Mineral Mapping at Pattipulam Village by Remote Sensing Technique

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Abstract: *Remote sensing, as a direct adjunct to field, lithologic and structural mapping, and more recently, GIS (Geographical Information system) have played an important role in the study of water tables and mineralized areas. Hydrogeological mapping of groundwater resources is one of the main tools for mapping ground water tables and locating silicate deposits, these maps can be used to prevent construction activities near these subsurface water table zones in order to prevent failure of the structure by means of concrete cancer. Concrete cancer is caused when the steel reinforcing within a concrete slab begins to rust due to reaction between the alkalinity of concrete and the silica in the aggregate ad the moisture content present in the soil. As the steel rusts it expands, displacing the concrete around it, causing it to become brittle and crack thus accelerating the process. In this project the rapidly developing locality of Pattipulam has been studied and mapped.*

Keywords: Remote sensing; Geographical Information system; silicate deposits; Water table zones; Concrete Cancer; Alkalinity

1. Introduction

Remote sensing is the science of acquiring, processing, and interpreting images and related data, acquired from aircraft and satellites that record theinteraction between matter and electromagnetic energy. This report reviews the use of remote sensing for exploration of minerals such as silica, ferrous, talc etc.[1] Remote sensing systems are employed in mineral exploration and introduces the computer techniques used to process digital data acquired by the systems. This literature review describes how multispectral data are digitally processed to recognize hydrothermal alteration minerals iron minerals, clays, and silicates., using Pattipulam as a training site. The methods developed at Chennai were used at pattipulam copper deposits.

2. Remote Sensing Technology

Taking a closer look from a distance is the concept behind remote sensing, broadly defined as a method of obtaining information about properties of an object without coming into physical contact with that object. A more specific definition of remote sensing relates to studying the environment from a distance using techniques such as satellite imaging, aerial photography, and radar. Remote sensors gather information by measuring the electromagnetic radiation that is reflected, emitted and absorbed by objects in various spectral regions, from gamma-rays to radio waves.[2] To measure this radiation, both active and passive remote sensors are used. Passive systems generally consist of an array of sensors which record the amount of electromagnetic radiation emitted by the surface being studied. Active systems transmit a pulse of energy to the object being studied and measure the radiation that is reflected or backscattered from that object. Passive radiometric methods of remote sensing technology include: imaging radiometer, spectrometer and spectroradiometer. Radar, scatterometer, lidar and laser altimeter are examples of active remote sensor technologies.

A. Landsat program

The Landsat Program is a series of Earth-observing satellite missions jointly managed by NASA and the U.S. Geological Survey. Landsat 8 (initially named Landsat Data Continuity Mission - LDCM) was the most recent satellite to be launched on February 11, 2013. Landsat 9 is in development, with a launch scheduled for late 2020. The Landsat Missions Timeline page contains more details on each of the missions The instruments aboard the Landsat satellites have acquired millions of images through the course of the missions, and the data are a valuable resource for global change research and applications in agriculture, forestry, geology, regional planning, and education.

B. Landsat 8

Landsat 8 launched on February 11, 2013, from Vandenberg Air Force Base, California, on an Atlas-V 401 rocket, with the extended payload fairing (EPF) from United Launch Alliance, LLC. The Landsat 8 satellite payload consists of two science instruments—the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). These two sensors provide seasonal coverage of the global landmass at a spatial resolution of 30 meters (visible, NIR, SWIR); 100 meters (thermal); and 15 meters (panchromatic).

USGS took over routine operations and the satellite became Landsat 8. USGS leads post-launch calibration activities, satellite operations, data product generation, and data archiving at the Earth Resources Observation and Science (EROS) center.OLI is a push-broom sensor with a four-mirror telescope and 12-bit quantization. "Fig.1,"

Table I: Comparison between Landsat 7 and 8

| Land-7 ETM + Bands (µm)			Landsat -8 OLI and TIRS Bands(µm)		
			30m Coastal/Aerosol	0.435-0.451	Band 1
Band 1	30m Blue	0.441-0.514	30m Blue	0.452-0.512	Band 2
Band 2	30m Green	0.519-0.601	30m Green	0.533-0.590	Band 3
Band 3	30m Red	0.631-0.692	30m Red	0.636-0.673	Band 4
Band 4	30m NIR	0.772-0.898	30m NIR	0.851-0.879	Band 5
Band 5	30m SWIR-1	1.547-1.749	30m SWIR-1	1.566-1.651	Band 6
Band 6	60m TIR	10.31-12.36	100m TIR-1	10.60-11.19	Band 10
			100m TIR-2	11.50-12.51	Band 11
Band 7	30m SWIR-2	2.064-2.345	30m SWIR-2	2.107-2.294	Band 7
Band 8	15m Pan	0.515-0.896	15m Pan	0.503-0.676	Band 8
			30cm Cirrus	1.363-1.384	Band 9
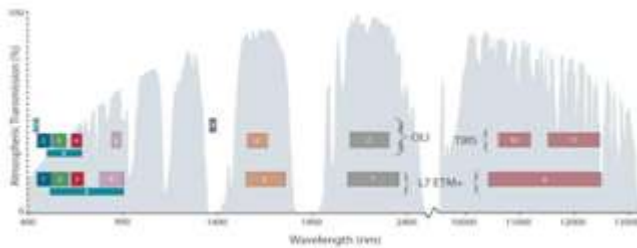
Figure 1: Operational Land Imager (OLI) and Lansat-7

TIRS collects data for two more narrow spectral bands in the thermal region formerly covered by one wide spectral band on Landsats 4–7. The 100 m TIRS data will be registered to the OLI data to create radiometrically, geometrically, and terrain-corrected 12-bit data products.

Landsat 8 is required to return 400 scenes per day to the USGS data archive (150 more than Landsat 7 is required to capture).

C. Hyperspectral imaging systems
Hyperspectral imaging, or imaging spectroscopy, combines the power of digital imaging and spectroscopy. "Fig.2,"For each pixel in an image, a hyperspectral camera acquires the light intensity (radiance) for a large number (typically a few tens to several hundred) of contiguous spectral bands. [4]
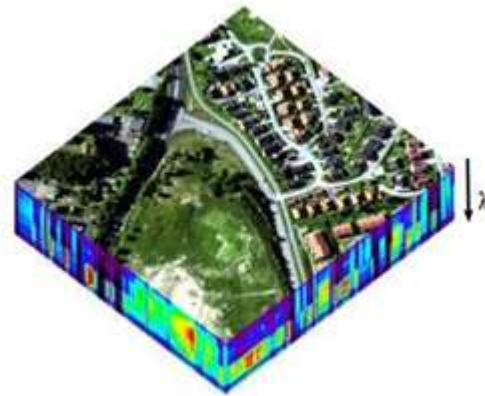

Figure 2: Hyperspectral image

Hyperspectral images obviously provide much more detailed information about the scene than a normal colour camera, which only acquires three different spectral channels corresponding to the visual primary colours red, green and blue. Hence, hyperspectral imaging leads to a vastly improved ability to classify the objects in the scene based on their spectral properties.

Recent advances in sensor design and processing speed has cleared the path for a wide range of applications employing hyperspectral imaging, ranging from satellite based/airborne remote sensing and military target detection to industrial quality control and lab applications in medicine and biophysics. Due to the rich information content in hyperspectral images, they are uniquely well suited for automated image processing, whether it is for online industrial monitoring or for remote sensing.

D. Digital image processing
Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modelled in the form of multidimensional systems.

Many of the techniques of digital image processing, or digital picture processing as it often was called, were developed in the 1960s at the Jet Propulsion Laboratory, Massachusetts Institute of Technology, Bell Laboratories, University of Maryland, and a few other research facilities, with application to satellite imagery, photo standards conversion, videophone, character recognition, and photograph enhancement.[5]The cost of processing was fairly high, however, with the computing equipment of that era. That changed in the 1970s, when digital image processing proliferated as cheaper computers and dedicated hardware became available. Images then could be processed in real time, for some dedicated problems such as television size conversion. As general- purpose computers became faster, they started to take over the role of dedicated hardware for all but the most specialized and computer-intensive operations. With the fast computers and signal processors available in the 2000s, digital image processing has become

the most common form of image processing and generally, is used because it is not only the most versatile method, but also the cheapest.

3. Study Area

Pattipulam is a village panchayat located in the Kanchipuram district of Tamil-Nadu state, India. The latitude 12.6882129 and longitude 80.2147423 are the geocoordinate of the Pattipulam. Chennai is the state capital for Pattipulam village. It is located around 45.9 kilometer away from Pattipulam. Pattipulam village is located in the UTC 5.30 time zone and it follows Indian Standard Time (IST). Pattipulam sun rise time varies 9 minutes from IST. Pattipulam's nearest beach is Mahabalipuram Beach located at the distance of 8.7 kilometers.

4. Mineral Exploration Overview

We have seen that geological mapping provides the ground for any mineral exploration programme. It involves the study of landforms, structures, and the subsurface, to understand physical processes creating and modifying the earth's crust. [6] Geological mapping is absolutely essential for the exploration and exploitation of mineral, hydrocarbon and other energy resources. Remote sensing is used as a tool to extract information about the land surface structure, composition or subsurface. Combined with data from other sources, it provides complementary measurements. Multispectral reflectance data can provide information on lithology, rock composition or rock alteration, which is so often associated with, and indicative of the presence of mineral deposits, particularly epigenetic deposits. Radar provides an expression of surface topography and roughness, and thus is extremely valuable, especially when integrated with other data sources in providing details of relief or physiography. Physiographic features, as we all know are excellent guides to the presence of ore.

5. Mapping Minerals Using Lands at 8 GEO TIFF Data

Most epithermal vein deposits are accompanied by hydrothermal alteration of the adjacent countryrocks. Not all alteration is associated with ore bodies, and not all ore bodies are accompanied byalteration, but the presence of altered rocks is a valuable indicator of possible deposits. Prospectors have long been aware of the association between hydrothermally altered rocks and ore deposits. Many mines were discovered by recognizing outcrops of altered rocks, followed by assays of rock samples.

Prior to remote sensing, altered rocks were recognized by their appearance in the visible spectral Bands. Today remote sensing and digital image processing enable us to use additional spectral bands for mineral exploration. In regions where bedrock is exposed, multispectral remote sensing can be used to recognize altered rocks because their reflectance spectra differ from those of the unaltered country Rock[7].

6. Pre-Processing Methodology

A. Data Acquisition

The data used in this review is landsat 8 OLI Geo Tiff data which was obtained from land sat look viewer. Providing moderate resolution imagery, from 5 meters of Earth's land surface and polar regions, Landsat 8 operates in the visible, near-infrared, short wave infrared, and thermal infrared spectrums. The Operational Land Imager (OLI): The Operational Land Imager satellite's acquisitions are in an 8 day offset to Landsat 7. The approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).

The spectral bands of the OLI sensor, while similar to Landsat 7's ETM+ sensor, provide enhancement from prior Landsat instruments with the addition of two new spectral bands: a deep blue visible channel (band 1) specifically designed for water resources and coastal zone investigation, and a new infrared channel (band 9) for the detection of cirrus clouds. Two thermal bands (TIRS) capture data with a minimum of 100 meter resolution, but are registered to and delivered with the 30-meter OLI data products. Landsat 8 file sizes are larger than Landsat 7 data due to additional bands and improved 16-bit data product.

B. Radiometric Correction

Radiometric correction is done to reduce or correct errors in the digital numbers of images which are meant to be processed. "Fig.3,"Radiometric calibration and correction are particularly important when comparing data sets over a multiple time periods and when they are made to mosaic.

Figure 3: Before Correction

The "Fig.4," energy that sensors onboard aircrafts or satellites record can differ from the actual energy emitted or reflected from a surface on the ground. "Fig.5," This is due to the sun's azimuth and elevation and atmospheric conditions such as water vapour, smoke, etc that can influence the observed energy.
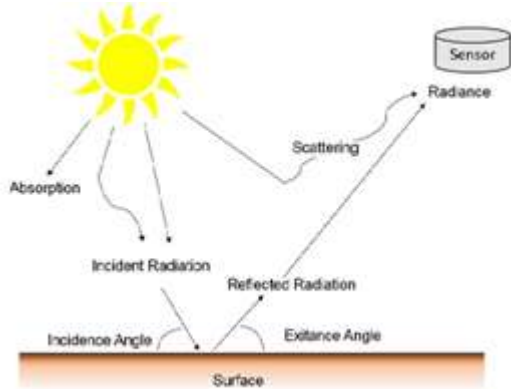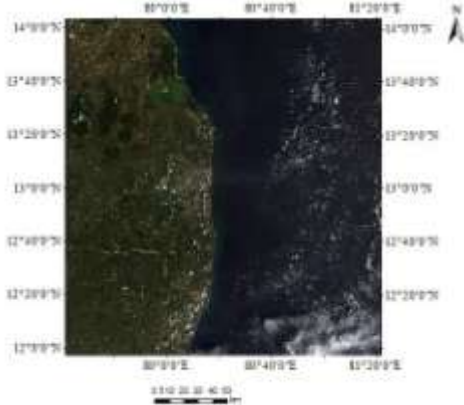
Figure 4: Radiometric Correction

Figure 5: After Correction

C. Radiometric Calibration

A sensor records the intensity of the electromagnetic radiation for each pixel as a digital number (DN). These digital numbers can be converted to more meaningful real world units like radiance, reflectance or brightness temperature. Sensor specific information is needed to carry out this calibration. In the case of Landsat data, the metadata file contains this information. Most image processing software packages have radiometric calibration tools. In ENVI some Landsat data can be converted directly to reflectance, without needing to first calculate radiance.

D. Converting DN values to Radiance and Reflectance

The raw digital numbers (DN) in the images can be converted to what is known as top-of-atmosphere (TOA) radiance or reflectance. Equation (1) rescale the data based on sensor specific information and remove the effects of differences in illumination geometry. Most software packages have tools to calibrate the data.

$$\rho\lambda = \frac{M_\rho Q_{cal} + A_\rho}{\cos(\theta_{SZ})}$$

$\rho\lambda$ = TOA reflectance
θ_{SE} = Local sun elevation angle provided in the metadata
θ_{SZ} = Local solar zenith angle; $\theta_{SZ} = 90^o - \theta_{SE}$
M_P = Band – specific multiplicative rescaling factor from the metadata
A_P = Band – specific additive rescaling factor from the metadata
Q_{cal} = Quantized and calibrated standard product pixel Values (DN)

E. Atmospheric Correction

Atmospheric models should be accounted for the effects of scattering and absorption in the atmosphere. [8] A number of parameters are required to accurately apply atmospheric correction and correct the errors, including properties such as the amount of water vapor, distribution of aerosols. Sometimes this data can be collected by field instruments that can be used to measure atmospheric gases and aerosols, but this is often expensive and time consuming. Other satellite data can also be used to help estimate the amount and distribution of atmospheric aerosols. [9]

F. FLAASH *Atmospheric Correction*

FLAASH is a first-principles atmospheric correction tool that corrects wavelengths in the visible through near- infrared and a shortwave infrared region, up to 3 μm [10]. "Fig.6,"FLAASH works with most hyperspectral and multispectral sensors. Water vapor and aerosol retrieval are only possible when the image contains bands in appropriate wavelength positions."Fig.7," FLAASH can correct images collected in either vertical (nadir) or slant-viewing geometries.

FLAASH starts from a standard equation for spectral radiance at a sensor pixel, L, that applies to the solar wavelength range (thermal emission is neglected) and flat, Lambertian materials or their equivalents. The equation (2)

$$L = \left(\frac{A\rho}{1 - \rho_e S}\right) + \left(\frac{B\rho_e}{1 - \rho_e S}\right) + L_a$$

(2)

ρ is the pixel surface reflectance
ρ_e is an average surface reflectance for the pixel and a surrounding region
S is the spherical albedo of the atmosphere
L_a is the radiance back scattered by the atmosphere
A and B are coefficients that depend on atmospheric and geometric conditions but not on the surface.
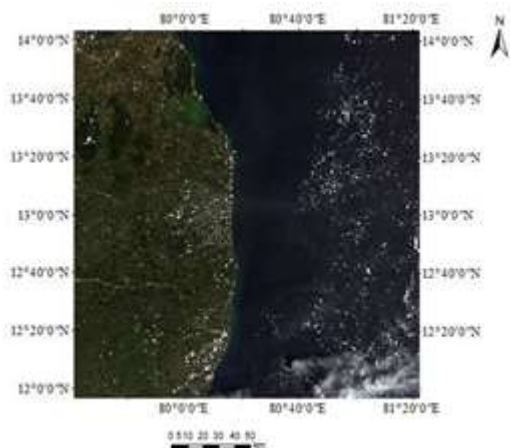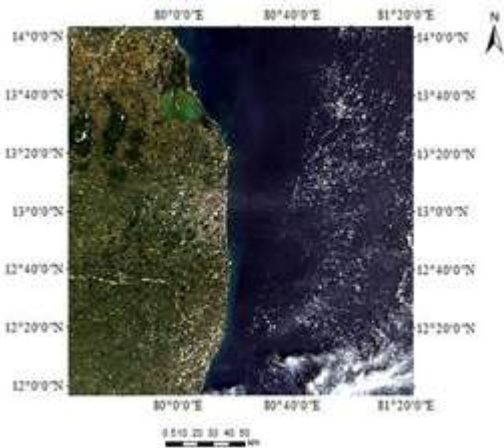

Figure 6: Before FLAASHING

Figure 7: After FLAASHING

The first term in Equation corresponds to radiance that is reflected from the surface and travels directly into the sensor, while the second term corresponds to radiance from the surface that is scattered by the atmosphere into the sensor. The distinction between ρ and ρe accounts for the adjacency effect (spatial mixing of radiance among nearby pixels) caused by atmospheric scattering. To ignore the adjacency effect correction, set ρe = ρ.

G. *Rescaling Reflectance Data with Band math*
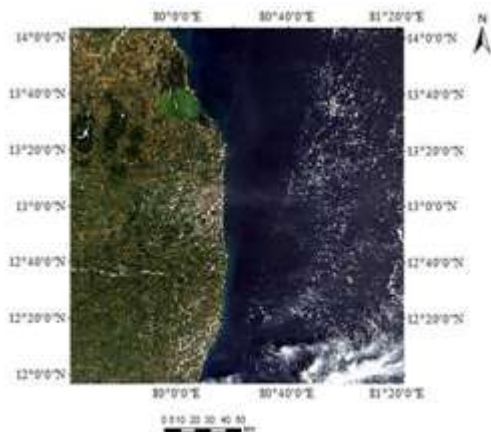
Figure 8: Before Rescaling

Figure 9: After Rescaling

"Fig.8,"In this process mathematical and statistical method is used to enhance images by exploiting relationships between spectral bands to create a new achievable [11]. "Fig.9," In

this review the following band math equation has been used to divide the obtained values by 1000 from equation (3)

$$(B1 \ le \ 0)*0+ (B1 \ ge \ 10000)*1+ (B1 \ ge \ and \ B1 \ it)*float (B1)/10000 \quad (3)$$

H. Resize data

Figure 10: Before Resizing Data

"Fig.10,"This process is done to increase the accuracy of the image by cropping out a smaller portion of the entire image to have a better view of the target location. "Fig.11,"The upper left coordinate (latitude = 13'0'31.44''N longitude = 80'17'15.54''E) and the lower right coordinate (latitude = 13'2'17.85''N longitude = 80'15'55''E) are chosen and the area of interest is cropped and has better clarity and can be processed separately.

Figure 11: After Resizing Data

I. Stretching

Figure 12: Before Stretching

Figure 14: After Stretching

"Fig.12,"In attempt to recognize objects by examining images image processing and analysis technique such as linear stretching is done. [12] "Fig.13,"Contrast enhancement by linear stretch is applied to the image with very low and very high variations of brightness. To apply the linear stretch algorithm of 2 %the image is converted into gray-scale and all 8bit pixels and then recorded into histogram.

"Figure 14: When the histogram and the image is created, maximum (OMAX) and minimum (OMIN) values can be identified.

7. Image Processing Methodology

a) Density Slicing

Figure 15: Before Density Slicing
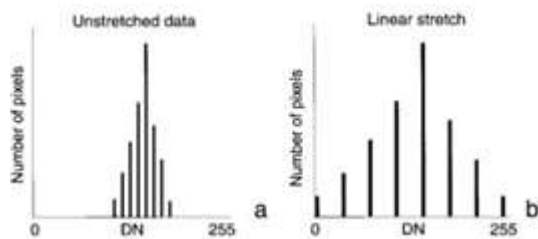
Figure 13: Comparison between Unstretched and Linear data
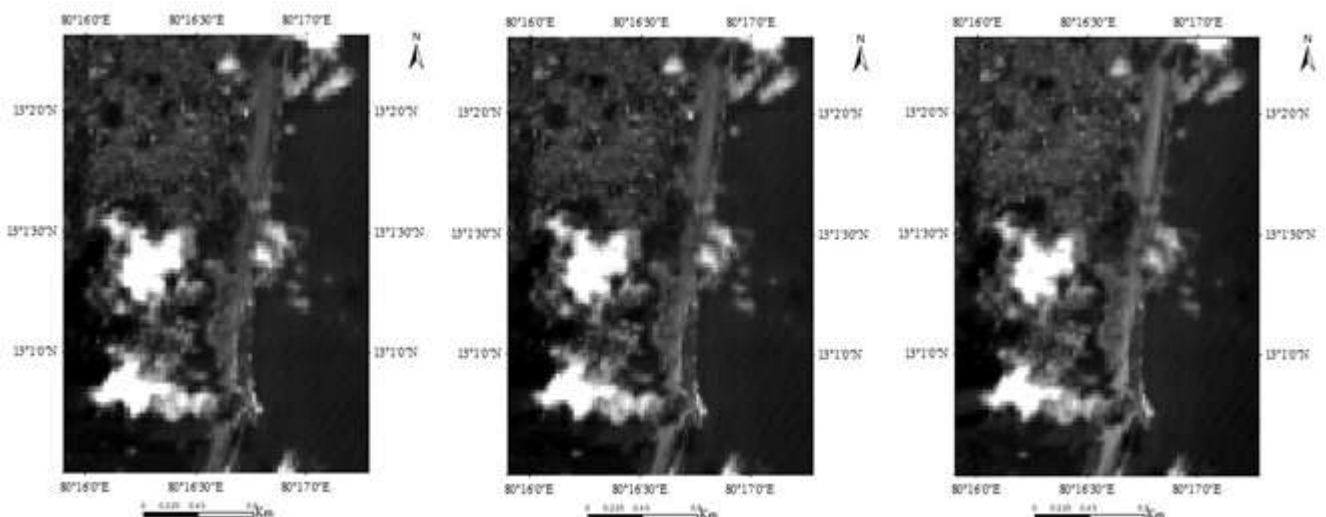
Figure 16: Density slicing of band

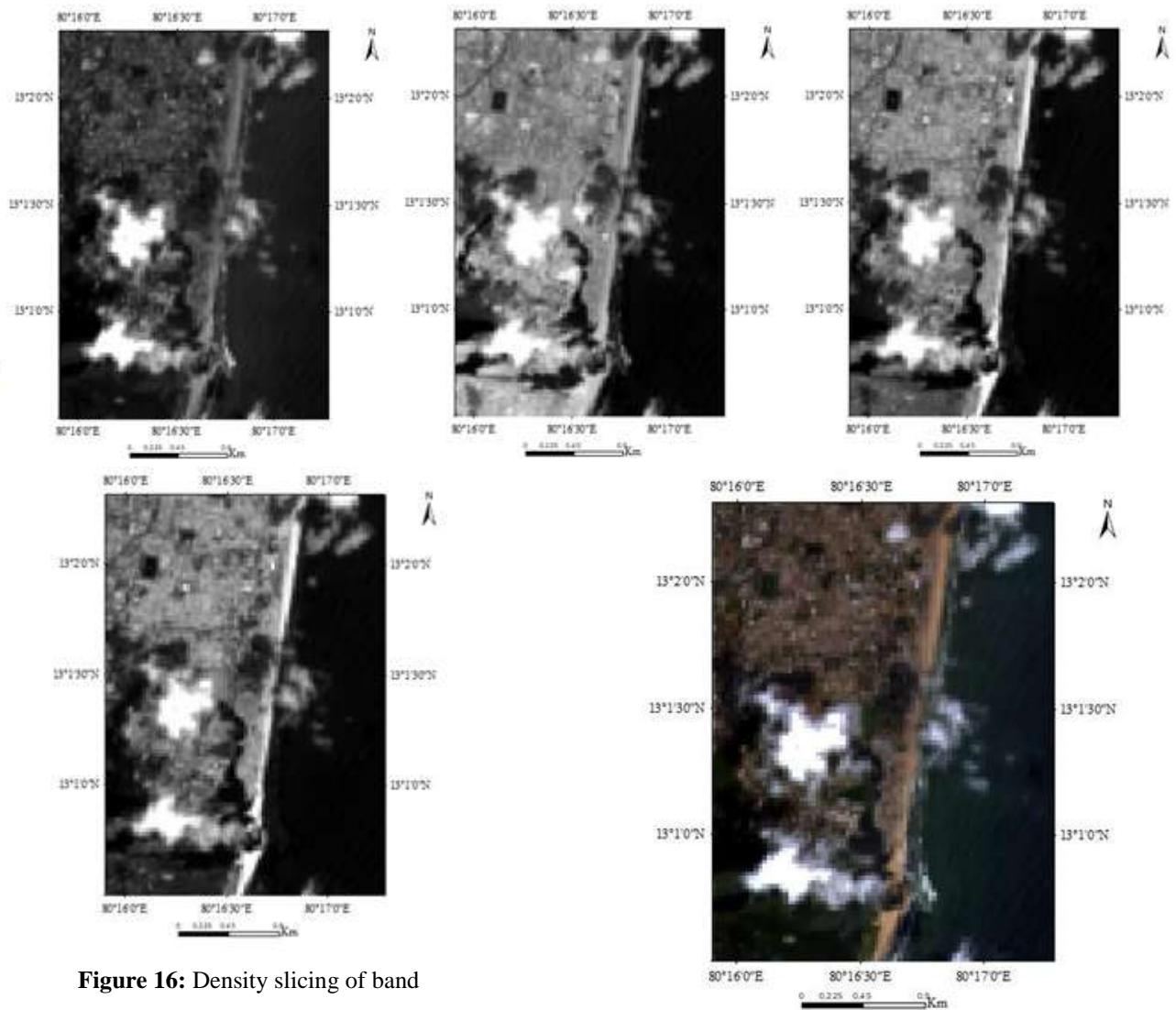**Figure 17:** After Mosaicing

"Fig.15,"Density slicing is a digital data interpretation method which we have used in analysis of our remotely sensed image to enhance the information gathered from an individual brightness band. [13] Density slicing is done by dividing the range of brightness's in a single band into several intervals, and then each interval is assigned with a color. "Fig.16,"The black-and-white thermal image temperature values in the image is into bands of 2°C, and each band represented by a color of the spectrum. [14] Therefore, the temperature information in the image can be analyzed more easily as the differences between the colors are greater than the black and white and therefore it is easier to analyze the data contained in the image.

b) Rastar Mosaicing
Mosaicing is used in the process to combine multiple, individual images into a single scene."Fig.17,"Mosaicing is done virtually by using ILWIS which mosaics multiple data sets that functions as a catalog, combining image datasets on the fly. Ultimately, the mosaic process yields as a new raster dataset. Regardless of the approach the input datsets overlap are considered and the software decides how the mosaic should handle the overlap area must be specified.

c) Compression
Compression is used to reduce the size of an image dataset. Lossless compression is done to reduce the file size, without any loss of data. Compression is used as the imagery is going to be used for visual analysis, as compression can have an adverse impact on automated feature extraction.

d) Radiometric Enhancement
Radiometric correction is done to reduce or correct errors in the digital numbers of images which are meant to be processed. This process improves the interpretability and quality of remote sensed data and increases the fineness of the image. Radiometric calibration and correction are particularly important when comparing data sets over a multiple time periods and when they are made into a mosaic. The energy that sensors onboard aircrafts or satellites record can differ from the actual energy emitted or reflected from a surface on the ground. This is due to the sun's azimuth and elevation and atmospheric conditions such as water vapour, smoke, etc that can influence the observed energy. Therefore, in order to obtain the realground irradiance or reflectance, radiometric errors must be corrected for the obtained data products.

e) Saturation Stretch

Figure 18: Before Saturation Stretch

"Fig.18,"Saturation Stretch is used to enhance the color of a 3-band input image by producing output bands that have more saturated colors. The input data are transformed from red, green, and blue (RGB) space to hue, saturation, and value (HSV) space. Then gaussian stretch is performed on the saturation band so the data fills the entire saturation range. "Fig.19," The HSV data are then automatically transformed back to RGB space.
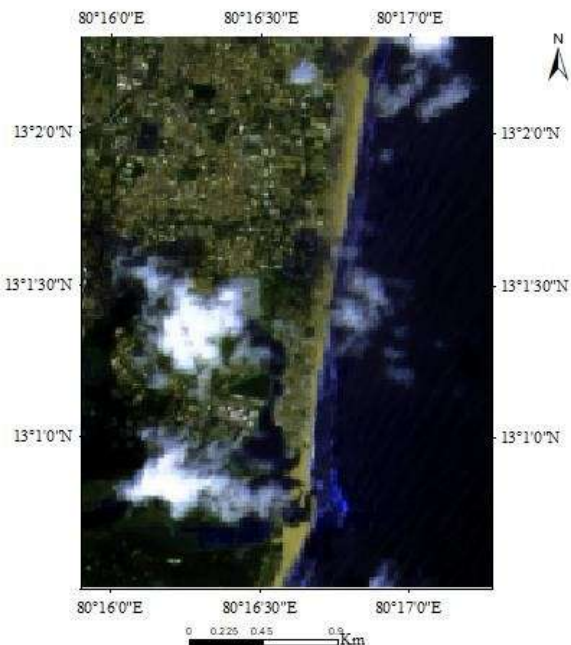

Figure 19: After Saturation Stretch
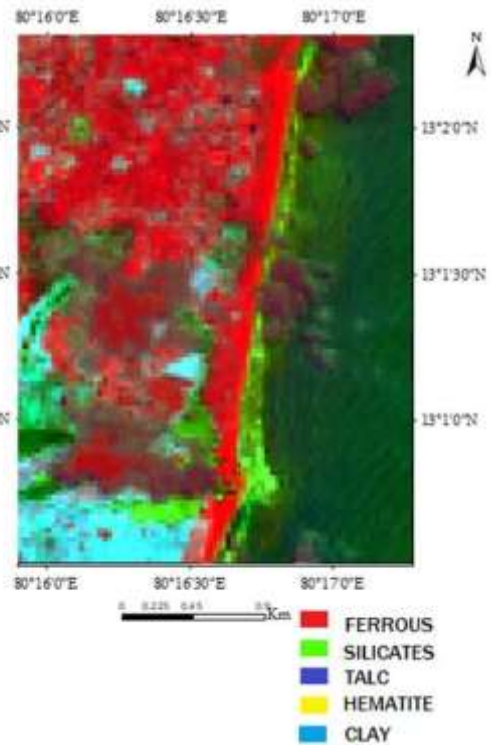
f) Band Ratioing

Figure 20: Band Ratio

This is a very useful image processing technique. each pixel is divided by the DN value of any one band by the value of another band. This quotient yields a new set of numbers that may range from zero (0/1) to 255 (255/1) but the majority are fractional (decimal) values between 0 and typically 2 - 3 (e.g., 82/51 = 1.6078; 114/177 = 0.6440). We can rescale these resulting ratio values to provide a gray- tone image, in which we can reach 16 or 256 levels, depending on the computer display limits. One effect of ratioing is to eliminate dark shadows, because these have values near zero in all bands.

"Fig.20,"This tends to produce a "truer" picture of hilly topography in the sense that the shaded areas are now expressed in tones similar to the sunlight sides. In other words, band ratioing has the effect of removing shadows.

8. Image Classification Methodology

a) Masking
Masking is the process of focusing a specific area in particular to analyze the data found with in this region. This process is done by creating an ROI with the ROI building tool provided in NV and this ROI is merged with the TIF file to create a mask.

b) Unsupervised Classification
In unsupervised classification the first groups pixels are combined into clusters based on their properties. In order to create clusters we use image clustering algorithms such as K-means and ISODATA. For the most part, then we use this list of free remote sensing software to create land cover maps.

After picking a clustering algorithm, we identify the number of groups we need to generate. With this we create 8 clusters. To be clear, these are unclassified clustersbecause in the next

step, we manually identify each cluster with land cover classes using "Fig.21,"

Overall, "Fig.22,"unsupervised classification is the most basic technique. Because we don't need samples for unsupervised classification, it's an easy way to segment and understand an image.
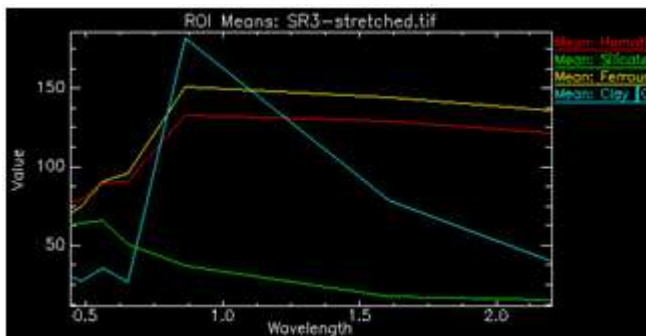
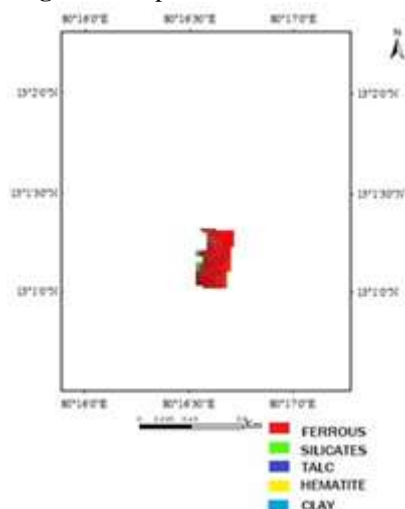

Figure 21: Spectral reflectance curve

Figure 22: Masking and Unsupervised Classification
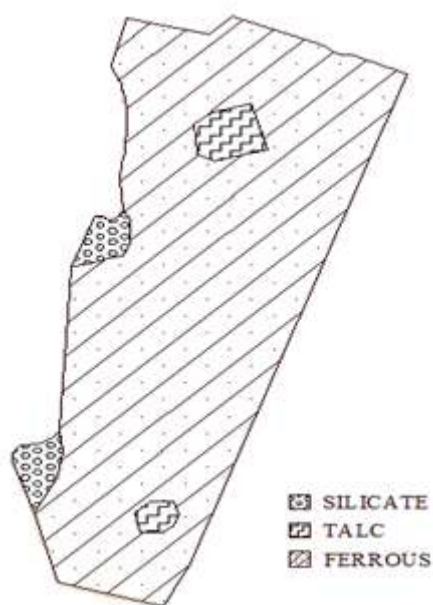
9. Result

Figure 23: Mineral Map of Pattipulam

By using the technic of unsupervised image classification, we conclude that there is an abundance of ferrous which covers 48%, silicates cover 23% of the total area, Talc covers 29% of the total area which shows dominance over silicates and there is an absence of hematite and clay minerals from "Fig.23,"

10. Discussion

From the obtained results we conclude that the village of Pattipulam has a moderate presence of silicate deposits.

11. Acknowledgement

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