IDENTIFICATION OF ROCK TEXTURES AND MORPHOLOGICAL BIOSIGNATURES WITH CLOSE-UP IMAGES – TOWARDS CLUPI'S OPEARATIONS DURING THE EXOMARS MISSION. G. Ligeza[1], T. R. R. Bontognali[12], B. Kuhn[1], J. L. Josset[2], and N. J. Kuhn[1], [1]Department of Environmental Sciences, University of Basel, 4056, Basel (gabriela.ligeza@unibas.ch) [2]Space Exploration Institute, 2000, Neuchâtel, Switzerland.

Introduction: ExoMars is an astrobiology program led by the European Space Agency, which foresees the launch of a rover that will look for signs of past life in a region of Mars named Oxia Planum [1]. CLUPI (a close-up imager) is one of the instruments that are part of the payload of the ExoMars rover. CLUPI will be used to acquire high-resolution images of rocks, geological outcrops, and drill cores [2,3]. Due to the limited amount of data that can be transmitted at once from Mars, only few CLUPI images will be available daily to the science team for assessing hypotheses and decide how to program the rover of the next cycle of activities. Thus, it is curial that each CLUPI image will contain a maximum of relevant information. For this reason, we are conducting preparatory tests and simulations to identify ideal CLUPI working conditions in view of the prime mission on Mars. In this work, we specifically explored the impact that different illumination conditions (i.e., direction of the illumination axis and intensity of direct light vs diffused light) may have on the detection of textures and sedimentary structures in close-up images. For the simulations, we gathered a collection of samples that are relevant for the ExoMars mission, both because we expect them to be present at the landing site based on orbital data or because they are considered highly interesting targets for finding evidence of past microbial life.

Methods:

Oxia Planum & targeted sampling area: Oxia Planum (Fig.1) is a 200 km plain terrain located between 16° and 19° N and −23° to −28° E on the eastern border to Chryse Planita. The remote sensing observations confirmed the presence of large, middle to late – Noachian age (3.9 Ga) deposits of stratified bedrock with hydrous Fe-Mg phyllosilicates, which are interpreted to be formed in an aqueous environment and are a good target for the search of biosignatures [4,5,6]. Moreover, these deposits are overlaid by a volcanic, weathering- resistant unit (i.e., Adru), which provided protection to the phyllosilicate formation against cosmic radiations known to negatively affect the preservation of biomarkers [7].

The ExoMars rover is expected to land in a 120 km long and 20 km large ellipse (Fig.1). Within this area, we have identified the following rocks as representative Mars-analogue lithologies for our CLUPI simulations: *A- picritic basalt:* one of the most common rocks on Mars, *B- laminated mudstone:* can contain phyllosilicates and preserve organic matter, give an insight on fluvial/deltaic activity; *C- conglomerate:* a rock with rounded/angular grains, could inform on aqueous processes and fluvial activity in the "Deltaic Deposits" unit; *D- altered basalt* with Mg phyllosilicates located in fine-grained laminations [8]; and *E- stromatolite:* a layered rock which was formed by biochemical processes on early Earth and, if present at the landing site, would represent an ideal putative morphological biosignature.

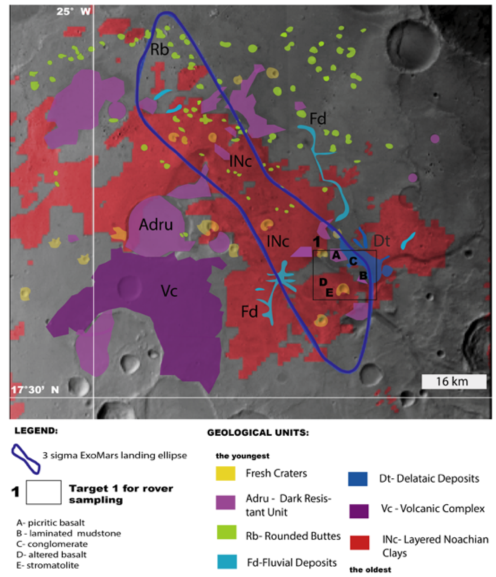

Figure 1: Geology of Oxia Planum & target exploration area. Modified after [4].

Image acquisition in Marslabor: Selected samples were photographed at the Marslabor of the University of Basel, an indoor facility that aims at reproducing Martian lighting conditions with different solar angles above the horizon and different azimuths relative to the target rock [9]. The images were acquired to simulate CLUPI's field of view 2 (FOV 2) with 50 cm working distance, which corresponds to the most common CLUPI configuration foreseen for the prime mission [2]. In this study, we only photographed target surfaces placed horizontally. Thus, the strike and dip of rocks is always 0° [9].

All images were acquired with a Canon EOS M50 with a Canon 110 mm fixed macro lens that, although with a different color calibration and detector technology, allows for obtaining photographs with the same field of view and resolution of CLUPI [9]. We simulated three different conditions; mid-day conditions with the solar angle of 70° (Fig.2A), evening/morning conditions with the solar angle of 25° (Fig.2B) and cloudy/sandstorm conditions (Fig.2C) when there is no direct/Sun illumination to the targeted rock. For the mid-day and evening/morning conditions, the images were acquired by adjusting the lamps position (Fig.2D) or by dimming their power to obtain a measured value on the sample of 5000 LUX of direct light and 1000 LUX of diffused light- corresponding to the current knowledge on Mars illumination [10]. For the cloudy/sandstorm conditions we used 1000 LUX of diffused light only.

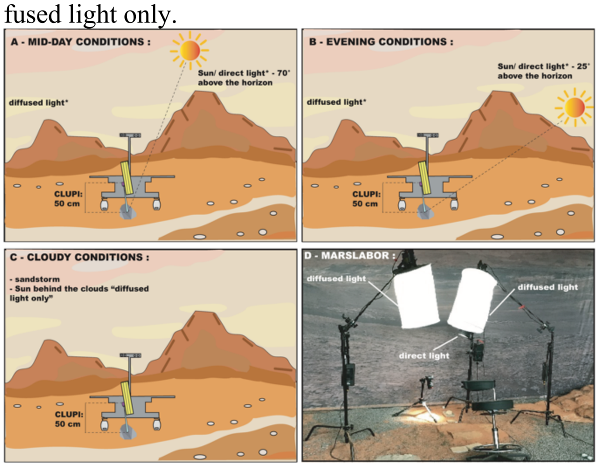

Figure 2: Simulated lighting conditions on Mars; A- mid-day conditions with solar angle of 70°- direct & diffused light, B- evening/morning conditions with solar angle of 25°- direct & diffused light, C- cloudy conditions (diffused light only), D- experimental set-up in Marslabor.

Results and discussion: The results (Fig.3) show that variable solar angles and different proportions of direct and diffused light on the targeted rock surface has a significant effect on recognizing rock textures and morphological biosignatures. For example, the higher solar angle of 70° is ideal to detect phenocrysts within the rock textures (Fig. 3A). Therefore, the mid-day condition seems to be better to distinguish sedimentary from volcanic rocks. On the other hand, the lower solar angle of 25° representing the evening/morning conditions is ideal to enhance the detection of laminations in mudstone (Fig.3B) and stromatolites (Fig.3E). Finally, diffused light and lack of direct illumination on the rock target tend to be better to detect small-scale features, such as size and shape of the grains within a conglomerate (Fig.3C), or fine-scale laminations with altered/secondary minerals (Fig.3D). This is caused by the weak contrast on the rock surface, allowing to expose even the smallest features, which are often the key for biosignatures detection.

Conclusions: Our simulations provide information helpful for planning CLUPI operations during the ExoMars mission. We showed that by acquiring images at different times of the day, under specific light conditions, it is possible to increase the chances of recognizing specific sedimentary and textural features, including morphological biosignatures.

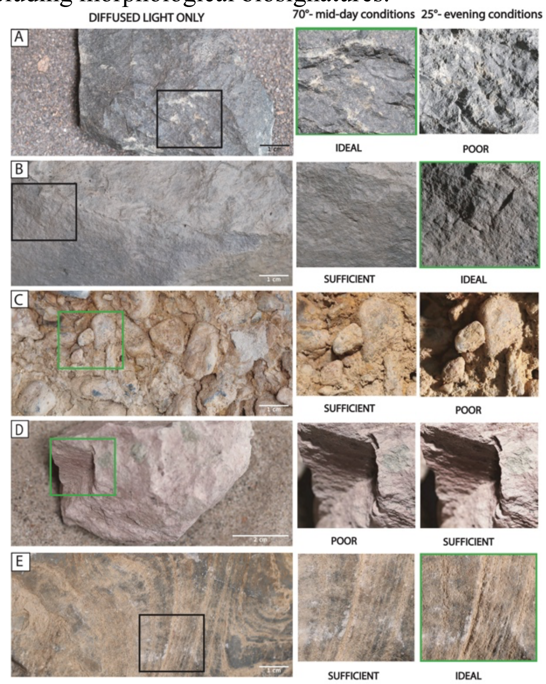

Figure 3: Rock textures & morphologies photographed under variable lighting conditions. A- picritic basalt with large phenocrysts; B- mudstone with laminations; C- conglomerate with sub-rounded grains; D- altered basalt with Fe/Mg-rich phyllosilicate layers; E- stromatolite with distinct layers.

Future work: A "mission catalogue" with a comprehensive collection of Mars-analogue rock textures and image processing algorithms for biosignature detection will be published to support scientists during the strategic and tactical planning of the ExoMars mission.

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References: [1] Vago J.L. et al. (2017) *Astrob*.17(6-7). 471-510. [2] Josset J.L. et al. (2017) *Astrob*. 17(6-7). 595-611. [3] Westall F. et al. (2015) *Astrob*. 15(11). 998-1029. [4] Quantin-Nataf C. et al. (2021) *Astrob*. 21(3). 345-366. [5] Carter J. et al. (2016*) LPS XLVII*, Abstract #2064. [6] Mandon L. et al. (2021) *Astrob*. 21(4). 464- 480. [7] Kminek G. and Bada J. (2006) *Earth and Planetary Science Letters* 245(1-2), 1-5. [8] Krzesinska A. et al. (2021) *Astrob*. 21(8), 997-1016. [9] Bontognali T.R. et al. (2021) *Planetary and Space Science* 208, 105355. [10] Appelbaum J. and Flood D.J. (1990) *Sol. Energ*. 45 (6), 353-363.