World Academy of Science, Engineering and Technology
International Journal of Geological and Environmental Engineering
Vol:11, No:2, 2017

Mapping of Alteration Zones in Mineral Rich Belt of South-East Rajasthan Using Remote Sensing Techniques

Mrinmoy Dhara, Vivek K. Sengar, Shovan L. Chattoraj, Soumiya Bhattacharjee

Abstract**—**Remote sensing techniques have emerged as an asset for various geological studies. Satellite images obtained by different sensors contain plenty of information related to the terrain. Digital image processing further helps in customized ways for the prospecting of minerals. In this study, an attempt has been made to map the hydrothermally altered zones using multispectral and hyperspectral datasets of South East Rajasthan. Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) and Hyperion (Level1R) dataset have been processed to generate different Band Ratio Composites (BRCs). For this study, ASTER derived BRCs were generated to delineate the alteration zones, gossans, abundant clays and host rocks. ASTER and Hyperion images were further processed to extract mineral end members and classified mineral maps have been produced using Spectral Angle Mapper (SAM) method. Results were validated with the geological map of the area which shows positive agreement with the image processing outputs. Thus, this study concludes that the band ratios and image processing in combination play significant role in demarcation of alteration zones which may provide pathfinders for mineral prospecting studies.

Keywords**—**Advanced space-borne thermal emission and reflection radiometer, ASTER, Hyperion, Band ratios, Alteration zones, spectral angle mapper.

I. INTRODUCTION

SATELLITE data have drastically improved the capabilities for imaging and mapping the Earth's surface. Optical remote sensing is highly effective in arid and semi-arid regions where geologic structures are extensively exposed. One of the main aims of geological remote sensing is to develop improved methods for the mapping of geological anomalies which can further help in mineral exploration and rock class discrimination; most of the minerals show unique spectral signatures for particular wavelength regions, which are minutely analyzed to distinguish among a variety of minerals [1]. In this context, the ASTER is important spectral information using a total of nine bands in the VNIR-SWIR Region, related to geological studies [2]. Hyperspectral sensor Hyperion provides fine spectral details useful for geological applications. In the present study, digital image processing techniques have been evaluated for the mapping of mineral alteration zones through various BRCs using ASTER. ASTER datasets are often more useful in the study for alteration mapping over the Hyperion data due to unavailability and narrow spatial coverage.

The main motivation behind carrying out this study is availability of well-defined ASTER indices for ASTER bands which can be used extensively for mapping of alteration zones as well as hyperspectral data processing using established processing methods. ASTER is a multispectral data capable of highlighting significant and broad spectral features of the terrain elements based on the derivation of indices or ratio images A comprehensive list of ASTER based mineral indices for mineral and rock mapping is provided and discussed in the 'ASTER Mineral Index Processing Manual' [3]. An attempt have been made for mapping alteration mineral zones in the study area through ASTER datasets and extraction of mineral end member using EO-1 Hyperion data. The RS based information extraction is generally a part of reconnaissance survey, and therefore, require validation with better data processing and field based evidences.

II. STUDY AREA AND GEOLOGY

The study area is in high mineral prospect region of SE Rajasthan in Udaipur district. This area is very rich in carbonate minerals and clay minerals, especially china clay. The study area extends from 22.805501 N to 23.447211 N and 73.578063 E to 74.318576 E.

Rajasthan is endowed with a wide range of geological time scale from Proterozoic rocks in northern to southern parts, to recent alluvium in the western parts of the state. Aravali – Delhi fold belt (AFB) being a part of the old Earth's crust contains a record of varied geological and tectonic processes since 3500 MY .The Archean Basement regime exposed in the study area includes Beach granite and Mangalwar complex. The Archean Proterozoic boundary in Rajasthan is marked by prominent phase of acid igneous activity, i.e. emplacement of Beach Granite nearly 2500 Ma. The Proterozoic period is marked various sedimentary facies which have been metamorphosed due to multiple deformation activities. Lower Proterozoic era is marked with Aravalli Basin containing various Meta volcanic and calcareous rocks. Proterozoic rocks are overlaid by Vindhyan and basalt flows [4].

From a geomorphologic point of view, Rajasthan is the product of protracted erosional and depositional processes. The study area is mainly covered with dissected hills which are of both structural and denudational origin. The second

Mrinmoy Dhara is with Indian Institute of Remote Sensing (phone: +918817741327; e-mail: mrinmoy0907@gmail.com)

Vivek K. Sengar and Shovan L. Chattoraj are with Indian Institute of Remote Sensing (e-mail: viveksengar@iirs.gov.in, shovan@iirs.gov.in).

Soumiya Bhattacharjee was with Indian Institute of Remote Sensing (e-mail: soumiya940@gmail.com).

most dominant physiographic feature in the study area is the pediplain peneplain complex of denudational origin. Wind is the most active geological agent active in the area. Due to various streams and some reservoirs a few amount of alluvial plain has also developed in the area [4].

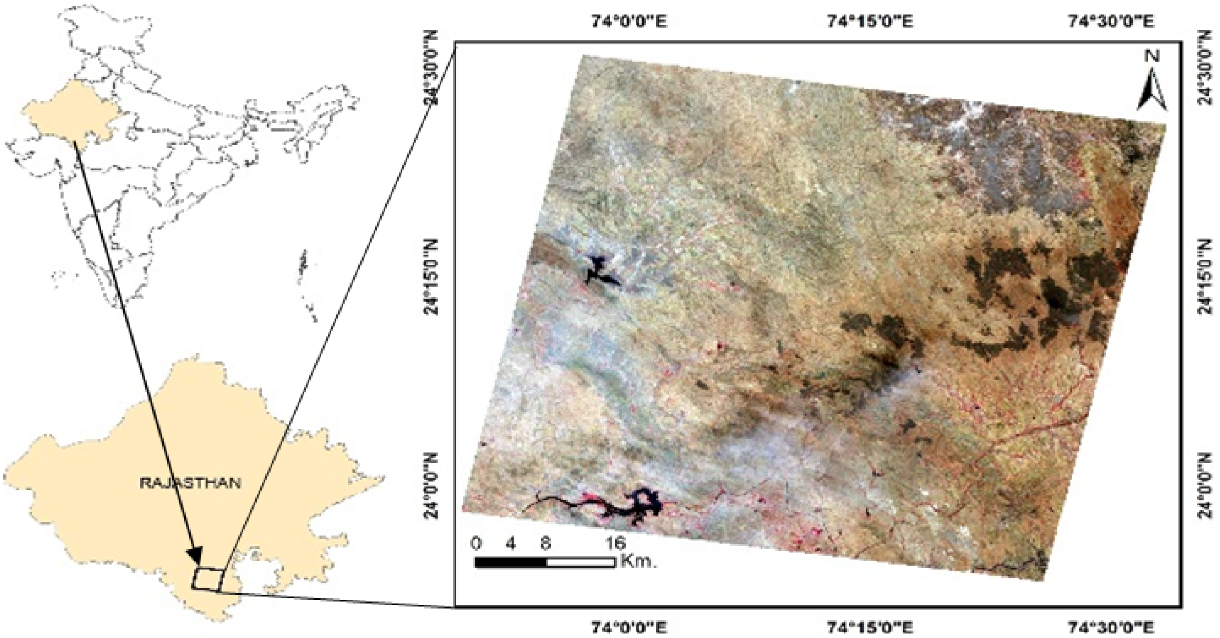

Fig. 1 Locater Map of Study Area

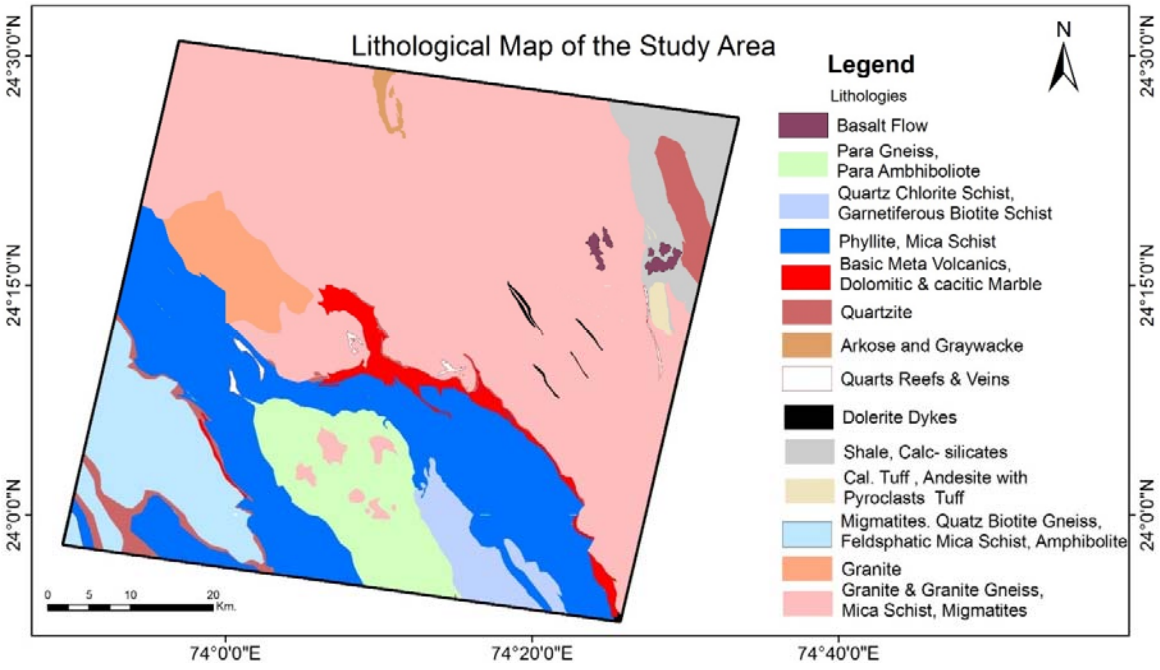

Fig. 2 Lithological map of the study area [5]

III. DATA SETS AND METHODOLOGY

ASTER L1A data scene id – 0404170543440404280501, data acquired on 17th April 2004 has been used for this study. Data processing was done using various software, namely ENVI v5.1, while ArcMap v10.2.2 was used for map composition. Additionally, geological maps of 1:50000 issued by Geological Survey of India maps number with topographic sheet no. 45L 03,04,07,08 and 46I 01, 04 were referred to produce the lithological map of the area. The geomorphology layers were referred to National Remote Sensing Centre (NRSC) Bhuvan data.

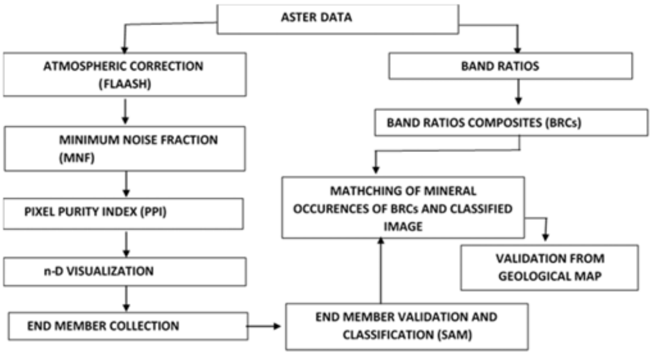

Fig. 3 Flow Chart of Methodology

The ASTER data were first preprocessed for radiometric correction and further followed by atmospheric correction through Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) inside ENVI. Different band ratios were generated from atmospherically corrected ASTER data as input for Minimum Noise Fraction (MNF), which is a data reduction technique. On the basis of the MNF results/statistics, Pixel Purity Index (PPI) is applied for identifying the uniquely occurring spectrally pure pixels. n-D Visualizer was run to identify the cluster of purest pixels and the extreme of axes in the dataset in n-dimensional space. After visualizing data in n-D visualizer, the pure pixel clusters are exported as ROIs and there spectra is collected in Endmember Collection for image classification using established SAM method [6]. Before classification these collected spectra are validated from spectral library (USGS) [7] resampled to ASTER through Spectral analyst module. Mathematically, SAM tries to obtain the angle between the reference spectra and the image spectra treating them as separate vectors in a space with dimensions equal to the number of bands [8]. SAM presents the formulation:

$$\alpha = \cos^{-1} \frac{\Sigma XY}{\sqrt{\Sigma (X)^2 \, \Sigma (Y)^2}} \tag{1}$$

where, α = Angle formed between reference spectrum and image spectrum, X = Image spectrum, Y = Reference spectrum.

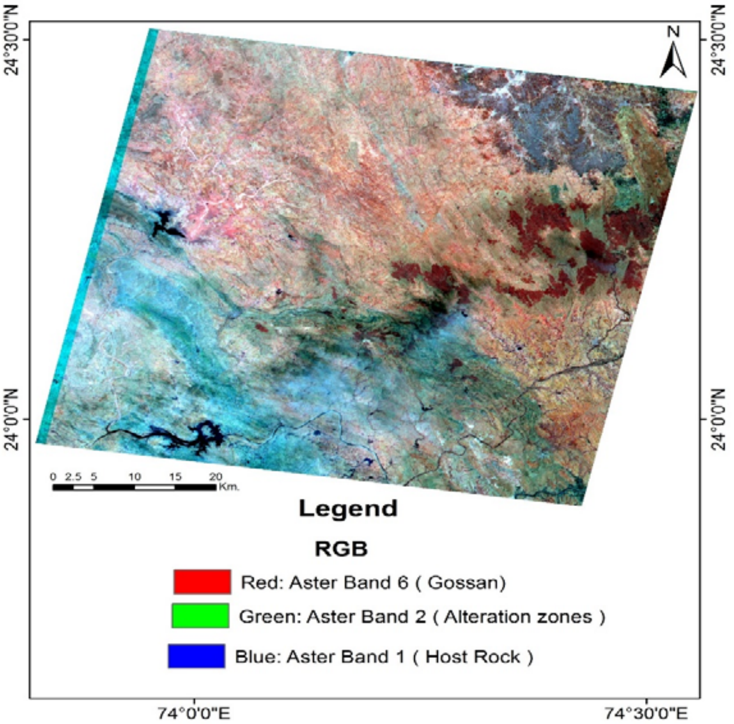

Fig. 4 ASTER derived FCC

Band rationing (BR) refers to dividing pixel value of one band to the corresponding pixel value of the other band. There are two main reasons of applying this technique: Firstly, the differences between surficial spectral reflectance curves can be brought out. The second is that illumination, and consequently the radiance of a surface may vary, but the ratio between areas of the same surface type with different illuminations will be the same [9].

BR = DN (a) / DN (b), a= Band 1, b= Band 2

Using these band ratios, various BRCs were developed and alteration zones were mapped by correlating them with the classified mineral map through SAM, and then validated with the local geology.

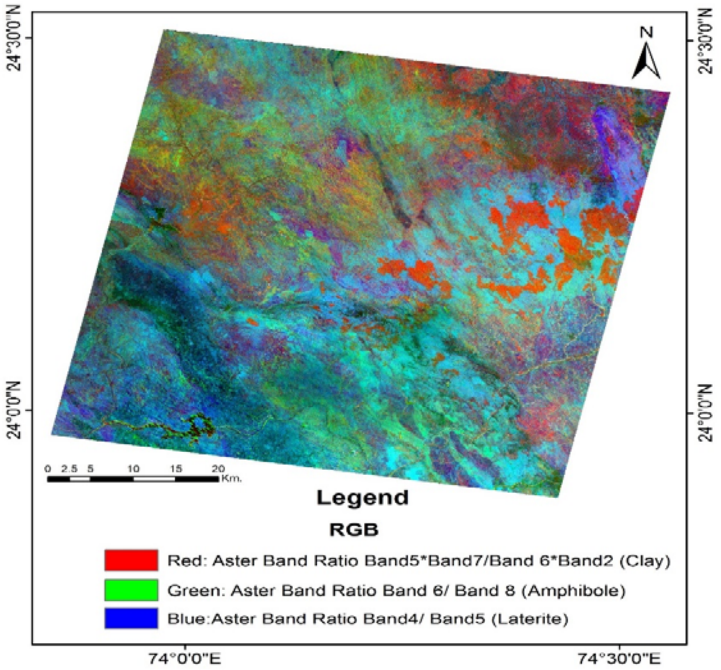

Fig. 5 ASTER derived BRC

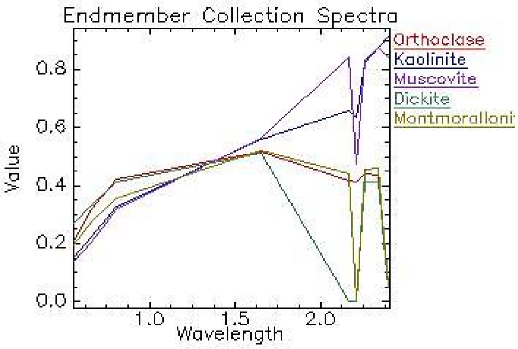

Fig. 6 Spectra of Mineral End Members used for classification of the ASTER dataset

IV. Results and Discussions

False color composite (FCC) image generated using ASTER bands 4, 6 and 8 (Fig. 4) highlighting Gossan, alteration zones and host rocks as red, green and blue, respectively. Shades of red color represent alteration areas dominated by OH bearing minerals while green color highlights Fe rich areas. BRC image derived using the ASTER band ratios viz. B5*B7/B6*B2, B6/B8, & B4/B5 (Fig. 5) highlighting clays, amphiboles and lateritic alteration with red, green and blue shades, respectively. Yellowish areas represent the mixed pixels of clays and amphiboles i.e. may be due to the presence of metabasics intruded in granitic basement rocks. So FCCs and BRCs are helpful for delineating the alteration areas.

Minerals identified through further ASTER processing (viz. Kaolinite, Feldspars, Muscovite, Dickite and Montmorillonite) have been studied carefully with respect to their location of occurrence in the field referring 1:50,000 geological maps issued by GSI.

As we can see in the SAM classified mineral map (Fig. 7), Muscovite and kaolinite are mapped in the eastern parts of the image which is dominated by Mica-schists and granitic gneisses with basic intrusions at places. Montmorillonite, Dickite and K-Feldspar which have been mapped in the bottom parts are resultant of lithological variation in this area. Presence of these mineral depicts a high temperature alteration zone.

V. Conclusion

ASTER data acquired by EO-1 Terra Satellite proved potential to carry out the mineral mapping as many significant altered minerals were identified during the study, which are of high significance to demarcate the hydrothermally altered zones guiding to the target ore. Processing of ASTER is of great importance due to the fact that its bands are distributed in such a way that they can record the characteristic absorption features of various Clay, ALOH and Iron bearing minerals. Credibility of ASTER data is proved in the present study. The results obtained through established procedure of data processing and those obtained from BRCs are highly interrelated and informative. Limited area coverage and non-availability of temporal data often limits the applicability of Hyperion image in detailed mineralogical mapping, and ASTER datasets are easily and freely available, thus it can become a trustworthy dataset for mineral prospecting studies.

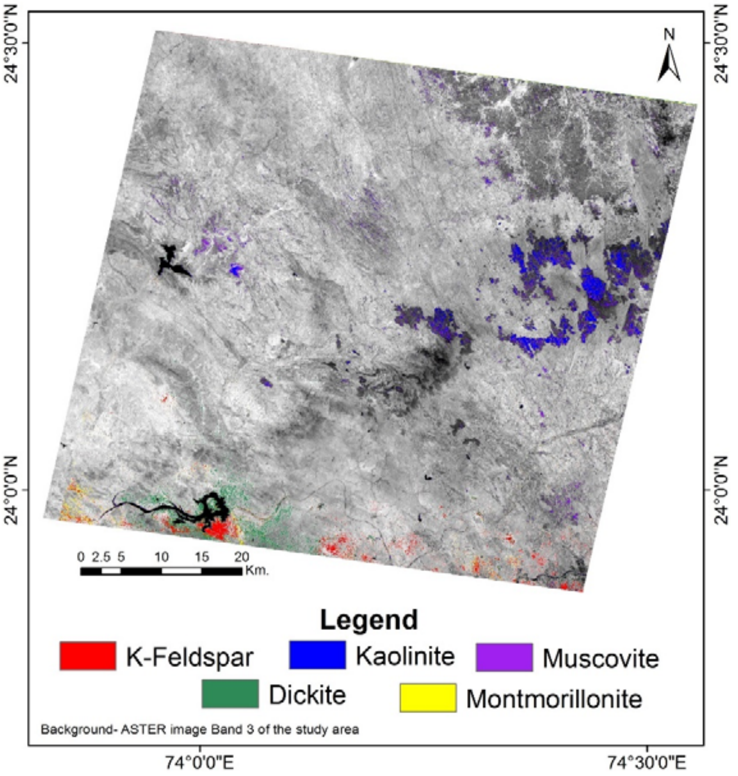

Fig. 7 SAM Classified Mineral Map

REFERENCES

[1] G. Hunt, "Spectral Signatures of particulate minerals in the visible and near infrared," *Geophysics,* vol. 42, pp. 501-513, 1977.

[2] F. F. Sabins, "Remote Sensing for mineral exploration," *Ore Geology Reviews,* pp. 157-183, 1999.

[3] A. Kalinowski and S. Oliver, "ASTER Mineral Index Processing," 2004.(Online).Available:http://www.ga.gov.au/webtemp/image_cache/GA7833.pdf (Accessed 01/07/2016).

[4] S. Roy Sinha, G. Malhotra and M. Mohanty, Geology of Rajasthan, Bangalore: GSI, 1998.

[5] Geological Survey of India (GSI), "Geological Quadrangle Map Toposheet no. 45L" 1975 (Accessed 22/05/2016).

[6] V. K. Sengar, A. Venkatesh, P. Champati ray, S. Chattoraj and R. U. Sharma, "Mineralogical Mapping in the Part of a Gold Prospect Using EO-1," in *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Prague, Czech Republic, 2016.

[7] R. N. Clark, G. A. Swayze, R. Wise, E. Livo, T. Hoefen, R. Kokaly and S. J. Sutley, "USGS digital spectral library splib06a," in *Digital Data Series 231*, U.S. Geological Survey, 2007.

[8] O. Carvalho and P. Menesses, "Spectral Correlation Mapper (SCM): An Improvement on the Spectral Angle Mapper (SAM)," NASA Workshop, 2000. (Online) (Accessed 05/11/2016). Available: http://aviris.jpl.nasa.gov/proceedings/workshops/00_docs/Osmar_1_carvalho__web.pdf

[9] T. Lillisend and R. Kiefer, Remote Sensing and Image Interpretation, Seventh ed., Wiley, 2015.