THE EXOMARS-LIKE FIELD TRIALS (ExoFiT): PanCam EMULATOR MULTISPECTRAL OBSERVATIONS.

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Introduction: The search for life and habitable environments dominates the mission profile of many of the upcoming martian surface missions, including ExoMars2020 [1]. ExoFiT is the latest installment of martian surface simulation missions designed to test the response of the ExoMars Instrument suite in an analogue Mars location. This field trial aims to highlight the rover instrument capabilities, building upon the previous work of the MURFI trials, further information of which can be found here [2].

ExoMars Context instruments. The Context Instrument suite on the ExoMars 2020 rover will provide insight into the martian landscape, allowing for the selection of the most interesting geological features for further investigation and possible sampling. The Panoramic, wide angle, stereo imaging system (PanCam) [3] will take multispectral images in 12 narrowband channels in the visible to near-infrared range (from 440 nm to 1000 nm) [4], and will be imperative in understanding the geology of the landing site, as well as the mission planning and target site acquisition. The rover will also be equipped with the High Resolution Camera (HRC) to provide submillimetre textural information. Within the field of view of PanCam and HRC, the Infrared spectrometer for ExoMars (ISEM) takes point measurements of spectra in the range 1150 nm to 3300 nm [5]. The PanCam spectral range provides wavelength coverage of the identification features of Hematite and various ferrous minerals [3]), while the ISEM spectral range is more targeted for hydrous mineral signatures [5].

ExoSpec: To utilize the PanCam observations to best inform mission operations, the PanCam data must be analysed within the tactical planning time frame for inclusion in mission plans on subsequent sols. An ENVI extension has been developed to enable time effective analysis of ExoMars multispectral data, details of which can be found here [6].

The ExoSpec software first applies both flat field and radiometric corrections, followed by environment colour correction using an in situ image of the PanCam calibration target, located on the rover body. The reflectance values from the in situ image of the calibration target and previous lab measured values, are used to determine illumination coefficients to transform between a radiometrically corrected image and R^* reflectance [7] images for analysis. Furthermore, ExoSpec contains multiple spectral parameters to aid in efficient analysis of PanCam images, with particular emphasis on Astrobiologically relevant features.

EXOFIT Trial: The ExoFiT program consists of two field trials, the first of which was based in southern Spain in September 2018. The first trial consisted of a field team and rover platform with emulator instruments, including AUPE, the PanCam emulator used here. AUPE contains a similar 12 filter set to PanCam, within a few nm of PanCam's central filter wavelengths [6]. The operations team, based in the Rover Control Centre (RCC) near Oxford in the UK, were given no location information except the data returned by instrumentation to guide the mission progress. This process provides insight into the data returned by PanCam and how best to utilise data within the strict time limit of the tactical planning phase, and best practices for meeting longer-term science goals. This first trial lasted for two weeks, with inclement weather at the field site limiting the mission to ~10 sols. Where possible, two sol missions were operated within one day to recover time lost due to inclement weather. Despite the compressed nature of the field trial, the overall goal was to follow the Reference Surface Mission (RSM) for ExoMars 2020 as closely as possible, including obtaining a deep drill sample.

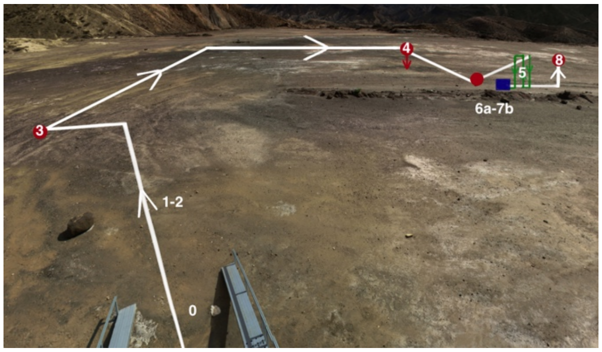

***Figure 1** Approximate travel path of ExoFit rover (white): AUPE imaging (red), Wisdom Grid- 'Brockenhurst' (green), Drill sampling- 'Rhyll' (blue).*

AUPE images were used to provide contextual information on the rover surroundings, and to plan the mission route. Upon successful egress of the rover, the approximately 0.5 m high 'Glengoyne Ridge', was highlighted as an interesting target from the 360°

landing site survey panorama images. The rover imaged Glengoyne Ridge from various vantage points with AUPE, the ISEM emulator, and CLUPI emulator instruments, performed ground-penetrating radar measurements with the WISDOM emulator instrument of an area near Glengoyne Ridge, as well as drill sample acquisition and analysis in this region.

Sol	Objective	Target	Instrument
0	Landing	Survey	P/C
1	Egress	Survey	P/H
2	Coordination	GPS	Orbital
3	Driving	Survey	P
4	MS Imaging	'Glengoyne'	P/C/W
5	Wisdom Grid	'Brockenhurst'	W/C
6a	Drill Targeting	'Rhyll'	P/H/I
6b	Drilling 0.1m	'Rhyll'	H/C/D/R
7a	Drill Targeting	'Rhyll'	P/H/I/C
7b	Drilling 0.5m	'Rhyll'	P/W/H/C/D
8	Ms Imaging	'Glengoyne'	H/C

Table 1 *Summary of the Sol by Sol operations during the ExoFiT trials. P: PanCam emulator (AUPE), C: CLUPI, H: HRC, W: WISDOM, I: ISEM, D: ExoMars Drill, R: RAMAN.*

AUPE Multispectral Observations: The most thorough multispectral imaging campaign occurred on Sol 4 and Sol 7b, targeting Glengoyne Ridge.

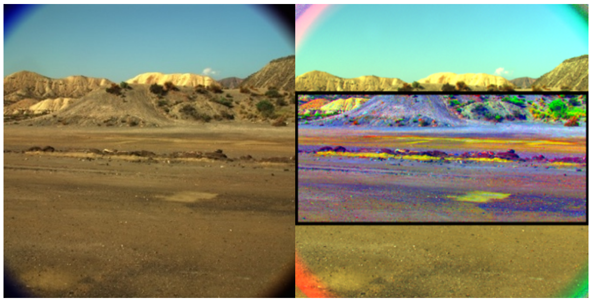

Figure 2 *PanCam Emulator Images Sol 4 Context Image of Glengoyne Ridge. Left, Raw image. Right, Flat fielded and Colour corrected image, overlaid with decorrelation stretch of Glengoyne Ridge.*

From the Sol 4 image of Glengoyne Ridge, distinct layering within the outcrop is visible, and emphasised, in the decorrelation stretch shown. The ridge appears to me made of a (darker) top layer, more resistant to erosion than the layers beneath. This insight led to closer targeting of the ridge to gain more information of the constituent materials, and drill targeting. The WISDOM and CLUPI emulator instruments were also used to gain information on the subsurface structure and textural information on the area surrounding the ridge before drilling.

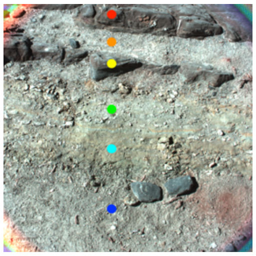

Figure 3 *Sol 7b close up image of Glengoyne Ridge, corrected Image with (enlarged) indication of ROI.*

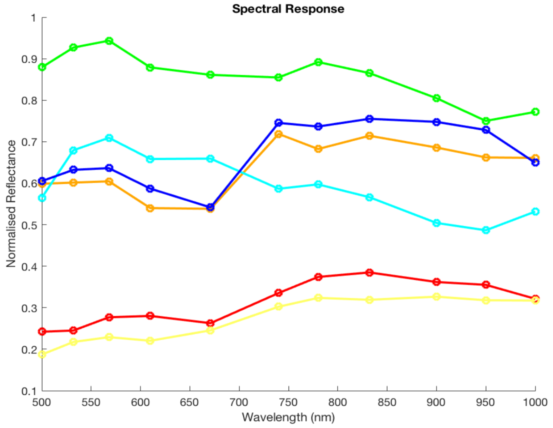

Figure 4 *Indication point spectra within respective coloured ROIs from figure 3.*

From the indication spectra observed spectral similarities can be seen between visually similar regions of Glengoyne Ridge. The first ROI (Red) shows potential Fe3^{+} absorptions features at 532nm and 671 nm respectively [4] and the distinct absorption feature in both ROI 2 (Orange) and 7 (Blue) indicates the presence of Chlorophyll a, a notable biological indicator on earth. Further, the downward slope of several of the ROIs from 950-1000nm may indicate the presence of a hydration feature at 1000nm, and hence the presence of water [8]. This information could lead to better target identification when combined with results from the remaining context instruments and lead to enhanced drill targeting and science return.

Future Testing: The multispectral observations taken during this first ExoFiT trial suffered to a certain extent from a water-saturated surface due to rain fall during operations. The second trial, scheduled for early 2019, aims to apply improved mission techniques learned during this first trial to a different location, and benefitting from no surface saturation.

References:[1] Vago J. L. et al. (2017) Astrobiology, 17, 471-510. [2] Balme M. R. et al. (2018) *Planetary and Space sciences, In The Press.* [3] Coates A. J. et al. (2017) *Astrobiology,* 17, 511-541. [4] Cousins C. R. et al. (2012) *Planetary and Space science,* 71, 80-100. [5] Korablev O. I. et al. (2017) *Astrobiology,* 17, 542-564. [6] Allender E. J. et al. (2018) *Image and Signal Processing for remote sensing* XXIV, 10789, 1078901. [7] Reid R. J. et al. (1999) *Journal of Geophysical Research,* 104, 8907-8925. [8] Rice M. S. et al. (2013) *Mars Journal*, 8, 15-57.