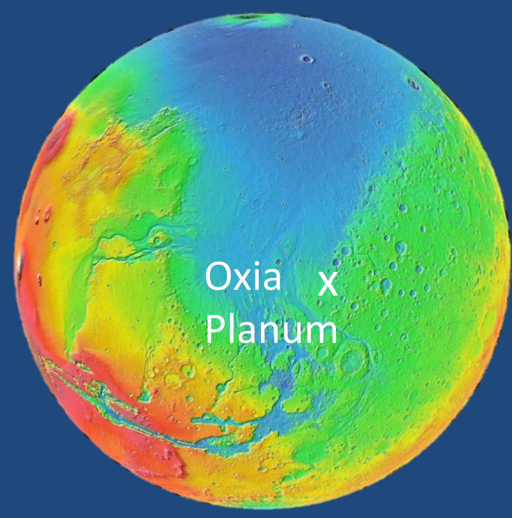
UNIVERSITY OF LEICESTER



Fracture Mapping and CaSSIS Imaging of the Exomars2020 Landing Site Oxia Planum: Characterising Clay-rich Sediments

A. Parkes Bowen[1], J. C. Bridges[1], J. Page[1], M. R. El-Maarry[2], N. Thomas[3], G. Cremonese[4], M. Pajola[4] , L. Tornabene[5]

[1]Space Research Centre, University of Leicester (acdpb1@le.ac.uk), [2]University of Birkbeck, [3]Universität Bern, [4]Istituto Nazionale di Astrofisica, [5] CPSX, Western University, Canada

Introduction

Following Oxia Planum's selection as the landing site for the Rosalind Franklin rover [1], characterising the sites' mineralogy and geological history in different ways is essential to maximise science returns from the mission. Analysis of fractured terrain could be a useful tool in this effort as the form a fracture network takes varies depending on several factors [2-4]. Use of the Colour and Stereo Surface Imaging System (CaSSIS) can provide high resolution (~4.5m/pixel) colour imagery across four bands comparable to the spectral range of HiRISE colour images [5]. Due to its increased image swath and colour differentiation compared to HiRISE and increased resolution compared to CRISM, CaSSIS could prove to be a useful tool in characterising Oxia's mineralogy, complementing existing imagery from HiRISE/CRISM.

Oxia Planum

- Composed of layered, fine-grained Fe/Mg clay-rich deposits formed during the Noachian epoch, overlain by a later Noachian fluvio-deltaic system and an Amazonian capping unit [6,7]
- Much of Oxia's surface exhibits extensive, well-preserved fractures, making Oxia an excellent site for fracture analysis
- A recent study using HiRISE colour imagery showed Oxia Planum's clay unit potentially has two distinct components; one a red-tinged vermiculite-rich Fe/Mg clay, displaying meter scale fracture polygons, the other a bluer mix of Al-Fe/Mg clays displaying decametre scale fracture polygons [8]
- Use of CaSSIS imagery could be useful for expanding the mapping of these sub-units, given limited HiRISE colour coverage

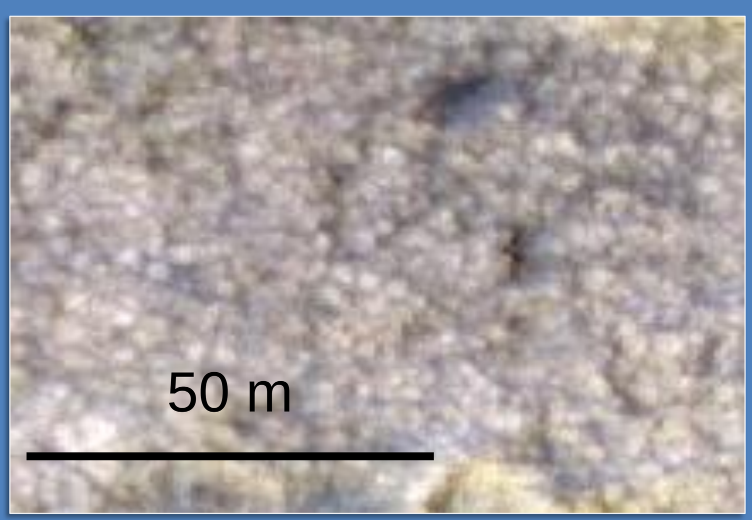
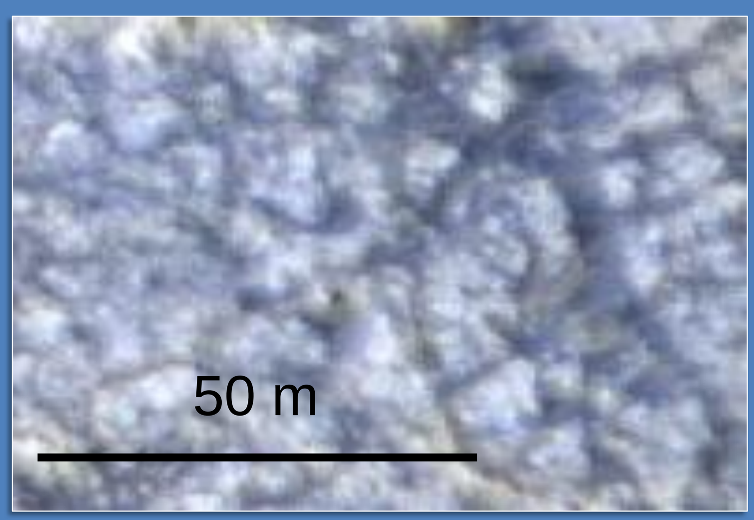


Figure 1/2: Left; Vermiculite-rich Fe/Mg clay member Right; Al-Fe/Mg clay mix [8]



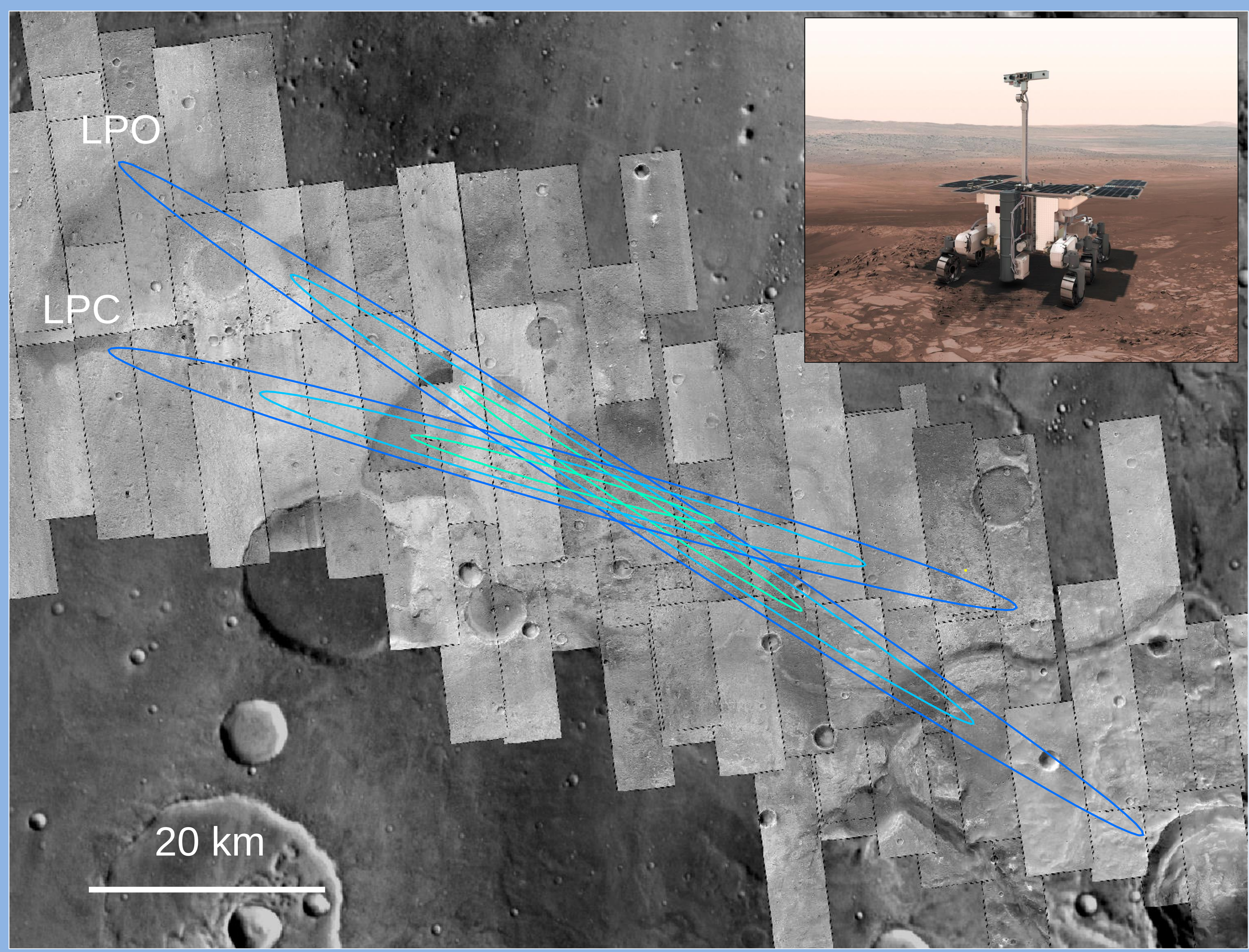
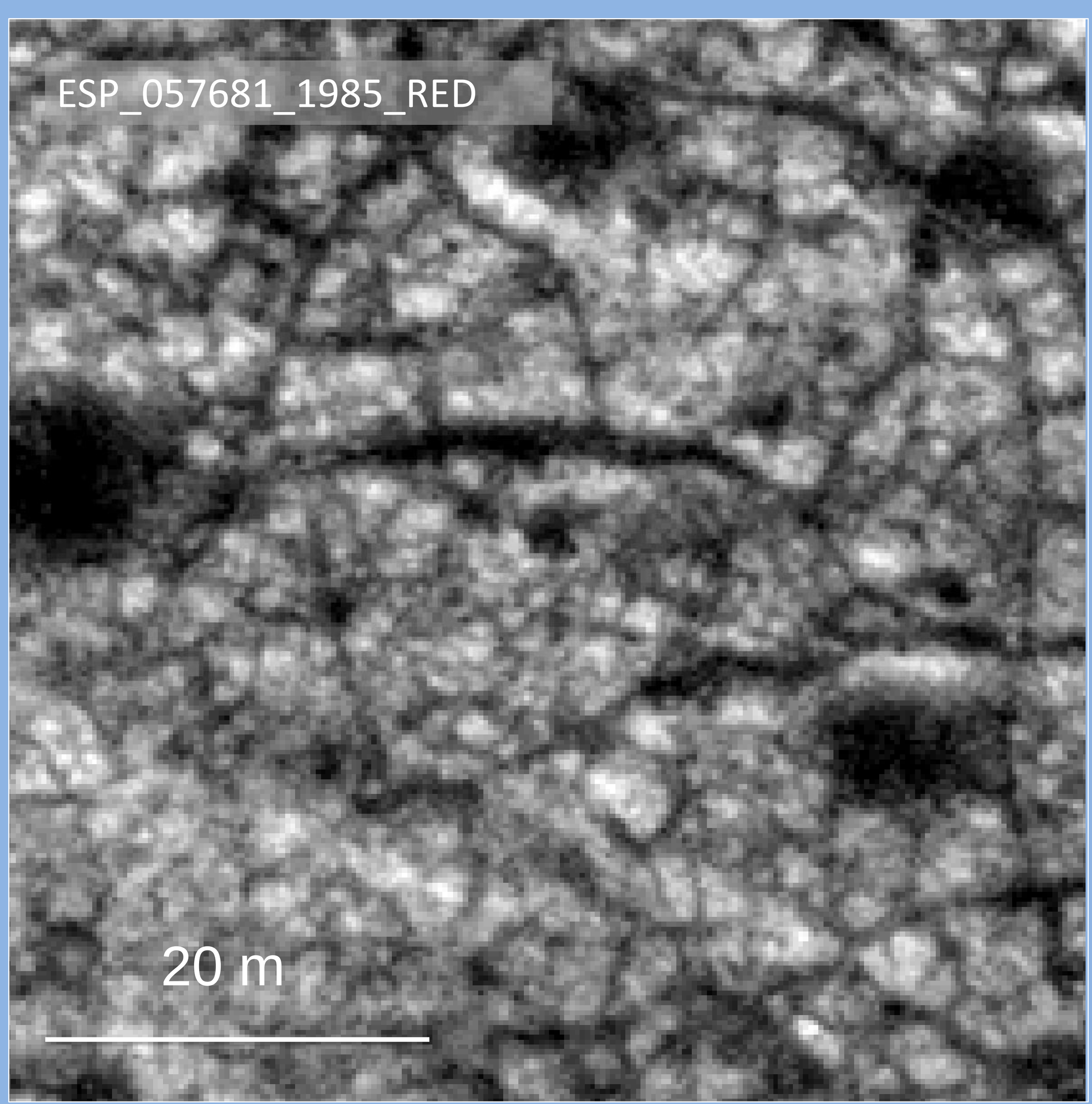


Figure 3/4: Top right; artists impression of the Rosalind Franklin Rover [9], Bottom left; HiRISE coverage of Oxia Planum with THEMIS base layer. LPO designates the landing ellipse at the opening of the launch window, LPC at its end.



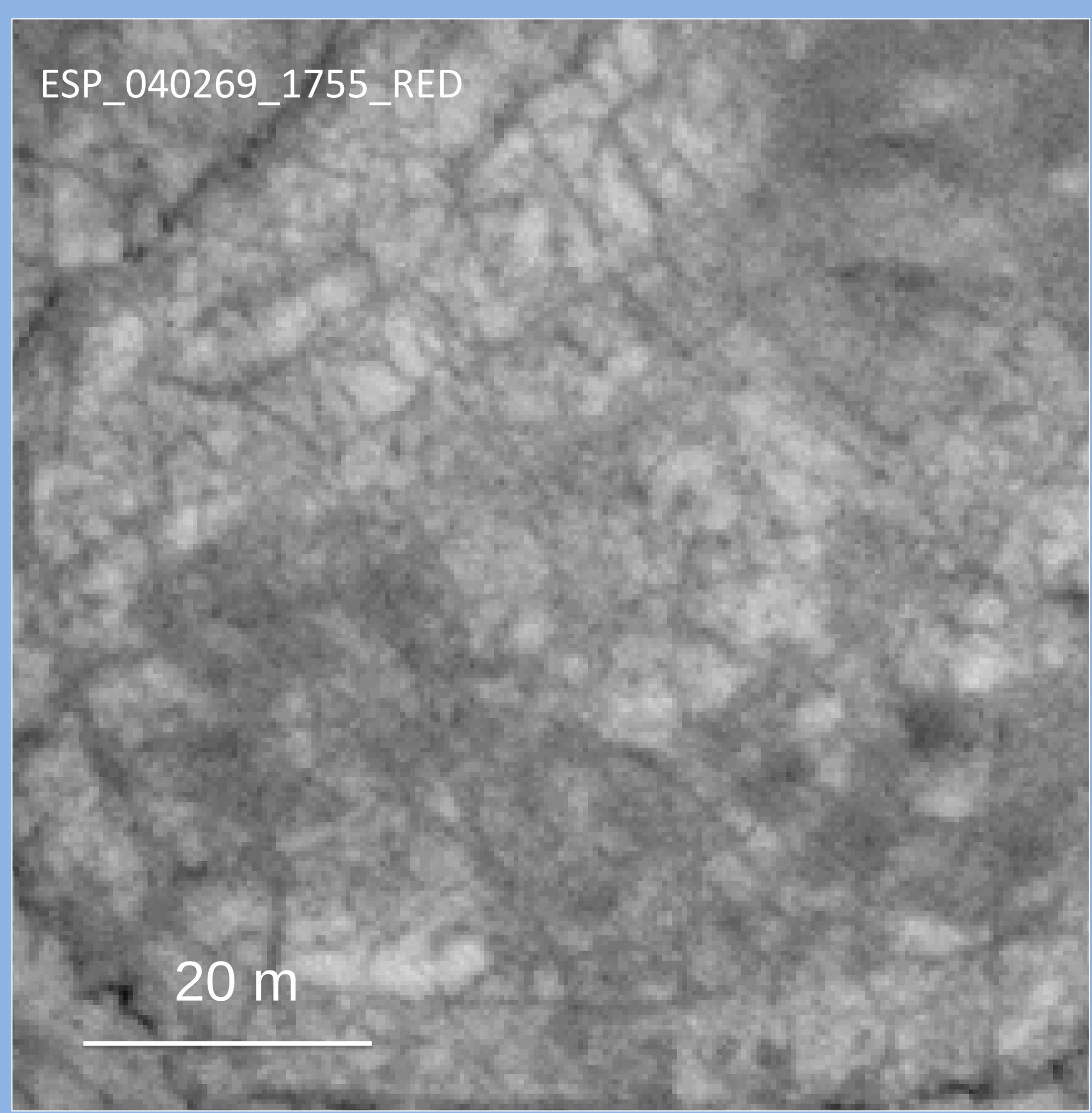
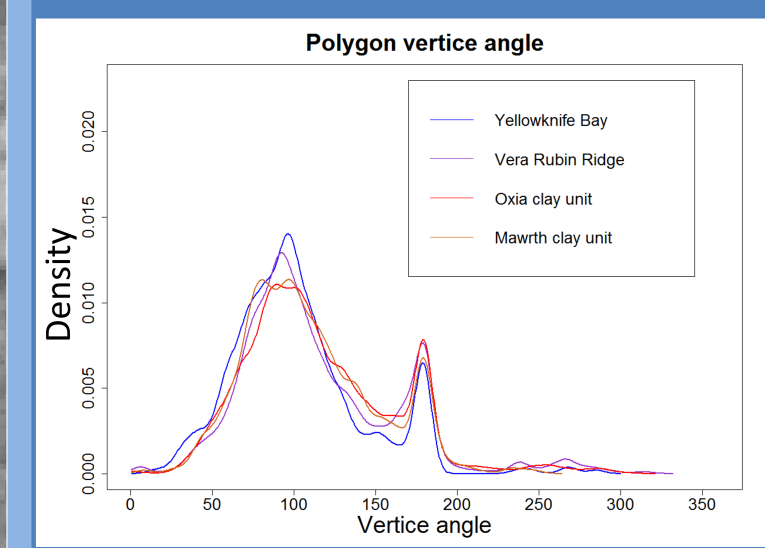


Figure 5/6: Left; example of Oxia Planum's fractured clay unit, Right; Yellowknife Bay, a clay exposure within Gale Crater visited by Curiosity. At both orbital and ground level it exhibits significant fracturing and acts as a key comparison for the units at Oxia.

Fracture Characterisation; Methodology and Results

- Fracture analysis involves mapping fracture networks in HiRISE imagery, measuring several metrics of the fractures and fracture polygons (areas enclosed completely by the intersecting fractures), such as the polygon area, polygon vertices angle, etc. subsequently. These are then compared and contrasted with other fracture networks using a kernel density graph (results thus far shown in figures 7/8)



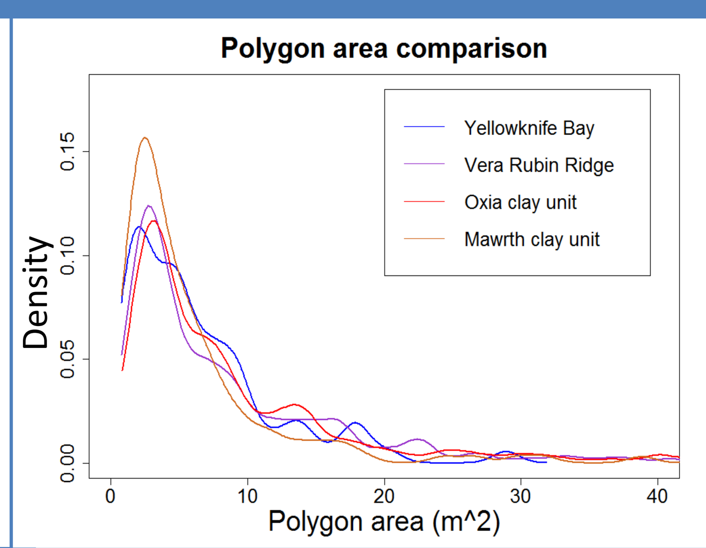


Figure 7/8: Left; Kernel density graph of polygon vertex angles, Right; Kernel density graph of the polygon area

- Results indicate parallels between the clays at Gale Crater [10,11] and Oxia Planum, with the distribution in polygon area showing distinct similarities. Polygon vertex angles show less of a difference between the two in comparison with other sites with most of the fracture networks showing a peak at ~90-120° with a smaller one at 180°. This latter peak, or specifically the lack of it, may indicate the fractures within these units have been subject to alteration after the fractures formed

Band Ratioing of CaSSIS images

In an effort to better map Oxia's clay unit and two potential sub-units, CaSSIS imagery of the site was band ratioed using ratio's highlighted in recent research [12] to distinguish materials rich in either ferric or ferrous material. These images were compared with CRISM and HiRISE colour data to see whether the ferric/ferrous regions correlated with the current known extent of the clay unit and its potential sub-units.

When compared with CRISM browse imagery with channels highlighting phyllosilicates containing Fe/Mg there is a clear correlation between areas rich in Fe/Mg phyllosilicates and those areas which register as being ferric-rich in CaSSIS imagery. This is also the case in other CRISM bands which are used to highlight Fe/Mg clays.

The comparison with HiRISE colour imagery also showed a broad agreement to what was expected, with the areas which registered as being high in ferric material matching those which were part of the red sub-unit i.e. the Vermiculite-rich unit.

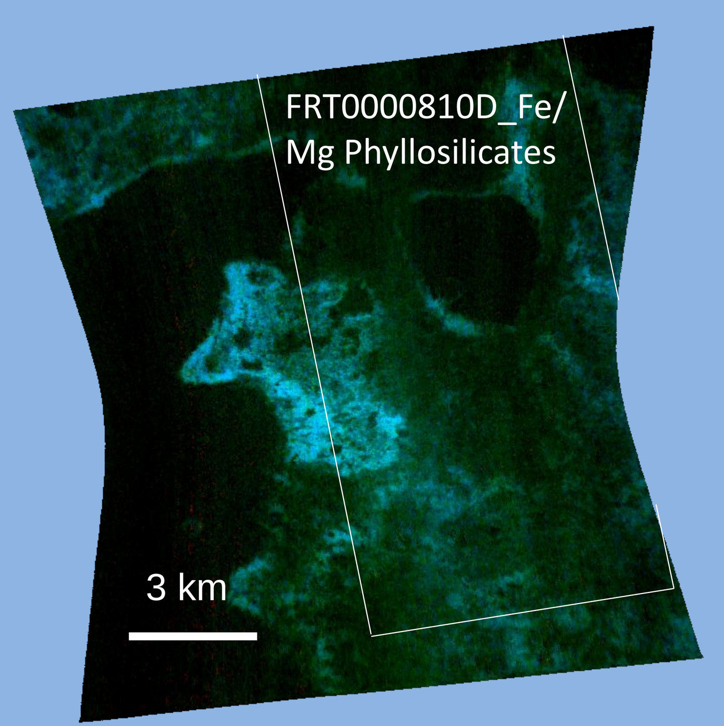
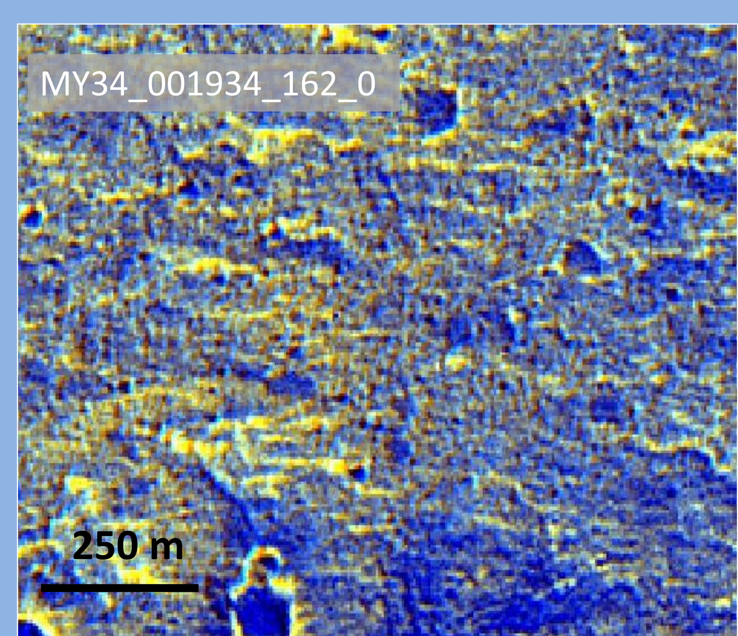


Figure 9: CRISM browse product used to highlight Fe/Mg phyllosilicates in cyan/blue



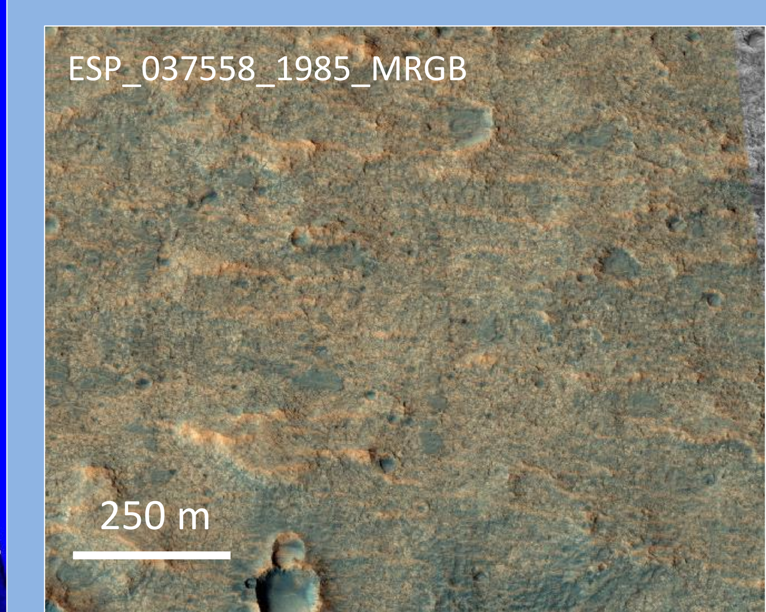


Figure 10-13: Left; CaSSIS image with the NIR, PAN and BLU filters used. Middle; Band ratioed version image, with the yellow areas highlighting ferric-rich terrain and the blue ferrous-rich terrain. Top–right; sub-section of band ratioed image. Bottom-right; HiRISE colour image of the same area as figure 12. Note that the white lines in Figures 9-11 represent where the CRISM and CaSSIS images overlap one another.

Conclusions and Future Work

- Fracture analysis and CaSSIS band-ratioed imagery are promising tools for characterising Oxia Planum; fracture analysis being useful for distinguishing different terrain types from one another and for ground truth comparisons, while CaSSIS band ratioing allows for more precise mapping of clay exposures at Oxia Planum than has previously been possible.
- Going forward further sites will be mapped out in the fracture study and possible useful additional metrics investigated. Due to the often small outcrops of Fe/Mg phyllosilicates and the significant difference in resolution between CaSSIS and HiRISE imagery, use of pan-sharpening of the CaSSIS imagery and more quantitative comparisons of the relative ratios of the colour bands in each image are to be carried out in the future.

References: [1] Loizeau D. et. al. (2019), this conference, [2] Tang C-S. at. al. (2011) Geoderma, 166(1):111-118, [3] Plummer P. S. et. al. (1981) JSR, 51:1147-1156, [4] Goehring L. et. al. (2010) Soft Matter, 6:3562-3567, [5] Thomas N. et. al (2017) SSR, 212:1897-1944, [6] Quantin C. et.al (2017) ExoMars LSSW#4, [7] Quantin C. et al. (2015) EPSC 2015, 704, [8] Quantin et al. (2018) 5th ExoMars landing site workshop, [9], ESA, [10] Grotzinger J. P. et. al. (2014) Science, 343:6169, [11] Yen A. S. et. al. (2017) EPSL, 471:186-198, [12] Tornabene L. L. et. al. (2018) SSR, 214:18