SPECTRAL ABSORPTION BAND MAPPING AT CERBERUS FOSSAE USING MARS EXPRESS OMEGA DATA. A. J. Brown, SETI Institute, 515 N.Whisman Rd, Mountain View, CA 94043. abrown@seti.org.

Introduction: The Observatoire pour la Minéralogie, l'Eau, la Glace et l'Activité (OMEGA) Instrument onboard Mars Express has been returning reflectance spectra of Mars since its orbit insertion in December 2003. OMEGA acquires pixels of varying resolution on the surface according to its height as Mars Express is in a highly elliptical orbit. It has a 1.2 mrad instantaneous field of view, and collects light in 352 contiguous channels from 0.35 to 5.1μm [1]. This wavelength range covers the VNIR and SWIR parts of the electromagnetic spectrum, and is ideal for detecting hydrous and hydroxyl-bearing minerals.

OMEGA data from the first 488 orbits of Mars Express was released to the scientific community in April of 2005. During the first 488 orbits, OMEGA imaged the Cerberus Fossae region just once, during scene 1 of orbit 228. The average pixel size for this scene was 898m (horizontal) by 900m (vertical resolution). Scene 1 of orbit 228 was 32 pixels (29km wide) x 2848 pixels (2563km long). The whole of scene 1 was analysed for this project, but only the the region around Cerberus Fossae is presented here. (Figure 1).

Athabasca Valles and Cerberus Fossae: Some researchers have suggested that the two roughly east-west rifts at Cerberus Fossae are the source of very recent (< 5 Myr) volcanism and flooding [2]. If Martian subsurface life is abundant, it is possible that the sudden eruption of volcanism and water from the rifts at Cerberus may have washed traces onto the surface around the rifts where it may lie today. Several researchers have noted the potential for hydrothermal activity and altered hydrothermal minerals in the area surrounding the Cerberus Fossae, along with implications for the search for life on the Martian surface.

OMEGA Data reduction: The OMEGA dataset was supplied through the European Space Agencies Planetary Science Archive website. The OMEGA data was supplied by the team led by Jean-Pierre Bibring at Institut d'Astrophysique Spatiale, Orsay Campus, France. Members of this team provided a suite of software (written in RSI's IDL programming language) in order to correct the raw OMEGA data for bad channels (so called 'hot bands'), solar illumination, and instrumental channel to channel gain. Atmospheric correction was not supplied. As a result, atmospherically affected regions of the Mars spectrum have been deliberately avoided.

SWIR Analysis method: I used the SWIR region of the EM spectrum (2.0-2.5μm) to look for evidence of hydroxyl-bearing minerals. An absorption band analysis was carried out using the 15 OMEGA channels covering the range 2.22 to 2.41μm. Deep atmospheric CO_2 absorption bands effectively mask the shorter wavelengths of the SWIR region (from 2.0-2.24μm) as shown in Figure 2.

The absorption band modelling technique (described elsewhere [3]) was applied to the restricted OMEGA dataset of scene 1, orbit 228. An absorption band histogram [4] was prepared grouping all absorption bands that were found in each pixel from 2.22 to 2.41μm. Thresholds for absorption band detection were set to 0.001 (0.1%) of the continuum removed spectrum. The histogram is shown in Figure 3.

The histogram shown in Figure 3 suggests the absorption bands may be grouped into three classes based on the three peaks at 2.3, 2.34 and 2.39μm. The three absorption band groupings were treated as classes, and pixels were mapped according to whether they displayed that absorption band, in order to assess the spatial occurrence of the absorption bands. The absorption bands were thresholded at varying levels, found by trial and error. If the bands were due to atmospheric effects, it would be expected that coverage would be ubiquitous and not restricted to patches on the ground.

Figure 4 shows that the coverage for each of the classes is quite patchy – this is due to the inherent signal to noise of the OMEGA instrument at these wavelengths. However, there are regions where there is spatial coherence for each of the classes. This suggests that the approach is reasonable, however the data at this point are not yet of a standard suitable for mapping on a pixel by pixel basis – clusters of pixels need to be discovered before an identification of a mineral deposit is assured at these wavelengths for the OMEGA instrument.

❶ <u>Class 1 concentration in low albedo region</u>. North of Cerberus Fossae lies a low albedo region which shows evidence of aeolian scouring. This region is closely associated with higher abundance of class 1 (absorption band at 2.3μm). Class 1 identifications are sparse elsewhere.

❷ <u>Class 2 absent on edge of low albedo region</u>. Class 2 minerals also seem to occur in the low albedo region at the top of the analysis area, however they are markedly absent from a small linear area marked at ❷.

❸ <u>Class 2 in lobate pattern near Fossae</u>. Class 2 minerals make an interesting lobate shape around the region between the two Fossae. This seems to have a good correlation with dark areas, and no class 2 material is found in the lighter region between the two Fossae. This indicates Class 2 is associated with ground deposits, but it is not determined yet whether this is a true absorption band effect or a grain size effect.

❹ Class 3 correlation with Class 2. Class 3 is fairly well correlated spatially with class 2, however in regions marked at point ❹, class 2 is abundant but class 3 is not. This could mean that the band designating class 3 (2.39µm) is a weak accessory band for minerals displaying the 2.34µm (class 2) band that is not always being detected. This suggests minerals like chlorite, talc and amphibole might be candidates to describe a combination of these classes.

Possible explanations for the absorption bands: Mg-OH bearing hydroxyl minerals such as chlorite, phengite, amphiboles and talc have absorption bands in the 2.3µm to 2.34µm region. All these minerals have minor accessory bands that were not reliably detected in the SWIR range for the OMEGA dataset. Sulfate minerals such as kieserite do have a broad absorption band in the 2.4µm region which may contribute to the bands found near 2.39µm (class 3).

Implications for Athabasca Valles: Figure 4 shows several possible 'deposits' of each class of absorption band. It is possible that class 1 (2.30µm) is associated with low albedo rock that has been blown clear of dust. Class 2 (2.34µm) and class 3 (2.39µm) might be associated with one mineral type, perhaps chlorite, talc or amphibole. If these should be found, it would probably indicate hydrothermal alteration or chemical weathering of basalt or komatiite flows (in the case of talc) [5]. Chlorite and amphibole could also be explained by high temperature metamorphism of basalt in a closed chemical system.

Conclusion: Mineral identifications on the basis of these weak absorption bands for this dataset are difficult, and this exercise is the first to attempt to do so automatically. Generally OMEGA investigators require a 5% absorption band strength for positive mineral identification. In the meantime, further analysis of more regions of the Martian surface may reveal further patterns in absorption bands in the SWIR and other regions that may extend our understanding of Martian surface chemistry.

References: [1] Bibring, J.-P. et al (2005) *Science, 307*, 1576–1581. [2] Burr, D. M. et al. (2002) *Icarus, 159*, 53-73. [3] Brown, A. J. (in press) *IEEE TGRS*. [4] Brown A. J. (2006) PhD Thesis, Macquarie University, Australia. [5] Brown, A.J. et al (2004) *LPS XXXV* Abstract #1420.

Additional Information: Further details and high resolution images from this project are at: http://aca.mq.edu.au/abrown.htm

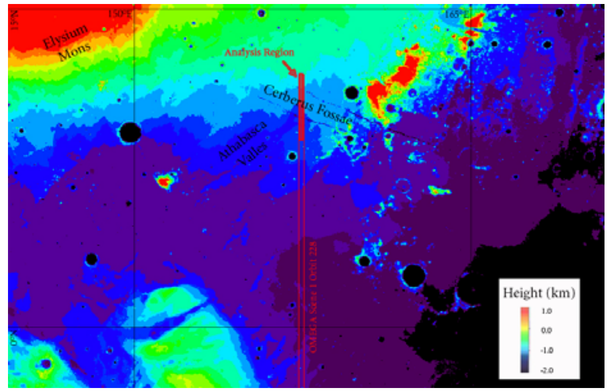
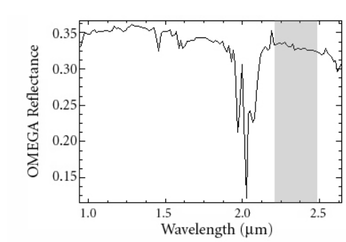


Figure 1 – Coverage of OMEGA scene 1 of orbit 228 in red outline. A red highlighted box shows the analysis region in Figure 4.



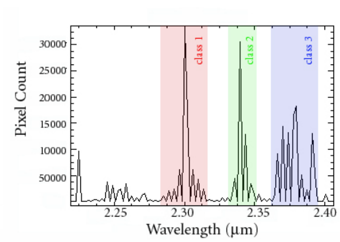


Figure 2 (left) –Example OMEGA spectrum from 0.9-2.6µm. Sharp absorption bands near 2.0 are due to CO2 in the atmosphere. The region covered by this investigation is highlighted.

Figure 3 (right) – Absorption band histogram of OMEGA scene 1, orbit 228 for the 2.22-2.41µm region, showing distribution of three grouped classes.

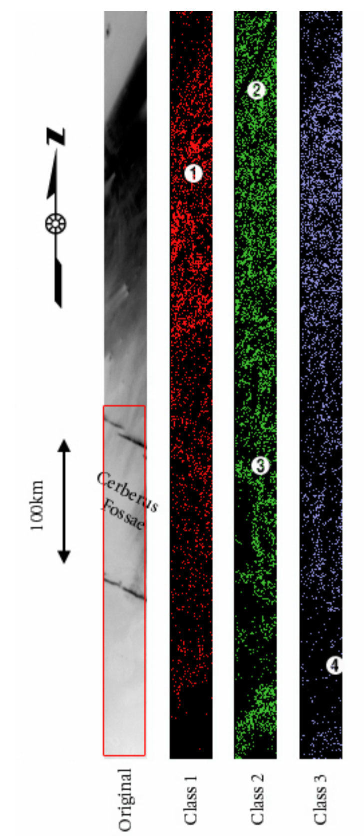


Figure 4 – Maps of coverage for selected absorption band classes in OMEGA scene 1 orbit 228. See text for discussion of numbers.