Identification of Iron Ore Mines of Noamundi, Jharkhand by Using the Satellite Based Hyperspectral and Geospatial Technology

Surajit Panda[1], Krishnendu Banerjee[2], Dr. Manish Kumar Jain[3]

[1]Jharkhand Space Applications Center, Department of Information Technology, Government of Jharkhand, Ranchi-834004, Jharkhand, India

[2]Jharkhand Space Applications Center, Dept. of Information Technology, Govt. of Jharkhand, Ranchi-834004, Jharkhand, India

[3]Indian School of Mines, Dept. of Environmental Science & Engineering, Dhanbad -826004, India

Abstract: ***Now a days the developing countries like India, where the population is over one billion, one-sixth of the world's population, affects the natural & commercial resources. Mineral resources play very important role to back up or support the economy of country. Iron ore is one of the important mineral to increase the industrial development and country also. In the context of Iron Ore, it is necessary to locate its presence in nature using modern, time and cost saving technology. Different types of survey and techniques are applied to demarcate the Iron ore possibility areas like Bore hole and Field survey etc, which are the more costly and time consuming. In the modern age, remote sensing & GIS technique can reduce the cost and time of spatial survey. In the field of Remote sensing technique it is possible to identify the surface mineral distribution by using the spectral characteristic of mineral. For example the Iron ore absorb the 0.85-0.9µm and strong reflectance at 0.7-0.75µm region of Electromagnetic Radiation (EMR). In this present study of Noamundi Iron ore mining areas of Jharkhand, Iron ore distribution has carried out by using angular reflectance (θ Fe) hyper spectral image and correlation of spectral character and field Fe content. In the final result it is shown that the Iron ore distribution areas are 90% match with known Iron ore mining areas. So it is possible to identify the Iron ore distribution without any field spectra but using only image spectra and Field Fe contents.***

Keywords: Atmospheric Correction, FLAASH, EMR, Reflectance, EO-1 Hyperion, Correlation etc.

1. Introduction

Land and water are the two basic natural resources which are being exploited for various developmental activities. As the population increases, the exploitation of these resources is also increasing and in this process they are subjected to stress. For example the demand of Iron ore is increasing in present years. Credit Suisse, 2010 shows the high demand from steel industries that lead the global iron ore deficit supply of between 20 million – 25.3 million tons in the subsequent years. So identification of Iron ore possibility in earth surface is more important. Different types of survey and technique are applied to demarcate the Iron ore possibility areas like Bore hole, Field survey etc, which is the more costly and time consuming. Now a day's Remote sensing & GIS technique is a power full tool to identify the surface mineral and mineral abundance etc. In the field of Remote sensing the surface reflectance is the more importance to demarcate the possibility of mineral. On earth surface different features reflectance and absorption are different in the range of electromagnetic spectrum. Minerals and rocks are reflects and absorb in the range of Visible (0.4-0.7µm), NIR (0.7-1.5µm) & SWIR (1.5-2.5µm) of Electromagnetic Radiation (EMR). The different types of mineral have different types of chemical components and different types of chemical component reflect and absorb the different range's wavelength. In the case of Iron ores, the maximum reflectance Hematite shows near 0.7µm and maximum absorption shows near 0.85µm range of EMR [9]. By using the characteristic of absorption and reflectance of Iron ore we can extract and demarcate the possible areas of Iron ore. Noamundi of Jharkhand is an active Iron ore mining areas (GSI 2006). Using the angular theta of Image reflectance based on correlation between spectral characteristic of image and Fe content of field sample of same coordinate, mapped the Iron Ore mining areas. So by using this geospatial technique we can show, this technique can provide the information of surface mineral mapping.

2. Objectives

The main objectives of the present study are mentioned as follows:

- Assessing the capability of remote sensing in identification of minerals through a comparative study with hyperpectral imagery, and laboratory based ground truth data.
- Use of the hyperspectral image based technique for mineral mapping using the angular theta of Image reflectance based on correlation between spectral characteristic of image and Fe content of field sample of common areas.

3. About Study Areas

This deposit is situated at Noamundi of Jharkhand state in India. The geographical location of this deposit is between 22°04'14"N to 22°10'41"N latitude, and 85°27'09E to 85°30'06E longitude. The deposit is located on the hill top at about 400 m to 650m above Mean Sea level. The deposit is now being mined by TATA Steel. As the mining progresses the benches are exposed and samples are collected from these exposed mining areas and faces.

Table 1: Details of EO-1 Hyperion data specification

Sensor	*Hyperion*
Type	Pushbroom grating spectrometer (VNIR-SWIR)
Path, Row	P-140, R-45
Date of acquisition	16/04/2011
Spectral range	400-2500 nm
Spectral coverage	Contiguous
Spectral resolution	10nm
Spatial resolution	30m
Radiometric resolution	16 bit
Temporal resolution	200 days
Number of bands	242 but Calibrated: 196 of 242
Swath width	70km
Sensor altitude	705km

Table 2: Details of FLAASH parameter using for atmospheric correction

Scene canter location	22 13 50.653 85 30 09.312	Initial visibility	40km
Sensor Altitude	705km	Spectral Polishing	Yes
Ground elevation	0.75	Width of bands	9
Pixel size9(m)	30	Wave length calibration	No
Flight date	April 16 2011	Aerosol scale height(km)	2
Flight ime(HH:MM:SS)	4:33:00	Co_2 mixing ratio(ppm)	390
Atmospheric Model	Tropical	Use adjacency correction	No
Water retrieval	No	Modtran Resolution	15 cm-1
Water absorption features	1	Modtran multiscatter Model	Scaled DISORT
Aerosol model	Rural	No of Disort streams	8
Aerosol Retrieval	2-Band(K-T)	Output reflectance scale factor	10000
Azimuth Angle	111.872439	Title Size	600

4. Data used and Methodology

The EO-1Hyperion sensor data on 16th April 2011 of the study areas (Noamundi mining areas of Jharkhand) has been acquired from USGS data center for the present study. The image has 242 unique spectral channels range of 400-2500 nm with 10 nm band width. But only 196 of 242 bands are calibrated (bands 8 to 57 for visible-to-near-infrared (VNIR) and bands 77 to 224 in the shortwave-infrared (SWIR) regions). The details of data specification are shows bellow Table 1. Before extracting spectral signatures from this imagery, some pre-processing operation needs to be done in this image to reduce the image Noise by using the Hyperion tools available from ENVI 4.7 [4]. These Noises are fixing bad and outlier pixels, local de-striping, atmospheric correction etc. The Hyperion image is obtained as level 1B data in scaled radiance units to facilitate the development of indices and measurements, these values are to be converted into apparent reflectance using Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) atmospheric correction model [5]. Hyperion data calibrations using FLAASH from ENVI includes atmospheric rectification, geometric correction of the image. The FLAASH algorithm along with the ground truth calibration can thus be used to convert Hyperion data from radiance to reflectance values. The used FLAASH parameter of the atmospheric correction is shown in Table 2.

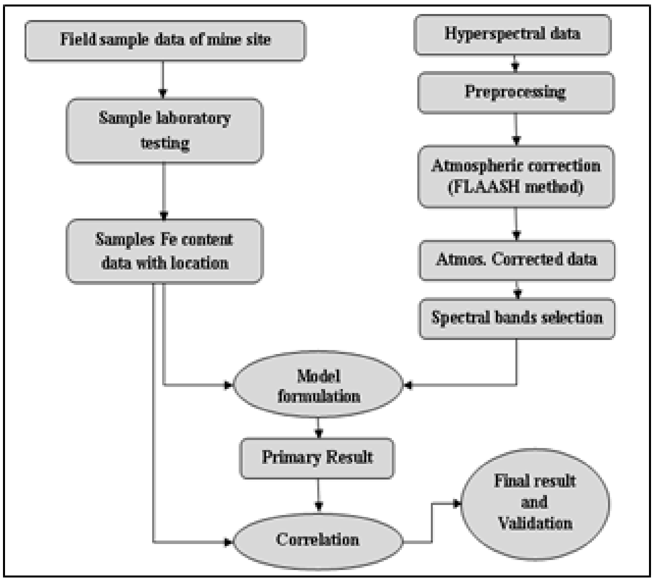

Figure 1: Flow diagram showing total processing steps

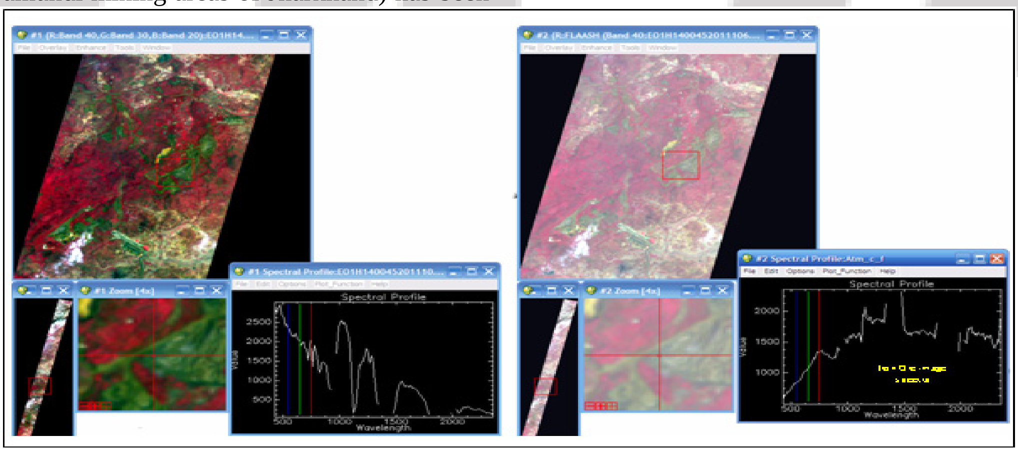

Figure 2: Showing the spectral profile of Iron ore mining areas of before and after atmospheric Correction. Hyperion Image before (Left) and after (Right) atmospheric Correction

The overall methodology of the study is presented through a schematic diagram as shown in Figure 1.

5. Result and Discussion

Before extracting spectral signatures from this imagery, some pre-processing operation needs to be done in this image. Some noises are including in raw satellite image. After fixing the bad and outlier pixels, local de-striping it is necessary to correct the atmospheric noise [6]. Preprocessing and Noise Reduction methods will be applied on Hyperion image using the Hyperion tools available from ENVI 4.7 [4]. In this present study, atmospheric correction was carried out by using FLAASH module [8]. Figure 2 shows the results of the atmospheric correction on the Hyperion image and the respective spectral plots for Iron ore features (pixels) [1]. From these spectral plots, it is observed that the reflectance of iron ore is obtained from the radiance image on the Hyperion image (Figure 2 Right). It is observed that very strong absorption of iron ore at 850-900nm (0.85-0.9µm) and strong reflectance at 700-750nm (0.7-0.75µm) region.

5.1 Modelling of Absorption Bands

Every mineral have specific absorption and Reflectance that are sensitive indicators of constituent minerals. The absorption features are characterized by their position, strength and width parameters. Through these characteristic of these spectra, the mineral can be visually detected by some band ratio and mathematical models etc [2]. In the case of Iron ore (Hematite), the maximum reflectance value (Rv) shows between 0.7 and 0.75 µm and maximum absorption band (Ab) shows between 0.85 and 0.9µm range on image base on field identified location. *After band ratio of reflectance band (Rv) and absorption band (Ab) it shows that the iron ore distributed area's maturity value is less than 1.21. On the other hand reflectance values of the pre define location is more than 1195. By using the ratio technique of these two results, the reflectance value is converted into angular (by using eq no.2) form of θ Fe [3].*

$$\theta\ \text{Fe image} = -\text{aerctan}\left(\frac{\left(\frac{Band_{Ref}}{Band_{Ab}}\right) - 1.21}{Band_{Ref} - 1195} \right) \qquad (1)$$

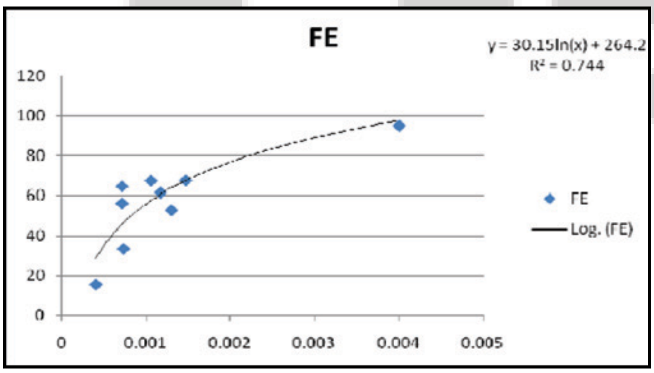

Figure 3: Field Fe content versus spectral iron parameter (θ Fe)

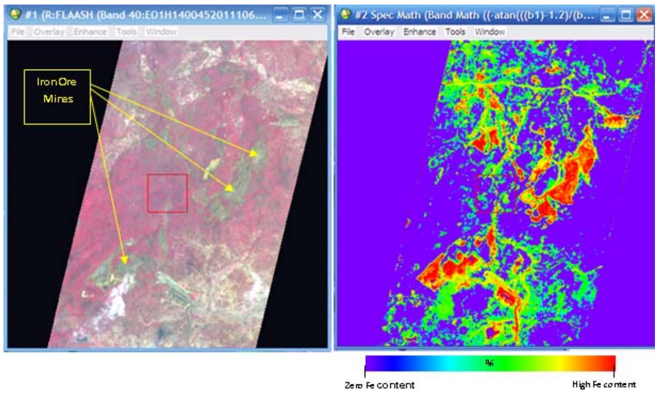

Figure 4: Showing the final result of Fe distribution of Noamundi areas. Hyperion Image (Left) and Fe distribution areas (Right)

5.2 Result

Figure 3 shows the correlation between the angular values of Iron ore image spectra or θ Fe and percentage of Iron ore Fe from field sample of same location. By using this correlation equation (eq no. 2), the final Fe distribution of the study areas extract from that theta Fe image. The figure 4 shows the Fe distribution of Noamundi areas. Here the dark red indicates the high maturity of Fe contents. The Fe content increase gradually towards the dark red tone which is shows at that place of Iron ore mining areas.

$$30.15*\ln(\theta\ \text{Fe image}) + 264.2 \qquad (2)$$

6. Conclusion

Integration of GIS and remote sensing provides the techniques to surface mineral mapping based on their spectral characteristics on satellite images. GIS enables the proper handling of databases necessary for the integration of data from different sources. Spectral analysis techniques for mapping the Iron ore distribution on providing the necessary map (Figure 4-Right) by band selection and derive the model and equation etc. The two stapes, one is angular reflectance or θ Fe model, another is correlation between angular reflectance (θ Fe) and percentage of field Fe content of same location is used for this study. By applying this θ model the mineral distribution (Iron ore) of Noamundi mining areas, Jharkhand is demarcate without any field spectra but using only image spectra and Field Fe contents.

7. Limitation

1. Hyperion image's spatial resolution is 30m. If spatial resolution is high the result will be more accurate than 30m resolution.
2. Resent images of that area are not available of that exact areas and path row due to 200 days temporal resolution of EO-1 Hyperion.
3. If date of field survey and date of acquired image was same then the result will be very accurate but that is hardly possible.

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Author Profile

Surajit Panda received the M.Sc in Remote sensing & GIS from Vidyasagar University in 2010 and B.Sc. degree in Geography (Hons) from Haldia Govt. College, Vidyasagar University in 2008. He is now Junior research Fellow (JRF) at Jharkhand Space Application Center (JSAC), Dept. of Information Technology, Govt. of Jharkhand and register at Indian School of Mines (ISM), Dhanbad for PhD.

Manish Kumar Jain received his Ph.D, from IIT-Kharagpur. He is Associate professor of Department of Environmental Science & Engineering, ISM Dhanbad, Jharkhand. He published several research papers in International Journals and conferences.

Krisknendu Banerjee received the M.Sc in Remote sensing & GIS from Vidyasagar University in 2010 and B.A. degree in Geography (Hons) from Barddawan University in 2008. He is now Junior research Fellow (JRF) at Jharkhand Space Application Center (JSAC)