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Appraisal Of Kanjamalai Iron Ore Deposit Using Remote Sensing And Geographical Information System

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Abstract

The iron ore deposits forms part of Pre-Cambrian iron ore formations occurring as narrow, highly deformed and metamorphosed belts with in Archaean granulites and gneisses older than 3,000 Ma. Analysis of satellite imagery coupled with field investigations has helped to elucidate the iron ore deposits. The literature reviews suggest that only few attempts have been made on Processing and Analyzing Advanced High Resolution satellite Image Data for Identification and Exploring Iron ore Deposits of Precambrian age in Tamil Nadu, India and detailed investigation on spectral analysis. The reflectance of Landsat ETM+ data pertaining to the study area was used for Band ratio of 4/2. The Minimum Noise Fraction (MNF) transformation was performed to reduce the noise of pixels to identify the iron ores of the study area. The pure pixel of iron ore is exported to MNF image, after identifying iron ore pixels. The results of interpretation show the accuracy of mapping iron ore deposits.

Keywords: Remote Sensing, GIS, Iron ore grade, India

1.INTRODUCTION

Occurrences and distribution of iron ores have got importance in mapping and grade-wise categorization of different types of iron ores, especially the banded magnetite quartzite. Hematite and magnetite are the two important iron ores from which iron is extracted. Hematite and magnetite are considered to be superior owing to their high quality and quantity. The world reserve of crude iron ore is estimated to be 170 billion tonnes (USGS Mineral commodity summary, 2013). Satellite remote sensing techniques globally plays very important role in identifying various mineral deposits in geological prospecting, because of this satellite remote sensing techniques offers large area exploration in very short time as well as low cost, possible to identify mineral deposits of inaccessible area and mountain ranges, where we cannot do surface geological operation.

This research uses remote sensing techniques for iron ore exploration and introduces the processing of satellite digital data. Identification and delineation of the spatial distribution of iron ore deposits become crucial in the exploration of mineral resources and reserves. It is also evident that the multispectral or hyperspectral sensors are effectively used to assess and characterize the surface iron ore deposits. With sufficient spatial and spectral detail for mineral exploration the remote sensing product can help in mapping the mineral deposits on a regional scale. Accordingly this study is an attempt to assess the potential spectral remote sensing and satellite image processing to delineate the resources potential of banded iron ore deposits of Kanjamalai, Godumalai and Nainarmalai of north-western districts of Tamil Nadu.

Major iron ore deposits in India are divided into five designated zones as Zone I to Zone V, based on country commercial ground (GSI, 2006). In addition in south India magnetite rich banded quartzites occur in parts of Andhra Pradesh near the East Coast and in Tamil Nadu good deposits of magnetite occur in Salem district, Namakkal and Trichirapalli areas. Detailed survey and exploration on land is done by Mineral Exploration Corporation, Directorates of Mining and Geology of State Governments and various central and state public organizations. (National Mineral Policy, 1993). As per the Geological Survey of India (2006), number of magnetite-quartzite bands in variable thickness and length occur in different part of Tamil Nadu, especially in the north and northwestern part of Tamil Nadu. Several of the prominent iron ore occurrences have been identified by mapping and sampling, which consists of major iron ore deposits occurring in Salem, Namakkal, Thiruchirapalli and Tiruvannamalai districts of Tamil Nadu.

Metallic iron is virtually unknown on the surface of the Earh except as iron-nickel alloys from meteorites and very rare forms of deep mantle xenoliths. Although iron is the fourth most abundant element in the Earth's crust, comprising about 5%, the vast majority is bound in silicate or more rarely carbonate minerals. The thermodynamic barriers to separating pure iron from these minerals are formidable and energy intensive, therefore all sources of iron used by human industry exploit comparatively rarer iron oxide minerals, primarily hematite. Prior to the industrial revolution, most iron was obtained from widely available goethite or bog ore, for example during the American Revolution and the Napoleonic Wars.

These deposits are commonly referred to as "direct shipping ores" or "natural ores". Increasing iron ore demand, coupled with the depletion of high-grade hematite ores in the United States, after World War II led to development of lower-grade iron ore sources, principally the utilization of magnetite and taconite. (Taconite is a rock whose iron content, commonly present as finely dispersed magnetite, is generally 25 to 30 %.)Iron-ore mining methods vary by the type of ore being mined. There are four main types of iron-ore deposits worked currently, depending on the mineralogy and geology of the ore deposits. These are magnetite, titanomagnetite, massive hematite and pisolitic ironstone deposits. In India, studies have mainly centered on the economic aspects of the iron ores. On the other hand, the detailed information on conditions of deposition, nature of depositional basin, stratigraphy, structure, tectonics, geochemistry, mineralogy, digenetic changes, metamorphism and paleoecology of iron ore deposits of granulite terrain of India are scanty.

2.STUDY AREA

Kanjamalai in Salem and Kavuthimalai and Vediappanmalai in Thiruvannamalai Districts of Tamil Nadu have low grade iron ore deposits . Mine able reservwes at Kanjamalai is estimated @ 75 million tonnes and at Kavuthimalai and Vediappanmalai @ 35 million tonnes. Tamil Nadu Iron Ore Mining Corporation Ltd. (TIMCO) a joint venture company of TIDCO and Jindal Vijayanagar Steel Limited is implementing the iron ore project at Kanjamalai , Salem District and at Kavuthimalai, Vediappanmalai at Thiruvannamalai Districts at a project cost of Rs.400 crores.

Figure 1 Kanjamalai Satelite Map

Kanjamalai is a hill located 14 km west of Salem District of Tamil Nadu, India. The estimated terrain elevation above sea level is about 643 metres.There is a Siddhar temple on the hill and there is also a Murugan temple. The simple temple is rich in legend. Salem is located at 11.669437°N 78.140865°E,[5] at an average elevation of 278 m (912 ft). The city is surrounded by hills: Nagaramalai on the north, Jarugumalai on the south, Kanjamalai on the west, Godumalai on the east and the Shevaroy Hills on the northeast. Kariyaperumal Hill is in southwestern Salem. The Thirumanimutharu River flows through the city, dividing it in two. The fort area is the oldest part of Salem.The city's climate is dry, except during the monsoon season. January and February are generally pleasant; the dry summer begins in March, with the year's highest temperatures during May. The weather becomes more temperate in June and July, and August is cloudy but still dry. The northeast monsoon occurs from September to November, and December is clear and pleasant. Figure 1 shows Kanjamalai Satelite Map

Iron ore found in the hills had an average Fe content of 35% and it was more than 45% in the northern flank of the hills. Iron ores are rocks and minerals from which metallic iron can be economically extracted. The ores are usually rich in iron oxides and vary in color from dark grey, bright yellow, or deep purple to rusty red. The iron itself is usually found in the form of magnetite (Fe3O4, 72.4% Fe), hematite (Fe_2O3, 69.9% Fe), goethite (FeO(OH), 62.9% Fe), limonite (FeO (OH).n(H_2O)) or siderite ($FeCO_3$, 48.2% Fe).Ores containing very high quantities of hematite or magnetite (greater than about 60% iron) are known as "natural ore" or "direct shipping ore", meaning they can be fed directly into iron-making blast furnaces. Iron ore is the raw material used to make pig iron, which is one of the main raw materials to make steel—98% of the mined iron ore is used to make steel.[2] Indeed, it has been argued that iron ore is "more integral to the global economy than any other commodity, except perhaps oil. Figure 2 shows Location of the Kanjamalai Iron ore deposit

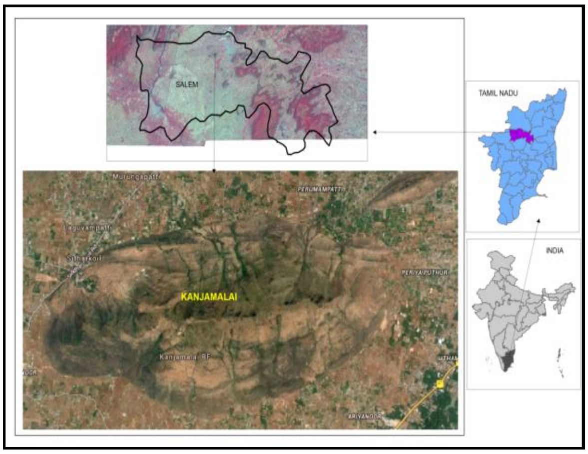

Figure 2 Location of the Kanjamalai Iron ore deposit

Kanjamalai is aprominent hill about 6.5 km WSW of Salem town. It measures roughly 7 km in E-W direction and 4 km in N-S direction. The thick magnetitequartzitebands and associated pyroxene granulite and other supracrustals are exposed in spectacular 'canoe' shaped hill. In the northwestern side, there is an off-shoot of the hill which looks almost completely isolated from it. Due to interference of superposed folds these bands have been refolded repeatedly to form doubly plunging basin.

There are mainly three bands, of which the lower band runs for about 12 km lengthwise all along the hills and constitutes a chain of low-lying hillocks, which are mostly disconnected. The width of the lower band varies from about 6 metres to as much as 50 metres. The second band, which is about 350 m elevated from ground level is exposed discontinuously. Its width is narrower than the first and third band, being only 5 metres. The third band is found more or less as a continuous one at an elevation of 400 m from the ground level. The average width of this band is 10 metres. Intense folding along the hinge of the hill enhance the thickening of the BIF bands.

Mineralogically the iron formation is essentially made up of quartz and magnetite with subordinate amount of ferro-magnesiansilicates. The iron ore bands have similar lithology with differences in their proportions of quartz and magnetite. In hand specimen, it is hard and compact and occurs as granular as well as banded in nature. Under the microscope, magnetite occurs as crystal aggregates and patches as well as euhedral to subhedral grains. In some sections, magnetite bands show flow banding indicating effects of stretching and shearing. Quartz form rounded to subrounded equigranular texture and some of the grains showing wavy extinction.

Grunerite shows pink to green pleochroism with an extinction angle of 220. Most ofthe 'grunerite are totally altered to chlorite and limonite. Anthophyllite occurs as fibrous aggregates with preferred orientation and has 200 extinction angle. They are also formed as zcicular inclusions in the quartz matrix In some sections, gedriteshows very strong preferred orientation of long prismatic colourless needles. Magnetite tend to have preferred orientation parallel to anthophyllite and gedriteneedles. Apatite forms an important accessory mineral. In some sections, magnetite-quartzite show moderate to intense shearing and stretching, showing pronounced development of cataclastic texture with quartz grains highly fragmented and welded together. The BIF bands are interbanded with pyroxene granulite, and with gametiferousgabbro and are most abundant lithounits next to BIF. Pyroxene granulites are mostly garnetiferous and are fresh. Garnets range in size from a few mm to a few cm in length and width.

In some places, the pyroxene granulite band shows retrogressive effect as in ManjavadiGhat-Kanjamalai fault, which cuts the hill in a curvilinear pattern. In hand specimen, it is medium to coarse grained. Under the microscope, it is seen that hypersthene, homblende, enstatite,diopside form the mafic components. Hypersthene shows pink pleochroism and has uralite, chlorite and biotite around the rim as well as in the cleavage cracks. Diopsideshows bottle green to yellowish green pleochroism. Prismatic grain of hornblende tend to have preferred orientation. Pink garnet show sieve texture with inclusions of quartz, pyroxenes and chlorite. Plates of plagioclase (oligoclase to andesine) with broad twin lamellae show sharp bend due to deformation. In some sections, andesine-labradorite occur with broad twin lamellae. Quartz is present as interstitial grains. Besides granulitic texture, a prominent gneissic banding is noticed in some sections. Figure 3 shows Field photograph of Kanjamalai Iron ore deposit

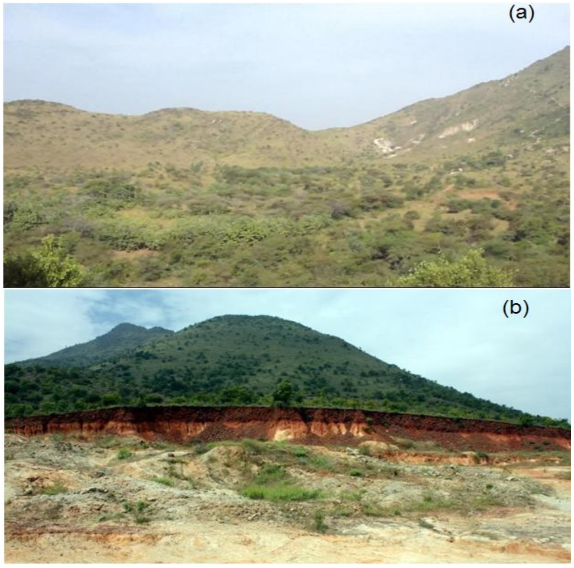

Figure 3 Field photograph of Kanjamalai Iron ore deposit

In the southern side of Kanjamalai, between lower and middle band, thepyroxene granulite show prominent retrogression along the shear. Under the microscope, extensive development of chlorite, clinozoisite, epidote is seen. Few grains of primary clinoenstatite and hypersthene with bleached pleochroismarepresent. Almost all the feldspar grains are covered by specks of zoisite and clinozoisiteLarge patches of carbonates are found as intergranular fillings. Apatiteandsphene forms the important accessories.In the above sequence, lenticular bands of pyroxenites and amphibolitesoccuras detached patches and are mainly confined to the south-eastern side of Kanjamblai. It is coarse grained, composed mainly of ortho-and clino-pyroxenes. Amphibolite is an altered product of pyroxenite. The homblende-biotite gneiss occur extensively in the plains as well as in the hill as detached bands and often carry lenticular patches of older supracrustal rocks and often show interaction along their contacts with older supracrustals to give rise to migmatites. In hand specimen, it is medium grained rock.

Under the microscope, homblende, biotite and quartz showing moderate to intensealteration to epidote, clinozoisite aggregates. Homblende grains are totally altered tochlorite aggregates while the feldspar grains showsextensive inclusion of epidote, dinozoisite and chlorite. Opaque patches of ilmenite show marginal alteration to leucoxene. Biotite flakes are mostly secondary after homblende grains.In some places quartzofeldspathic gneiss + garnet is interbanded with BIF.Thequartzofeldspathic gneiss occurring in the shear zone contain lenses of granitic and syenitic injections. It also shows retrogressive effects under the microscope.Younger uttramafic rocks comprising dunite, with magnesite veins and pyroxenitedisplay cross-cutting relation to the older supracrustals at Siddarkoil. Pink granites grading into graphic granite occur as an intrusive prominently along the disturbed zones.

3.METHODOLOGY FOR IRON ORE STUDIES

In this study Landsat ETM+ data were acquired for different wavelengths (Figure 4). Band radioing of Landsat ETM+ data minimizes the effects of environmental factors and was used to provide unique information not available in any single band. For instance, band ratios have proven useful for discriminating between soils, different rock types and effects of land use. In addition, ratioed images reduce the effects of slope and shadows to a marked degree and atmospheric correction before ratio generation reduces the effect considerably. Likewise, band ratios are significant for various differences in topography, reflectance and grain size of the rocks. Band ratios give importance also to profile of spectral reflectance's curves. Several studies around the world have used band ratios. Band 3/1, 4/3 and 5/7 successively in Red, Green and Blue (RGB) band ratio was used to construct images for mapping in southeast Wyoming where this particular ratio was very helpful for enhancing lithologic contrast. They defined several band ratios e.g. 7/1, 5/7, 4/7, 3/7, 2/5, 4/3 and 2/7. The method of Sultan et al. (1987) uses band ratios and multiplications to maximize the rock discrimination based on rock mineralogy. Sultan et al. (1987) proposed that band 5/4×3/4 is useful to distinguish between mafic and non-mafic rocks, because it is sensitive to rocks that have high Fe bearing alumino silicate concentrations such as amphibole and biotite. Interpretation of iron ore formations of the study area has been carried out by the image processing techniques using Landsat ETM+ and 5.8 m spatial resolution data.

The methodology adopted for magnetite mapping involves three major components namely,

1. Remote sensing based approach (band ratioing and multisensor image fusion)
2. Field studies and sample collection.
3. Geochemical analysis

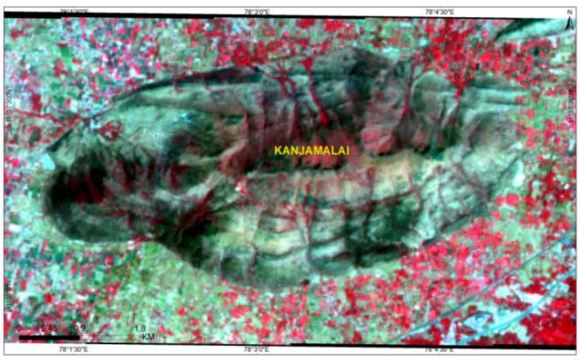

Figure 4 False Color Composite image of Landsat ETM+ of Kanjamalai

Figure 5. depicts the methodology adopted. The individual components of the flowchart are described in details as follows. The first two methods were image processing technique used to explore the iron ore deposit using image data (ratoing and image fusion) and the third method is used by us to prove the results obtained from the first three methods. For each method different procedures were adopted.

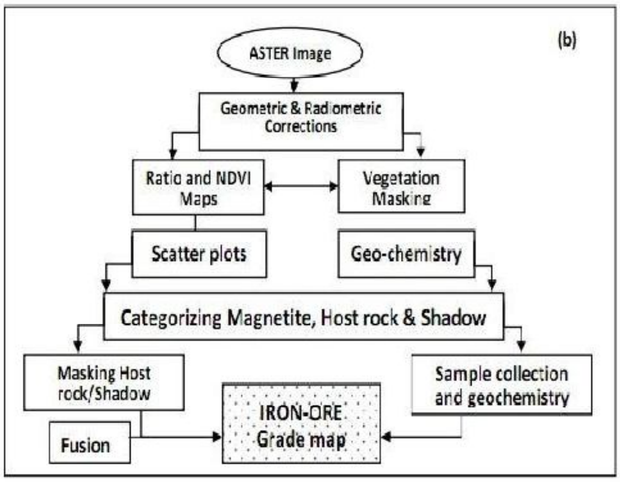

Figure 5 Flow chart – methodology

The spectral curves of minerals are characterized by reflectance peak and absorption bands caused by electronic and vibrational processes with their crystal lattices. It is seen that iron oxides have a reflectance peak in the visible red (0.73 microns) and absorption feature near 0.9 microns and 0.4 microns. These minerals, which include hematite, goethite, limonite andjarosite have a diagnostic spectral reflectance that was used by Rowan et al (1974) to process the earliest Landsat MSS images to identify ferric iron associated with mineralized gossans in the Goldfield mining district, Nevada.This involved a processing technique called ratioing where brightness (reflectance) values in one channel are divided by values for the same pixel in another channel. Ratios enhance the contrast between materials with different reflectance at a specific wavelength, and suppress the effect of shadows (topography), since low reflectance values are divided by low values.

3.1 Geological Setup Of The Study Sites

Kanjamalai is a structural hill well known on account of magnetite iron ore deposits located at a distance of 8 Km west of Salem town. It has an elevation of 986 m above MSL and total length of 7.2 Km from east to west with width of about 3.2 Km. According to Rajendran et al (2007) the major rock types associated with the oldest magnetite quartzite are pyroxene granulates, pyroxenite, quartize, dunite, amphiboles, granite, hornblende biotite gneiss and pegmatite magnetite ores exhibits banded structure around the hill at various height is shown in the Figure 6.

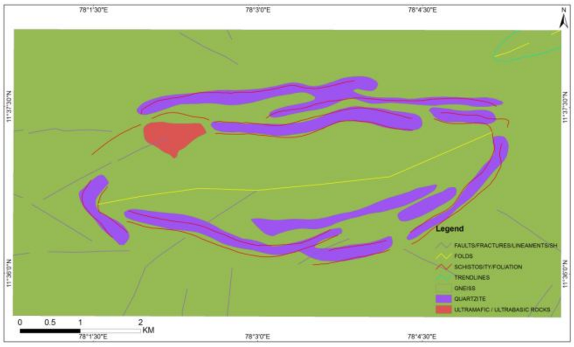

Figure 6 Geology and structure of the Kanjamalai

3.2 3D-Surface Profile

A geology map is one of the most effective tools to show the geometrical relationships among rock bodies. However, their geometry may be better appreciated in three dimensions by applying geometrical techniques (e.g. Ramsay and Huber, 1987; Powell, 1992; Groshong, 1999; Moore and Johnson, 2001). This is especially true in high mountain ranges with a strong topographic relief, where 3D geological structures can be directly observed. Systematic use of this tool is provided in Geographic Information Systems (GIS) mapped in field makes easy for the management of information commonly found in a geological map (Breunig, 1999). Exposed structural boundaries structural information (attitude of planar and linear features: bedding, faults, foliations, fold, lineation), are a potential source of information to be used in 3D reconstruction (Jessel, 2001; Chile` s et al., 2004). These data represent spatially continuous information on the geological framework of a region and have been traditionally used by generations of geologists to make previsions for the extension of geological structures at depth. Topographic data, including detailed 2D elevation contour lines (100m contour interval). Vector to raster conversions and linear interpolations are needed to obtain Digital Elevation Models (DEM), in raster format (Figure 7 and 8). The contour interpolation method is based on the Borgefors distance method and the pixel size has been chosen according to the complexity of the topographic surface; as points with properties (strike, dip-direction, dip, trend, etc.).

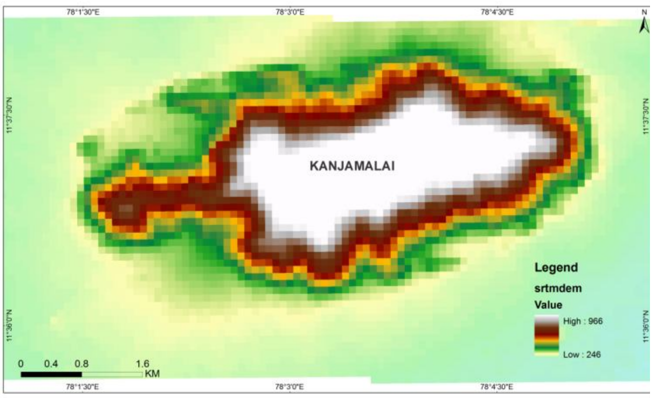

Figure 7 Digital Elevation Model of the Kanjamalai

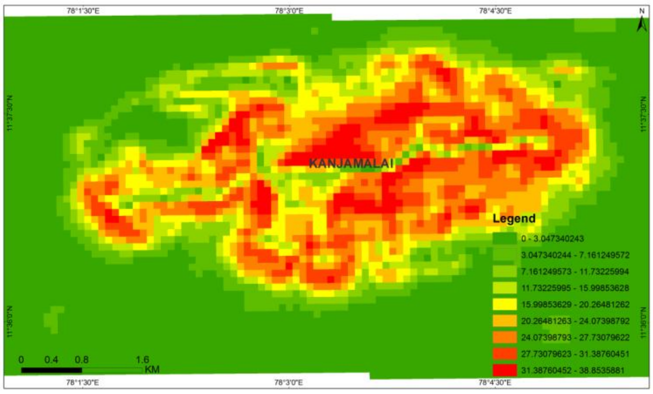

Figure 8 Slope angle of the Kanjamalai

3.3 Ratio Maps

The process of dividing the pixels in one image by the corresponding pixels in a second image is universally known as ratioing. It is one of the most commonly used transformations applied to remotely-sensed images. There are two reasons why this is so. One is that certain aspects of the shape of spectral reflectance curve of the different earth-surface cover types can be brought out by ratioing. The second is that undesirable effects on the recorded radiances, such as the effect of variable illuminations (and consequently radiance) resulting from variations in the topography can be reduced. Band ratios have been used extensively in mineral exploration and to map vegetation condition. Bands are chosen to accentuate the occurrence of a particular material. The analyst chooses one wavelength band in which the material is highly reflective (appears bright), and another in which the material is strongly absorbing (appears dark). Usually the more reflective band is used as the numerator of the ratio, so that occurrences of the target material yield higher ratio values (greater than 1.0) and appear bright in the ratio image. Ratio images are prepared by dividing one DN value in one by the corresponding DN value from another band of the same image. The resulting values are plotted as a ratio image. In a ratio image the black and white extremes of the gray scale represent pixels having the greatest difference in reflectivity between the two spectral bands. The darkest signatures are areas where the denominator of the ratio is greater than the numerator. Conversely, the numerator is greater than the denominator for the brightest signatures. Where denominator and numerator are the same, there is no difference between the two bands, ferric-iron (Fe^{3+}) rich rocks exhibit a sharp fall-off in reflectance approximately from 0.8 micrometers to shorter wavelengths, thus ferric-iron rich exposures exhibit very low ASTER band 1/band 2 values. When band rationing has been applied to Cheleken data, the lowest band ratio values clearly represent red Series situated in the middle of the scene and confirm supposition, that red-coloring of beds is caused by higher iron content of rock layers. Besides the red Series, low ratio values appear in some areas of the North Plain located most likely at summits of sand dunes, which are one of landscape-forming feature mention.The ferrous mineral abundance map is used to highlight the ferrous minerals mainly ores of iron in the map. The algorithm to prepare this map is given as: Band 4 / Band 3.

4.MATERIALS AND METHODOLOGY

Since the aim of the study is to examine the structural, mineralogical characteristics of the iron ores, the iron ore samples were analyzed with standard geochemical analysis techniques. The overall methodology for this study includes, field work and sample collection, geochemical analysis, and examination of the structural patterns/trend of the banded iron ore formations of the selected study area.

4.1 Field Work And Sample Collection

Field investigation and sample collection form the major components of this study. 40 samples were collected from various parts of the study sites. Care was taken during the sample collection in such a way that the samples fall in structural trend lines (iron ore ridges). Hence the relationship between the geological structure of banded iron ore formations and grades of iron ores of the corresponding samples can be correlated. The description of the various samples collected in the study area .Since, this study involves the detailed geochemical analysis of the banded iron ore samples, samples were collected from different parts of the study area along with geographical locations (latitude and longitude) using a global positioning system (GPS with + or – 2m). the field photographs of certain sample location containing banded iron ore formations in the study area.

4.2 Geochemical Analysis

Geochemistry of the samples is an important parameter to relate with the structural trends of the iron ore formation and appraise the grades of iron ores. After collecting sample from field investigation (ground truth verification), various iron ore samples were powdered to 100 micron size and the samples were prepared for XRF analysis to identify the total iron content in the ore samples

4.3 Geological Structure And Geomorphology

An important observation on the structural and geomorphic set up of all the study sites reveals that the occurrences of various types of iron ores are different. The sites exhibit different structural and geomorphic set-up and hence the variation in the geochemistry of the iron ore samples is observed. Figure 9 shows Irs-P6 LISSIV Image Of Study Area With Band Ratio Of 4/3

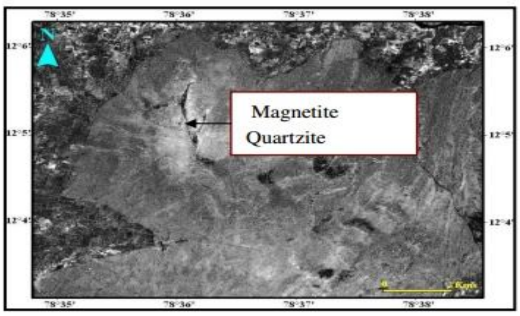

Figure 9 Irs-P6 LISSIV Image Of Study Area With Band Ratio Of 4/3

4.4 Predicting Iron Potential

Iron ore deposits have unique geophysical signatures that make them well suited to GIS analysis. These properties moderate to strong magnetic signature, association with gravity highs and distinctive shape of aeromagnetic anomaly — can be used to highlight areas that are more prospective for these deposits. Figure 1 shows the location of major iron ore prospects in South Australia on a state total magnetic intensity (TMI) image, and Figure highlights areas of coincident magnetic and gravity highs.

Regional metamorphic.Refers to regionally metamorphosed BIF with magnetite as the dominant iron oxide. Such deposits are usually very fine grained, and may be cheaply processed by fine grinding, followed by beneficiation by wet magnetic separation. There are large resources of BIF where hematite is the dominant iron oxide, but these are not considered to be an economic resource due to the prohibitive costs associated with processes to recover the hematite. Such resources often occur as a weathered/altered BIF capping to an underlying magnetite-bearing BIF. The Warramboo prospect on the central Eyre Peninsula is an example of Archaean BIF with a metamorphic grade of upper amphibolite to granulite facies. The rocks generally have a prominent magnetic signature, with assays for iron averaging 15–25%.

4.5 Contact Metamorphic/Skarn

This refers to a hydrothermally altered rock with either hematite or magnetite as the dominant alteration mineral. An example is Iron Magnet in the South Middleback Range, a magnetite-rich rock developed in a host BIF, with local controls being both structural and stratigraphic. Magnetite/hematite-rich skarn is commonly associated with IOCG (iron oxide – copper–gold) deposit style of mineralisation. Examples include Olympic Dam and Prominent Hill deposits and Manxman prospect, all located in the eastern GawlerCraton region.

4.6 Supergene Enrichment

This deposit style is the most economically significant in South Australia. The supergene enrichment process has resulted in complexly shaped pods of massive hematite, the most significant of which occur in the Middleback Range. These deposits are hosted by the basal stratigraphicsection of the Palaeoproterozoic Lower MiddlebackJaspilite of the Hutchison Group. Other. Other iron ore deposit styles include residual, hydrothermal vein, shear-hosted, magmatic differentiate, and colluvial/eluvial. They form minor deposits and are of relatively little economic significance.

5.ABOUT SOFTWARE

5.1 GIS For Mining

Mineral exploration geoscientists use diverse types of datasets to search for new economic deposits. Data sources vary from geologic maps, hyperspectral airborne and multispectral satellite images, and geophysical images to databases in many formats. GIS is an ideal platform to bring them together in a geoscientist’s computer and deliver meaningful outcomes. GIS is now able to help geoscientists in many aspects of their activities: data collection, management, analysis, and reporting. Field geologists can now capture fi eld data electronically using ArcPad and global positioning system (GPS) receivers. Other datasets may be downloaded from the Internet. All of these datasets can be integrated, manipulated, and analyzed using GIS. Pipelines, electric lines, roads, ramps, and other mining facilities change frequently. Engineers and operations staff use GIS for facility planning applications. Keeping track of existing infrastructure and integrating it with the mine plan and block models can be achieved with GIS. GIS can also be used to integrate recent survey data with block models or mine design data from other mining software packages such as GeoSoft, Vulcan, MineSight, SURPAC Range, or Mining Visualization System (MVS). Most mining information, including financial and asset information, has some sort of spatial component that can be represented in map form. Management and mineral economists are using GIS in their evaluation of corporate and competitor assets. Mining companies also use GIS to actively monitor the environmental impacts that may be caused by their activities and conduct reclamation. Various types of geologic datasets, such as geophysical images, geochemistry, geologic maps, radiometric measurements, boreholes, and mineral deposits, can be displayed, interrogated, and analyzed simultaneously using GIS.

6. IRON ORE

6.1 Iron Ore

Iron ores are rocks from which metallic iron can be extracted. It is one of the most abundant rock elements, constituting about 5% of the Earth's crust and is the 4th most common element in the world. It is abundant in Australia and mined mostly in Western Australia but is also common around the globe and is mined in around 50 countries. Almost 93% of Australia's identified iron ore resources are found in Western Australia, according to the Federal Government's Australian Mines Atlas. The quality of Australia's iron ore is considered to be some of the best in the world. Iron ore is part of our everyday lives and our modern world would look completely different without it. 98% of world iron ore is used to make steel, which accounts for over 90% of all metals used in the world. Steel is used in building for so many things, from cars, trains and ships through to the high rise buildings in our cities and the bridges that connect us. Steel is used to create pipes, cars, ships, engines, roofs, nails, nuts, bolts, tools, machinery, in building & construction, to make white goods, in manufacturing, food cans and much more.

Nearly all of Earth's major iron ore deposits are in rocks that formed over 1.8 billion years ago. At that time Earth's oceans contained abundant dissolved iron and almost no dissolved oxygen. The iron ore deposits began forming when the first organisms capable of photosynthesis began releasing oxygen into the waters. This oxygen immediately combined with the abundant dissolved iron to produce hematite or magnetite. These minerals deposited on the sea floor in great abundance, forming what are now known as the "banded iron formations." The rocks are "banded" because the iron minerals deposited in alternating bands with silica and sometimes shale. The banding might have resulted from seasonal changes in organism activity. The primary use of iron ore is in the production of iron. Most of the iron produced is then used to make steel. Steel is used to make automobiles, locomotives, ships, beams used in buildings, furniture, paper clips, tools, reinforcing rods for concrete, bicycles, and thousands of other items. It is the most-used metal by both tonnage and purpose.

6. 2 Physical Properties

Iron is a silvery-white or grayish metal. It is ductile and malleable. Ductile means capable of being drawn into thin wires. Malleable means capable of being hammered into thin sheets. It is one of only three naturally occurring magnetic elements.

The other two are **nickel** and **cobalt**.Iron has a very high tensile strength. Tensile means it can be stretched without breaking. Iron is also very workable. Workability is the ability to bend, roll, hammer, cut, shape, form, and otherwise work with a metal to get it into a desired shape or thickness.

The melting point of pure iron is 1,536°C (2,797°F) and its boiling point is about 3,000°C (5,400°F). Its density is 7.87 grams per cubic centimeter. The melting point, boiling point, and other physical properties of steel alloys may be quite different from those of pure iron. A tumble strength test measures two mechanisms of feedstock degradation, that is, the Tumble Index (TI) and the Abrasion Index (AI). It was carried out following the International Standard ISO 3271:1995(E) for determination of Tumble Strength for iron ore [7]. Precisely, a 15 kg test block sample was tumbled in a circular drum rotating at 25 rpm for 200 revolutions. Subsequently, the ore was screened and fractions +6.3 mm and −0.5 mm were obtained. The percentage of the fractions in proportion to the feed weight is the value of the TI (+6.3 mm) and AI (−0.5 mm). The test was repeated four times and the average values for these tests represent the final TI and AI data.For estimation of a Shatter Index, a dried lump iron ore sample (10 kg) of size −40 + 10 mm was dropped 4 times from a height of 2 m onto a cast iron floor (0.5 × 0.5 × 0.03 m). Thereafter, the iron ore was screened and the shatter index expressed as the wt% passing through a 5 mm sized screen (i.e., −5 mm fraction). This procedure followed a test procedure suggested by , which were carried out on other ores. Table 1 shows Iron Properties

Table 1 Iron Properties

What are the Physical Properties of Iron?	
Color	Silver-gray metal
Malleability	Capable of being shaped or bent
Ductility	Easily pulled or stretched into a thin wire
Luster	Has a shine or glow
Conductivity	Good transmission of heat or electricity
Allotropy	It occurs in two or more crystalline forms in the same physical state
Tensile	It can be stretched without breaking
Ferromagnetic	Easily magnetized

The apparent porosity was determined using the GeoPyc 1360 pycnometer. A quantity of helium was placed in the sample chamber and its volume was measured. Thereafter, a 2.0□g iron ore piece was placed in the chamber together with the helium gas and the equipment registered the new volume values. The difference in the new and original helium volume gave the sample's envelope and skeletal volumes. The difference in the envelope and skeletal volumes indicates the percentage of porosity of the sample.

6.3 Chemical Properties

Table 2 Iron Chemical Properties

What are the Chemical Properties of Iron?	
Chemical Formula	Fe
Toxicity	Non Toxic
Reactivity with water	Reacts with very hot water and steam to produce hydrogen gas
Oxidation	Readily combines with oxygen in moist air which produces iron oxide also known as rust
Solubility	Dissolves in acids

Iron is a very active metal. It readily combines with oxygen in moist air. The product of this reaction, iron oxide (Fe_2O_3), is known as rust. Iron also reacts with very hot water and steam to produce hydrogen gas. It also dissolves in most acids and reacts with many other elements. Table 2 shows Iron Chemical Properties

6.4 Metallurgical Properties

- Thermoanalysis was performed using the Thermogravimetry-Differential Thermal Analysis-Mass Spectrometry (TGA and DTA) with a Netzsch STA 409 operated in an argon atmosphere. Heating was performed at a constant rate of 10°C/min, from 20°C up to 1450°C. The temperature was held at 1450°C for 30 minutes and then ramped to 20°C.
- Reducibility was estimated following the procedure described by Chatterjee (1994), using the Netzsch STA 409. The test employs isothermal reduction of the test portion, 500□g, on a fixed bed at 950°C using reducing gases consisting of 40% CO and 60% N_2. During the test, the sample's weight reductions were recorded at specified intervals.

6.5 Extraction

Iron goes through a number of stages between ore and final steel product. In the first stage, iron ore is heated with limestone and coke (pure carbon) in a blast furnace. A blast furnace is a very large oven in which the temperature may reach 1,500°C (2,700°F). In the blast furnace, coke removes oxygen from iron ore: The limestone removes impurities in the iron ore.Iron produced by this method is about 91 to 92 percent pure. The main impurity left is carbon from the coke used in the furnace. This form of iron is known as pig iron. Pig iron is generally too brittle (it breaks too easily) to be used in most products.Most scientists believe that the Earth's core consists largely of iron.A number of methods have been developed for purifying pig iron. A common method used today is called the basic oxygen process. In this process, pig iron is melted in a large oven. Then pure oxygen gas is blown through the molten pig iron. The oxygen burns off much of the carbon in the pig iron: A small amount of carbon remains in the iron. The iron produced in this reaction is known as steel.The term "steel" actually refers to a wide variety of products. The various forms of steel all contain iron and carbon. They also contain one or more other elements, such as silicon, titanium, vanadium, chromium, manganese, cobalt, nickel, zirconium, molybdenum, and tungsten**.** Two other steel-like products are cast iron and wrought iron. Cast iron is an alloy of iron, carbon, and silicon. Wrought iron contains iron and any one or more of many other elements. In general, however, wrought iron tends to contain very little carbon.

6.6 Uses

It would be impossible to list all uses of iron and steel products. In general, those products can be classified into categories:

(1) Automotive;
(2) Construction;
(3) Containers, packaging, and shipping;
(4) Machinery and industrial equipment;
(5) Rail transportation;
(6) Oil and gas industries;
(7) Electrical equipment; and
(8) Appliances and utensils. (For more information on specific kinds of steel alloys, see individual elements, such as titanium, vanadium, chromium, manganese, molybdenum, and tungsten.)

6.7 Sources

Metallic iron is virtually unknown on the surface of the Earth except as iron-nickel alloys from meteorites and very rare forms of deep mantle xenoliths. Although iron is the fourth most abundant element in the Earth's crust, comprising about 5%, the vast majority is bound in silicate or more rarely carbonate minerals. The thermodynamic barriers to separating pure iron from these minerals are formidable and energy intensive, therefore all sources of iron used by human industry exploit comparatively rarer iron oxide minerals, primarily hematite.

Prior to the industrial revolution, most iron was obtained from widely available goethite or bog ore, for example during the American Revolution and the Napoleonic Wars. Prehistoric societies used laterite as a source of iron ore. Historically, much of the iron ore utilized by industrialized societies has been mined from predominantly hematite deposits with grades of around 70% Fe. These deposits are commonly referred to as "direct shipping ores" or "natural ores". Increasing iron ore demand, coupled with the depletion of high-grade hematite ores in the United States, after World War II led to development of lower-grade iron ore sources, principally the utilization of magnetite and taconite. (Taconite is a rock whose iron content, commonly present as finely dispersed magnetite, is generally 25 to 30%.).Iron-ore mining methods vary by the type of ore being mined. There are four main types of iron-ore deposits worked currently, depending on the mineralogy and geology of the ore deposits. These are magnetite, titan magnetite, massive hematite and pisolitic ironstone deposits.

6.8 Beneficiation

Lower-grade sources of iron ore generally require beneficiation, using techniques like crushing, milling, gravity or heavy media separation, screening, and silica froth flotation to improve the concentration of the ore and remove impurities. The results, high quality fine ore powders, are known as fines. Figure 10 shows Field Photos Of Kanjamalai Iron Ore

Figure 10 Field Photos Of Kanjamalai Iron Ore

7.RESULTS AND DISCUSSION

Ferrous Mineral Abundance Mapping in Kanjamalai Landsat Thematic Mapper bands 3 / band 2 ratios has been used to map iron-bearing rocks in Lisbon Valley, Utah by Segal (1989). Further, according to Hunt (1977), ferric-iron (Fe3+) rich rocks exhibit a sharp fall-off in reflectance approximately from 0.8 micrometers to shorter wavelengths, thus ferric-iron rich exposures exhibit very low band 1/band 2 values. When band rationing has been applied to Cheleken data, the lowest band ratio values clearly represent red Series situated in the middle of the scene and confirm supposition, that red-coloring of beds is caused by higher iron content of rock layers. Besides the red Series, low ratio values appear in some areas of the North Plain located most likely at summits of sand dunes, which are one of landscape-forming feature. The ferrous mineral which has a strong absorption in band 3 and have reflectance in band 4 there by the ratio band 4 / band 3 will highlight the ferrous minerals. In the map all the white pixels are indicated by the presence of ferrous minerals. Figure 11 shows Ferrous Mineral Abundance Map of Kanjamalai

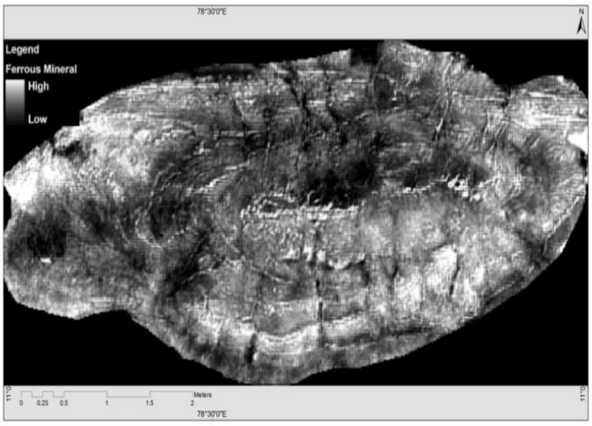

Figure 11 Ferrous Mineral Abundance Map of Kanjamalai

Iron Oxide Abundance Mapping Kanjamalai The iron oxide abundance map has been generated in order to highlight the iron oxide minerals. This index map is differentiated from the ferrous mineral abundance map in such a way that the iron oxide includes all the materials having red color. That is it includes iron ores, red soils, rust, laterites etc. The algorithm for the preparation of iron oxide abundance map is band ratio. The iron oxides which are red in color have absorption in the band 1 and have a reflectance in the band 2, so the ratios 2/1 highlight the red materials. The iron oxides are red in color which is highlighted in the map (Figure 12).

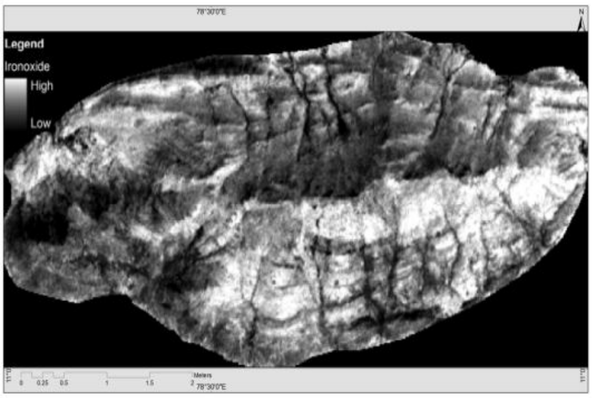

Figure 12 Iron Oxide Abundance Map of Kanjamalai

From the image showing only the iron ores, again scatter plot is generated. It is observed that each point in the scatter plot has a different DN values which indicates the amount of absorption and reflection of EMR. If the same substance (at different places) shows different absorption and reflection, it is indicative of the quality of the substance. Here, the difference in the absorption of iron in the VNIR region tells about the quality of iron oxide in that place. Based on these reasons, the iron ores in that region are classified after mainly into 4 classes from the image namely. They are high grade iron ore, medium grade iron ore, low grade iron ore and very low grade iron ore (Figure 13).

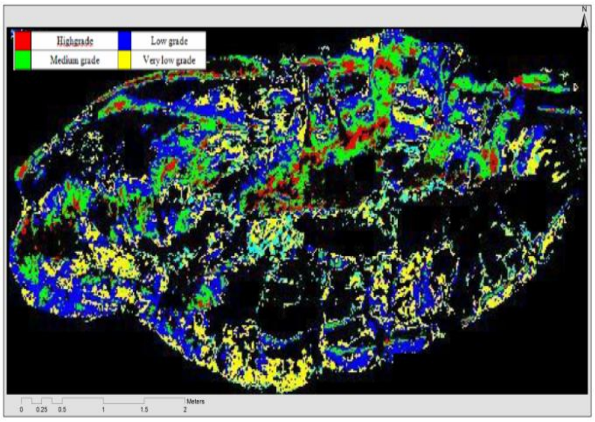

Figure 13 Image showing iron ore grades in Kanjamalai

8.CONCLUSION

This study has made an attempt to investigate the capability of IRS-P6 LISS IV data for discrimination and exploring of iron ore deposits of Precambrian age in Kanjamalai region. It was digitally processed and analyzed by band ratio of 4/2. In this study the ability of satellite data in detecting iron ore deposits is obvious by applying the best image processing techniques. Edge enhancement techniques could identify structural features such as fold, shear zone, and fault. The initial analysis of the satellite data using MNF and 2D scatter plot techniques are matched with satellite spectral data and library spectra with laboratory spectra, with that identification of Magnetite iron ore deposits of the purest pixels of 302 were exported to MNF band 4. The current study showed that it is possible to detect the narrow and low iron oxide content and quantitatively estimate its spatial distribution Ratio techniques were useful for identification of the abundance of iron oxide content including lateritic areas. This study has demonstrated that using the spectral remote sensing and digital image processing of satellite images such as ASTER data, iron ore deposits can be mapped and characterized with limited field work.

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Ring Road Alignment For Thuraiyur Using GIS

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Abstract

Design of ring road deals with the development of a comprehensive plan for Construction and operation of transportation facilities. In order to develop efficient and better transport facility, it is necessary to have a proper procedure transport movement. This ring road helps to a great extent in improving the safe and fast movement of both human and goods traffic, thereby increasing the economy of the City. The first and foremost step is reducing the traffic for the particular route by diverting the density of the vehicles to enhance the safe transport and environmental pollution. This project deals with the traffic problem of the Thuraiyur city and provides better transportation. In this project GIS is used for surveying, for preparing Contour maps, for developing three dimensional Digital Elevation Models, for various types of route alignments and for estimation of cutting and filling volumes. The purpose of this study was to develop a tool to locate a suitable less route between two points. The GIS approach using ground parameters and spatial analysis provided to achieve this goal. Raster based map analysis provide a wealth of capabilities for incorporating terrain information surrounding linear infrastructure. Costs resulting from terrain, geomorphology, land use, drainage and elevation resulting low cost estimation for implementing the shortest routes for the study area. Finally Ring road for Thuraiyur city of 20kms all around which connect the major roads of bye pass was formulated.