



## Hyper spectral signature and ASTER data analysis for mapping of Bauxite deposits in Shevaroy hill of Tamil Nadu, India

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### Abstract

India is well enriched with bauxite deposits. Bauxite deposits of Shevaroy hills in Salem district, Tamil Nadu are derived from laterites by lateritization process. Bauxite, the chief source of Alumina, is an aggregate of minerals most of which are oxide and hydroxide of aluminum and iron rich like gibbsite, boehmite, goethite and hematite. Bauxite is used in the refractory industries and its quality is controlled by presence of impurities such as iron and silica. In the study area bauxite is a whitish red to brown aluminum ore mineral mainly made up of hydrous aluminum oxides and aluminum hydroxides and laterites are mostly found in humid tropic climatic condition due to intense weathering of bed rock. To delineate bauxite deposits from the associated laterites ASTER satellites (Advanced Space Borne Thermal Emission Radiometer) image is processed. For this, bauxite's spectral signatures and aluminous laterite samples were analyzed in the lab with respect to gibbsite (mineral constituent of bauxite) and goethite (mineral constituent of laterite) in VNIR-SWIR (Very near Infrared and Short Wave Infrared) region. For spectral discrimination of minerals, ASTER data acquired in the VNIR - SWIR regions were used. To understand the different chemical composition of bauxites there is difference in absorption peak of spectra while analyzing the spectral signature of lateritic bauxite samples from the lateritic spectral data generated from the instrument Analytical Spectral Devices (ASD- Field spec 3) which operates in spectral region of 0.35 - 2.5 $\mu$ m (350 - 2500 nm) with 10 nm band width was used. The Bauxite sample has a strong absorption peak in the spectral regions of 2.26 $\mu$ m. Different grades of bauxite samples collected from Shevroy hill matches well with USGS (United State Geological Survey) library spectra. ASTER based relative band derived from the laterites are based on these differences. Based on the spectral similarity of the bauxite pixels it is validated conceptually from the ASTER convolved lab spectra of bauxite samples.

**Keywords:** Spectral signature, hyper spectral, Bauxite, Laterite, ASTER, Shevaroy hill, Eastern Ghats etc.

### Introduction

India has well enriched deposits of Bauxite. Lateritic-Bauxite deposits occur as capping over charnockite-leptynite rocks of Eastern Ghats. The Indian bauxites are majorly accompanied by blankets of laterites capping at high elevated plateaus of 700m to 2100m above MSL. Bauxite is of medium grade and is characterized by low titanium and high silica<sup>1</sup>. Based on the bedrock types, bauxite can be categorized as Karstic bauxite (bauxite present on carbonates) and lateritic bauxite (bauxite present on aluminosilicate)<sup>2</sup>. Most bauxite deposit occur as capping over plateau deposits at altitudes of about 700 to 2100m MSL<sup>3</sup>.

The tropical weathering process leads to the formation of laterite and bauxite. Under same geological and geomorphological conditions, laterite or bauxite formation depends on the geochemical leaching intensity<sup>4,5</sup>. In general, bauxite is enriched with hydroxides of Aluminum while that of laterite is hydroxides and oxides of iron<sup>6</sup>. Bauxite is considered as a resource if its chemical and mineralogical properties satisfies cut off grade. The general cut off is 30 to 50% of Al<sub>2</sub>O<sub>3</sub><sup>7</sup>.

The present study focus to discriminate the bauxite ore associated with the laterite in the Visible, Near infrared and Short wave infrared (VNIR-SWIR) spectral signature data of bauxite from the Advanced Space Borne Thermal Emission Radiometer Terrain platform launched on Dec 18, 1999 is used for mineral mapping<sup>8,9</sup>. In Visible near Infrared (VNIR) three spectral band with 15m spatial resolution and Thermal Infrared (TIR) band of five numbers with resolution of 90m are present in ASTER sensor. The sensor is used to demarcate the rich bauxite mineralized zone within the deposits of laterites. Advanced Space borne multispectral ASTER sensor has wide spectral coverage, spatial and spectral resolution. In the absence of narrow range of hyperspectral image, the Space borne ASTER image with 14 band data is considered as moderate mode of hyperspectral data. 14 spectral bands range from 0.52 $\mu$ m to 11.65 $\mu$ m wavelength region. Spectral Signatures were generated by using the Instrument Analytical Spectra Devices (ASD) in attempt for application of techniques of hyperspectral remote sensing in exploration of mineral.

**Study area:** The area under study is located at shevroy hill in Salem district, Tamil Nadu at latitude and longitude of (11°55'; 78°10' and 11°45'; 78°20') (Figure-1).

In survey of India Topographic sheet no.58I/1, Salem is situated about 17km south of Yercaud which is a hill station. Shevaroy hill consist of numerous capping over the plateau with their altitude varying from 552m to 1640m from MSL. From the field observation a sharp contact between brownish red laterite at the top underlined by pinkish white Gibbsite as Bauxite ore at the bottom. Veppadi River drains the area towards NE.

**Geology of study area:** The study area is essentially occupied by charnockite of Achaean age. Dunite of Neoproterozoic age is

found in the southwestern part of the area. Laterite associated with bauxite of Cenozoic age occurs NNE of Yercaud. The trend of foliation in charnockite is NE-SW with dips varying from  $45^{\circ}$  to  $80^{\circ}$  towards SE. The study area has six deposits of bauxite capping six hilltops are located in Shevaroy hills (Figure-2). The aerial extent of the individual deposits range from 22,000sqm to 1, 55,000sqm with an aggregate of 4, 05,000sqm. The thickness of the bauxite zone is inferred to be 5 to 15m. The grade variable in run of the mill (ROM) in ore  $Al_2O_3$  content varies between 40 and 43%<sup>10-12</sup>.

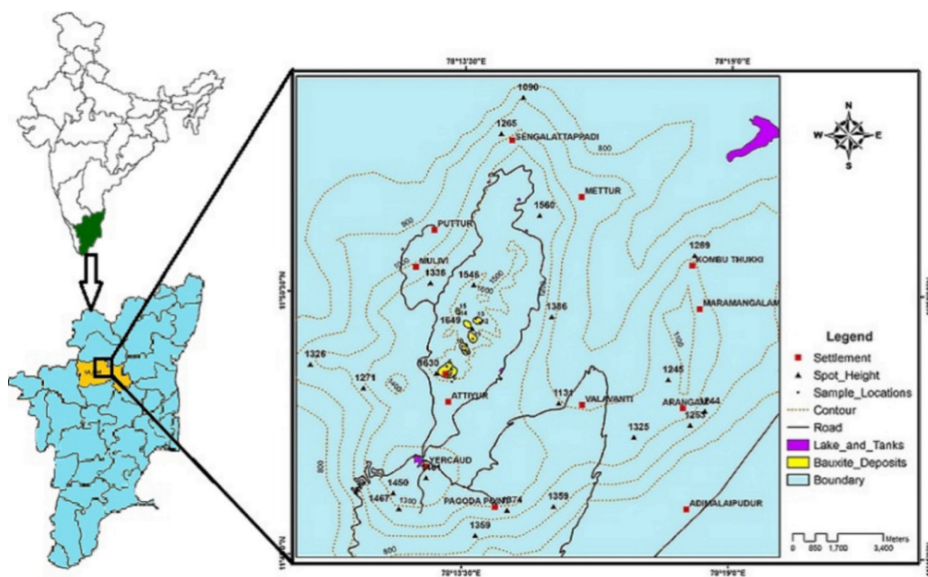


Figure-1: Location map of the study area.

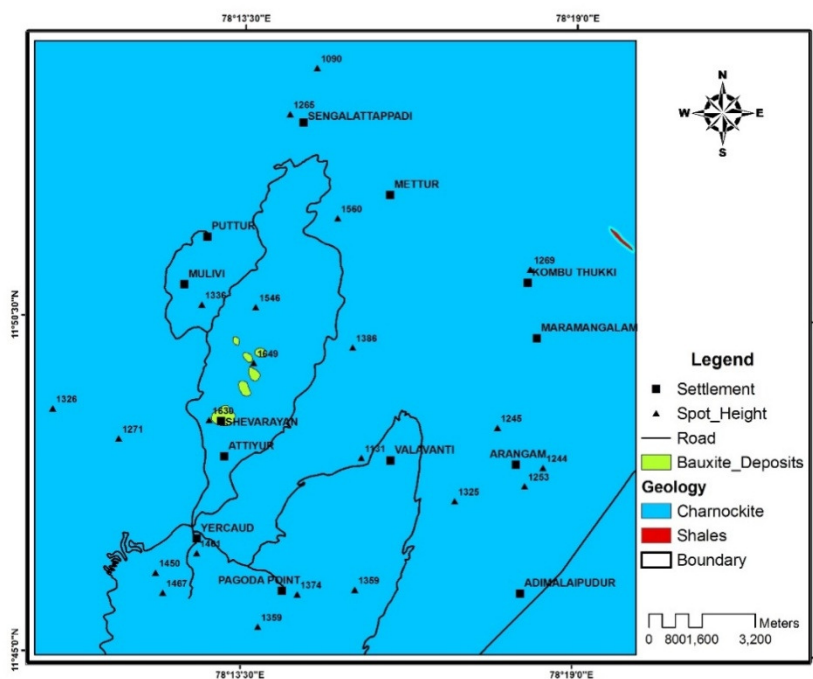


Figure-2: Geological map of study area.

## Materials and methods

**Data: ASTER data:** Moderate resolution data with 14 bands from visible to TIR (Thermal Infrared) wavelength capability of stereo view for creation of DEM (Digital Elevation Model) was acquire by ASTER satellite image (ASTER, 2003). An attempt was made with 9 spectral channels in VNIR and SWIR region within spectral range of 0.52-2.43 $\mu$ m. ASTER level 1 product for VNIR – SWIR channels is used for the study, SWIR channels are useful to study the absorption peaks of materials like Al –OH, Mg –OH, Ca – CO<sub>3</sub> molecules where VNIR channels are used for iron-hydroxides. Worldwide ASTER products were used to map alteration zones of hydrothermal deposits and for specific lithologic mapping<sup>13-18</sup>. ASTER convolved spectral signature of lateritic bauxites to separate bauxite from laterite based on the analysis of ASTER derived spectral indices. In Table-1 specification of ASTER data is shown.

**Table-1:** Specification ASTER data (ASTER, 2010).

Data product	Spectral bands	Range	Spatial resolution	Radiometric resolution
VINR	1	0.50-0.60	15	8
	2	0.630-0.69	15	8
	3N	0.780-0.86	15	8
	3B	0.780-0.86	15	8
SWIR	4	1.60-1.70	30	8
	5	2.145-2.185	30	8
	6	2.185-2.225	30	8
	7	2.235-2.285	30	8
	8	2.295-2.365	30	8
	9	2.360-2.430	30	8

**Spectral signature datasets:** Analytical Spectral Devices (ASD) has developed portable spectroradiometer (Field spec 3) to collect spectral signatures. Bauxite's spectral signature is used to select the ratios of ASTER band in order to demarcate the regions of bauxite deposits. The spectroradiometer is operating in the wavelength range of 0.35 – 2.5 $\mu$ m portion with spectral resolution of 3nm at 700nm and 10nm at 1400–2100nm. The spectral signatures were collected from the Remote sensing lab of Indian Institute of Space Science & Technology, (ISRO) Thiruvananthapuram, and Kerala.

## Methodology

**Spectral signatures of Bauxite and Laterite:** From different parts of the study area lateritic bauxite samples were collected (Figure-1).

Limited area was covered as accessibility by road is poor and connection was only with few outcrops. The geological setup dictates remotely sensed survey for bauxite. Samples were collected from the field and spectral signatures were acquired in the lab under controlled environment. The reflectance of the samples was quantized by mounting the optical gun vertically towards sample. Samples were illuminated by light source at 45° angle with reference to vertical gun above the sample. Vertically adjusted measuring gun is needed for observations to create Ground Sampling Diameter (GSD) to cover all the variability's of the samples. Ten observations were recorded for each sample and averaged to get their characteristic spectral curve and other details.

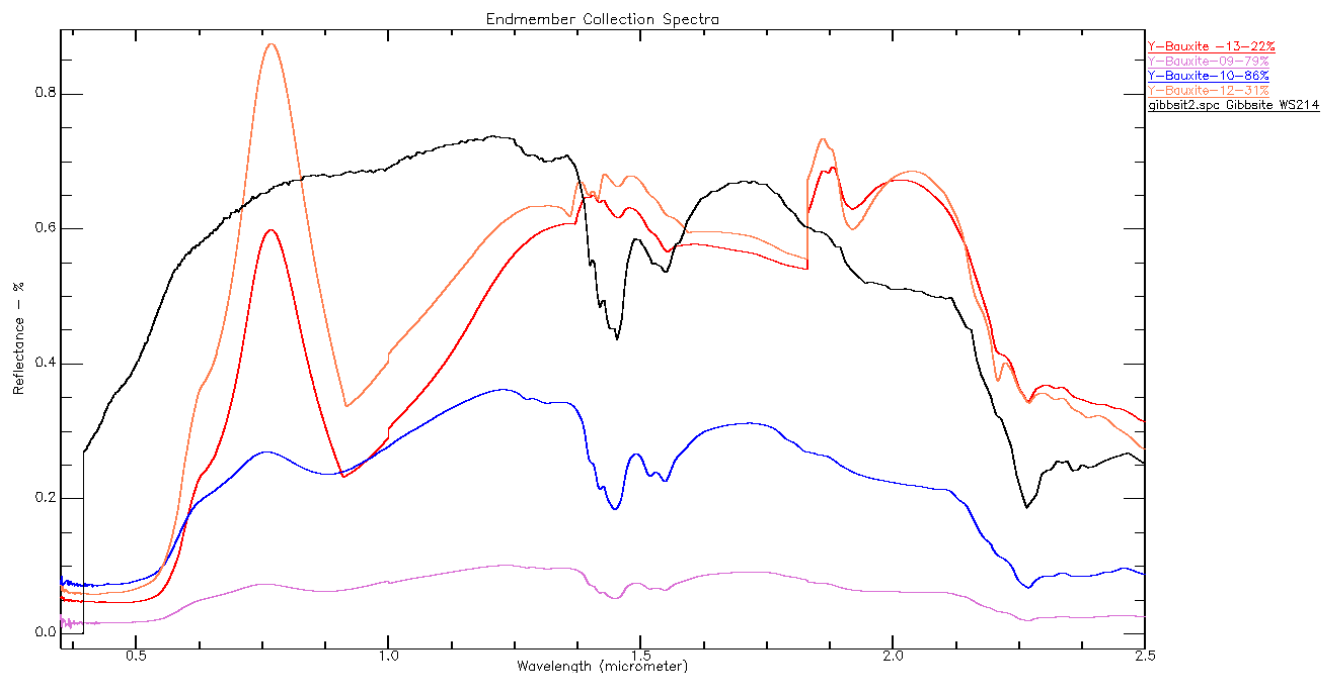
Imaging Spectral signatures was plotted in Envi 4.7 image processing software (Figure-3). The spectral signatures of bauxites were analyzed with reference to USGS (United State Geological Survey) spectral library. For bauxite and laterite rocks, spectral profiles of gibbsite and goethite were observed as the main constituent ore minerals. Spectral signatures of the main constituent minerals of laterite and bauxite samples are convolved in ASTER images to understand the wave form of these spectral signature band widths. Spectral features of lateritic bauxite samples were compared with spectra of gibbsite and goethite. Analyses were compared for characterizing lateritic bauxite samples either as bauxite or laterite dominant.

**Preprocessing of ASTER data:** To calibrate the ASTER level 1T image preprocessing step is required to geo rectify radiance data in order to derive the apparent reflectance image. Georeferenced ASTER level 1T image is corrected at Short wave infrared bands (SWIR) “sensor-radiance” data. Calibrated apparent reflectance of ASTER data was used by adopting log residual methods. From radiance data Log residual (LR) method is corrected for instrument gain, topography and albedo effects. Thus effective calibration methods were carried out for correcting as transmittance atmospheric effects. This correction method is suitable for mineral mapping, where it is carried out for imaging spectroscopic study as well.

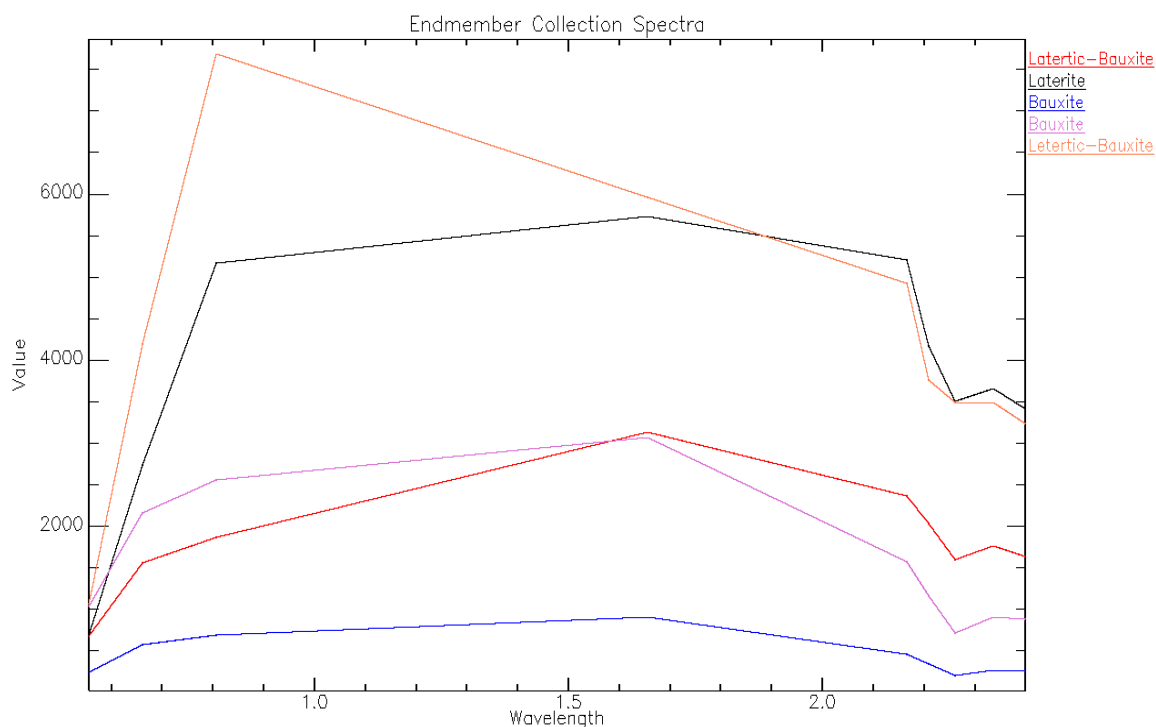
**Image processing of ASTER data:** ASTER convolved laboratory spectral analysis was carried out for processing apparent reflectance product. From the observed analysis the spectral profiles of lateritic-bauxite can be broadly sub-divided two categories. Goethite and gibbsite are the major minerals of laterite and bauxite respectively which are characterized from lateritic bauxite samples either as bauxite or laterite based on the relative matching of diagnostic spectral features of these minerals with the spectral features of each lateritic bauxite samples. Each lateritic bauxite spectra matching either with goethite or gibbsite spectra is the observation made. Sharp fall in reflectance from fourth channel of ASTER data with one set of samples centered at 1.65 $\mu$ m with a dip around 0.55 $\mu$ m. Absorption feature of the goethite corresponds to the above spectral behavior. Reflectance falls towards higher wavelength bearing SWIR channel from the fourth channel of ASTER data

(Figures-4, 5, 6) for another set of samples. Strong absorption at 2.26  $\mu\text{m}$  (7<sup>th</sup> channel of ASTER) for the study area and 2.33 $\mu\text{m}$  (8<sup>th</sup> channel of ASTER) is found. Above spectral behavior typically resembles the spectral signatures of gibbsite.

Difference in the spectral signature of bauxite is based on the relative absorption depth of the image were brought out to delineate bauxite rich mineral within mixed lateritized bauxite ore.

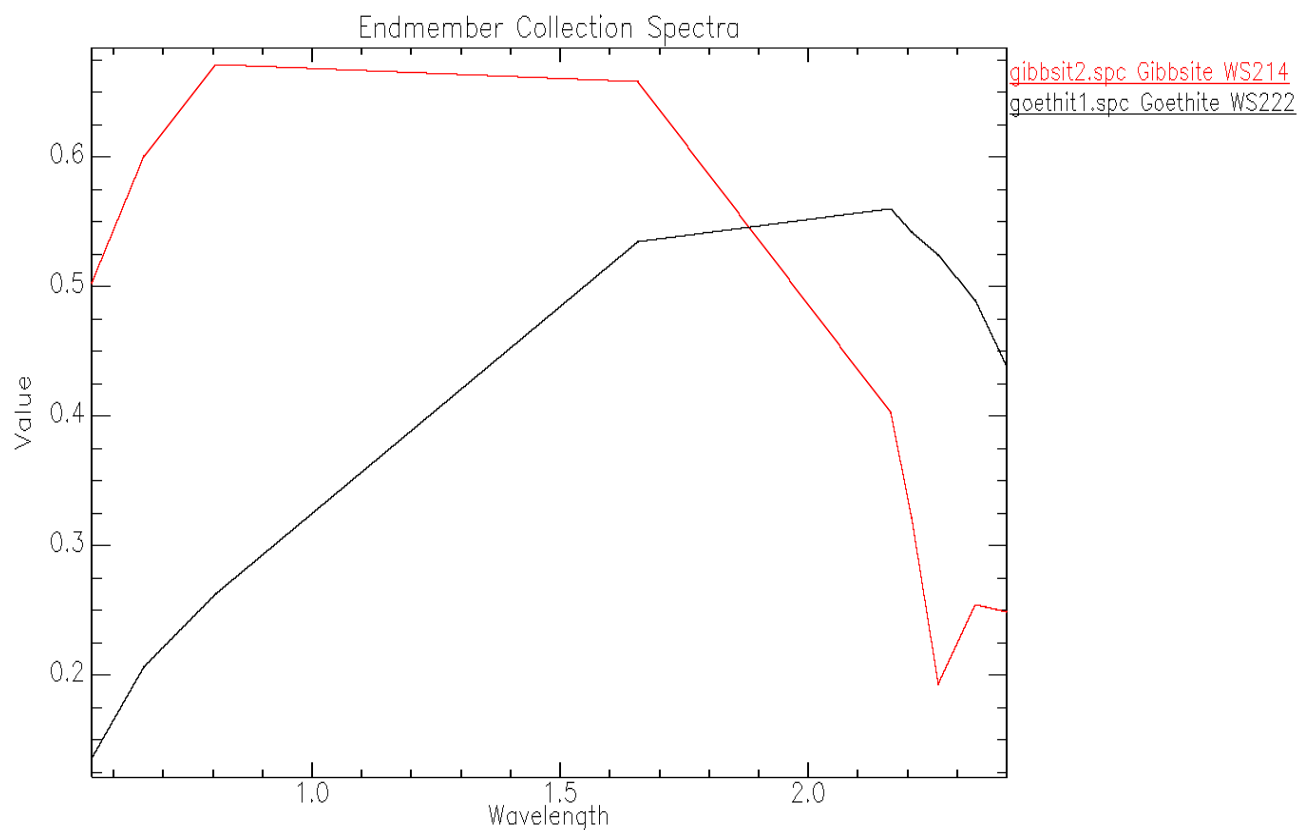


**Figure-3:** Laboratory spectra of bauxite samples in Envi- plot.

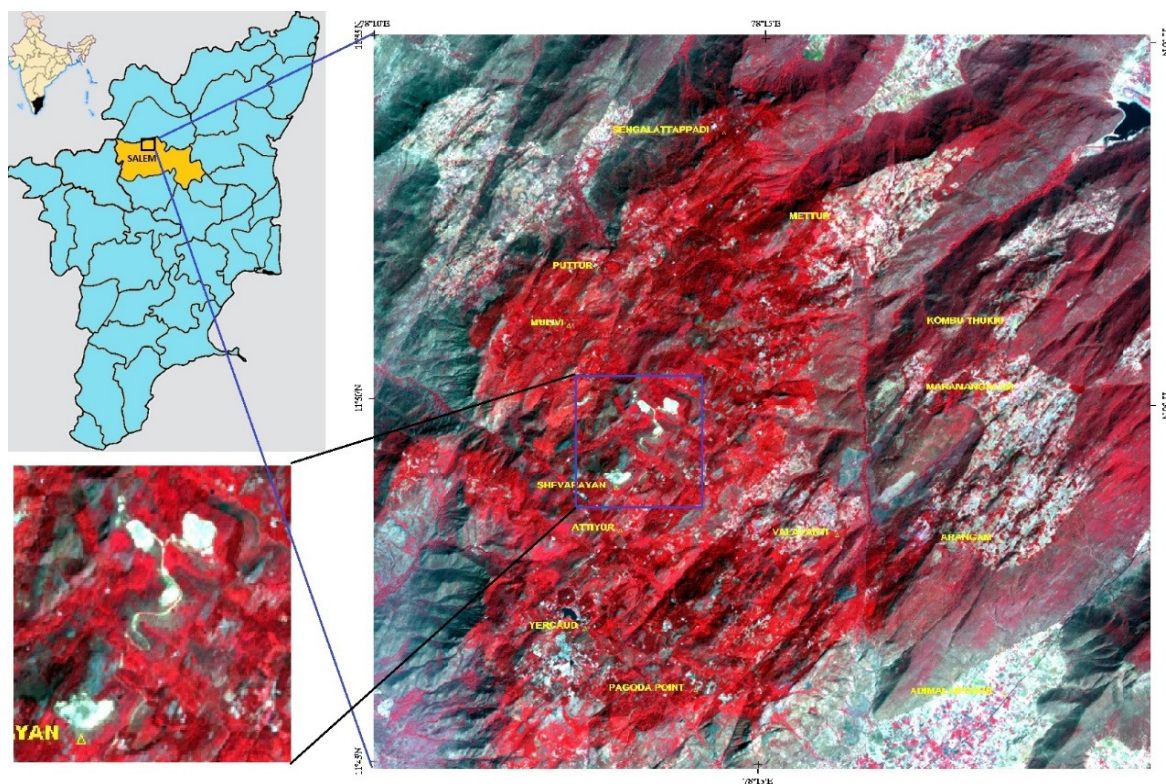


**Figure-4:** ASTER convolved signature of gibbsite and laterite mineral.

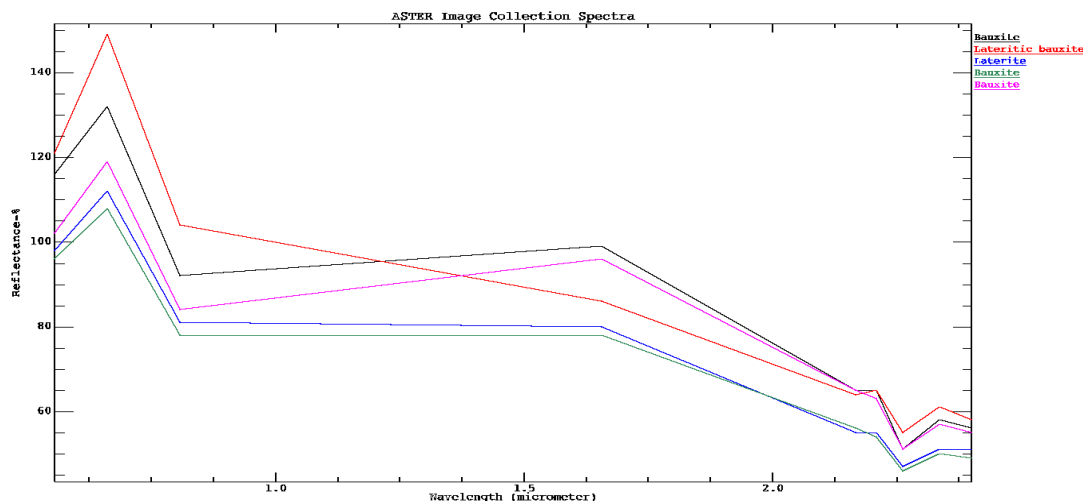




**Figure-5:** ASTER derived spectra of Gibbsite and Goethite in USGS library.



**Figure-6:** ASTER FCC of the study area with RGB (321) band combination.



**Figure-6:** Comparative analysis of image spectra of bauxite sample locations in ASTER data.

## Conclusion

The Bauxite sample has a strong absorption peak in the spectral regions of 2.26 $\mu$ m. This samples collected from Shevroy hill is respective of the grade matches well with United State Geological Survey (USGS) spectral library. The study reflects the use of the wide spectral material of ASTER documents in the (VNIR-SWIR) region to demarcate bauxite present within the lateritic deposits. The variations in spectra between laterite and bauxite are prominent in VNIR-SWIR field and the variations bring out the ASTER related depth of band and ratio image for their spectral separation. Tropical weathering process contributes to the formation of lateritic bauxites depending on the topography. Therefore, not only the bauxite pockets were identified through the spectral information but also the topographic conditions were demonstrated. The spectral report agrees to the geomorphic information which is used to demarcate the bauxite deposits. The bauxite deposits extracted from the geological map was found to be useful as another ground validation. The imaging spectra attempted for the bauxite rich zones was delineated to compare it with the ASTER based lab spectra of bauxite. The comparison of spectral profiles derived from the respective image locations of ores along with the laboratory spectra of bauxite especially for the diagnostic absorption peak at 2.26 $\mu$ m confirms the bauxite rich zone at Shevroy hill in Salem district.

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