CLOSE-UP IMAGES OF OXIA PLANUM ANALOG SAMPLES UNDER DIFFERENT ILLUMINATION CONDITIONS: PREPARING FOR THE EXOMARS 2028 MISSION, G. Ligeza1, T. Bontognali2, J. L. Josset3, and N. Kuhn1, 1Department of Environmental Sciences, University of Basel, 4056, Basel (gabriela.ligeza@unibas.ch) 2Space Exploration Institute, 2000, Neuchâtel, Switzerland

Introduction: The ExoMars program, led by the European Space Agency, plans to launch a rover to search for past life in Mars’ Oxia Planum region [1]. CLUPI, a close-up imager within the ExoMars rover’s payload, is designed for acquiring high-resolution images of rocks, geological outcrops, and drill cores [2,3]. Due to limited data transmission from Mars, only a few CLUPI images will be available daily for the science team’s assessment and programming of the rover’s next activities. Therefore, it is crucial that each CLUPI image contains a maximum of relevant information.

This study explores the impact of different illumination conditions on texture and sedimentary structure detection in close-up images produced with a CLUPI analog camera, aiming to identify ideal working conditions for CLUPI during the prime mission on Mars. Our work also provides insight for post-processing CLUPI data to enhance the probability of detecting morphological biosignature and other textures and sedimentary structures that are relevant for the scientific goals of the mission.

Methods: Oxia Planum and rock sample selection: The ExoMars rover is expected to land in Oxia Planum region, which is known to have a geologically diverse terrain, including a stratified bedrock with hydrous phyllosilicates of Noachian age, several igneous units, and fluvial & deltaic deposits [4-6]. To identify the lithologies potentially occurring in this region, we conducted a review of the existing geological remote sensing data. We also analyzed Curiosity and Perseverance rover images at https://mars.nasa.gov/ for surface textures and studied The Planetary Terrestrial Analogues Library (PTAL) as a potential Martian rock analogue.

Image acquisition in Marslabor and with CLUPI EM+ (an Engineering Model which is flight representative): 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 [7]. 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° [7].

Figure 1: 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. EM-S – pictures of sandstone taken with the CLUPI EM+ CA-S – pictures of sandstone taken with the Canon M50 camera.

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 [7]. Additionally, we also took pictures with CLUPI EM+ (an engineering Model which is flight representative) at the CLUPI science operations laboratory of the Space Exploration Institute in Neuchâtel to cross-correlate pictures from two cameras and validate our results (Fig.1. EM-S & CA-S).

For all simulations, we simulated three different conditions; mid-day conditions with the solar angle of 70° (Fig.1A), evening/morning conditions with the solar angle of 25° (Fig.1B) and cloudy/sandstorm conditions (Fig.1C) 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.1D) 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 [8]. For the cloudy/sandstorm conditions we used 1000 LUX of diffused light only.

**Results & discussion:** In total, we gathered 28 Oxia Planum analog rocks and we divided them into five main groups: (1) clastic sedimentary rocks, (2) rocks with Fe-Mg phyllosilicates, (3) igneous rocks, (4) evaporites, carbonates & putative biosignatures, and (5) rocks with various sedimentary structures. For each of these groups, we identified the diagnostic textures and lithologies supposed to be visible with CLUPI (e.g., laminations, alteration veins, vesicles, etc.). Here, we show an example of 7 rock types and their textures (Fig.2 A-G) photographed with the CLUPI analog camera.

The results (Fig.2) 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.2E). Therefore, this is an ideal time of a day to distinguish igneous from sedimentary 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.2C) and circular features in the sediment, which are sometimes associated to microbially induced sedimentary structures (MISS) (Fig.2G). 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.2B), fine-scale secondary Fe-Mg phyllosilicate minerals (Fig.2D) or precipitated minerals, such as jarosite within the sulfate host rock (Fig.2F). 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. Also, the features which are directly linked to the color, such as lamination in Fig.2A are also better visible with a diffused light and a low contrast. This was also shown for the pictures acquired with the EM+ (Fig.1. EM-S & CA-S).

These findings offer guidance for CLUPI data post-processing. To identify sedimentary structures and potential biosignatures, applying a high-contrast filter to close-up images can enhance feature detection. Conversely, reducing picture contrast can unveil hidden small-scale features, enabling a more detailed assessment of samples, including the shape and size of secondary minerals and pebbles.

**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. Additionally, our results provide useful information for further post-processing of CLUPI data.

![Figure 2: Rock textures & morphologies photographed under variable lighting conditions with CLUPI analog camera-Canon EOS M50. The green boxes show the condition in which features of interest are the most visible.](image-url)