Analysis Absorption Band Positioning: A New Method for Hyperspectral Image Treatment

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Abstract This work demonstrates a new program for the spectral classification of hyperspectral images based on the positioning of the absorption band. The program generates an image where the value of the pixel is the wavelength of the absorption band after the continuum removal. This program, when used with similar spectral features, provides a classification with better results than the usual procedures (i.e., SAM, SCM, SFF, correlation coefficient R used by Tricorder). This program was tested in AVIRIS hyperspectral images obtaining excellent results as much in mineralogical as vegetation discrimination.

Keywords: spectral classifier, absorption band, hyperspectral, remote sensing.

1. Method of the Analysis Absorption Band Positioning (AABP)

The main spectra classifiers SAM (Kruse *et al*. 1992, Kruse *et al*. 1993a and b), MCE (Carvalho & Meneses, 2000), SFF and the correlation coefficient R used by Tricorder (Clark & Swayze, 1995) have problems in separating near and similar absorption features due to the high correlation between the features. This problem increases when they are mixed, as in the case of goethite and hematite, which generate intermediary features. For those minerals and their mixtures, the identification can be better determined by the absorption band position. Therefore, a program was developed to determine the absorption band from continuum analysis of reflectance spectra and generates an image relative to its wavelength. This method was named Analysis of the Absorption Band Positioning (AABP).

The continuum removal can alter the absorption band value in relation to the spectrum without continuum removal. Thus, it is always necessary to analyze the absorption positioning before and after the continuum removal.

2. The Use of AABP in Hyperspectral Images

AABP can be used for two purposes: a) previous image segmentation and b) the discrimination of specific absorption bands. The first case is characterized as an exploratory stage used in a wider spectral range. In the second case, the use of the method should be restricted to specific absorption bands.

AABP was tested in the AVIRIS image obtained during the SCAR-B mission (Smoke, Clouds and Radiation - Brazil) done in 1995 in Brazil. The study area is the lateritic nickel mine located in Niquelândia (GO). The image was corrected for the atmospheric effect, using the Green method.

First, AABP was used in the 0,46-µm to 0,74-µm spectral range. The image on gray levels shows a strong contrast among the vegetation areas and the exposed soil area (Figure 1). The visualization of the histogram demonstrates the data distribution. Due to the low contrast, an interactive density slicing is necessary according to the absorption band. The use of a profile in the image highlights the differentiated nature of the pixels. In Figure 2, the areas with vegetation cover are well discriminated from the areas with exposed soil and saprolite in the *Fazenda* mine.

To obtain a better visualization of the two segments previously selected, AABP was used in the spectral range relative to the vegetation and exposed soil. The vegetation was analyzed in the 0,65-µm to 0,70-µm spectral range, which can be separated into areas with predominance of green vegetation (0,6754 µm) and nonphotosynthetic vegetation (0,6849 µm) (Figure 3). The relative spectra for the two classes are presented in Figure 4.

The Fe^{+3} band is well defined in the 0,46-µm to 0,62-µm spectral range. Figure 5 presents the AABP classified image. A gradation of iron minerals behavior can be seen, more goethite in the base of the weathering profile is observed and more hematite is observed on the top, as was verified in the field. The class with the feature positioning in 0,4995 µm in the mine represents areas with silica impregnated with goethite and limonite.

Figure 6 presents the mean spectrum of the Fe^{+3} band among the goethite and hematite mineral from the USGS spectral library (Clark *et al*., 1993). That procedure is effective in separating these two minerals indicating the relative mixture degree.

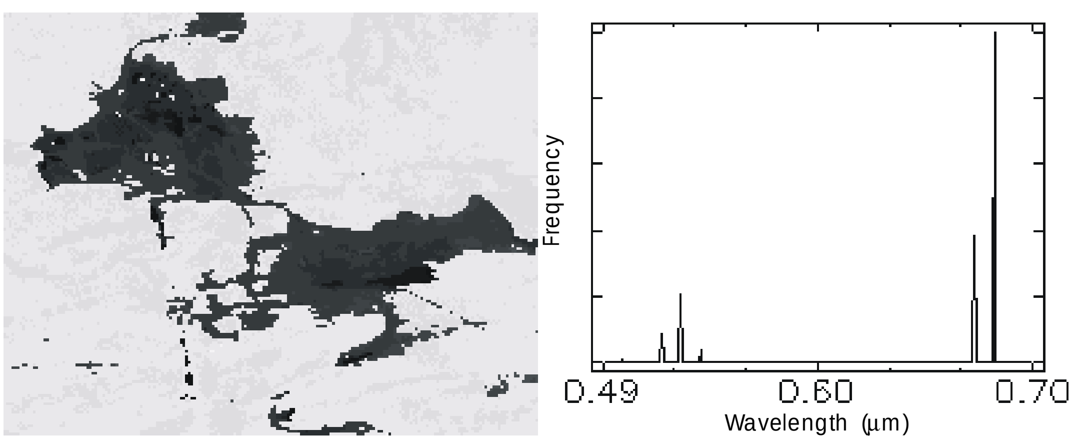

Figure 1 - Wavelength image of the absorption band.

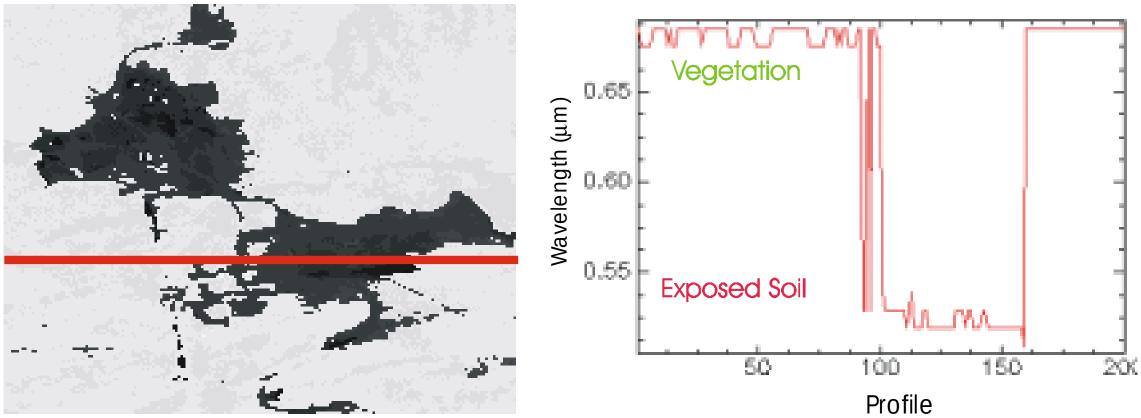

Figure 2 - Horizontal profile in the wavelength image of the absorption band.

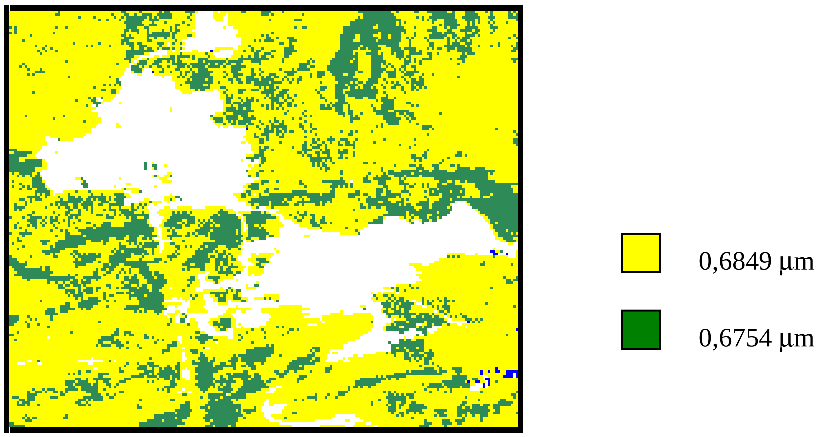

Figure 3 -Image regarding the wavelength image of the absorption band in the 0,65-µm to 0,70-µm spectral range highlighting the areas with vegetation cover.

a) b)

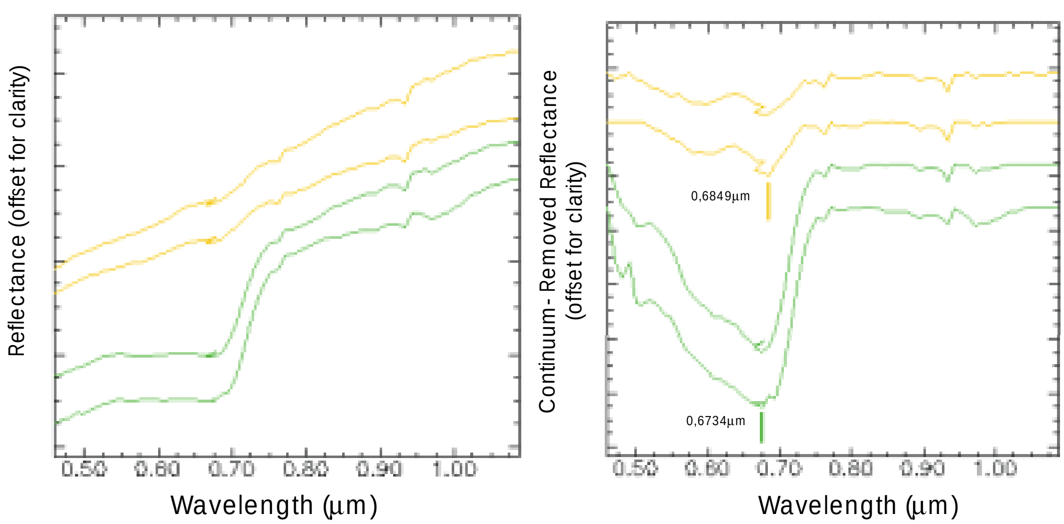

Figure 4 - Spectral curves refer to green vegetation (0,6849 µm) and nonphotosynthetic vegetation (0,6754 µm): a) reflectance and b) continuum removed reflectance.

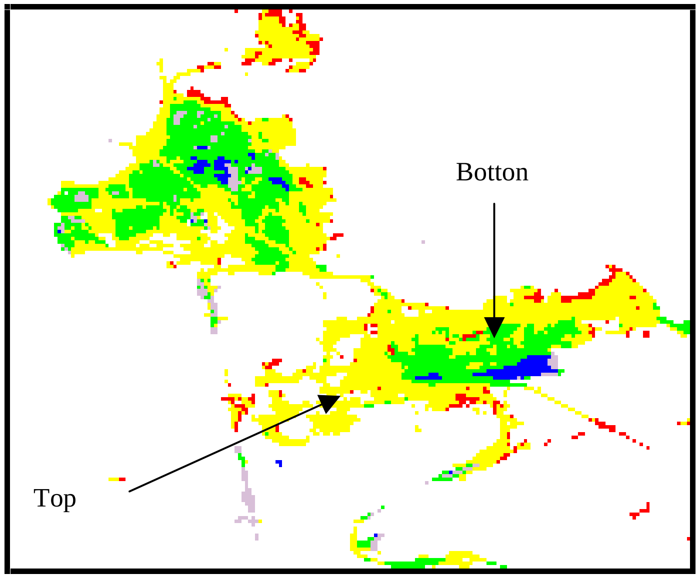

Figure 5 - Image regarding the wavelength image of the absorption band in the 0,46-µm to 0,62-µm spectral range.

0,5390 µm Hematite

0,5291 µm

0,51920 µm

0,4995 µm

0,4897 µm goethite

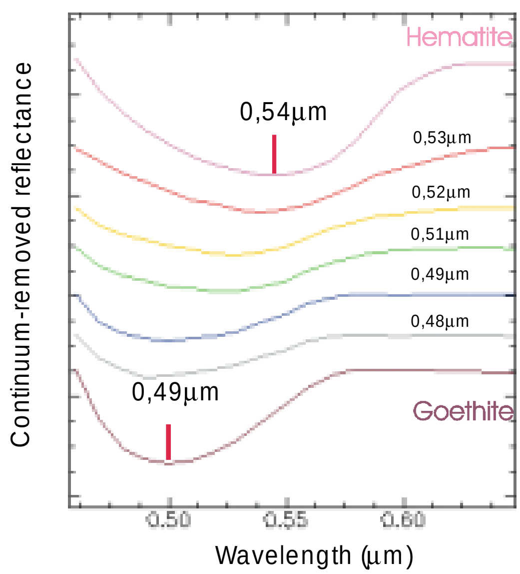

Figure 6 –Spectral curve sequence between goethite and hematite (0,46 µm and 0,62 µm).

Another interesting application of AABP in the study area is in the characterization of the garnerite main spectra representative of the facies with a concentration of nickelliferous silicated minerals. The term garnerite has a generic connotation to define a mixture of hydrated silicate of Ni-Mg from the montmorilonite group (Trecasses *et al*., 1980; Brindley & Pham, 1973). In the mine area, pimelite and saponite with serpentine (antigorite) are mainly constituted of garnerite. The garnerite coloration varies from green at the base, to brown on the top, due to the presence of goethite .

The garnerite is characterized by the Mg-OH band that presents a small displacement in conformity with the preponderant mineral, varying between 2,22 μm and 2,36 μm. The AABP method allows detection of the dominant minerals: pimelite/saponite, saponite and antigorite (Figure 7). The differences between each one of those minerals correspond to an interval of little bands for the AVIRIS sensor.

Figure 8 presents the AABP image where the wavelength values of the absorption bands are characterized. The antigorite and the saponite are seen to be limited to restricted areas. The differentiation of the antigorite can also be obtained using the absorption band at 2,11 μm.

3. Conclusion

This new method (AABP) aims to generate an image relative to the wavelength of the absorption band. This method can be used as an exploratory stage and as in the analysis refinement stage. This method presents advantages in the spectra discrimination with high similarity and proximity. Therefore, AABP can be used as a refinement after the employment of others spectral classifiers. In the *Fazenda* mine, the use of AABP method made easier the identification of the vegetation patterns and also the discrimination of the soil mineralogy. In the vegetation, it was possible to separate areas with a prevalence of green vegetation and those with non-photosynthetic vegetation. In the soil mineralogy, it was possible to distinguish gradations of soils hematitics for goethitics as well as garnerite types.

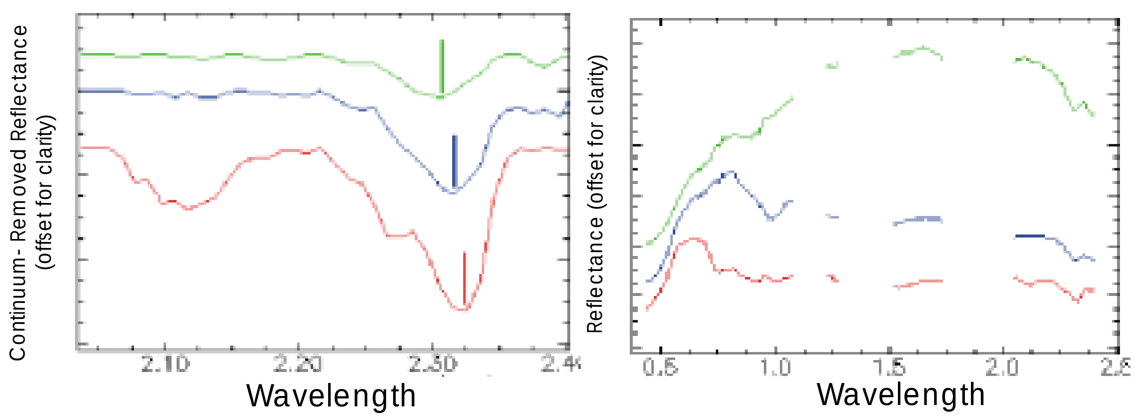

Figure 7 – Spectrum with Mg-OH bands: pimelite-saponite (green), saponite (blue) and antigorite (red)

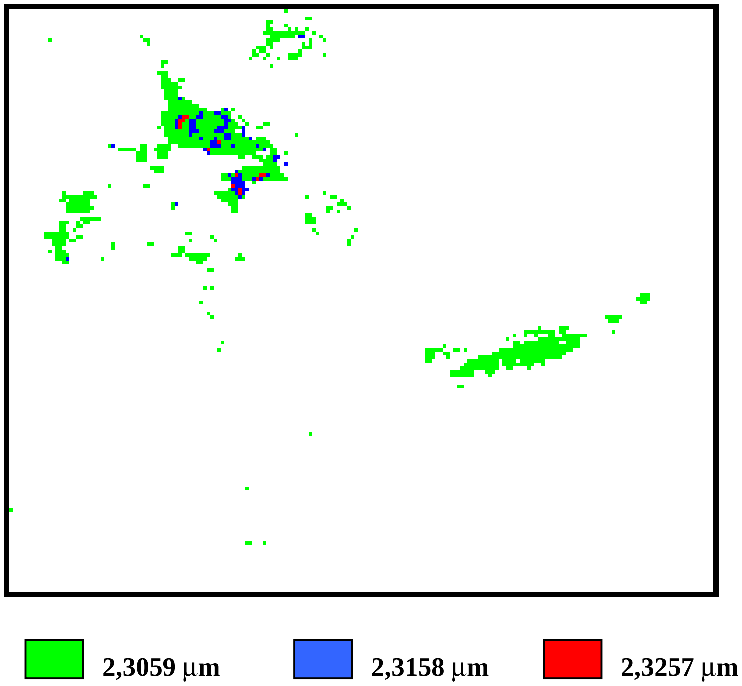

Figure 8 – AAPB image relative to the Mg-OH band.

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