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Identification of the Mineral Alteration Zones, Lithology and Structural Features using Remote Sensing and GIS Techniques in Pindwara - Swaroopganj Belt in Sirohi District of Rajasthan

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Abstract: ***Remote sensing is a technique to study characteristics of area in respect to structures, alteration, and lithological variations by measuring its reflected and emitted radiation from distance (satellite or aircraft). In this study the ASTER and ASTERDEM data has been used for identifying mineral alteration zones, major lineaments, structures, and lithology through different band ratios, band math techniques. Further, Delineation of hydrothermal alteration Zones inclusive of Phyllic, Argillic, Prophyllic, Iron, carbonate, host rock alteration, Chlorite, sericite alteration etc. also been attempted. The study area is located in Sirohi district of Rajasthan and geologically falls under SDFB (South Delhi Fold Belt) of the Delhi Supergroup. The area composes of various rock types like Granite/Gneiss, Amphibolite, Schists (Chlorite, Qtz - Biotite, and Sericite), Limestone/marble and quartzites.***

Keywords: Aster Data, South Delhi Fold Belt, Mineral Alteration, Band ratio techniques

1. Introduction

Remote sensing is the process of detecting and monitoring the physical characteristics of rocks/minerals covering the target areas by measuring its reflected and emitted radiation from the distance (typically from satellite or aircraft). Further, it can also be described as a method for getting information about of different objects on the planet, without any physical contacts with it. The technique is used for gathering information over large area in initial phase of exploration to reduce the targets.

Remote Sensing is being used as an important tool in Exploration of Mineral deposits. The results of the study depend upon the resolution and quality of satellite data acquired. In mineral exploration, Aster data/images have been widely used to identify hydrothermal alterations, large lineament structures, folds, faults, lithological contacts, etc.

This input data will be used to create preliminary Lithology maps for the study area. Remote sensing research also helps save time and money. This has been shown to be an important factor in the mineral exploration process. This study uncovers the historical scientific literature and uses Aster, and Asterdem data to generate a litho - structural model for target generation and detail in the study area extending north of Pindwara to south of Swaroopganj. It describes the application of remote sensing studies in comparison with subsurface data for more detailed exploration. It is located in Sirohi district of Rajasthan.
The Location map of the study area is given below:

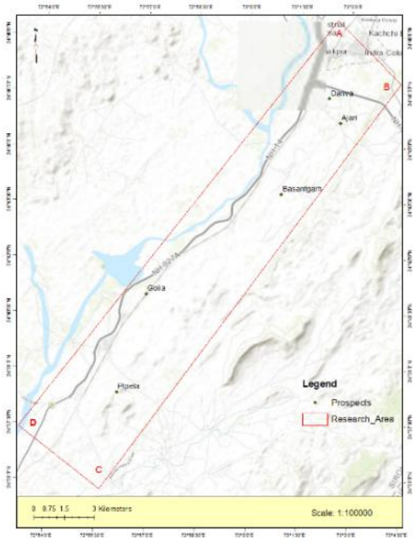

Figure 1: Location Map of Study Area - Satellite topography Image

2. Regional Geology

The Rajasthan can mainly divide into the various geological regions. Eastern part of the province occurs the younger Vindhyan Group of Rocks which range from upper Proterozoic to Lower Cambrian in the age. The Central part is dominated by Precambrian rocks which are subdivided stratigraphically as the Pre - Aravalli Group (Banded Gneissic Complex), The Aravalli Supergroup and The Delhi Supergroup. The Southeastern part of province is covered partly by Deccan Traps overlying by Vindhyan and the

Delhi Supergroup of rocks and in the North - western part occurs MalaniVolcanics and younger Mesozoic and Eocene strata.

The basic framework of the Precambrian geology of Rajasthan is captured on basis of the work done by Coulson (1933), Gupta (1934), Gupta and Mukherjee (1938) and Heron (1917a &b, 1923, 1024, 1935, 1936, 1953). The Study area falls in Sirohi District of Rajasthan and having rocks of The Delhi Supergroup.

The Aravalli Mountain Ranges (AMR) consists of an Archean basement and two main unconformities bound Supracrustal sequences deposited successively over the basement. Heron (1953) recognized Banded Gneissic Complex (BGC) and Bundelkhand Massif (renamed by Pascoe, 1950 as Berach granite) as the basement upon which younger Supracrustal of Aravallis, Raialo and Delhis were deposited. The pioneering work of Heron (1953) has remained the basis of all the subsequent stratigraphy and structural revision (Naha & Heliburton, 1974; Raja Rao, 1976; Gupta et, al, 1980).

Heron (1953) recognized the Delhi System of rocks as a sequence, which unconformably overlies the Aravalli System. Gupta et al., (1980) revised the stratigraphic succession in Delhi Fold Belt and raised the status of Delhi “System” to “Supergroup”. There is no consensus among the geoscientists about the contact between Aravalli and Delhi Supergroups of rocks, It has been interpreted as structural discordance (Gupta et. al 1980, an unconformity (Heron 1953, saini et. al 2006) and suture representing the closure of Proterozoic Ocean (Sudgen and Windley, 1984Sudgen et. al 1990).

The rocks of the Delhi Supergroup (DSG) are traceable from Delhi in the NE to Himmatnagar in SW over a strike distance of 850 km in the form of linear belt. Heron (1917a) proposed a threefold classification of the Delhi System comprising of Raialo Series, Alwar Series, Ajabgarh Series rests unconformably over schist and gneisses of the Pre - Delhi age. Gupta et al. (1980) revised stratigraphic succession and divided the Delhi Supergroup into Gogunda Group, Khumbhalgarh Group, PhuladOphiolite suit, Kishangarhsyenite, Sirohi Group, and Punagarh Group. The authors correlated Gogunda Group and Kumbalgarh Group of southern terrane withAlwar and Ajabgarh Groups of North Delhi terrane. According to Singh (1988a&b), the Delhi basin initially formed in the north - eastern part of Rajasthan, subsequently extended to the axial zone of Aravalli mountain.

Sinha Roy (1984) proposed a diachronous sedimentation history for Delhi Supergroup and subdivided it into an older northern part namely as North Delhi Fold Belt (NDFB) and younger southern part South Delhi Fold Belt (SDFB). Evolution of Delhi Fold Belt (DFB) can be explained due to rifting. It is also suggested that the DFB was evolved by the formation of rifts in the basement where the North Delhi Belt was deposited and preceded the ocean opening in the South Delhi Belt. The North Delhi rift was aborted, but the South Delhi basin developed into an oceanic trough by 1.3 Ga and this was closed by successive subduction (Satyavani et al., 2004) during 850 Ma (Mahadani et al., 2015). Concept of older North Delhi Fold Belt and younger South Delhi Fold Belt is contradicted by the detail field study bySengupta (1984). Feature which goes against the concept are based on age of granite and evolutionary history of both the belts are distinct supported by Geological Survey Of India.

The NDFB was age constrained at 1.8 to 1.7 Ga age (BijuSekhar et al.2003; Kaur et al., 2007, 2009, 2011a, b; McKenzie et al., 2013) and the SDFB was age constrained at 1200 to 750 Ma age (Desai et al., 1978; Choudhary et al., 1984, Biswal, 1988; Volpe and Macdougal, 1990; Tobisch et al., 1994; Biswal et al., 1998 a, b; Fareedudin and Kroner, 1998; Mokhopadhya et al., 2000; Deb et al., 2001; Pandit et al., 2003., Srikarni et al., 2004; Khan et al., 2005, Singh et al., 2010, McKenzie et al., 2013). The Neoproterozoic geological history began with intrusion of 1Ga continental collision manifested in 1000 Ma diorites and Gabbro in Ranakpur (Tobisch et al., 1994) and 967 Ma old calc - alkaline granitoids in Sendra area (Pandit et al., 2003). Sendra and related granitoids occur linearly along the western flank of the Delhi Fold Belt in the southern domain. The western margin of Delhi Fold Belt is marked by linear exposure of mafic - ultramafic rocks called Phulad lineament (Gupta et. al, 1980) which runs more than 500km from south of Palanpur to north of Pisangan. A vast granitoid terrace to the west of southern domain of Delhi Fold Belt is known as Erinpura Granite of age 870 - 830 Ma. Malani Igneous Suit consider to be the third largest felsicvolcanic province of the world erupted around 770 - 750 Ma (Pandit et al., 2010).

Aster and Its Application

The Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) obtains high - resolution (15 to 90 square meters per pixel) images of the Earth in 14 different wavelengths of the electromagnetic spectrum, three in the visible (0.520 to 0.860 micrometers (μm) and near infrared (VNIR), six in the short - wave infrared (SWIR) 1.0 to 2.43 μm and five in the Thermal infrared (TIR) 8.125 - 11.650 μm (Ravi P Gupta; 2014) ranging from visible to thermal infrared light. VNIR, SWIR and TIR has different roles to play in spectroscopy for geological applications such as the VNIR region provides spectral features of transition metal such as Iron, SWIR region is very effective for analyzing spectral characteristics of carbonate, hydrate, and hydroxide minerals and TIR region are effective for silicates. ASTER data is used to create detailed maps of land, surface temperature, emissivity, reflectance, Alteration, Structures, and elevation.

3. Methodology

Remote sensing plays important role in the mineral exploration for identifying the potential zones, structures, and Mineral alteration by reducing the search area for targets, scanning large area addressing the time factor where the licenses are granted for limited period in the country. Various data and methods have been used for remote sensing study in the research area. The raw Aster/Asterdem data has been downloaded from UGSG Earth explorer open portal available for different analysis. The data have been processed using Geo - referencing/ layer stacking techniques by using "ENVI5.5" software.

For the structural analysis, Asterdem data has been processed with different sun angles, to identify clear pictures of Geological structures within the study area. The different band ratios, band math techniques have been used to delineate different alteration Zones (Hydrothermal inclusive of Phyllic, Prophyllic, Iron, carbonate, host rock alteration, Chlorite, sericite alteration etc.). Further, lithological classification defined for map preparation and target generation using ARC GIS platform for delineating targets for detailed exploration in the area.

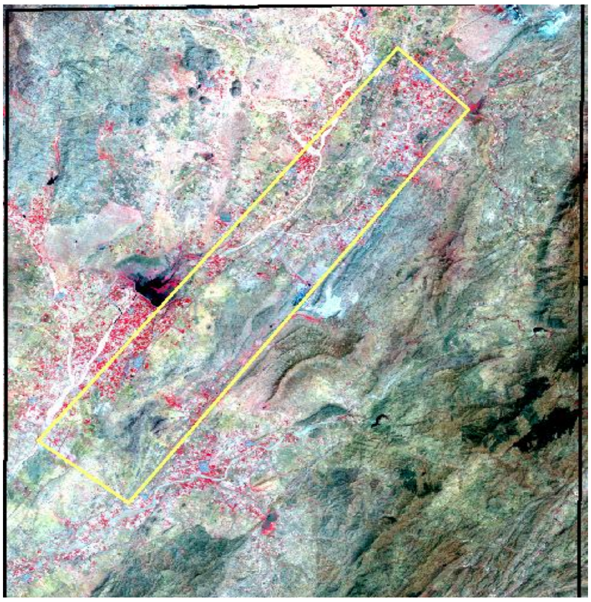

Figure 2: Location Map of Study areas on Aster (RBG) Image

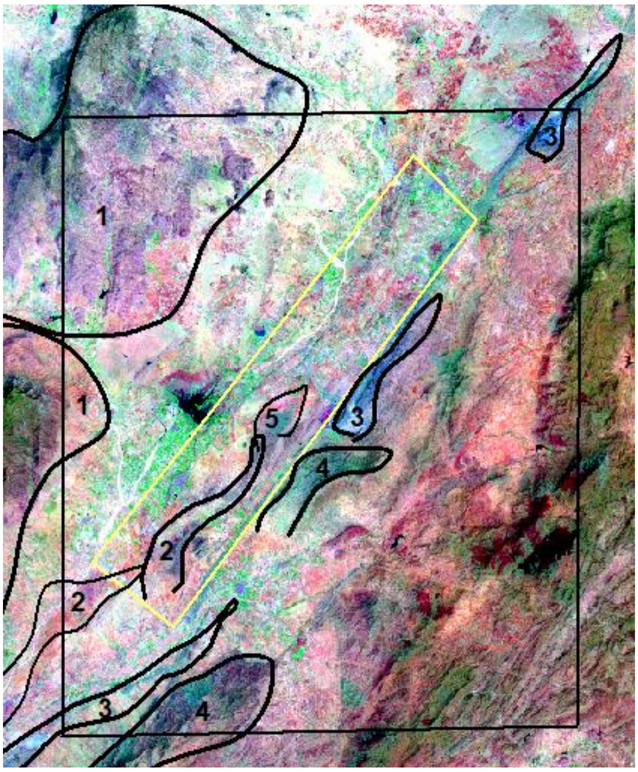

Figure 3: Lithological units identification

Figure 4: Lithounits comparison with Ground Truthing

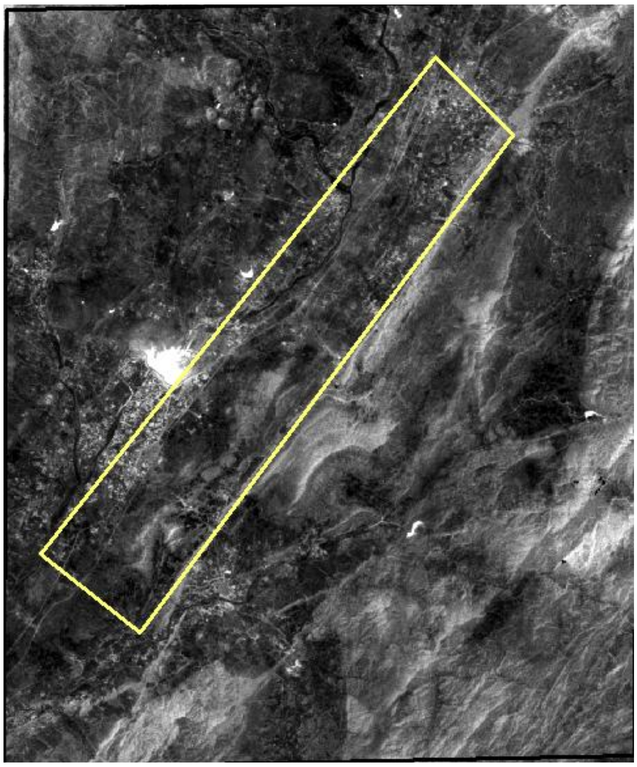

Figure 5: Carbonate - Chlorite - EpidoteAlteration

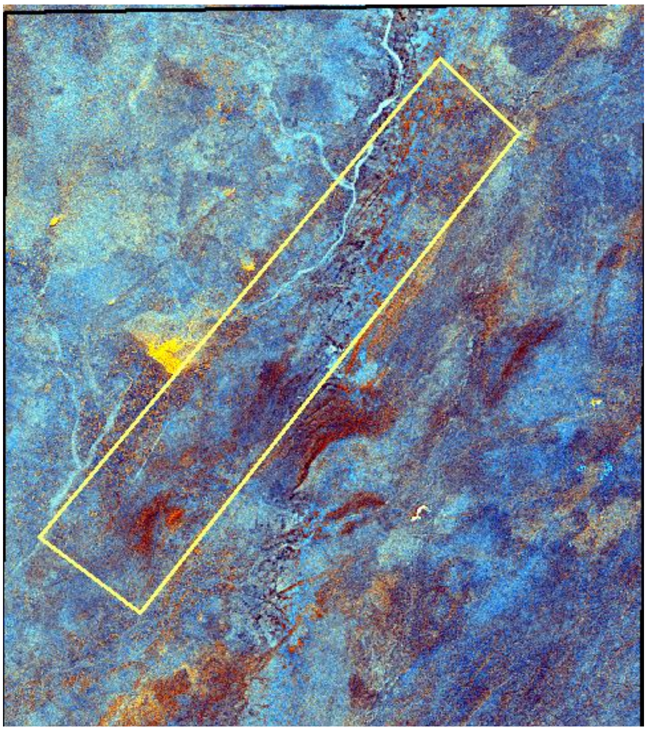

Figure 6: Advanced Argillic Alteration (RBG).

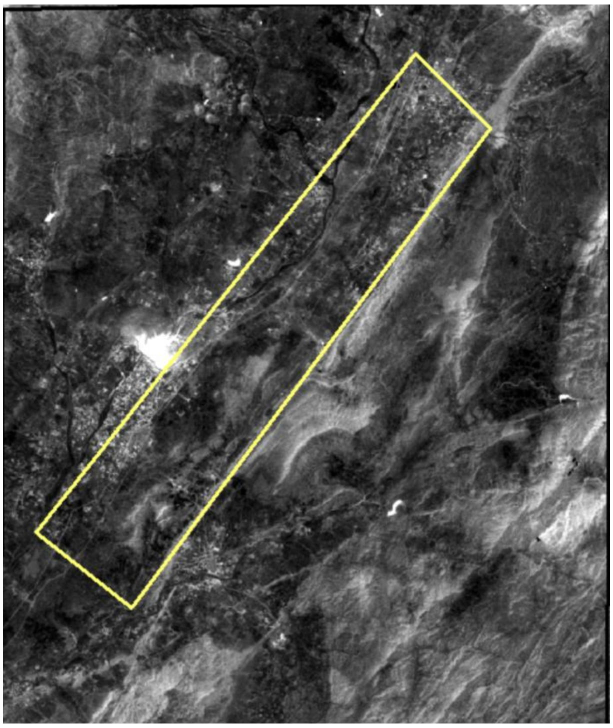

Figure 8: Phyllic Alterations

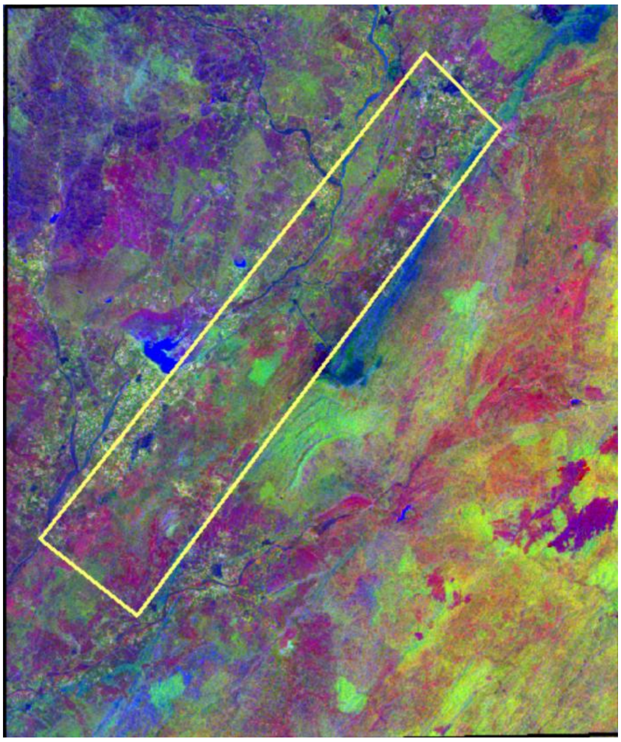

Figure 7: Gossans - Ferruginous Alterations (RBG)

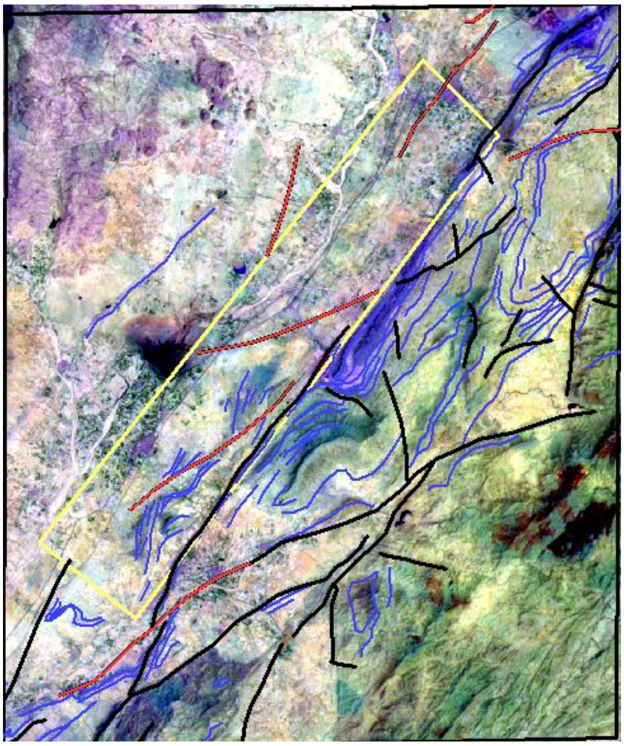

Figure 9: Structural features identification

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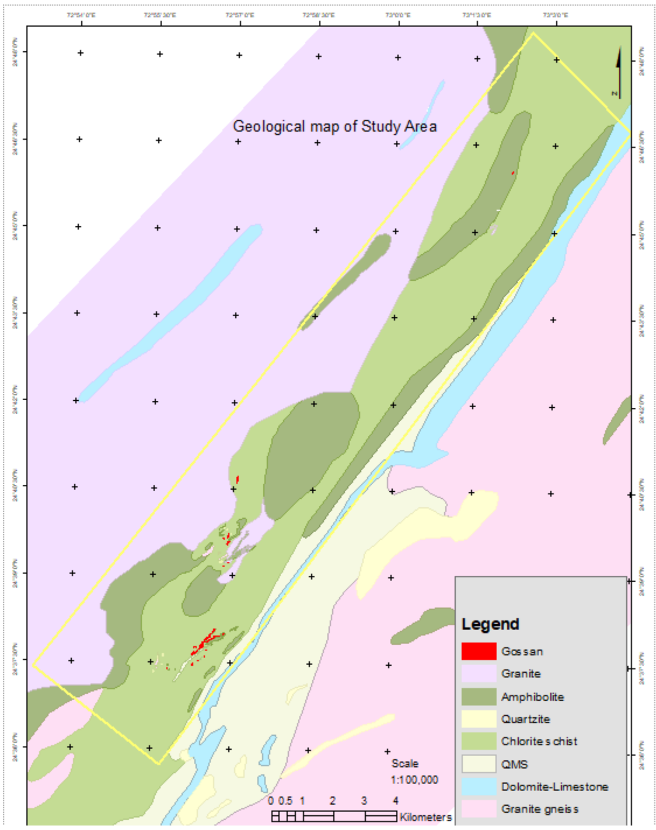

Figure 10: Geological Map of Study Area

Mapping of different lithology in the Sirohi district of Rajasthan through Aster data processing was undertaken through band Ratio technique, the spectral signature enhancement is used to increase the spectral contract between the various bands and reduce the other effects like the topography.

Figure - 1 &2 is showing a broad coverage of the study area representing by topography and the visible RGB band 3/2/1 respectively. Red colour patches are representing vegetation in the area. Various algorithms were used to define the lithological variations in the study area. Mainly five types of rock types could be identified denominated as 1 to 5 in the figure.3. Band ratio techniques with (4/7, 3/4, 2/1) and (4/7, 4/1, 2/3 * 4/3) was used. Rock type classified as number 1 represented by purple colour are granites and granite gneisses located in western part of the study area. Mount Abu batholith giving distinct structure in image. Some part is showing greenish patches representing the vegetation effect in the area. Rock type classified as number 2 represented by blackish green colour are chlorite schist which are present as small hillocks as well as plains in the area. Further, chlorite is altered in sericite and muscovite which represent ferruginous oxidized rocks “Gossan” and represents surface manifestation of Sulphide mineralization. Further, Rock denominated as No.3 in elongated manner with bluish tint are limestone/Dolomitic marble. The band ratio used for discrimination is ((7+9) /8). Patchy dark folded rock seen on the eastern margin of the area are quartzites where in the field are also mapped as quartz mica/ biotite schist in the field mapping. Rock no 5 with dark greenish tone represents ophiolitic sequence of amphibolites in the central part of the study area. Variations of these mafic rocks area seen as hornblende schist, quartz amphibole rock, Pyroxenites and at places Gabbro. The litho - units are extrapolated in the lithology map on basis of mapping post Remote sensing study of the area (Figure - 4).

Figure - 5 represents the carbonate alteration in the area which is seems like whitish grey elongated features (using band ratios technique (7+9) /8 of ASTER image). Hydrothermal alteration minerals have diagnostic spectral absorption characteristics in visible and near infrared through the short wavelength infrared regions and can be mapped using multispectral and hyperspectral satellite data as tool for initial stage of exploration (Bedini et al, 2009; Carranza and Hall, 2002; DI Tommaso and Rubinstien, 2007; Garb eta al, 2010; Kruse et. al, 2003; Mars and Rowan, 2006; Moorie et. al 2008).

The study was also undertaken to identify hydrothermal alteration which are commonly associated with the Volcanogenic Massive Sulphide deposits where the area is known to host such types of deposits proved historically by Geological Survey of India. Phyllic, Argillic, Gossans alterations attempted are shown in figure 6 (by band ratios technique (5/6, 7/6, 7/5) and figure 7 (band ratio (4/2, 4/5, 5/6)). It is difficult to identify Gossans alteration on the large scale of remote sensing but mapped in the field for few tensof meters at places and shown in Figure - 11. Phyllic or sericite alteration is characterized by the presence of Muscovite, sericite and illite. With the metamorphism, Chlorite is altered to muscovite and sericite. In the figure 8, The band ratio ((5+7) /6 has been picked up Phyllic alteration at Pipela prospects discriminating chlorite in light whitish grey tone and verified in the field.

Asterdem data was also processed to identify major structures including faults, folds, and lineation. RBG Aster band ratio (7/4/2) & and different shaded relief images derived from ASTER Dem with illumination direction of 45*, 90*, 180*, 270*315 was used to identify the structures shown in the figure 9. Lineament is represented by flowing Banas and its tributaries in the area.

Gossans (Ajari Prospect)

Kaolin Alteration in Ferruginized Quartz Sericite schist

Figure 11: Field photographs showing Gossanat Ajari and Kaolin Alteration within Ferruginized Quartz Sericite schist at Goliya

The study for various alterations reveals to the identification/ combination of Minerals. The following is summarized in the table - 1 below:

Table 1: Summary of Mineral association with various Alterations

Alteration	Mineral Association
Argillic	Epidote, Chlorite and Carbonate
Advance Argillic	Alunite
Oxidation	Hematite, Goethite, Gossan
Phyllic	Sericite, Muscovite, illite
Propylitic	Epidote, Chlorite, Carbonate

With broad interpretation of Remote sensing study/data, and further field verification, a regional geological map of the area has been prepared on 1: 50K (Figure - 10) for detail investigations.

4. Conclusion

The study illustrates the effectiveness of Aster band techniques / Principal component analysis of ASTER SWIR 14 bands data to identify hydrothermal alterations like Advanced Argillic, Phyllic, carbonate, and gossans and discriminate various lithological units in the area. The lithological map derived from the ASTER data could be linked with the hydrothermal alteration /sulphide bearing zones (Oxidized) over Cu - Zn Mineralization occurrences /deposits in the study area under ferruginous gossanous alterations represented by Quartz - sericite schist on the ground verified in the field validation post remote sensing analysis. It is further recommended to study the whole belt through Aster data processing to identify various alteration and associated mineral occurrences/ deposits in the South Delhi Fold Belt for economic Metal Mining in the beltin future.

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Hemant Nagda holds a master’s degree in (Geography and Remote Sensing & GIS) with +13 years of experience in applications of GIS and remote sensing technologies in the field of Mineral Exploration, Environment, and Urbanization Studies, Town Planning and Watershed management. Presently working as Associate Manager (Corporate Services) with Hindustan Zinc Limited.