic context of Mars Orbiter Laser Altimeter (MOLA) data [11].*