Multispectral imaging of hydrothermal alteration terrains using an ExoMars PanCam prototype

J. K. Harris[1,2], C. R. Cousins[3], M. Gunn[4], P. M. Grindrod[1,2], I. Crawford[1,2], and D. Barnes[4]

[1]Department of Earth and Planetary Sciences, Birkbeck University of London, UK (jennifer.harris@bbk.ac.uk), [2]Centre for Planetary Sciences at UCL/Birkbeck, London, UK, [3]UK Centre for Astrobiology, University of Edinburgh, UK, [3]Institute of Mathematics, Physics and Computer Science (IMPACS), Aberystwyth University, UK

1. Introduction

Hydrothermal environments feature heat and water, making them ideal places to search for signs of life. It has been suggested that Mars has hosted such environments over the course of its history [1]. Hydrothermal sites are often characterised by small scale (cm to m) features and as such are difficult to spot from orbit. Detection of small scale features is therefore most likely with rover-based instruments. This poster presents a field trial of a prototype ExoMars PanCam in a hydrothermal environment in Iceland.

Fig 1

The Aberystwyth University PanCam Emulator (AUPE) with major components highlighted including the two 34° field of view wide angle cameras (LWAC and RWAC), the 9 band filter wheels associated with each WAC and the High Resolution Camera (HRC). The Pan/Tilt unit enables full 360° panorama views to be captured

2. ESA/Roscosmos PanCam Emulator

The 2018 ESA/Roscosmos ExoMars rover is currently in development and will feature a multispectral, stereoscopic camera system, PanCam. This type of instrument has already proven its utility on both Spirit and Opportunity rovers [2]. PanCam combines 2 wide angle cameras (WACs) fitted with spectral filters to allow the creation of RGB panoramas and 12 point multispectral images (400-1000 nm), and a narrower angle high resolution camera (HRC) for high resolution targeted images. Aberystwyth University have built a prototype PanCam emulator (AUPE) [3]. AUPE mimics the current PanCam configuration as closely as possible using off-the-shelve commercial components. AUPE allows us to test the usability of the PanCam data products and develop efficient analysis routines.

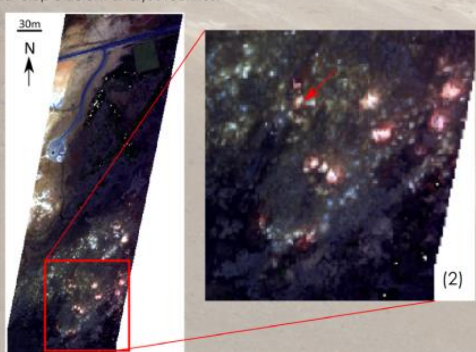


Fig 2: NERC ARSF Aerial stretched RGB image showing Námafjall region. The red arrow highlights the specific target site detailed in the following figures. The spatial resolution here is 2m/pixel. This data is used for spatial context between the various field target sites and as an analogue for the hyperspectral orbital data available on Mars.

3. Fieldwork

AUPE was taken to Námafjall, a small geothermal region located in the Northeast of Iceland near Lake Mývatn and within the Krafla volcanic area. Full AUPE datasets were collected from four separate targets covering a variety of structures and mineral alteration suites typical of hydrothermal environments. In addition complementary in-situ VNIR spectra and rock and soils samples were also collected.

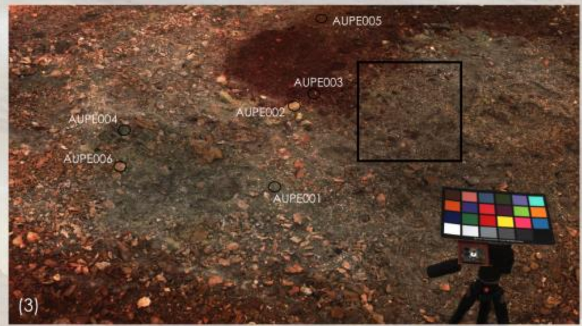
4. Data Analysis

The AUPE multispectral data were analysed in a number of ways:

a) spectral parameter maps were generated based on spectral parameters developed by Farrand et al [4] and adjusted for AUPE's filter wavelengths.

b) ROI spectra were extracted (Figure 3) and compared to the complementary in-situ field spectra (Figure 7)

c) Principal Components Analysis were performed on ROI spectra (Figure 5)



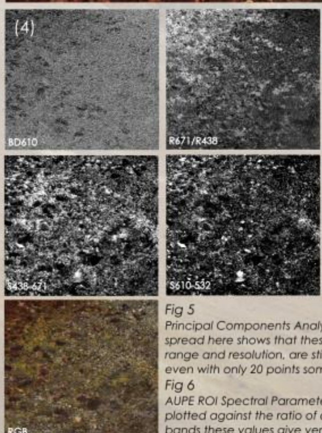


Fig 3

Site A06 AUPE RGB mosaic showing location of [Fig 4]. ColorChecker calibration target and prototype ExoMars rover calibration target.

Fig 4

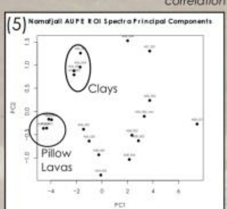
LWAC AUPE images from site A06 showing the differences highlighted by 4 key spectral parameters; the band depth at 610nm (BD610), the red/blue ratio (R671/438), the slope between blue and red (S438-671) and the slope between 610nm and 532 nm (S610-532). Even in greyscale general regions of difference can be identified and certain minerals can be picked out. Sulphurous patches in the general soils are emphasised in the R671/438 image and BD610 shows up small red stones with low values that otherwise blend into the other parameters and the RGB image.

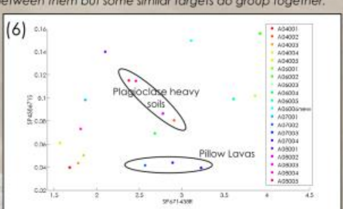
Fig 5

Principal Components Analysis results using the AUPE ROI spectra. The spread here shows that these spectra, whilst limited in terms of wavelength range and resolution, are still capturing a wide span of differences and that even with only 20 points some groupings can still be made.

Fig 6

AUPE ROI Spectral Parameters, the slope between 438nm and 671nm plotted against the ratio of 671nm to 438nm. Despite involving the same bands these values give very different information and there is no correlation between them but some similar targets do group together.





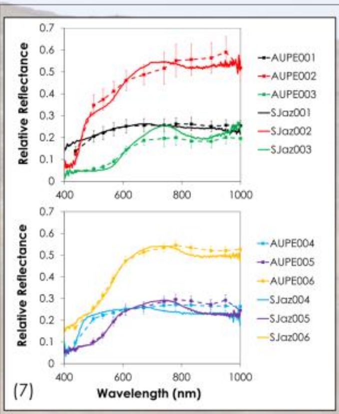


Fig 7:

Spectra extracted from ROI's within AUPE multispectral image sets and spectra taken from the corresponding locations in the field using a point field spectrometer (an Ocean Optics Jaz spectrometer). The point spectra have been scaled to match at 610nm to better show similarities and differences. Spectra are presented from site A06 shown in figure 3 where ROI locations are also indicated. The broad spectral shapes are captured correctly in the AUPE data with some slight differences in the Infrared. Some subtlties are lost due to the coarse spectral resolution of AUPE in comparison to the field spectrometer.

5. Results

A general good agreement was noted between the AUPE and in-situ spectra. The major area of disagreement was in the near-infrared. Reasons for this are currently being investigated. The wavelength range covered is not optimal for mineral identification but a number of mineral types were correctly identified including sulfur and iron-oxides. Major minerals identified in the laboratory analysis included opaline silica, smectite clays, iron-oxides and sufur, backing up the rough identifications from the AUPE data. PCA and spectral parameter maps were both efficient methods of quickly identifying regions of interest and demonstrating any correlations between the different spatial targets wtihin the wider region. The spectral parameters were even capable of picking up structural features and textures that were not immediately obvious in the RGB composite images as seen in figure 4.

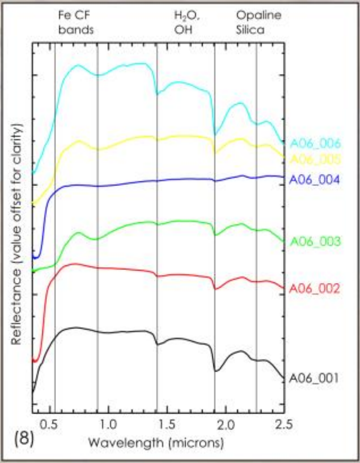


Fig 8: Laboratory acquired VNIR spectra from samples of ROI targets within each AUPE target site. All spectra are presented with continuum removed using the inbuilt ENVI tool to emphasis absorption features. Key features are highlighted.

6. Future Work and Conclusions

Combining the multispectral, RGB and HRC data from AUPE allows a confident identification of this region as a hydrothermally altered environment.

Future work will concentrate on combining these datasets with aerial and orbital data to extend the range of spatial and spectral scales available for the remote investigation of hydrothermal alteration.

References:

[1] Schulze-Makuch, D. et al (2007) *Icarus, 189*, 308-324, [2] Johnson, J. et al (2006) *JGR, 111, E2*, 1-39, [3] Pugh, S. et al (2012) *i-SAIRAS.*, [4] Anderson, R. et al (2012) *Icarus, 223*, 157-180

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