MULTISPECTRAL IMAGING OF HYDROTHERMAL ALTERATION TERRAINS USING AN EXOMARS PANCAM PROTOTYPE. J. K. Harris[1], C. R. Cousins[2], M. Gunn[3], P. M. Grindrod[1], I. Crawford[1], and D. Barnes[3], [1]Department of Earth and Planetary Sciences, Birkbeck University of London, UK (jennifer.harris@bbk.ac.uk), [2]UK Centre for Astrobiology, University of Edinburgh, UK, [3]Institute of Mathematics, Physics and Computer Science (IMPACS), Aberystwyth University, UK

Introduction: The Námafjall geothermal field in the volcanic Krafla region of Iceland was used to field test the current configuration of the Aberystwyth University PanCam Emulator (AUPE), a prototype of the ESA/Roscosmos ExoMars Panoramic Camera (PanCam) [1]. The minerals commonly found in this type of environment include phyllosilicates, iron oxides, and opaline silica, all of which have been detected on the surface of Mars [2,3,4] making the region a suitable Mars analogue site. AUPE datasets are compared and groundtruthed to in-situ field spectroscopy data and laboratory spectral library data. The ability of AUPE to identify and characterise extreme habitable volcanic environments is examined and the differences between AUPE multispectral data and in-situ point hyperspectral data are scrutinised and discussed.

Motivation: Remote Sensing and visible and near infrared (VNIR) reflectance spectroscopy are fundamental tools in the exploration of isolated environments on Earth and of our neighbouring planetary bodies, in particular Mars. One of the current objectives of the Mars science community is to identify regions of the planet that may have previously been habitable. This search is primarily focused on mineral assemblages and lithologies that form in the presence of liquid water. Key instruments that have already been utilised for this purpose include the multispectral cameras on both the Spirit and Opportunity rovers (Pancam) and MSL Curiosity (MastCam).

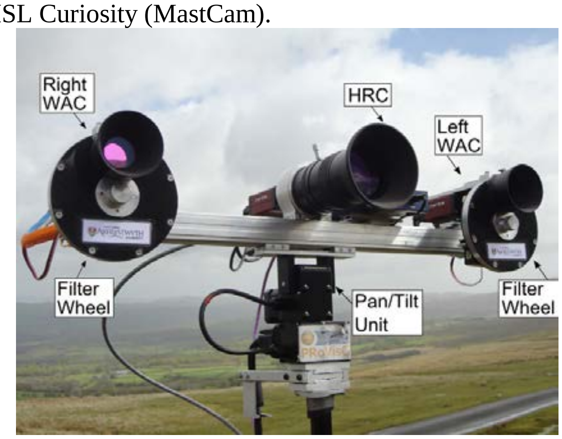

Fig 1: The Aberystwyth University PanCam Emulator (AUPE). WAC = Wide Angle Camera; HRC = High Resolution camera.

The upcoming ESA/Roscosmos 2018 ExoMars rover will continue to use in-situ reflectance spectroscopy for geological target selection at the Martian surface, within which to search for signs of life [5]. It is imperative therefore to conduct groundtruthed field tests of the ExoMars PanCam to ensure adequate target selection for the mission and reliability of PanCam datasets

Volcanogenic hydrothermal environments are a particular type of habitat proposed to have existed on Mars [6]. The Krafla volcano and fissure swarm in Iceland is characterised by such conditions. The environment here is dominated by a recent eruption event (1975-1984) and a series of acidic - neutral hydrothermal fields including boiling mudpools, acidic fumaroles, and extensive alteration of the surrounding basaltic lavas resulting in the deposition of hydrated mineral species. Such deposits are typically on a centimetre to metre scale, making remote identification and detailed examination challenging with spectral optical datasets. Finding evidence of similar environments and aqueous activity on Mars would be of extreme interest to the astrobiology community.

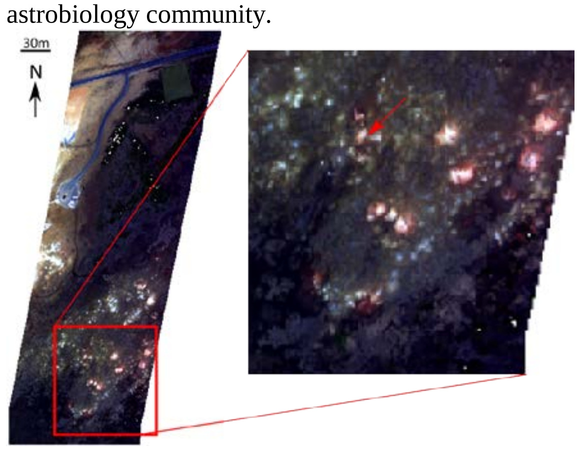

Fig 2: RGB aerial image showing a section of the field site. Bright-toned hydrothermally altered soils show up clearly against the dark unaltered lava. Target site is highlighted with a red arrow.

Data: A variety of target-sites were imaged using the AUPE and in-situ hyperspectral data captured from regions of interest (ROIs) within each AUPE scene using a portable Jaz field spectrometer. Aerial hyperspectral imagery covering the site was acquired prior to the field work and used to guide the initial target-site selection. Target-sites were selected to span the range of small scale features that can form in hydrothermal alteration zones and regions of volcano-ice interaction, and included pillow basalt outcrops, semi-consolidated geothermally altered soils, hydrovolcanic sediment layers and intrusive mineral veins. Rock and soil samples were collected for each spectral ROI and analysed in the laboratory to determine the mineralogy of the sites. At the NERC Field Spectroscopy Facility reflectance spectra from 400-2500nm were collected from dried, powdered (<210µm) sample fractions. X-ray diffraction (XRD) data were also acquired and the two datasets analysed to qualitatively identify the minerals present. Smectite clays, opaline silica, gypsum, hematite and zeolites dominated the samples across the site.

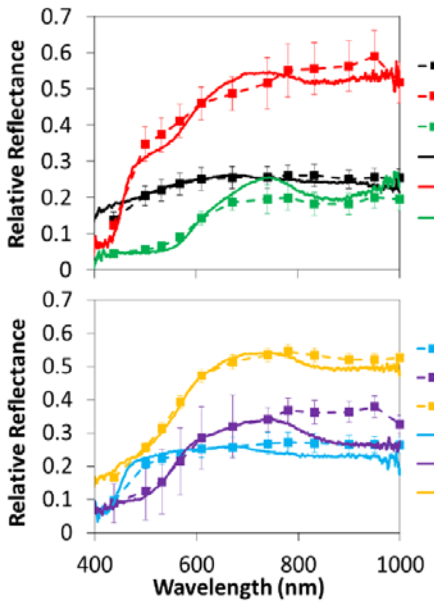

Fig 3: AUPE target spectra (dashed lines) and in-situ validation spectra (solid lines). Target 005 was collected near the edge of AUPE field-of-view and this is thought to be the reason for the poor match and large error bars in the IR. Target 004 has a sharp slope between 400-450nm indicative of sulfur. The large error bars are predominantly caused by the high variability between pixels in each ROI due to the small scale spectral variance of the terrain and each individual target.

Spectral results: The AUPE multispectral image cubes were analysed and examined in a number of different ways. Spectral parameter maps [7,8] were generated using the visible wavelength filter images, and 12 point full VNIR spectra (400-1000nm) extracted from the ROIs within each scene for comparison with the in-situ spectra. In the visible range these spectra matched well, however the infrared data showed a higher deviation from the validation spectra. Spectral features indicative of specific minerals were noted enabling specific minerals and mineral types to be identified from the AUPE data, including the sharp blue slope of sulfur and the absorptions around 500-600nm that can indicate iron oxides. Spectral parameters were used to trace these features within the target-sites in which they were present. Firm distinction between minerals such as goethite and hematite was not possible in the AUPE data due to the coarseness of the spectral resolution.

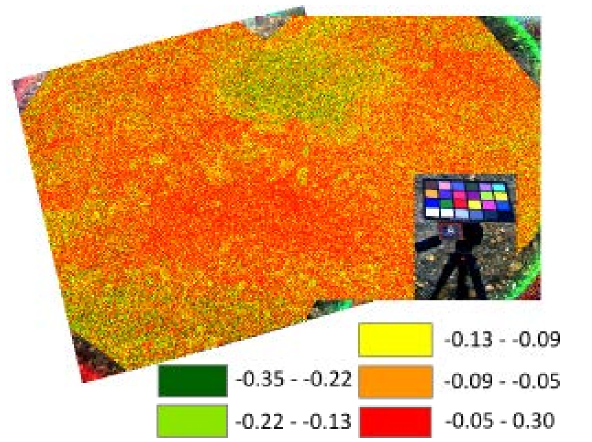

Fig 4: Band depth spectral parameter at 610nm. Low values (green) highlight regions of strong absorption at this wavelength indicative of iron- oxide minerals. In particular goethite and hematite have strong absorptions either side of this wavelength that would show up in this band in the AUPE data. The mixture of values shown in this image demonstrates how well mixed the soils of this target site are.

Conclusions: The AUPE datasets allow the production of a number of data products including high resolution images, RGB panoramas, spectral parameter images and 12 point spectra from individual targets of interest. The accuracy of the 12 point target spectra were generally good and allowed for the identification of certain specific minerals and mineral types. Combined with the other data products this result allows a confident identification of this region as one of hydrothermal alteration. Future research will look at combining these data with aerial datasets to utilise different spatial and spectral scales in the investigation of hydrothermal regions.

References: [1] Pugh, S. et al (2012) *i-SAIRAS*. [2] Mustard, J. et al (2008) *Nature, 454, 7202*, 305-9. [3] Christensen, P. et al (2004) *Science, 306, 5702*, 1733-9. [4] Poulet, F. et al (2005) *Nature, 438, 7068*, 623-7. [5] Vago, J. L. (2005) EXM-MS-PL-ESA-00002. [6] Schulze-Makuch, D. et al (2007) *Icarus, 189*, 308-324. [7] Farrand, W. et al (2007) *JGR-Planets, 112*, E06S02. [8] Rice, M. S. et al (2010) *Icarus, 205, 2*, 375-395.

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