Spectral Analysis of Hyperion Data for Mapping the Spatial Variation of Bauxite Mineral in a Part of Katni District, Madhya Pradesh, India

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ABSTRACT - Hyper-spectral remote sensing has the potential to provide the detailed physico-chemistry (mineralogy, chemistry, morphology) of the earth's surface. This information is useful for mapping potential host rocks, alteration assemblages and mineral characteristics, in contrast to the older generation of low spectral resolution systems. In the present study EO-1 hyperion data has been used for assessing the quality of bauxite deposits and also targeting bauxite mineral by using image processing approach viz , spectral unmixing.MNF transformation was applied to reduce the data noise and for extracting the extreme pixels. The limits of the Hyperion imagery for mineral mapping are the apparent strips in several bands even those important absorption bands and the low signal-to-noise ratio of imagery.The field checking and geological map of the study area illustrate that Hyperion data is useful for identifying mineral abundances and mapping the geological characteristics.

Keywords: Bauxite, hyper spectral, Hyperion data, signal-to-noise ratio, spectral unmixing

1.0 Introduction:

The technique of Imaging Spectroscopy represents one of the most advanced and dynamic trend in remote sensing. Hyper Spectral sensors measure reflected radiation at a series of narrow and contiguous wavelength bands. When seen at a spectrum for one pixel in a hyperspectral image, it looks very much like a spectrum that would be measured in a spectroscopy laboratory. This is due to the fact that Hyperion sensors have 242 contiguous spectral bands, sampling the electromagnetic spectrum from 400 to 2,400 nanometres (visible to short wave infrared). Hyperspectral Remote Sensing or Imaging Spectroscopy is concerned with the measurement, analysis & interpretation of spectra acquired from a region or part of the Earth by an airborne or satellite sensor. Different mineral have a unique reflectance and absorption pattern across different wavelength. So, minerals can be uniquely identified. The present study helps in identifying the bauxite reserves in Katni region with the help of hyper spectral analysis using EO-1hyperion data.

Bauxite is an ore of Aluminium and is a term for sediments rich in alumina but low in alkalis, alkaline earth and silica. The term is also extended to cover lateritic weathering products rich in gibbsite on basalt. The production of aluminium consumes over 90% of world production of bauxite, while the remainder is used for abrasives, chemicals and refractory. Bauxite deposits are one of the few ore deposits which occur close to the surface and possess the characteristics that can be precisely identified and described through the imaging spectroscopy.

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The primary aims and objectives of the present work is to study and analyze the spectral signatures of bauxite deposits and to assess the potential of the hyper spectral image data for assessing the quality of bauxite deposits and to explore for new bauxite deposits and also to use spectral unmixing as an image processing approach for mineral targeting of Dhangawa village of Katni district of Madhya Pradesh which is rich in bauxite deposits.

2.0 Location of study:

The study area of this report includes bauxite deposits of Katni region of Madhya Pradesh which is of high grade. The field area lies in the Dhangawa village of Sleemnabad tehsil of Katni district of M.P. The toposheets comprising this area lies in 64 A/3, A/4, A/5, A/6. This area lies between 23'N to 25'N and 80'E to 82'E.Fig. 1 and Fig. 2

2.1 Data used

Satellite Data: Hyperion data onboard EO-1 satellite acquired on 22.12.2003 is used for this study. The Hyperion is a push-broom. Imager with 242 bands of 10 nm covering the spectrum from 400 nm–2400 nm.

Software Used: ENVI 4.4 (Environment for Visualizing images Research System, Inc) software was used for processing of Hyperion Data.

3.0 Methodology:

3.1 Pre Processing of Hyperion Data

Signal-to-noise- ratio:

To estimate signal-to noise ratio of Hyperion Datasets used in the present study homogeneous area method is used (Smith and Curran , 1998).The method is widely used and employed to make a quick estimate SNR. The signal (Ra) was estimated for each landcover by averaging the pixel responses in the window used. The noise (Rsd) component was estimated by standard deviation of the pixel response within the window.

Ra Equation:1

Rsd Equation:2

SNR= Ra/Rsd Equation:3

Where

n=number of pixels in the homogeneous area

Rij=Pixel Value (response) at ij location in the homogeneous window.

A ratio of estimated signal and noise was calculated as SNR. The SNR of the used image of Vegetation varies from -4.84 to 489.75. Similarly, the SNR of the Barren land lies between -13.94 to 111.30 and of Water body is between -6.57 to 235

Minimum Noise Fraction (MNF):

(MNF) is a linear transform used to estimate the actual dimension of an image,

Remove noise, and reduce processing time. MNF projects input data (a multidimensional image) into a new space that is split into two parts: The first one is associated to the signal; the second one is dominated by noise affecting the image. Using only the first subspace of data, an improvement of the image is produced in terms of a reduced dimension and an increase of the signal to noise ratio (SNR).

Thus the image obtained of KATNI region was enhanced in terms of clarity using this process.MNF Rotation Transforms are used to determine the inherent dimensionally of image data, to segregate noise in the data. And to reduce the computational requirements for subsequent processing. Before processing this image, bad bands of the image are removed.

Fig. 3 (i), (ii), (iii) explains the process of calculating MNF.

The final result is output MNF of all the good bands as shown in the graph in Figure 3.

Pixel Purity Index(PPI) :

PPI is used to find the most spectrally pure(extreme) pixels in multi-spectral and hyper-spectral images. These typically correpond to mixing endmembers. The PPI is computed by repeatedly projecting n-D scatter plots on a random unit vector Fig.4

Region of Interest:

Region of Interest (ROIs): It contains only the pixel with high PPI values. Minimum threshold is to be given for ROI and if bad data points also exists minimum as well maximum threshold can also be calculated.

n-Dimensional Visualizer:

THE n-D Visualizer is used in conjunction with the Minimum Noise Fraction Transform (MNF) and Pixel Purity Index (PPI) results to locate, identify, and cluster the purest pixels and most extreme spectral responses in a data set. The n-Dimensional Visualizer is an interactive tool to use for selecting the endmembers in n-space. When using the n-Dimensional Visualizer, you can interactively rotate data in n-D space, select groups of pixels into classes, and collapse classes to make additional class selections easier. The selected classes can be exported to Regions of Interest (ROIs) and used as input into classification, unmixing or matched filtering techniques Fig. 5

3.2 Linear Spectral Unmixing:

Linear Spectral Unmixing is used to determine the relative abundances of materials that are depicted in multi- or hyper-spectral imagery based on the materials' spectral characteristics. The reflectance at each pixel of the image is assumed to be a linear combination of the reflectance of each material (or endmember) present within the pixel. So given the resulting spectrum (the input data) and the endmember spectra, the linear unmixing is solving for the abundance values of each endmember for every pixel. The number of endmembers must be less than the number of spectral bands and all of the endmembers in the image must be used. Spectral unmixing results are highly dependent on the input endmembers and changing the endmembers changes the results Fig. 6

The results of spectral unmixing appear as a series of gray-scale images, one for each endmember, plus a root-mean-square (RMS) error image. Higher abundances (and higher errors for the RMS error image) are represented by brighter pixels (larger floating-point numbers). For example, in Output Image, the brighter pixels represent abundances of kaolinite unmixed from the other components using an ROI spectrum and the linear spectral unmixing technique. The unmixing results should have a data range (representing endmember abundance) from 0-1. The RMS error image will help to determine areas of missing or incorrect end members.

4.0 Result:

Comparing the result with the field checking and geological map of the study area illustrate that Hyperion data is useful for identifying mineral abundances and mapping the geological characteristics. Hyperion data covering the study area were analyzed using several hyperspectral image analysis techniques, which have demonstrated their potential in identifying bauxite deposits. Within the 242 spectral bands only 145 bands are calibrated because of an overlap between the VNIR and SWIR focal planes. The pixel size of E01 Hyperion data is 30m and hence the area of highlighted Bauxite region is 75930 m^2.

Acknowledgements

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Location of Study:

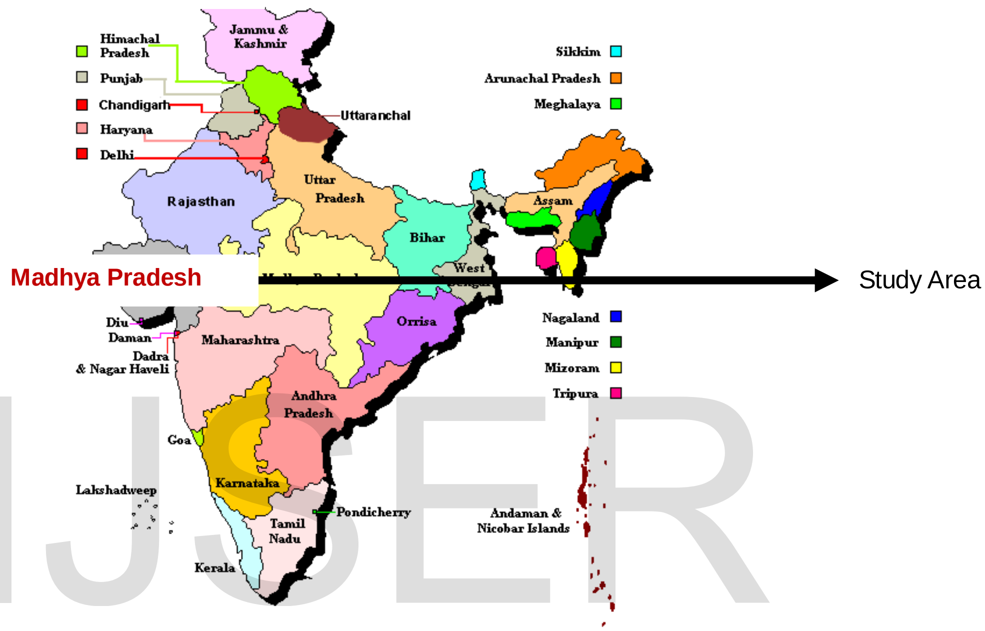
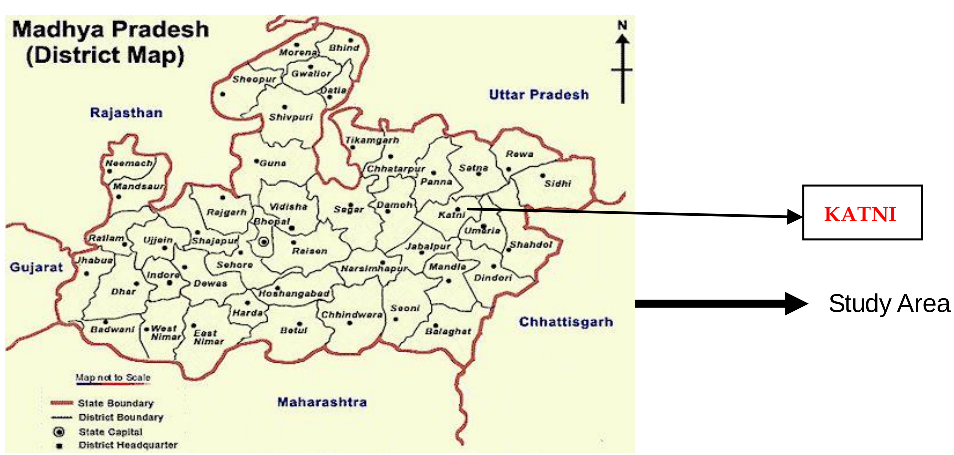


Fig. 1



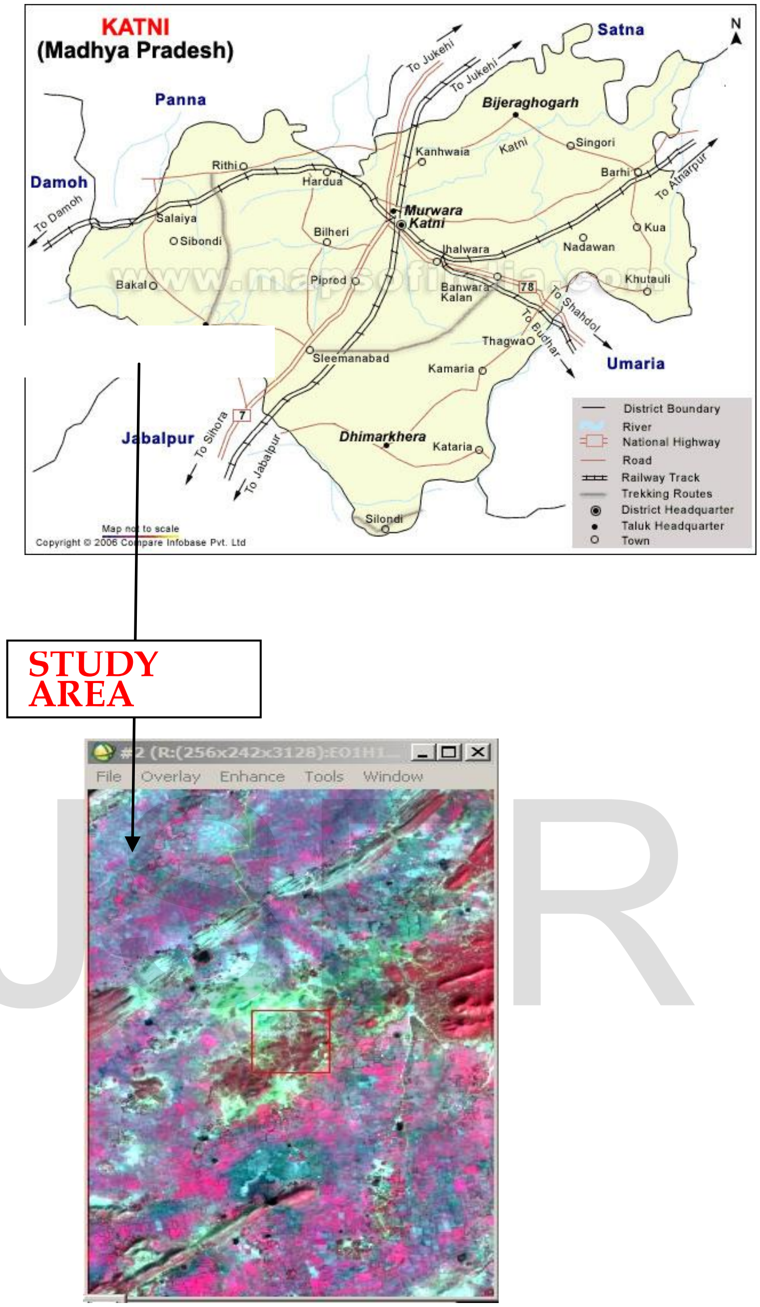


Fig. 2

Methodology:

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Fig. : 3 (i), (ii), (iii) explains the process of calculating MNF

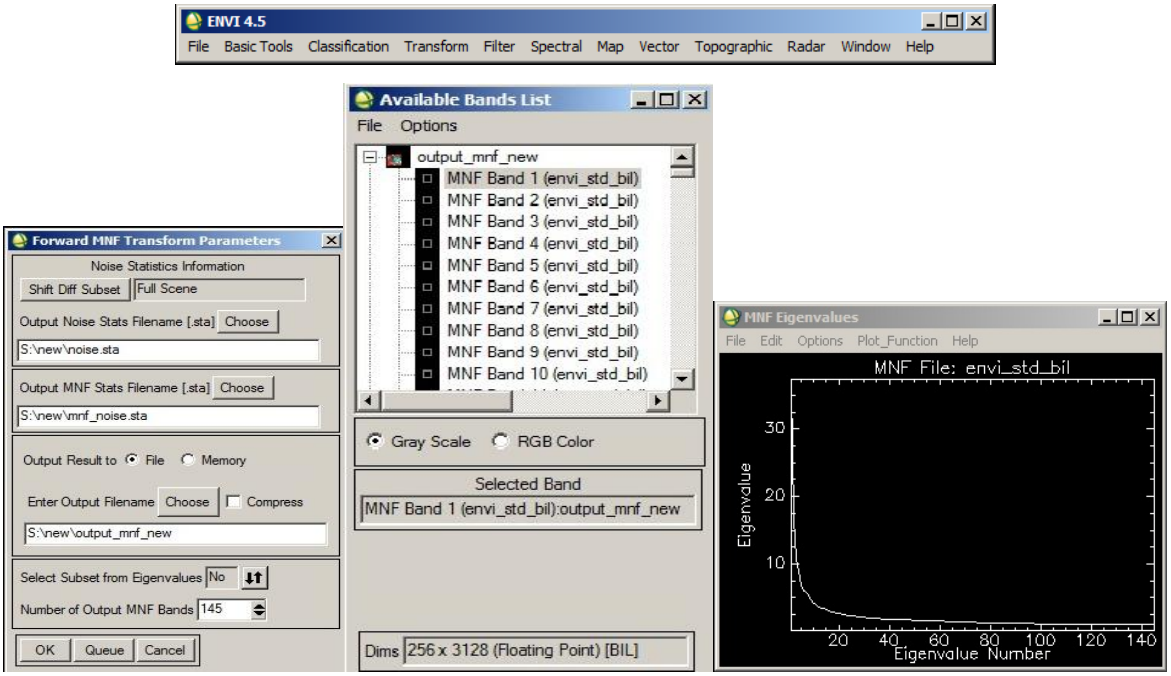
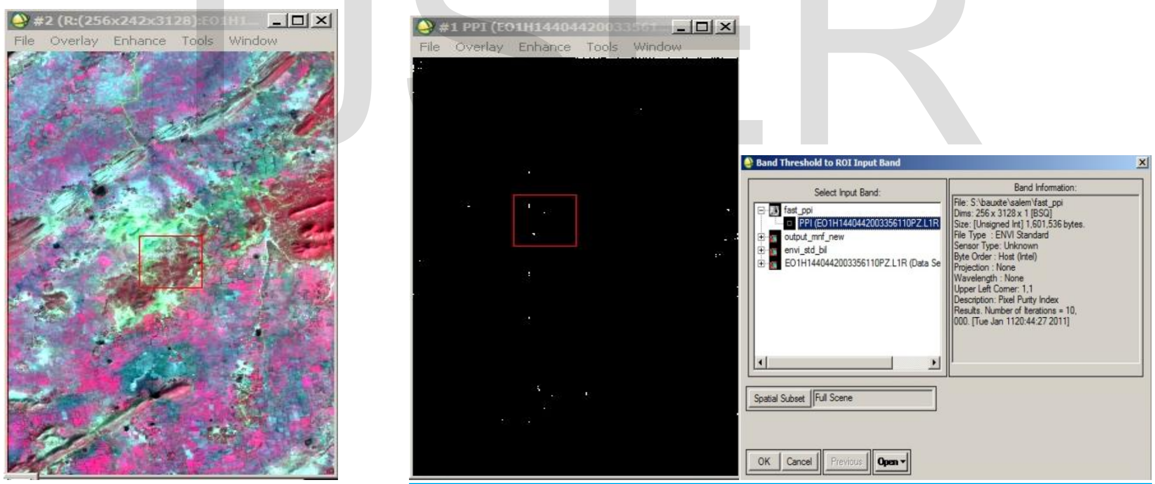


Fig. 3(i) **Fig.3(ii)** **Fig.3(iii)**



A Original Image Fig. B

Fig.4 These images shows the results of Pixel Purity Index(PPI).

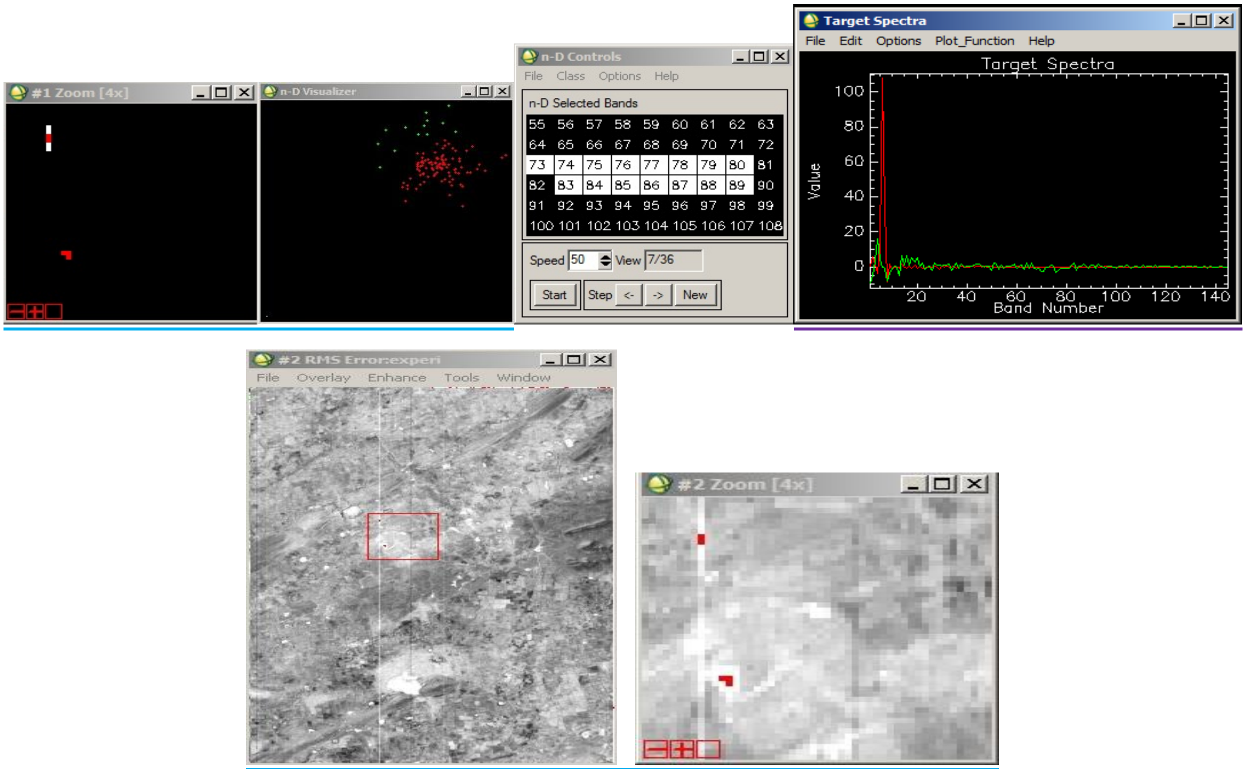
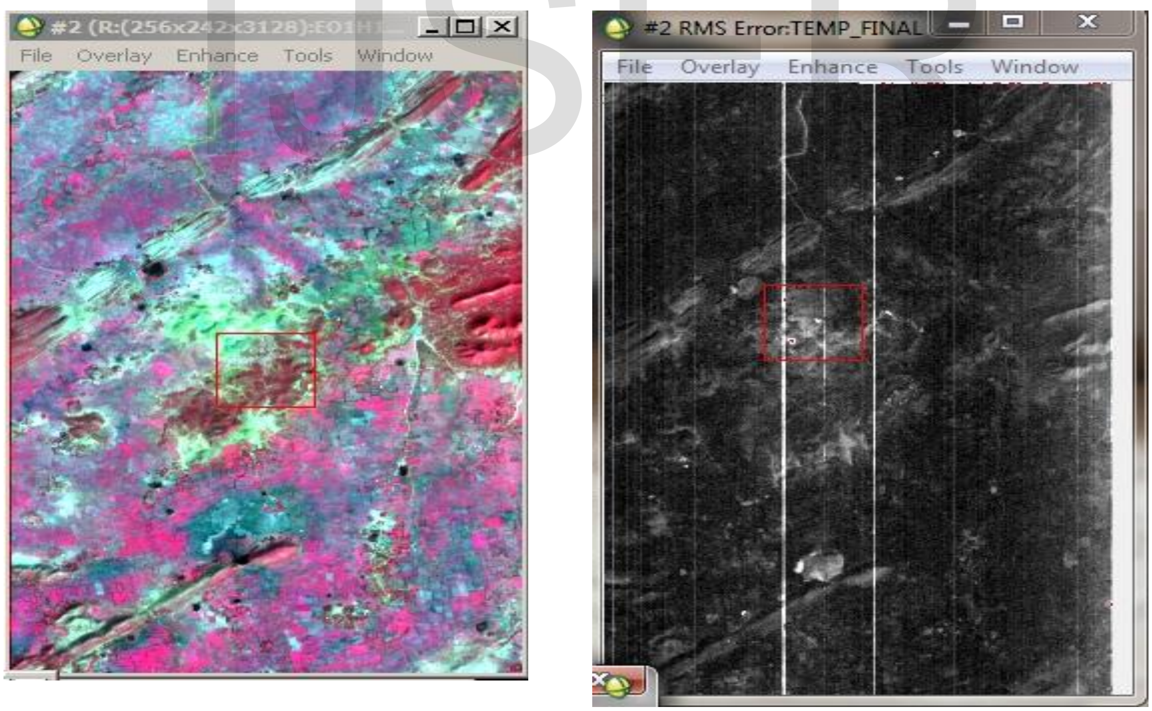


Fig. 5 Above figures shows results of n-D visualizer technique.



ORIGINAL IMAGE FINAL OUTPUT IMAGE
(Using Linear Spectral Unmixing)
Fig. 6

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