LCP-BEARING ROCKS WITHIN THE OXIA PLANUM LANDING SITE: POSSIBLE EARLY CRUSTAL & ALH84001 ANALOGOUS MATERIALS FOR IN SITU INVESTIGATION BY THE EXOMARS ROVER.

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Introduction: ESA's ExoMars Rosalind Franklin (EMRF) rover (now anticipated to launch in 2028) will explore Oxia Planum (335.5ºE, 18.2ºN). Based on detailed mapping and chronology [1,2], the landing site may prove to contain the oldest rocks investigated by a surface mission yet, providing insights into the early history of the planet.

We report on the orbital detection of relatively unaltered Low-Ca pyroxene (LCP) rocks that lie exposed just beyond the 3σ landing ellipse and that underlies the Oxia clay-bearing unit. Such rocks would represent a high-priority target given they may represent ancient and relatively pristine primary crustal materials and possibly analogous materials for the only orthopyroxenite Martian meteorite, ALH84001.

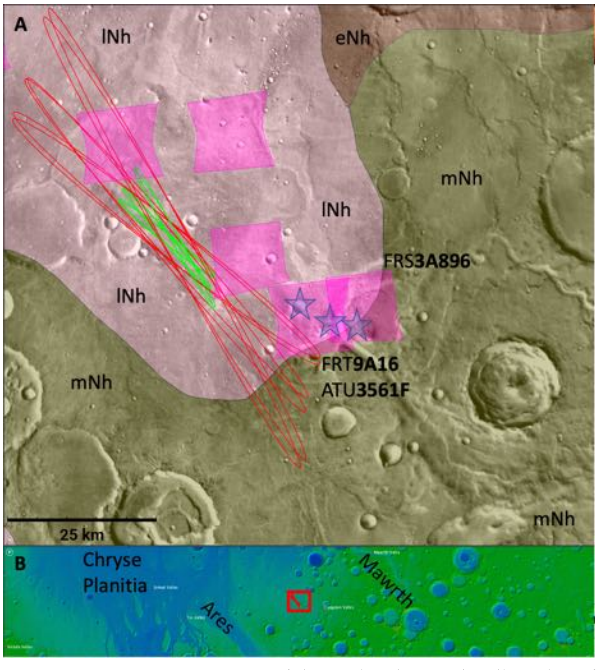

Fig. 1. A. Geologic context of the Oxia Planum landing site of [1] on THEMIS daytime IR (1024 ppd) with the 2022 landing ellipses (1σ - green; 3σ - red) and local CRISM FRT and FRS observation coverage (magenta). Abbreviations correspond to Late, Middle and Early Noachian highlands units. **B.** HRSC/MOLA color shaded relief (32 ppd) provides regional context.

Methods: We first use standard CRISM analysis methods [e.g., 3] applied to the latest calibrated data to spectrally determine the presence of LCP around the landing site. Our survey includes both higher resolution ~18m/px targeted – both S- and L-detector merged (MTRDRs [4]) and unmerged (TRDRs), and lower resolution ~180m/px mapping data (MRDRs [5]). A Dark Subtraction (DS) correction is applied to CRISM targeted observations only (TRDRs and MTRDRs). This is a relatively new method for CRISM analysis that improves isolation of the spectral shape of surface components by reducing scatter from time-variable atmospheric aerosols and without having to employ the spectral ratioing method [6,7]. Our survey uses all CRISM targeted observations over the landing site region (18 total; [8,9]) and 6 (15ºx15º) MRDRs spanning a 30º by 60º area. Finally, spectral results are correlated with other datasets spanning global to local scales (i.e., elevation, geologic maps, moderate to high-resolution TIR and VNIR images) to provide morphologic information and geologic context.

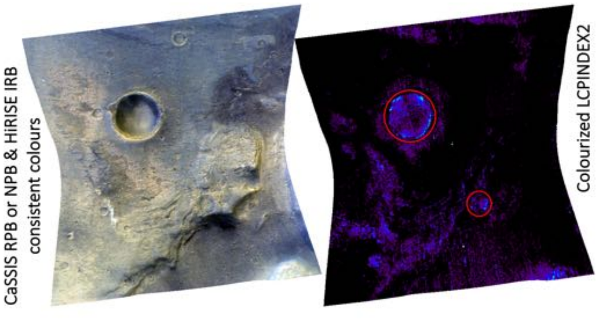

Fig. 2. CRISM FRT9A16 Color-infrared composite (R:67, G:31, B:11) and associated LCPINDEX2 (stretched 0.01 to 0.04) showing possible occurrences of LCP-bearing rocks.

Results: Fig. 1 shows blue stars representing locations with 1 or more CRISM spectra exhibiting a positive match with LCP across three targeted observations (FRT**9A16** ATU**3561F &** FRS**3A896**). The first two correlate with exposures in the crater walls of two simple craters, one well-preserved (D~2.5 km) and one degraded (D~1km) (**Fig. 2**), into the lNh unit while the third correlates with bedrock exposed on a small hill or mound within mNh terrain.

Fig. 3 presents one example spectrum retrieved from the NW wall of the 2.5-km crater. The position of the major absorption features, ~925 nm and ~1900 nm, are consistent with LCP. Thus far, narrow absorption features signifying alteration phases are not observed in any of the LCP spectra retrieved.

HiRISE and CaSSIS color-infrared images of the strongest LCP spectral signatures show that these signatures correspond to outcrops of aqua coloured bedrock.

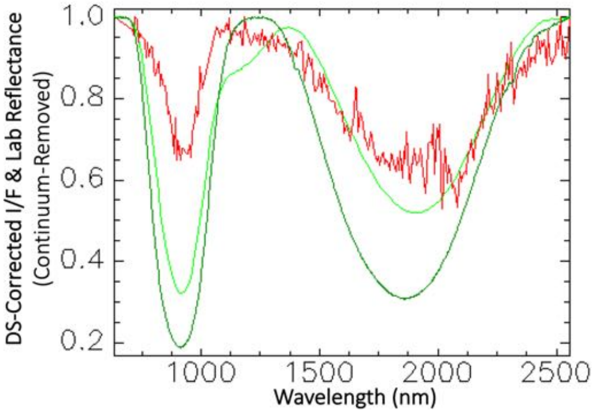

Fig. 3. A 3x3 pixel averaged DS-corrected I/F spectra extracted from CRISM FRT 9A16 over Oxia Planum (red) vs. scaled reference spectra from RELAB (LAPP47B – dark green) [10] and Klima et al. (En70, Fs30 – light green) [11].

Discussion: Through a synthesis of observations, we provide a summary and discussion of the likelihood, and implications thereof, of investigating Oxia LCP with EMRF.

Implications for the Petrogenetic and Chronologic History of Mars: LCP appears to dominate primary materials that crystallized early in the history of Mars [12-14]. Moreover, the Oxia LCP is consistent with respect to both the composition and age of the ~4.1 Ga Martian meteorite ALH84001[15], which has been extensively studied as a partially altered but nearly pristine sample of the Martian ancient crust. LCP in ALH84001 has a mean composition of Wo3.3 En69.4 Fs27.3 [16], which is roughly the composition of the light green reference spectrum shown in **Fig. 3**. From an age standpoint, the landing site is notably situated just within the SE rim of the pre-Noachian (>4.15 Ga [17]) Chryse Planitia impact basin (**Fig. 1**), which straddles the Martian crustal dichotomy boundary. Here, ancient heavily cratered highlands, dominated by early (eNh) and mid-Noachian (mNh) surfaces (~3.85 – 4.15 Ga), are found just to the south and east of the landing site, with younger, modified, smoother and less-cratered lowland plains to the north and west. The two LCP-exposing craters reported here occur within a late-Noachian surface (lNh; ~3.56 – 3.85 Ga), but LCP could be much older since it originates from the subsurface. With lNh estimated to be on the order of 100s of meters thick [1] and the proximity to older units (~2 km and 35 km from mNh and eNh surface units, respectively), the craters reported here may be tapping into and exposing mid- to early Noachian or even 4+ Ga impactites or target rocks from the Chryse impact basin. Thus, Oxia LCP represents a high-priority target for investigation by EMRF.

In Situ Investigation Potential: While the occurrence of LCP-bearing rocks detected from orbit are limited to the far-east side of the landing ellipse, the EMRF may still encounter these materials within the greater landing ellipse at meter- to submeter local scales (i.e., scales not readily detectable from orbit). Such materials would likely include ejecta blocks and/or fluvially transported materials. Evidence for these two possibilities come from understanding the larger scale occurrences of the LCP-bearing rocks and their geologic context. Proximal ejecta from the 2.5-km crater shows LCP signatures (**Fig. 2**). All craters produce discontinuous distal ejecta (>5R) and crater rays, some reaching more than 100 crater radii from the primary [18]. More LCP-exposing craters are difficult to find due to the poor coverage and limited spatial resolution of targeted CRISM data. However, it is highly likely that there are more such craters in the area and that LCP-bearing blocks may be dispersed throughout the landing site.

Regarding the possibility of detrital LCP-bearing materials occurring within the lower elevations covered by the landing ellipses, the LCP mound, reported herein, is on mNh terrain, interpreted to be 10s to 100s of meters thick [1], and is straddled by deeply incised inlet channels associated with Coogoon Vallis (**Fig. 1**). Given the proximity to surface exposed eNh terrain to the north, abundant ancient 4+ Ga detritus, including LCP-bearing rocks, are likely to be found within the greater landing ellipse.

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