LITHOLOGICAL IDENTIFICATION OF ROCK UNITS USING ASTER L1-T1 DATASET (GEOLOGICAL MAPPING), LINEAMENT MAPPING USING LANDSET-8 DATASET AND 3D MODELS USING SRTM DATASET OF CHAGAI, BALOCHISTAN PAKISTAN

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CERTIFICATE

This dissertation submitted by **FAZAL UR REHMAN s/o NAZIR AHMED** is accepted in its present form by the Department of Earth Sciences, Quaid-i-Azam University Islamabad as satisfying the requirement for the award of degree of BS Geophysics.

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EXTERNAL EXAMINER ____________________

DEDICATION

MY WHOLE THESIS WORK IS DEDICATED TO MY PARENTS, MY BROTHERS and SISTERS, TEACHERS, FRIENDS WHO BUILD ME SO HIGH AND ALL THOSE WHO LOVE ME AND WHOM I LOVE.

ACKNOWLEDGEMENT

First praise is to Allah, the most Beneficent, Merciful and Almighty, on whom ultimately, we depend for sustenance and guidance. I bear witness that Holy Prophet Muhammad (PBUH) is the last messenger, whose life is perfect model for the whole mankind till the Day of Judgment. I thank Allah for giving me strength and ability to complete this study.

I am especially thanks to my honorable supervisor **Dr. Anees Ahmed Bangash** for giving me an initiative to this study. I specially acknowledge there efforts and support of **Bilal Aslam (SUPARCO), Fahad Naseer (IST),** without them, I was unable to reach at this stage. I Specially thanks to My cousin **(RIFFAT SHAMSHAD, SUPARCO)** At last, I must acknowledge the help, encouragement, endless love, support and prayers Of all my friends through this 4 years journey.

ABSTRACT

The objective of this dissertation is to integrate Remote Sensing with Geology. Remote Sensing techniques have been applied in this study to identify and delineate rock units in Chagai, Balochistan basin, which is our study area. To delineate lithologies respectively, digitization is carried out over the lithological map of the study area. Followed by pre-processing of the ASTER dataset,which is further aided by processing of the data and is made ready to interpret. .To correlate the results for accurate interpretation, processed datasets are compared with the spectral signatures provided by USGS Spectral Library.

Furthermore, faults in the study area are confirmed by lineament mapping technique, using LANDSAT-8 dataset. Multiband analysis for the identification of lineaments is used which are compared with the faults, already provided by Geological Survey of Pakistan. In addition, density maps of these lineaments are also prepared. Finally, Shuttle Radar Topographic Mission (SRTM) datasets are used to develop 3D models of the study area using Raster Terrain Analysis.

Contents

Chapter 1

1. Introduction

1.1 Remote Sensing And GIS

Remote sensing can be defined as studying the Earth surface by collecting data and Analyzing it for extracting information about a phenomenon or object without physical contact. Remote sensing build upon principles of electromagnetic radiations.

1)- Electromagnetic Radiations

It can be defined as energy coming from a source in the form of waves. Remote sensing build upon measuring such reflected and emitted energy from other objects.

2)-Wavelength:

It is define as a distance between successive crests or trough. Its unit is expressed in meters or other order of magnitudes of meter such as nanometers, micrometers.

3)-Difference between Raster Data Vs Vector Data:

Raster Data:

It use as a matrix of square areas to define Where features are located. Theses Squares, also Called Pixels, Cells and grids typically are of uniform size and their Size determines the details that can be maintained in the data.

Vector Data:

Vector data use X and Y coordinates to define the location of Points, lines and polygons(areas),that correspond to map features such as location of roads,Buildings, Geological structures, rock units etc.

1.2 Background

The geological and mineral maps are essential for advancement and investigation of mineral assets to acquire bona fide geosciences data. The geological maps represent the outcropping pattern on the surface of the ground. This pattern may show bed rocks. The boundaries and the strata of outcropping features are represented in geological maps. The reason for investigating the landmass can be given by these maps in search of its assets .Common mapping strategies and mineral investigation systems are labor intensive and experimental methods of extrapolation and interpolation utilized for mapping makes these techniques costly, hard and long. To conquer these issues, the satellite data can be utilized for the significant wellspring of data. As a matter of fact, geological highlights which are on the surface of the earth might be distinguished in bedrock outcropping, through air photos (photogeological surveillance) as well as from remote sensing imageries. In fact, every sensor has the precise qualities to quantify the physical properties of land surface like spatial, spectral and radiometric resolutions, viewing angle, acquisition time etc. The information is digital and geo-referenced which is present in remote sensing data for geological mapping. Numerous previous researches have suggested that hyper spectral and multispectral remote sensing data sets can be used for surface feature mapping and lithological discrimination (Rencz,1999).The aim of this study is to provide an overview of the use of ASTER images of remote sensing data, in the field of lithological mapping in the region of Chagai, Balochistan.. This will be achieved mainly using digital processing, particularly Principal Component Analysis (PCA), Band Ratioing, Minimum Noise Fraction (MNF) and Supervised Classification by enhancing the capability of lithological discrimination among different rocks of the study area.

The Chagai Balochistan has a distinctive lithology, stratigraphy, hydro-carbon bearing region and wealth of minerals deposits however; the region is mostly under-exploration due to its rugged terrain and remote locality. This area is economically important .The recent progression in the satellite based remote sensing and geospatial techniques and the use in isolated areas, have proved these techniques quite successful especially in rough terrain in unraveling the geology and mineral resources .

Remote sensing datasets are frequently and proficiently used for mapping different minerals for economic gain and rock units with diverse lithology and stratigraphy. The purpose of this study is to employ these modern technologies of SRS and GIS to map lithological units and detection of mineralized zones.

1.3 ASTER sensor

In December 1999 the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is launched on NASA's Terra (originally called EOS AM-1) spacecraft (Yamaguchi and Naito. 2003). The ASTER instrument has three spectral bands in the visible and Near Infrared (VNIR), six bands in the short-wave-infrared (SWIR) and five bands in the thermal infrared (TIR) with 15, 30 and 90m spatial resolution respectively (Table 1). Stereo coverage is provided by an additional backward-looking near infra-red band as well (NASA ASTER, 2004) (figure 1). ASTER data has the quality of high spatial resolution and the unique arrangement of wide spectral coverage. It has a particular importance to remote sensing in the field of geology because it gives a comparatively wide spectral range and fine spatial resolution. Because of this advantage, ASTER images have been used with time more for geological purposes (Gad 2007).

ASTER			
Bands	Band Pass	Band Center	Spatial Resolution
1	0.520-0.600	0.560	15m
2	0.630-0.690	0.660	15m
3	0.780-0.860	0.820	15m
4	1.600-1.700	1.652	30m
5	2.145-2.185	2.164	30m
6	2.185-2.225	2.204	30m
7	2.235-2.285	2.259	30m
8	2.295-2.365	2.329	30m
9	2.360-2.430	2.394	30m
10	8.125-8.475	8.300	90m
11	8.475-8.825	8.650	90m
12	8.925-9.275	9.100	90m
13	10.250-10.950	10.600	90m
14	10.950-11.650	11.300	90m

Table 1 - ASTER spectral and spatial characteristics As given in following table.

.To measure the reflected solar radiation ASTER has designed six spectral bands of the SWIR telescope to discriminate between different elements like Al OH, Fe, Mg OH and Si O H (M. Abrams et al.1995). The data for mineral alteration zones, geothermal investigation and for lithological mapping can be provided by ASTER sensor (Yamaguchi et al 1992,. Rowan et al. 2005 Qari et al. 2008,. Pour and Hashim 2011, 2012).

1.4 Optimization of ASTER data

To compare the ASTER sensor with Landsat, for geological and non-geological investigations Enhanced Thematic Mapper (ETM+) images of Landsat sensor are also considered as popular base maps (Bamousa etal . 2011, 2012). In Figure 1 the comparison between ASTER sensor bands like VNIR, SWIR and TIR and Landsat (ETM+) telescope bands can be observed (Adams2006).The bands 2, 3 and 4 of Landsat (ETM+) are equivalent to the bands 1, 2 and 3 of VNIR telescope of ASTER sensor which detect visible Electromagnetic Radiation (EMR (Figure 1).Band 7 of the ETM+ sensor is equivalent to bands 5–9 of the SWIR telescope, and band 6 of the ETM+ is equivalent to bands 10–14 of the TIR telescope (Fig. 1). Bands 1–9 of the ASTER sensor are reflected as well as 1–5 and 7 of the Landsat ETM+, whereas ASTER bands 10–14and Landsat ETM+ band 6 are emitted. In the Landsat ETM+ sensor bands 1–4 are visible, bands 5 and 7 are infrared and band 6 is thermal infrared. For the purpose of non –geological studies visible bands are suitable such as hydrological or biological, whereas infrared bands are useful for geological purposes (Geller et al. 2007).

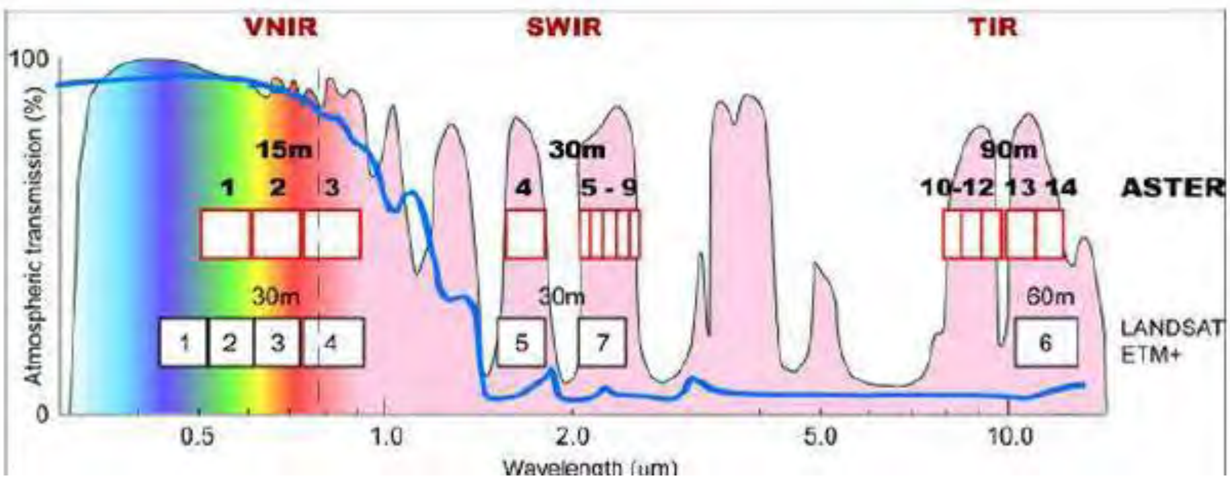


Figure 1.1: Location of the ASTER and Landsat spectral bands in the atmospheric transmission
spectrum (Geller et al. 2007).

1.5 Problem Statement

a. Currently many researchers are using different datasets like ASTER and Landsat for geological purposes in different regions of Pakistan, but in this study the area which is selected is undiscovered for geological mapping through Remote Sensing techniques.

b. As it is stated in the literature that this is mineral potential area, so through lithological units identification using remote sensing techniques these maps will further used for economic gain.

1.6 Research Objectives

A. Objective of the study is to identify the lithological units of the study area using Visible Near- Infrared (VNIR), Short Wavelength Infrared (SWIR) bands of Aster data set.

B- Comparison of different techniques of remote sensing in the field of geology for the particular study area.

Different image processing techniques which are Principal Component Analysis, Band Ratioing and Forward MNF will be used in the study. As we know the other Different techniques of REMOTE Sensing And GIS, which also helpful for the identification of rock units or minerals, but I used four of them in this study:

1. F-MNF (minimum noise fraction)
2. BAND Ratioing
3. PCA Analysis (principal component Analysis).
4. Supervised Image Classification (Maximum likelihood

CHAPTER 2

2. Materials

2.1. Study area

Chagai is the capital city of chagai District. It is located at Balochistan, Pakistan. The Coordinates values which lie in the center of the study area are 29.3058° N to 64.6945° E the projection is UTM, Zone 41 N, WGS-84.chagai is present at Balochistan,. some portion is extended towards Iran and it lies between the boundary of Afghanistan.

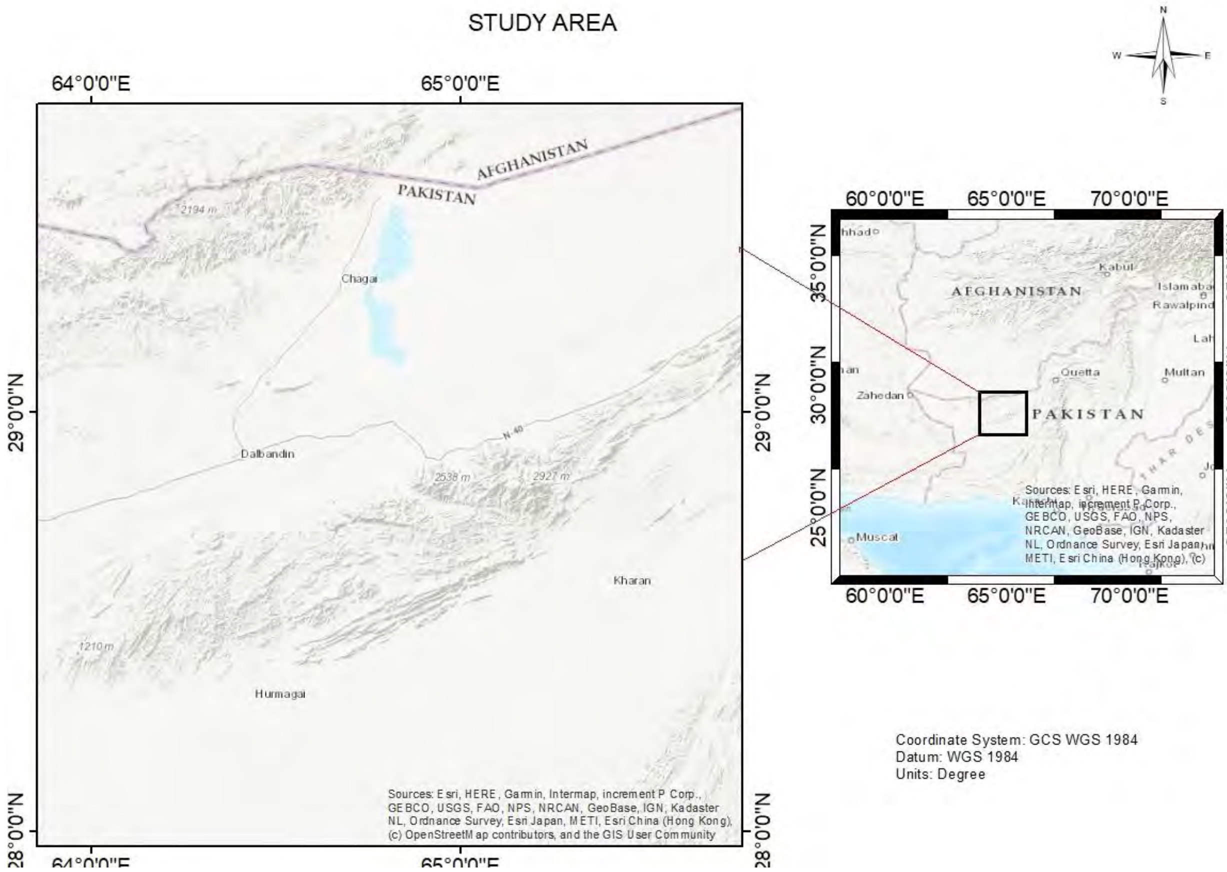


Figure (2.1) Location map of study area.

2.2. Litho-Stratigraphic units of CHAGAI ,BALOCHISTAN PAKISTAN

2.2.1Recent Deposits

These are unconsolidated deposits

Q: Shows Eolian sands,

Qes: Shows Extrusive mud.

*2.2.*2 KV

1.(Humai formation).

Cretaceous Sedimentary and Volcanic rocks These include limestone, Shale, sandstones, Conglomerate, and agglomerate.

2.Sinjrani and Kuchakki Volcanic groups.

Mostly agglomerates, lava and tuffaceous sediments. Thickness up to 1000ft .Include insepareable chagai,intrusions.

2.2.3 Te

Dalbandin formation

Pishi formation is named here after pishi group which is named after the Pishi Rud lies in the Ras koh Range while Dalbandin formation is named .After the Dalbandin valley. These rocks are found in between Gauoch Hamun and Bunap..It consist of Shale, mudstone, Soft sandstone and Conglomerates.The sucession of dominant Shale units resembles to Hoshab Shale And sandstone, and shale is similar to panjgar formation of southern Balochistan .

2.2.4 Silt and Clay

Silt:

The particles classified as silt are intermediate in size and chemical and physical properties between clay and sand. The silt particles have limited ability to retain plant nutrients, or to release them to the soil solution for plant uptake. Silt tends to have a spherical shape, giving a high silt soil a soapy or slippery.

Clay

Clay size particles are the source of most of the chemical properties of soil, because of their very small size and very large surface area, are able to retain greater amounts of water than sandy soils.

2.2.5 shale and limestones

Shale is a sedimentary rock with a fine-grained structure. It form due to compaction of silt and clay-size mineral particles which are known as mud. It can be distinguished easily from other mudstones due to fissile and laminated.
Limestone is also a sedimentary rock that is composed of calcium carbonate in the form of the mineral calcite. It is an organic sedimentary rock.

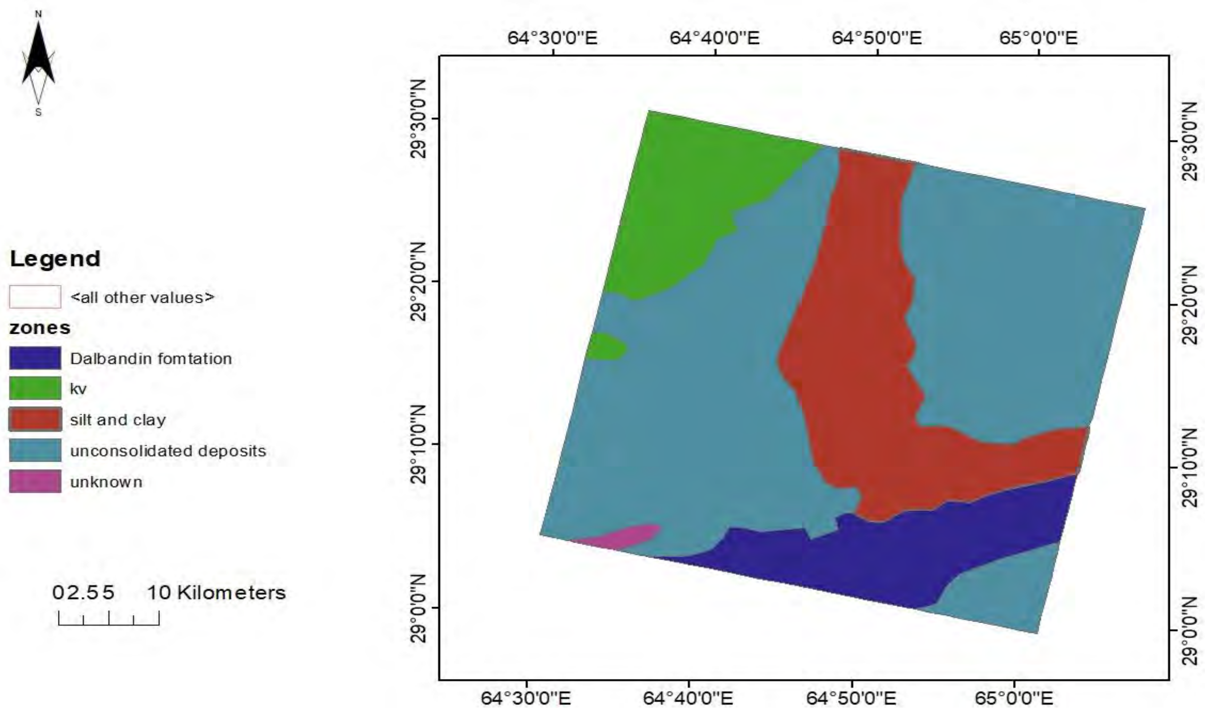


Figure (2.2) Digitized Lithological map of CHAGAI.

2.3 Tectonic zones of Pakistan

Pakistan is divided into Eight tectonic zones ,following are:

1-Indus Platform and Foredeep

2- East Balochistan Fold and Trust belt

3-Northwest Himalayan Fold and Thrust Belt.

4- Kohistan -Ladakh Magmatic arc

5- Karakoram Block

6-Chagai Magmatic Arc.

7- Pakistan offshore

2.4 Basins of Pakistan

1-Balochistan basin

2-Pishin basin

3- Indus basin

2.4.1 .Balochistan Basin

The Balochistan basin is located on the south western part of Balochistan Province (Pakistan). Balochistan basin is subdivided into northern Balochistan (Pishin basin or Kakar Kohorasan basin represented as back arc basin), central Balochistan (Chagai-Raskoh-Wazhdad Magmatic arc and Hamuns-Inter arc basin) and southern Balochistan (Makran Siahan basin) basins. Balochistan basin consists of Cretaceous to recent sediments, diverse igneous rocks and low grade metamorphics. Balochistan basin is a leading basin which consists of very significant mineral deposits especially copper and gold deposits. These mineral resources need to be developed for the development of areas, province and Pakistan. During previous half century a lot of geological work has been done in Balochistan basin.

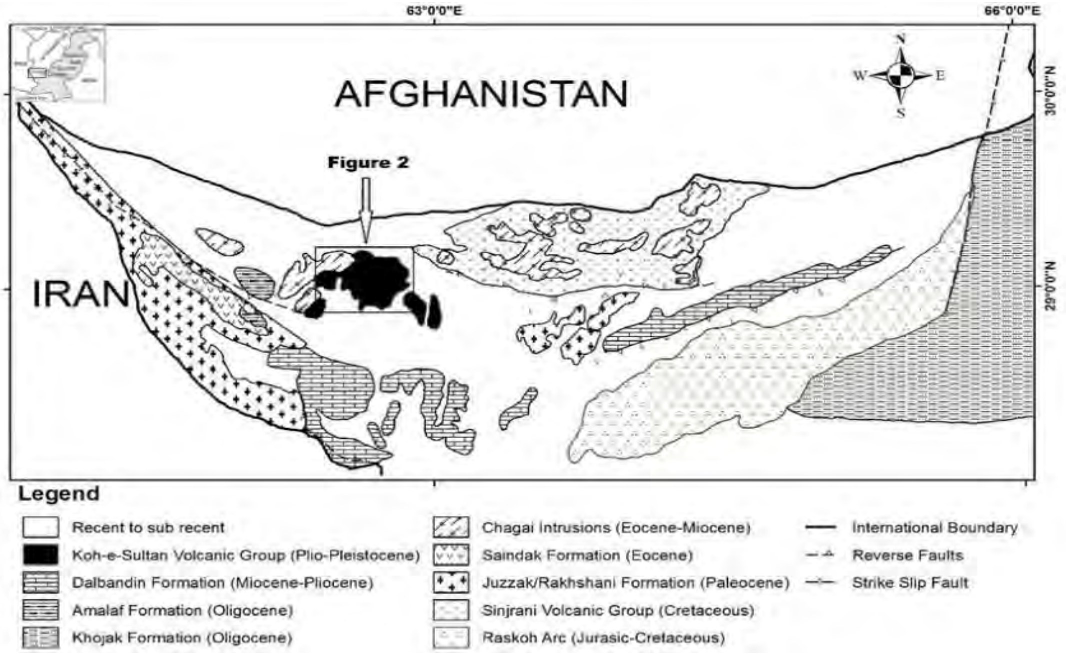


FIGURE (2.3):Geological map of chagai (Siddiqui al. 2015).

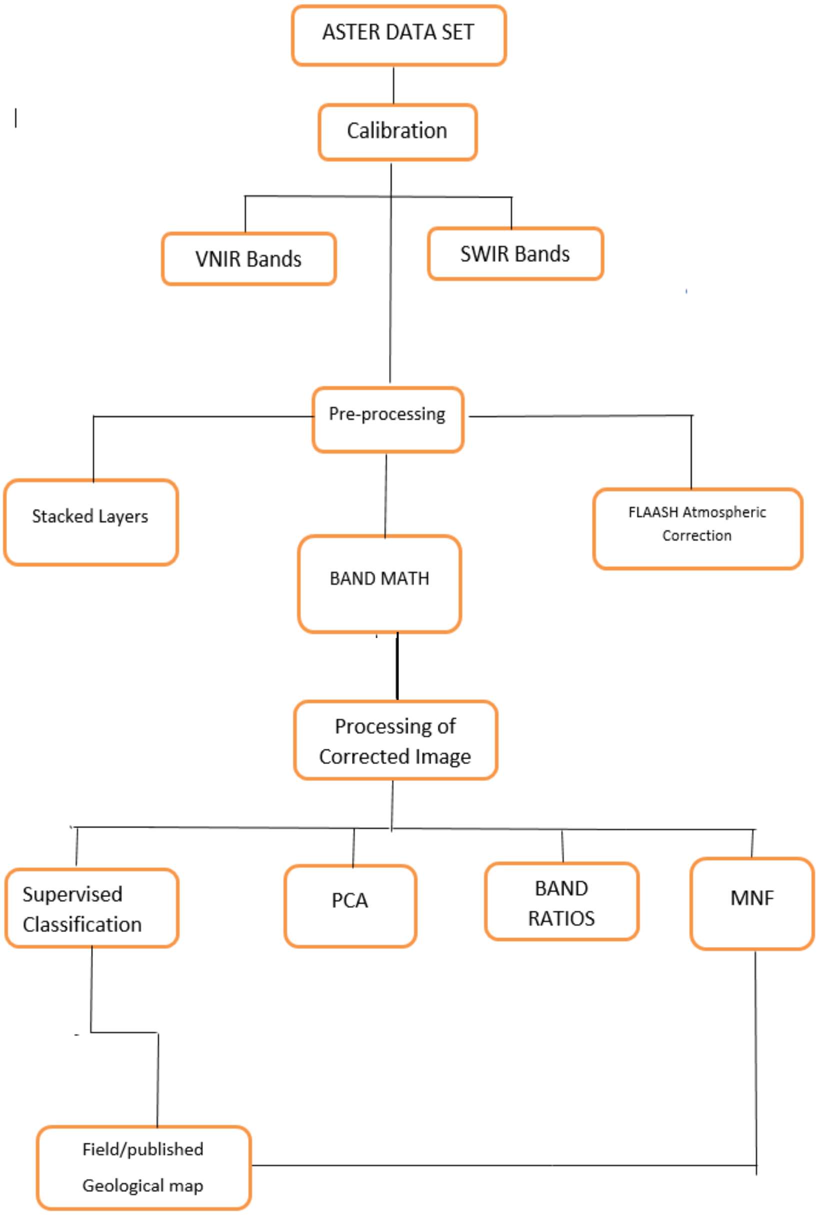
2.5 Tectonic setting of Chagai

The Chagai arc is an EW trending subduction related magmatic arc it is 500 km long 150 km wide. The major part of the Chagai arc occurs in Pakistan but it also extends westward in Iran and towards north in Afghanistan. The oldest rock sequence in the Chagai arc is Late Cretaceous Sinjrani Volcanic Group Chagai-trench arc is which is developed in response to northward movement of Indian and Arabian plate and subduction of Neotheys under the southern margin of Afghan Block. Eastward Chagai arc is abruptly truncated by Chaman fault.

CHAPTER 3

METHODOLOGY

3.1 FLOW CHART



Methodology Flow chart 3.2

3.2 Processing

3.2.1 Data Acquisition and Computer Software

ASTER image is preferred based on availability of cloud free imagery, the quality of the image and the time of acquisition (NASA Land Processes Distributed Archive Center). The image was at first viewed and chosen via https://lpdaac.usgs.gov/ and preprocessed using ENVI software routines, which performed atmospheric correction and converted radiance data to reflectance products (VNIR and SWIR) images.

ASTER data was then processed using a 64 bit PC running Microsoft Windows 10, preloaded with ENVI 5.3 (spectral image processing software). Processed imagery was then compiled with other datasets using ArcGIS 10.5 geographic information system (GIS) software.

3.2.2. Preprocessing of ASTER data

Preprocessing of ASTER data is essential to acquire information on the minor difference of Minerals /rock units . Surface objects such as clouds, snow, ocean, lakes and the edges have to be masked because these have considerably different spectral features to alteration minerals, that masking allows visualization of the minor differences of alteration minerals in the zone of alteration while applying band ratio or PCA. Dense vegetated areas should also be masked to obtain better results from alteration zones because when only SWIR bands are used they show the vegetation as an alteration during data processing and interpretation.

This study is performed on an ASTER level 1T image which is already terrain corrected and also cross-talk correction was already performed. The VNIR ASTER data with spatial resolution of 15-m were re-sampled at 30 m to fit with SWIR data using the nearest neighbor resampling method. Thus, the VNIR and SWIR bands were stacked to form nine bands with the spatial resolution of 30 m.

The Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) algorithm (Adler-Golden et al.1998, Cooley et al. 2002) was adopted to the VNIR-SWIR ASTER radiance data subsystems to remove the atmospheric influence and convert radiance dataset to surface reflectance. The lithological features were digitized from the geological map at a scale of almost 10 km of the area. The map was used as input datasets in remote sensing image interpretation in order to identify major lithologic units in the study area.

All the data pre-processing procedures were implemented by ENVI software and later visualization, mapping and vectorization were conducted on ARCGIS platform .

3.2.3 General Methodology

Various techniques have been used to identify lithological features and update existing map of the study area. The flow diagram shows the general methodology of the study area. The methodology used in this study involves several steps. The review of literature was the first step in obtaining information on the general geology in the study area. This was followed by data preparation and pre-processing of remotely sensed images of ASTER dataset.
In order to clearly visualize the image the preprocessing steps, such as FLAASH Atmospheric Correction, Post FLAASH Atmospheric correction and Image enhancement were implemented While implementing the image processing techniques, the image of study area was geo-referenced into one projection system WGS1984.

Then the techniques which are PCA, band ratoing, Forward MNF and supervised classification Were applied for the discrimination of lithological units of the area, And for the cross validation of these techniques which were mentioned above, geological map of the study area was used, The extracted lithological features were digitized to generate the updated lithological map.

For rock-type discrimination, information provided by spectral characteristics of the terrain is important and multispectral colour composite images are most useful. Selection of three bands from the given reflected channels of the ASTER image is time-consuming, considering the number of possible three-colour combinations from all the bands. Formulae exist for quantitative optimization of the bands for colour composites, based on statistical approaches (e.g. Sheffield 1985).

The results do not necessarily produce images aesthetically most suitable for qualitative interpetation. The Crosta method is known for obtaining information of alteration zones using PCA to Landsat data (Crosta and Moore, 1989; Loughlin, 1991). The Crosta method has been also applied to ASTER data (Crosta et al., 2003).

Combinations of ASTER bands used by previous authors to discriminate between rock types in similar climatic conditions (Rothery 1987) were not found to be particularly useful in this area. Consequently, the combination used in this study was selected empirically, on the basis of experimentation and interpretative experience (Crosta et al., 2003). Display colour allocation was influenced by the fact that the human visual system is more responsive to saturation and intensity changes in the blue but less in red and green hues (Crosta et al., 2003). Therefore in this research the well known Crosta technique was followed.

3.2.4 Results After corrections

We Apply cross talk correction than after we performed a process called **"Stacking layers"** than Apply **FLAASH Atmospheric correction ,**

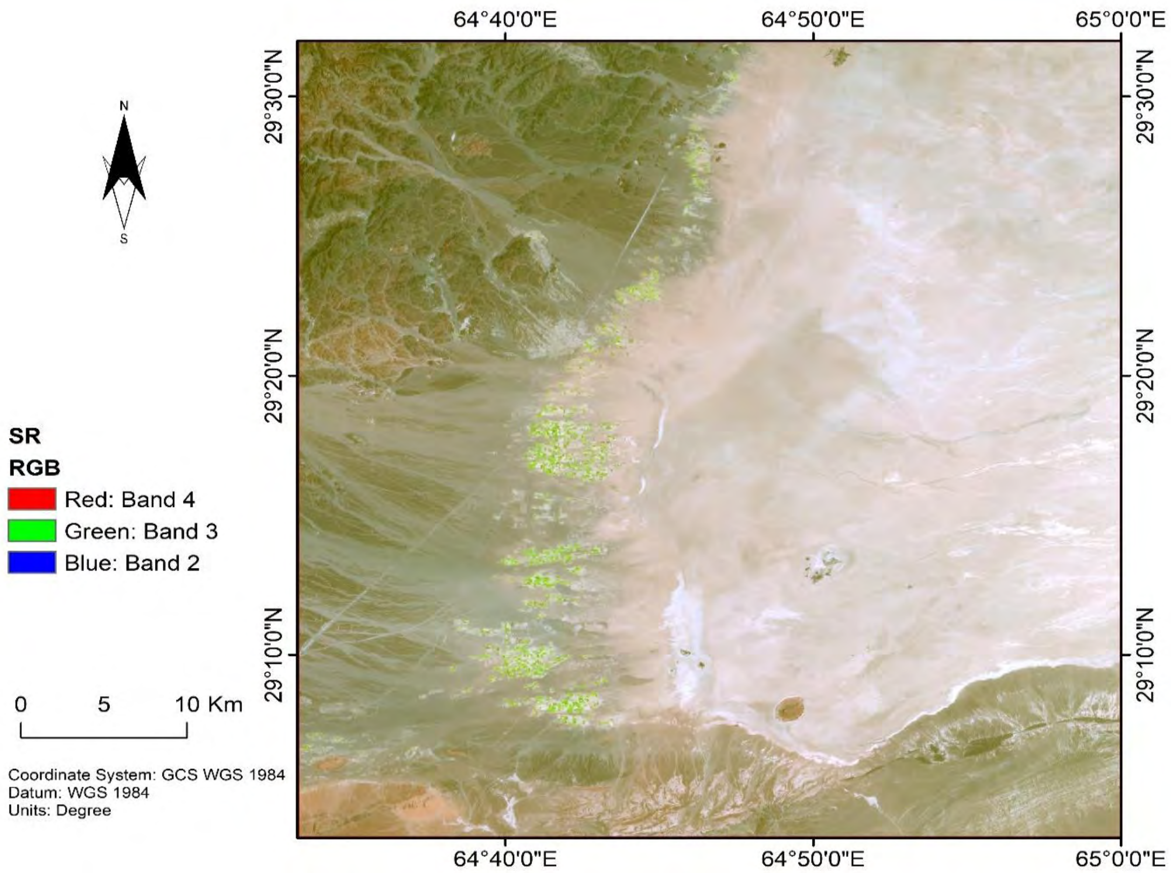


Figure (3.1)

Result After the **POST FLAASH Atmospheric Correction** (also called BAND MATH).

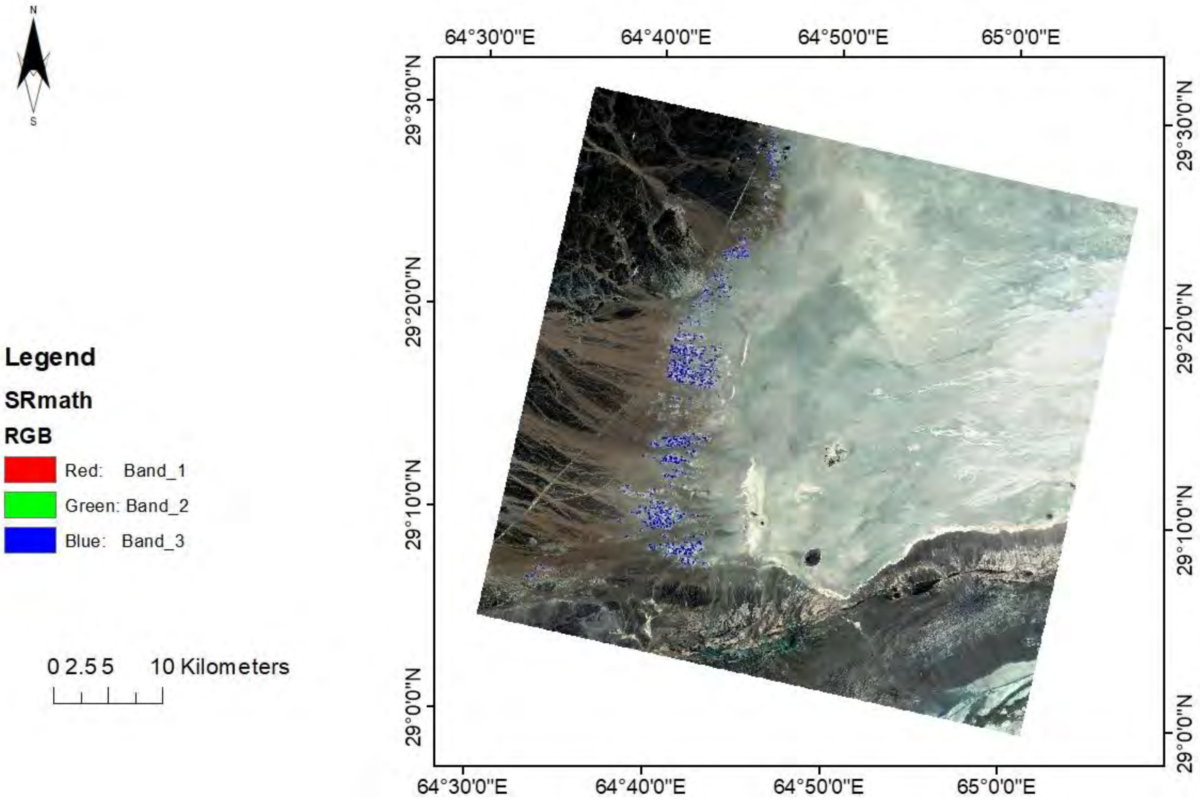


Figure (3.2)

3.3. TECHNIQUES

3.3.1. Principal component analysis

The decorrelation of data and the reduction of the study dimension on the nine ASTER bands have been realized by a principal component analysis (PCA) (Richards and Xiuping 1998). The PCA is a multivariate statistical method which is largely employed for multispectral image interpretation founded on linear algebraic matrix operations. The PCA chooses uncorrelated linear combinations (eigenvector loadings) of variables in order that each component successively extracts linear combination and possesses a smaller variance. The principle is to create a new set of orthogonal axes that have their origin at the data mean and that are rotated in order that the data variance is optimized (Pour and Hashim 2011). Thus, the number of output PCA bands is identical to the input spectral bands. The first PCA band includes the widest percentage of data variance and the second PCA band includes the second widest data variance, and so on; the last PCA bands appear noisy because they contain very little variance which is dueto the noise in the original spectral data (Pour and Hashim 2011). Between the nine ASTE bands (VNIR and SWIR), the correlation coefficient is generally higher than 0.9.

3.3.2. Band Ratio

Detection of spectrally similar features can be enhanced by the use of band ratios. Band ratio is one type of techniques the enhancement of image resulting from division of digital number (DN) values in one spectral band by the corresponding values in another band. Ratio images convey
the spectral or color characteristics of image features, regardless of variations in scene illumination conditions, which is the major advantage of band ratio (Lille sand and Kiefer, 1987).Band ratios are very useful for highlighting certain features or materials that cannot be seen in the raw bands (Rowan et al. 1977).

3.3.3. Minimum Noise Fraction (MNF)

Minimum Noise Fraction (MNF) transformation is used to determine the inherent dimensionality of image data, segregate noise in the data and reduce the computational requirements for subsequent processing (Green et al. 1988).

3.3.4. Image classification

Image classification is the most common analysis of multispectral remotely sensed data in order to produce thematic maps that provide representation of the spatial distribution of a particular heme (Foody and Mathur, 2004). Multispectral classification is useful to obtain information with respect to ground cover and surface characteristics. It helps translate continuous variability of image data into map patterns that provide meaning to the user.

CHAPTER 4

4.1. Results and Discussion

4.1. Results

This study has two major comparison firstly, between the different band combinations of bands in different classification techniques that which band combination in that specific classification technique provides the best possible result and secondly, comparison between the different techniques itself that which technique provides the best possible result.

4.2. VNIR and SWIR bands

4.2.1. Principal Component Analysis (PCA)

Different PCA combinations were studied to delineate the lithological setup in the area of interest. In first calculation PCA of 4,3.,1 were calculated and layer stacked with same pattern and classify as RGB respectively.

First combination :

In this combination lime stone of sedimentary and volcanic group of KV formation can be seen in yellow and Shale can be seen in Greenish color. Shale (Calcereous) of Dalbandin formation can be seen in Yellowish and greenish light-yellow color. Unconsolidated deposits can be seen in Mostly (sand) can be seen in Olive green color. Silt and clay can be seen in Sea foam with Navy blue shade color.

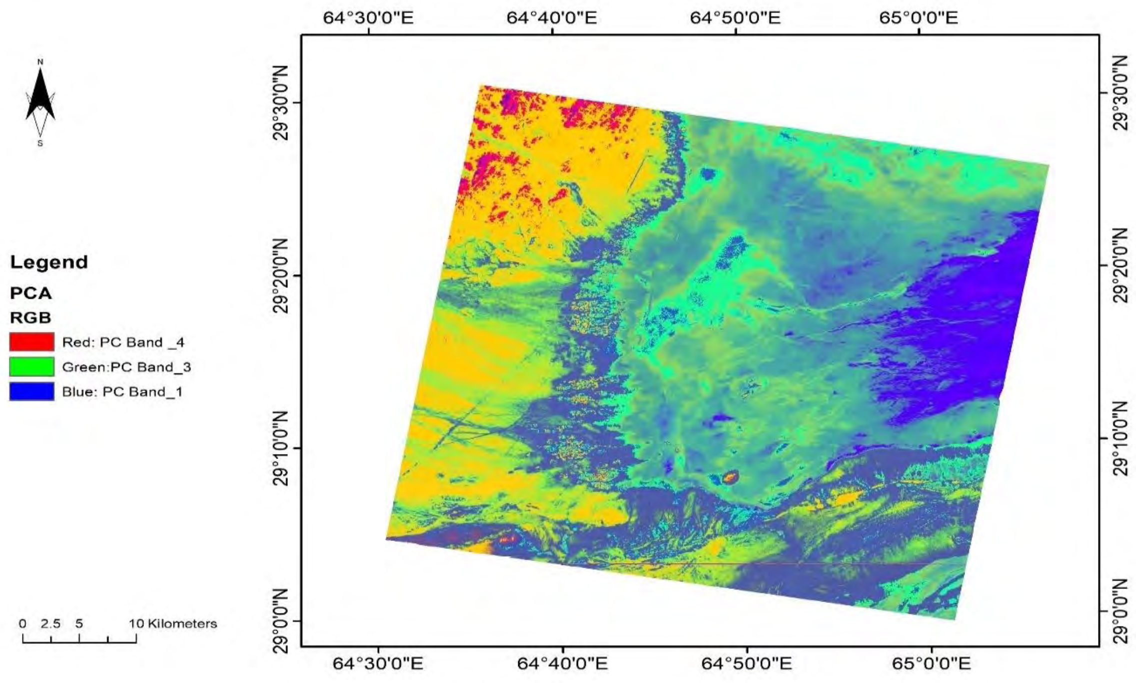
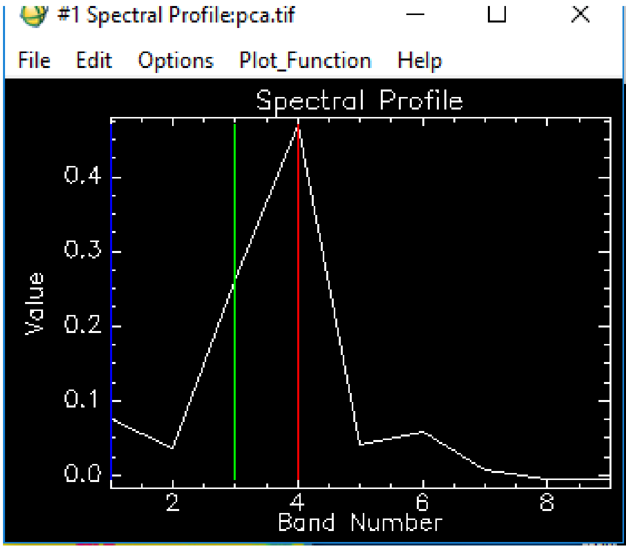
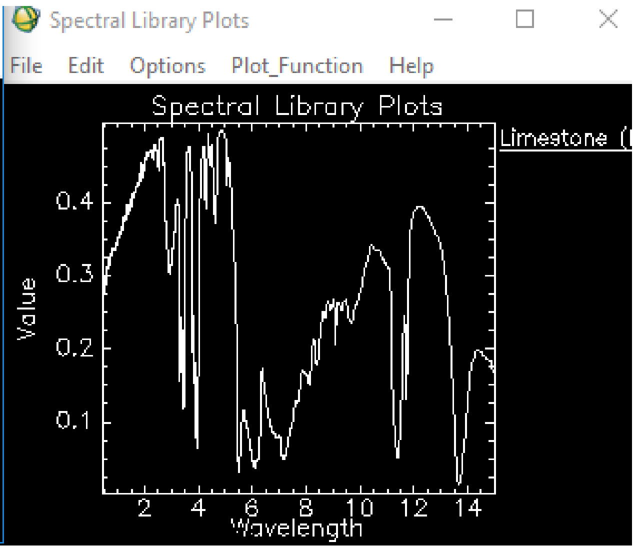


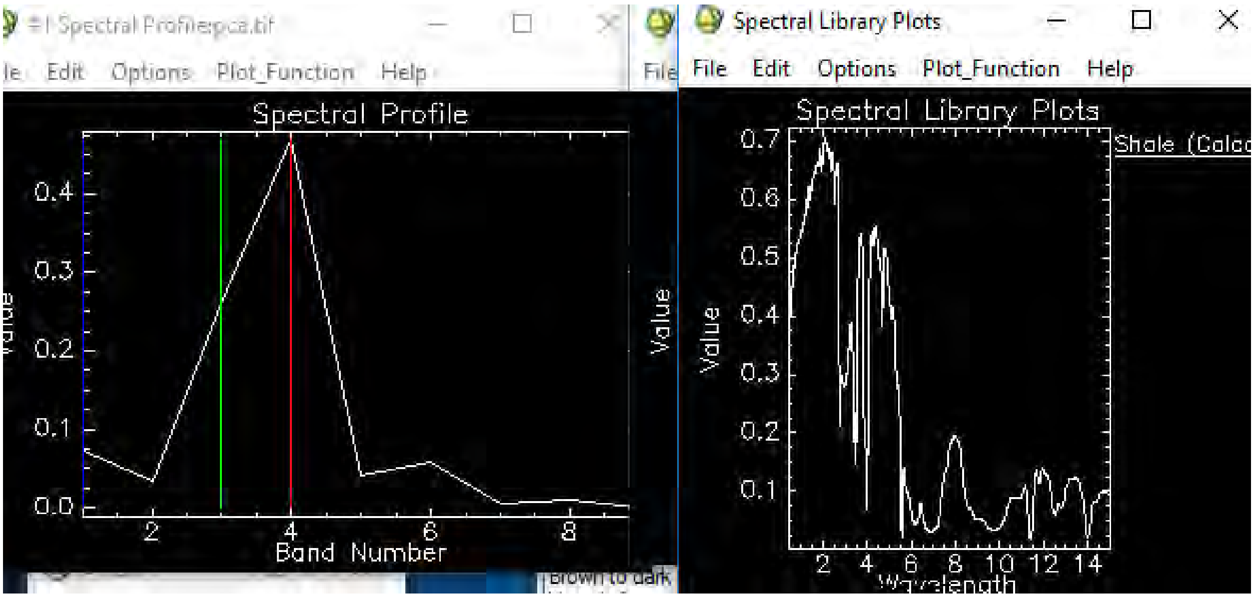
Figure (4.1)

Spectral signatures:

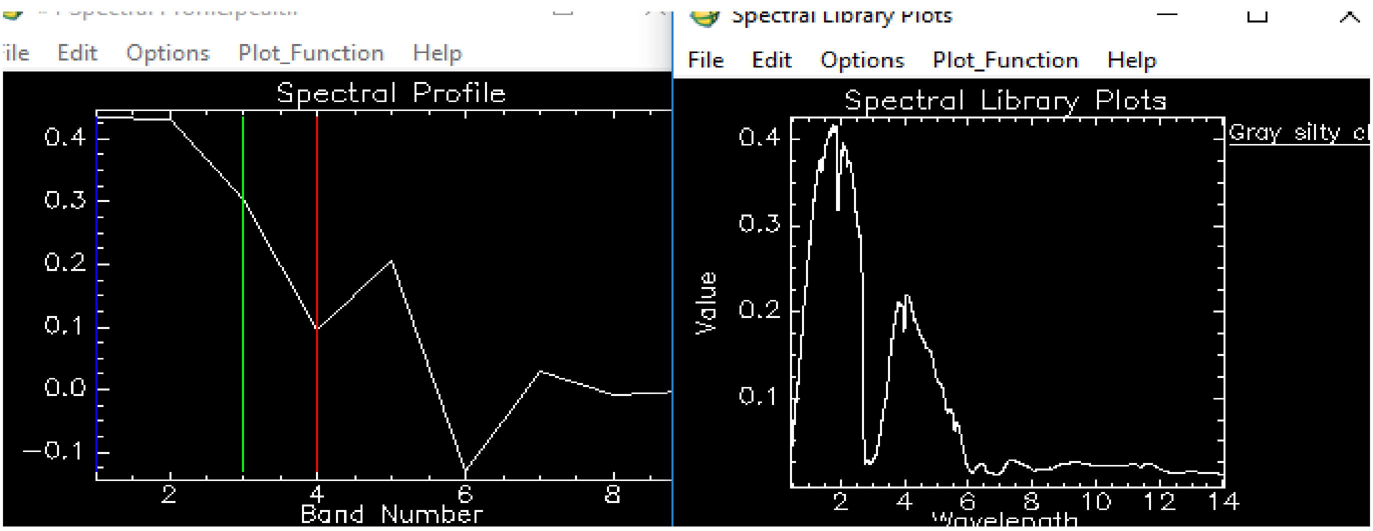




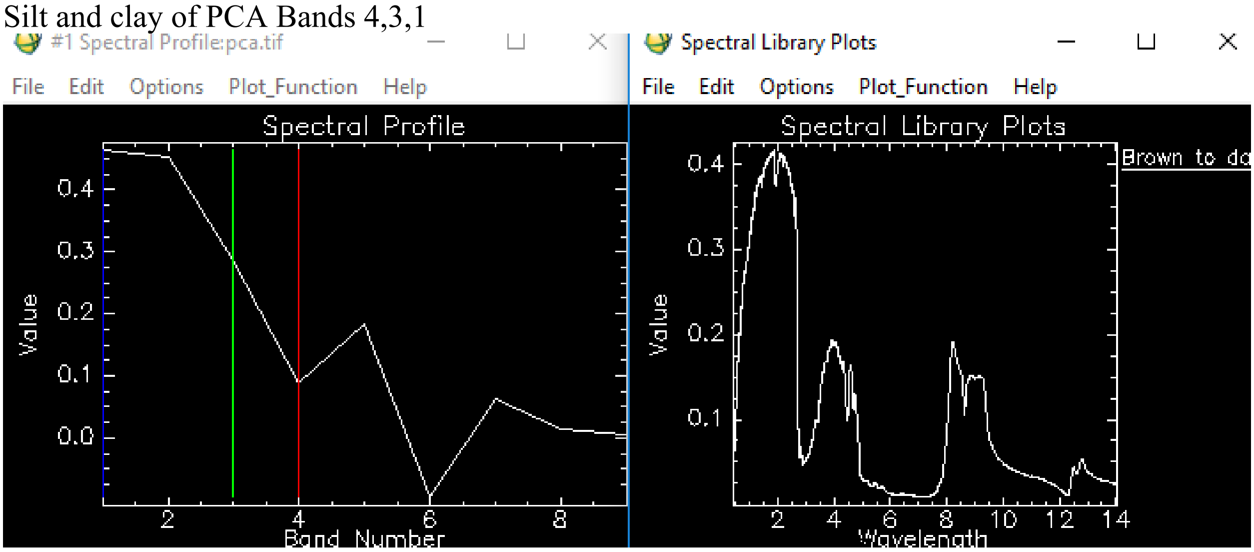
Limestone OF PCA 4,3,1



Shale of Dalbandin and KV formations of PCA Bands 4,3,1



Silt and clay of PCA Bands 4,3,1



Unconsolidated deposits (Sand) of PCA Bands 4,3,1

TABLE (A) shows a Results of Limestone OF PCA 4,3,1

PCA Bands	USGS Spectral Results	Our Results
Band 4	0.369	0.4
Band 3	0.31	0.27=0.3
Band 1	0.3	0.26

TABLE(B) Shows a Result of shale (KV Formation) OF PCA 4,31

PCA Bands	USGS Spectral Results	Our results
Band 4	0.3	0.289
Band 3	0.29	0.3
Band 1	0.15	0.12

TABLE(C) Shows a Result of shale (Te Formation) OF PCA 4,3,1

PCA BANDS	USGS Spectral Signatures	our results
Band 4	0.37	0.4
Band 3	0.28	0.2
Band 1	0.1	0.1

TABLE(D) Shows a Result of Silt and Clay of PCA 4,3,1

PCA BANDS	USGS SPECTRAL Results	Our results
Band 4	0.2	0.1256
Band 3	0.02	0.30
Band 1	0.36	0.4

TABLE(E) Shows a Result of Un Consolidated Deposits of PCA 4,3,1

PCA BANDS	USGS Spectral Results/signature	Our results
Band 4	0.18	0.13
Band 3	0.1	0.2
Band 1	0.357	0.4

In Second calculation of PCA 6,5,3 were calculated and layer stacked with same pattern and classify as RGB respectively;

In this combination Limestone and shale (Little -bearing) of Sedimentary and Volcanic group (KV formation) Can be seen in Amethyst Purple color. Shale (Little -barring) of Dalbandin formation can be seen in reddish pink with Amethyst purple color. Silt and Clay can be seen in Pink color. Unconsolidated Deposits can be seen in Sky blue color.

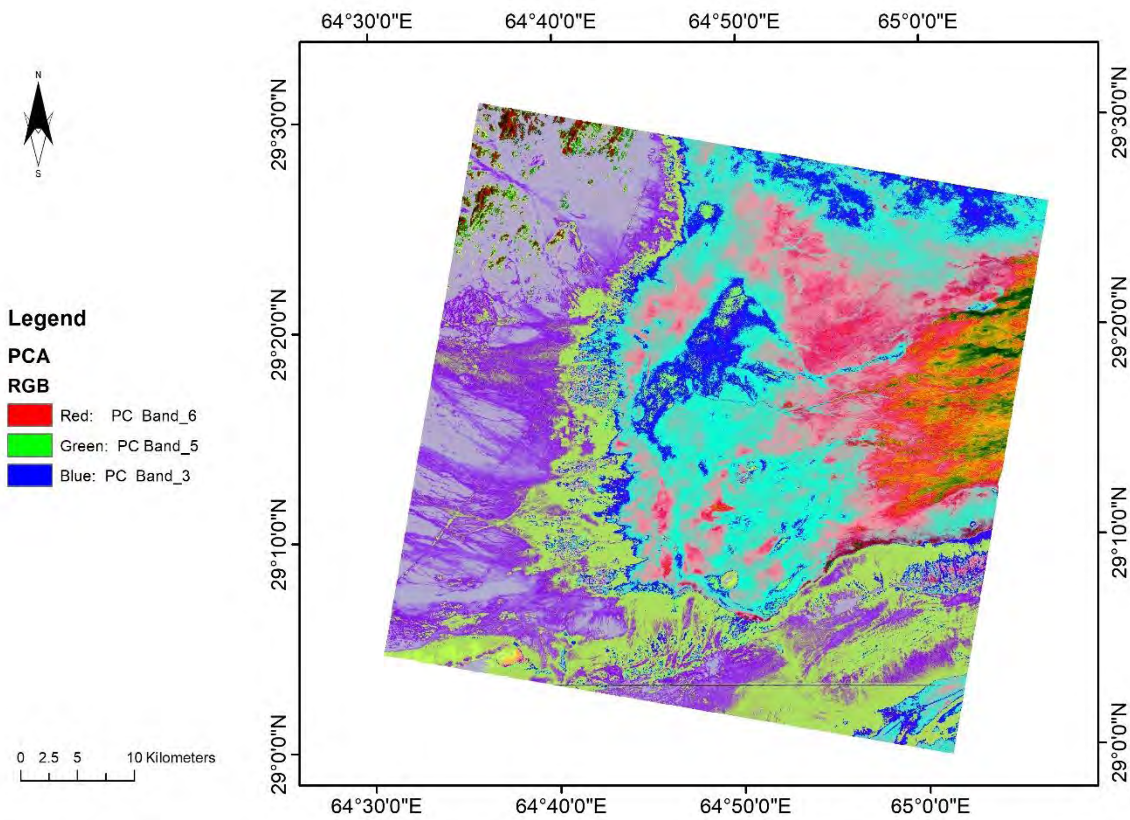
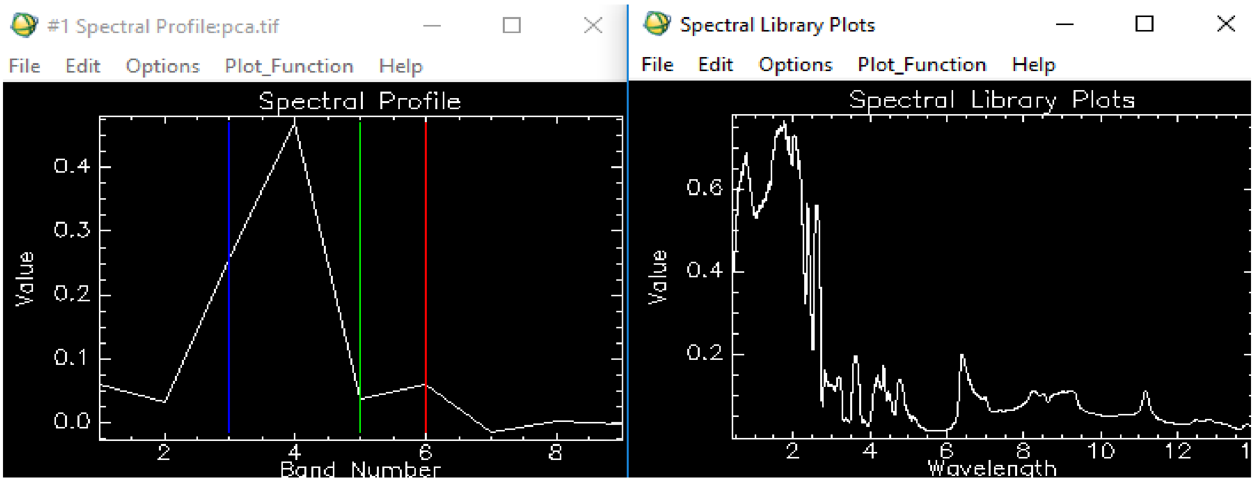
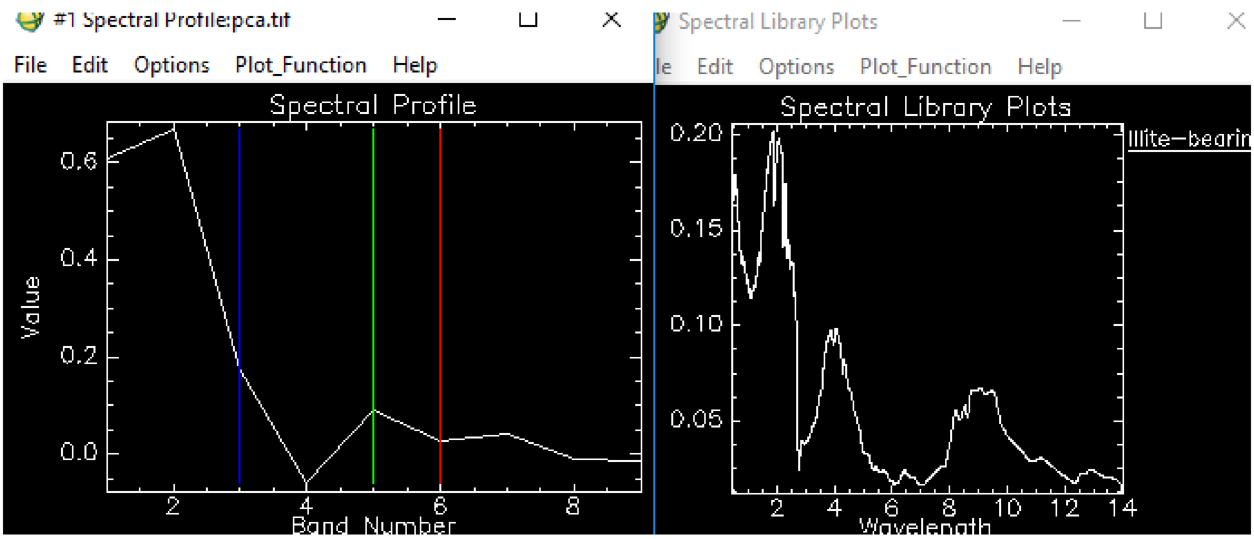


Figure (4.2)

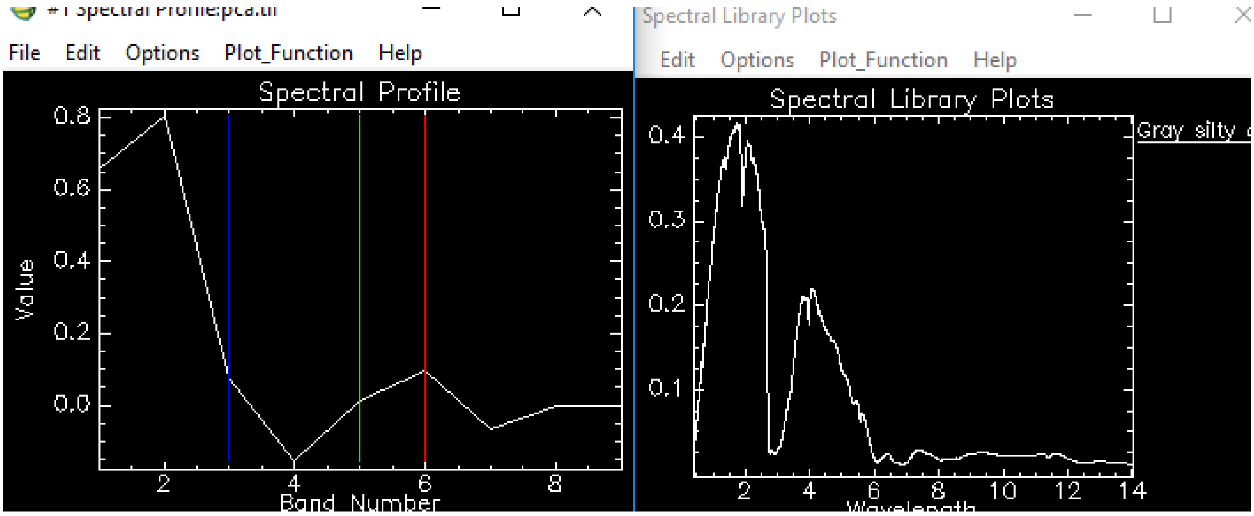
Spectral Signatures:



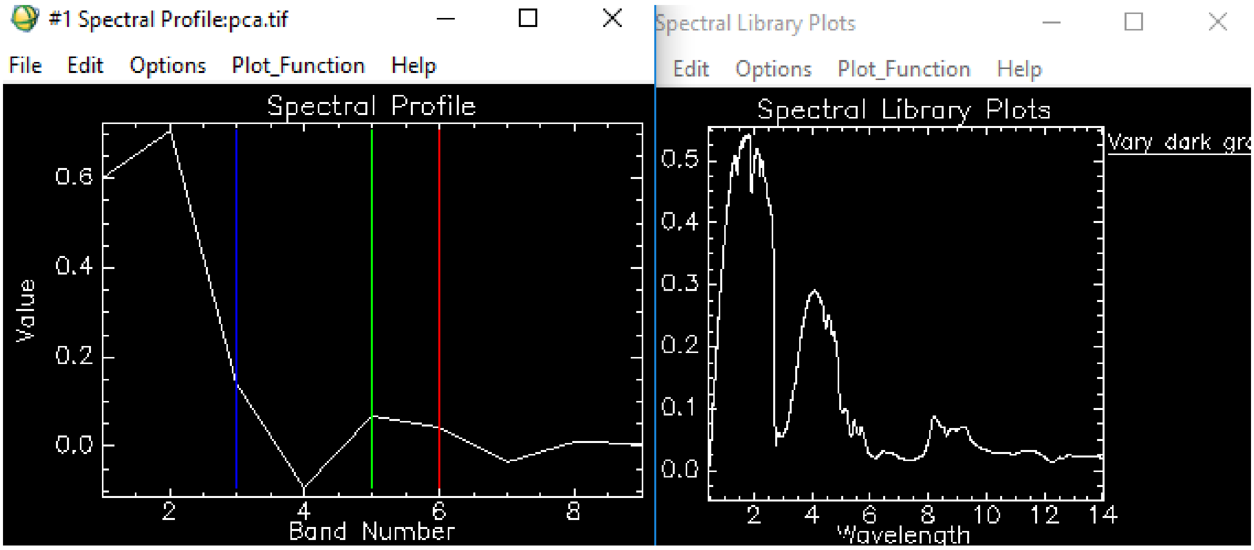
Limestone OF (KV Group) PCA 6,5,3



Shale of (Te and Kv formation) PCA 6,5,3



Silt and Clay of PCA 6,5,3



Unconsolidated deposits of PCA 6,5,3

Table (a) Shows a results of limestone (kv group) PCA 6,5,3

PCA Bands	USGS Spectral Signatures	OUR results
Band 6	0.02	0.05
Band 5	0.05	0.04
Band 3	0.126	0.26

Table (b) Shows a results of Shale (kv and Te groups) PCA 6,5,3

PCA Bands	USGS Spectral signatures	Our results
Band 6	0.02	0.02
Band 5	0.03	0.09
Band 3	0.046	0.12

Table(c) Shows a result of Silt and clay of PCA 6,5,3

PCA Bands	USGS Spectral Signatures	OUR Results
Band 6	0.01	0.01
Band 5	0.12	0.01
Band 3	0.03	0.04

Table (d) Shows a result of Unconsolidated Deposits of PCA 6,5,3

PCA Bands	USGS Spectral Signatures	Our Results
Band 6	0.025	0.028
Band 5	0.09	0.08
Band 3	0.1	0.06= 0.1

4.2.2. Band ratios

Different band ratio combinations were studied to delineate the lithological setup in the area. The ASTER band ratio image is shown below the fig.

A Band Ratio 4/2,4/1 and 4/3 Shows a different result; this Combination we identify a Shale and limestone of Sedimentary and Volcanic Group. Shale Can be seen in Medium Apple Green color. Shale can also be seen in Dalbandin Formation. Silt and Clay cannot be identified from this combination. And sand of Un Consolidated can be seen in Mars red color. Limestone can be seen in cherry cola color.

Band Ratios	Min	Max	Mean	Standard deviation	T.H
4/2	0	255	76.38	57.59	250.8
4/1	0	255	80.03	55.83	192
4/3	0	255	81.51	59.85	142

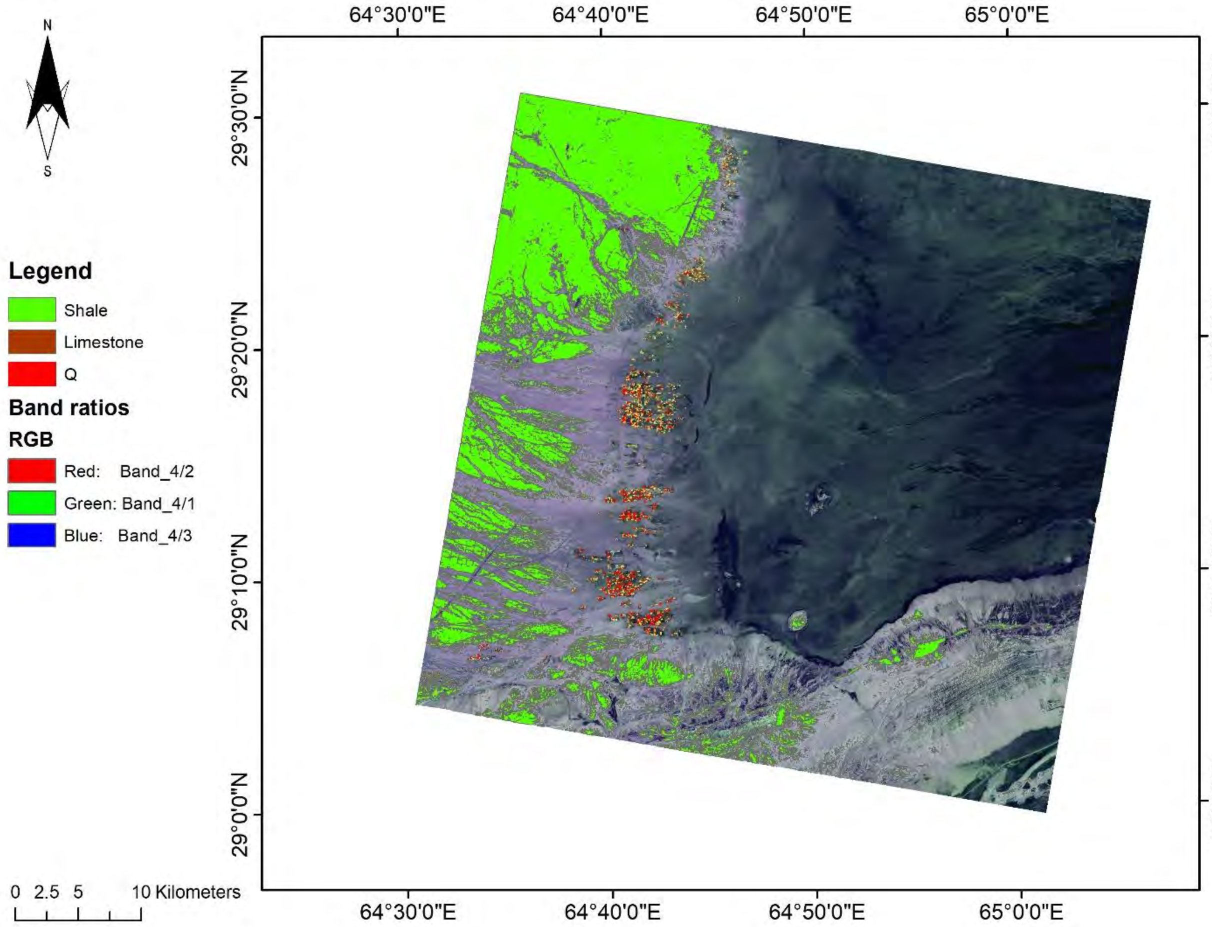


Figure (4.3)

In second phase band ratios of 2/1,2/3 and 2/4 was calculated and layer stacked and classify as RGB respectively (Figure4.3). It delineate the surface very well as it highlighted the spectral difference of multiple Surface very well.

In this combination Un consolidated deposits can be seen in Dark umber color. Silt and Clay Can be seen in lime dust color. Clues of Sand and shale of Dalbandin formation can also Seen in Pinkish white with Light grass greenish color. Shale and Limestone of KV group can Not be identified from this combination.

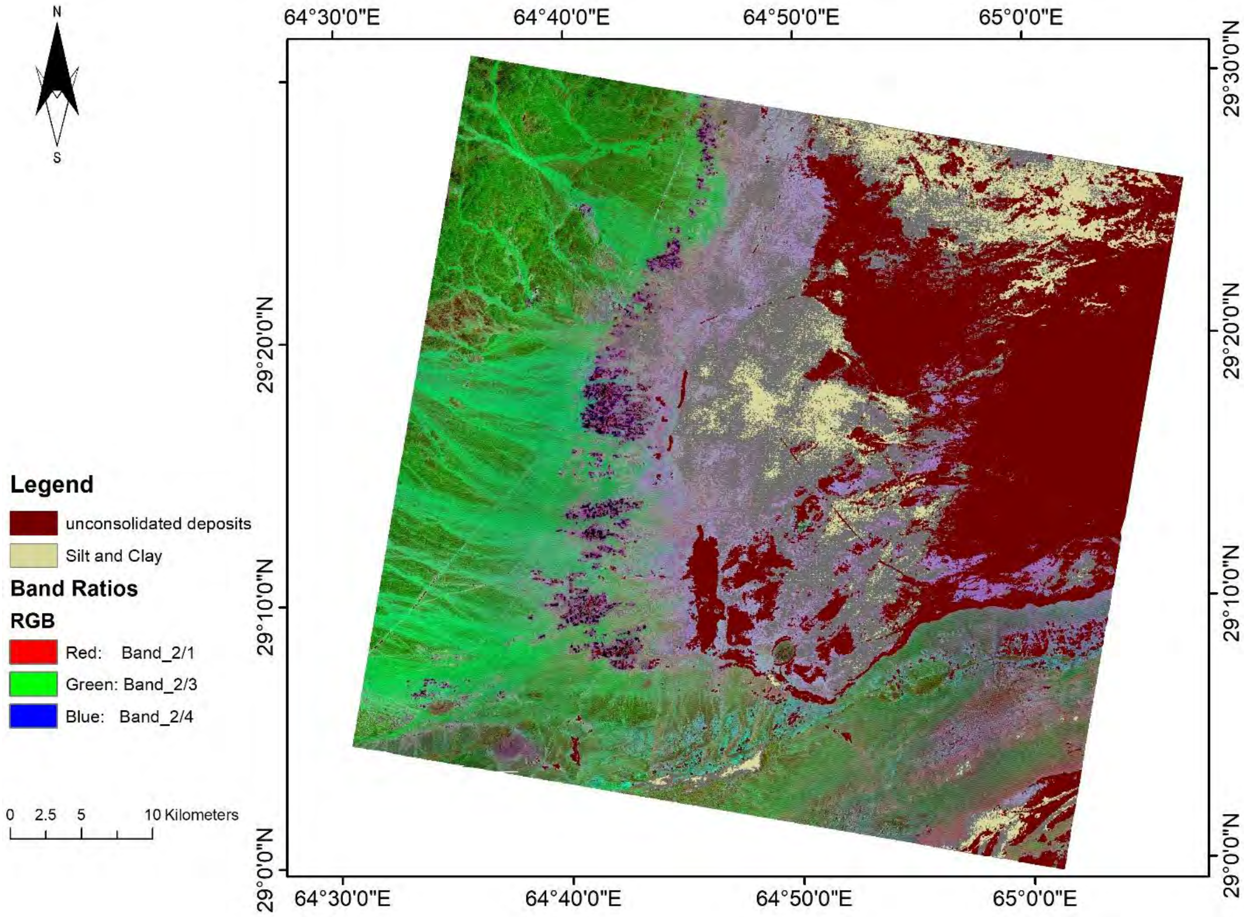


Figure (4.4)

Bands	Min	Max	Mean	S.D
2/1	0	255	158.7	64
2/3	0	255	173	48
2/4	0	255	157.6	65

4.2.3 Forward Minimum Noise Fraction F-MNF

To delineate the lithological setup in the study area two different F-MNF combinations were studied. In first calculation F-MNF of 7,5,4 were calculated and layer stacked with same pattern and classify as RGB respectively (Figure4.5)

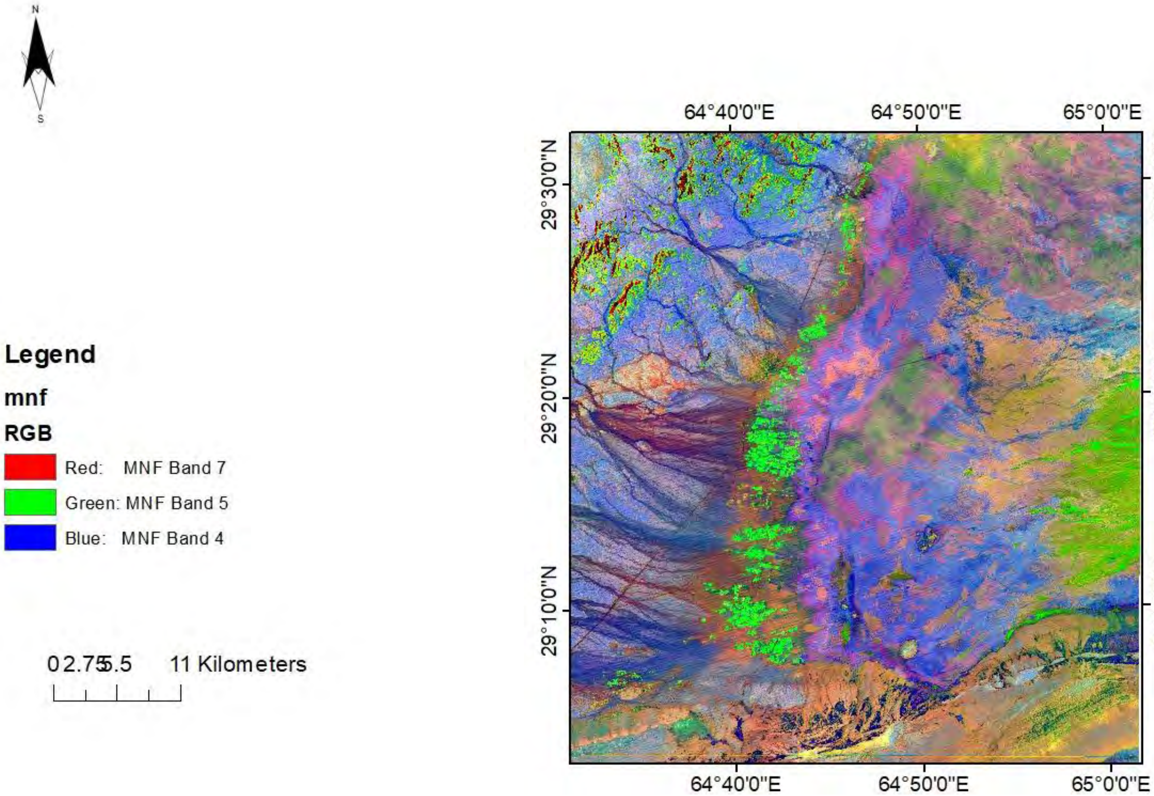


Figure (4.5)

Limestone, and shale can be seen in green cover zinc and mixture of ferozi (turquoise) ;white and royal blue color. Un consolidated deposits can be seen in mixture of leaf green and light orange color. Silt and Clay can be seen in sky blue, light-purple with shades of vegetation grass cover. Shale of Dalbandin formation can be seen in mixture of chili with yellow and yellow to dark orange color.

In second phase F-MNF of 5,7,9 was calculated and layer stacked and classify as RGB respectively

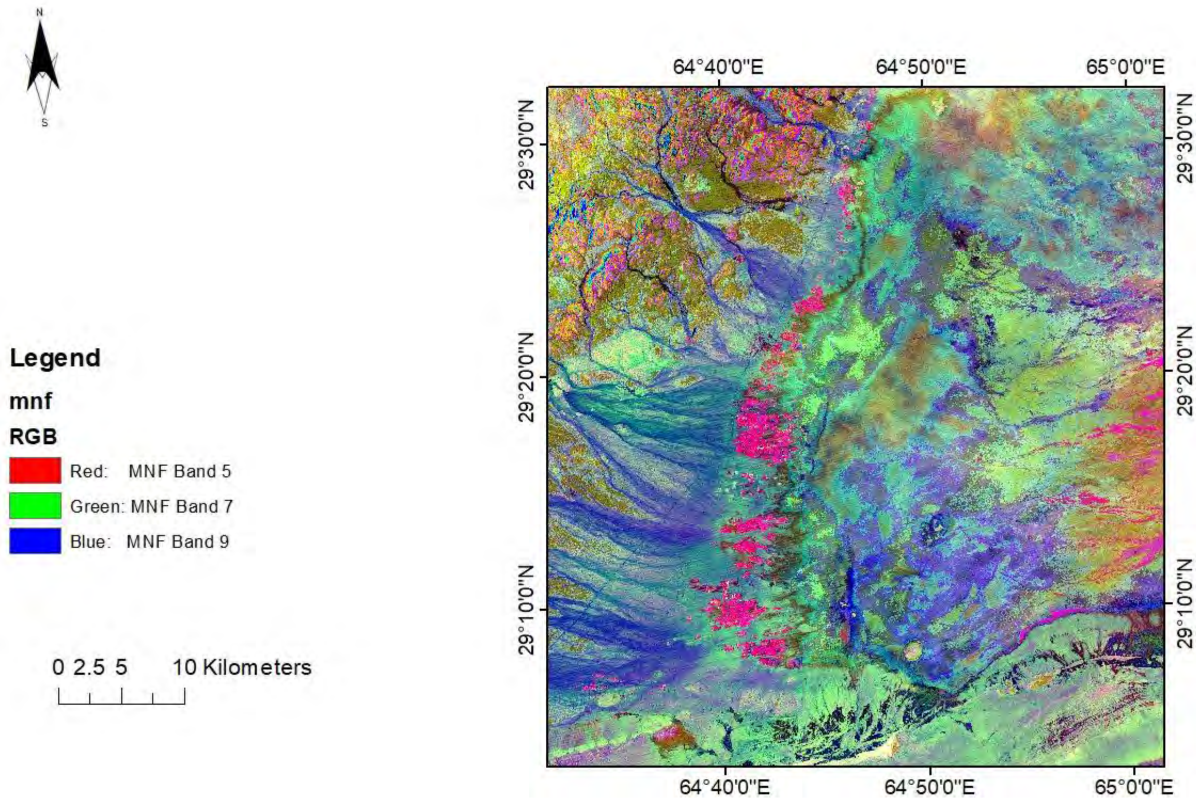


Figure (4.6)

Limestone and shale can be seen in mixture of peach,-purple color and mixture of parrot green color. Unconsolidated deposits can be seen in pink mehndi and Royal blue color. Silt and clay can be seen in sky blue with cover of mehndi color . Shale of Dalbandin formation can be seen in light sea green color with mixture of syrup color.

4.2.4 Maximum likelihood classification

Supervised image classification

Maximum likelihood classification is also performed on SR MATH pre-processed image,
Here we have different results we can see in given figure (4.7).

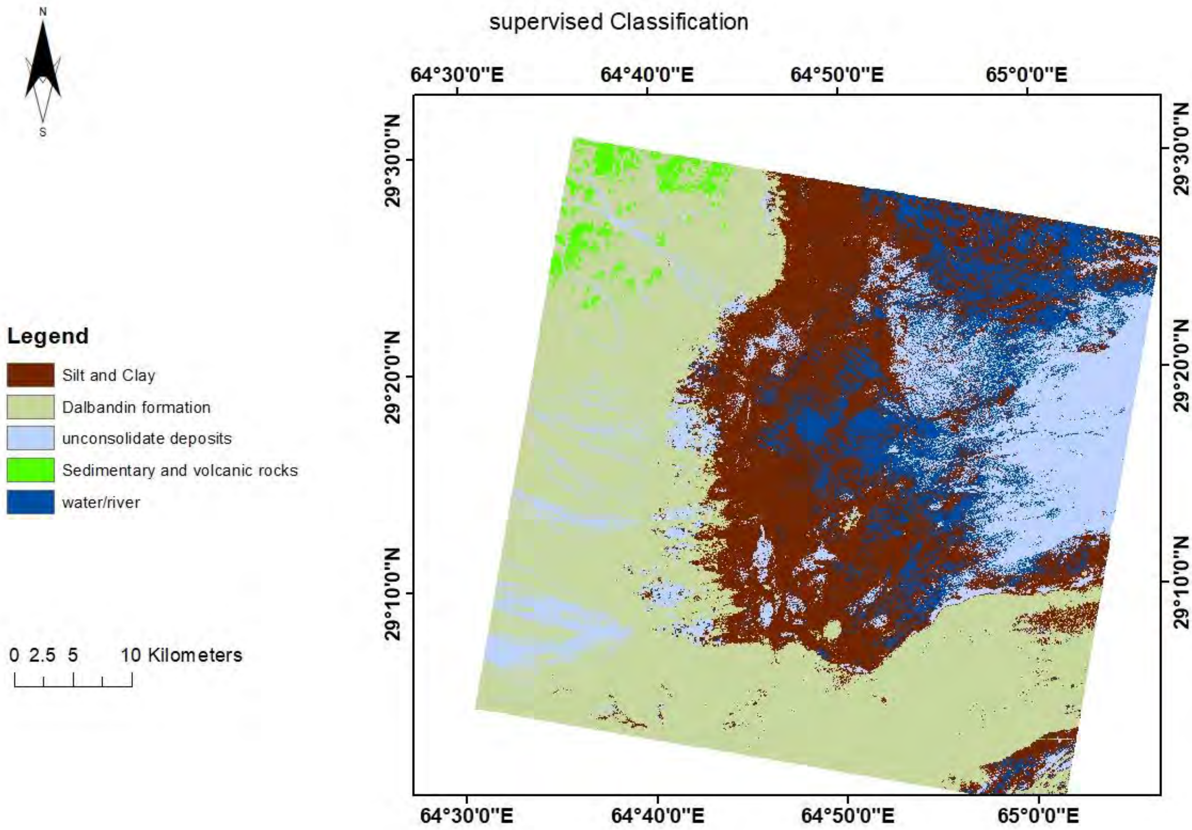


Figure (4.7) showing the classified map of chagai.

CHAPTER 5

LANDSAT 8

5.1 Optimization of Landsat data

To compare Landsat with Aster sensor , for geological and non- geological investigations Enhanced Thematic Mapper (ETM+) images of Landsat sensor are also considered as popular base maps (Bamousa et al. 2011, 2012). In Figure 1 the comparison between ASTER sensor bands like VNIR, SWIR and TIR and Landsat (ETM+) telescope bands can be observed (Adams 2006). The bands 2, 3 and 4 of Landsat (ETM+) are equivalent to the bands 1, 2 and 3 of VNIR telescope of ASTER sensor which detect visible Electromagnetic Radiation (EMR) (Figure 1).Band 7 of the ETM+ sensor is equivalent to bands 5–9 of the SWIR telescope, and band 6 of the ETM+ is equivalent to bands 10–14 of the TIR telescope (Fig. 1). Bands 1–9 of the ASTER sensor are reflected as well as 1–5 and 7 of the Landsat ETM+, whereas ASTER bands 10–14 and Landsat ETM+ band 6 are emitted. In the Landsat ETM+ sensor bands 1–4 are visible, bands5 and 7 are infrared and band 6 is thermal infrared. For the purpose of non-geologic studies visible bands are suitable such as hydrological or biological, whereas infrared bands are useful for geological purposes (Geller et al. 2007).

5.2 What is landsat 8

Landsat 8 (formally the Landsat Data Continuity Mission, LDCM) was launched on an Atlas-V rocket from Vandenberg Air Force Base, California on February 11, 2013.Landsat 8 is the most recently launched Landsat satellite and carries the Operational Land Imager (OLI).

Band 1 Visible (0.43 - 0.45 µm) 30 m

Band 2 Visible (0.450 - 0.51 µm) 30 m

Band 3 Visible (0.53 - 0.59 µm) 30 m

Band 4 Red (0.64 - 0.67 µm) 30 m

Band 5 Near-Infrared (0.85 - 0.88 µm) 30 m

Band 6 SWIR 1(1.57 - 1.65 µm) 30 m

Band 7 SWIR 2 (2.11 - 2.29 µm) 30 m

Band 8 Panchromatic (PAN) (0.50 - 0.68 µm) 15 m

Band 9 Cirrus (1.36 - 1.38 µm) 30 m

The Landsat data provides repetitive acquisition of high resolution multispectral data of the Earth's surface on a global basis. The data from Landsat spacecraft constitute the longest record of the Earth's continental surfaces as seen from space. It is a record unmatched in quality, detail, coverage, and value.

5.2.1 Pre-processing of landset- 8

Pre-processing of landset-8 is same as Aster dataset. We perform pre-processing on ArcGis Or Envi (5.3).First of all we apply corrections, As landset-8 and Aster dataset is already geometrically corrected so there is no need to apply geometric correction. First of all we stacked layer ,than we apply FLAASH Atmospheric correction and we apply Post- Flaash Atmospheric correction, which also called band math.

1- Atmospheric correction

The energy that is captured by Landsat sensors is influenced by the Earth's Atmosphere. These effects include scattering and absorption due to interactions of the electromagnetic radiation with atmospheric particles (i.e., gases, water vapor, and aerosols). Atmospheric correction attempts to account for these effects. However, some atmospheric effects are highly variable over the Earth's surface and can be difficult to correct in Landsat imagery. As we process in ENVI software that's why we called it FLAASH.

FLAASH:(First line of sight Atmospheric Analysis of Spectral Hypercubes)

2- Bandmath

Its also called post flash Atmospheric correction./band math; its called band math because we used math equation which is given below:

(B1le 0)*0+(B1 ge 10000)*1+(B1 gt 0 and B1 lt 10000)*float(b1)/10000

5.2.3 Digitize lithology map

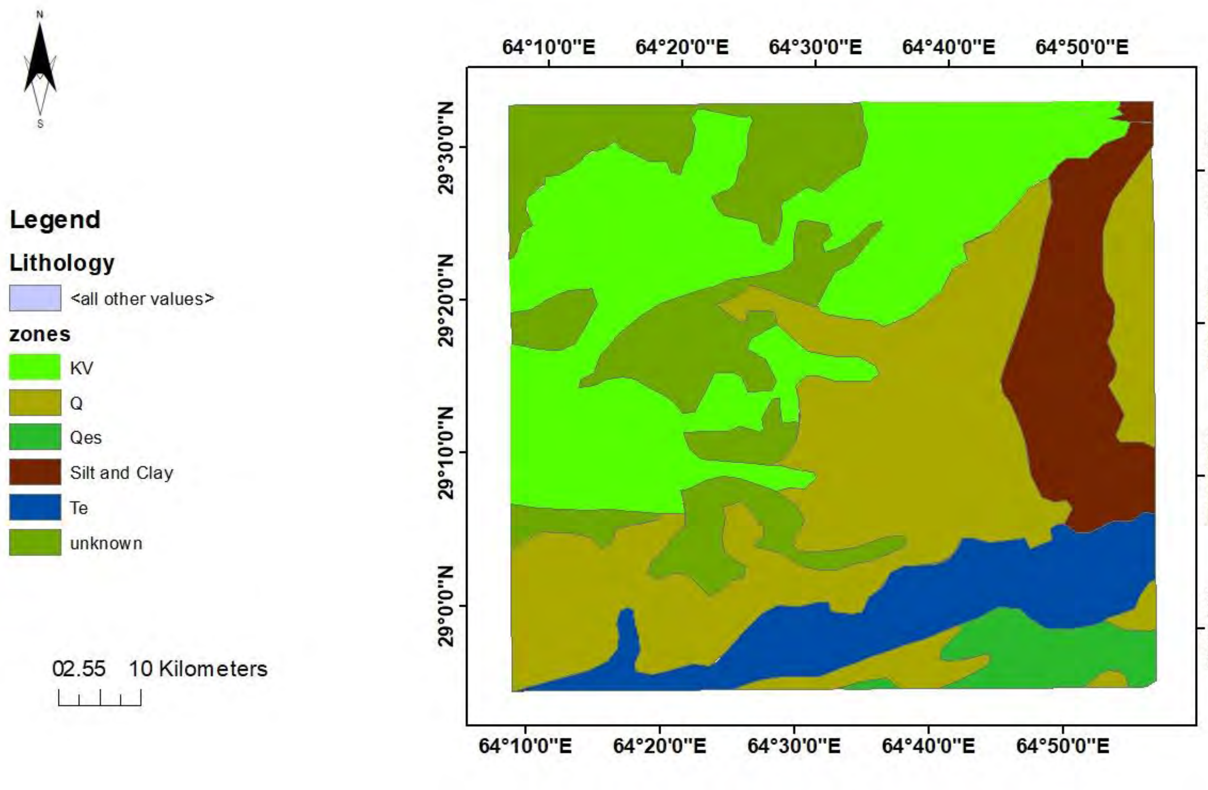


Figure (5.1)

Kv:

Shows a sedimentary and volcanic group rocks: which include limestone, shale , sand stone, conglomerates and agglomerates.

Q and Qes ;Alluvium and extrusive mud

Unconsolidated deposits .Q: Eolian sand ,Qes: Extrusive mud

Eolian sands:

Eolian sediments consist of wind-blown sand, silt and fine-grained, long-range-transported (LRT) dust.

Te: Dalbandin formation which include Shale, soft sandstone and mudstones.

Unknown deposits:

May be its Recent to subrecent deposits but its not defined by Geological Survey of Pakistan. So that s why I give unknown deposits.

5.2.4. Pre-processed imagery

Here we have pre-processed imagery of landset-8. Same processes apply first of all stacked-layer than we apply Flaash Atmospheric correction than we apply Post -flaash Atmospheric correction. As we compare Landset-8 pre-processed image with Aster pre-processed image We can see same lithologies with more visibility, as if you see water in this imagery is more visible than Aster image. If we sediments in landset-8 image is not much better visible as they visible in Aster Imagery hence we Apply same techniques to interpret the lithologies.

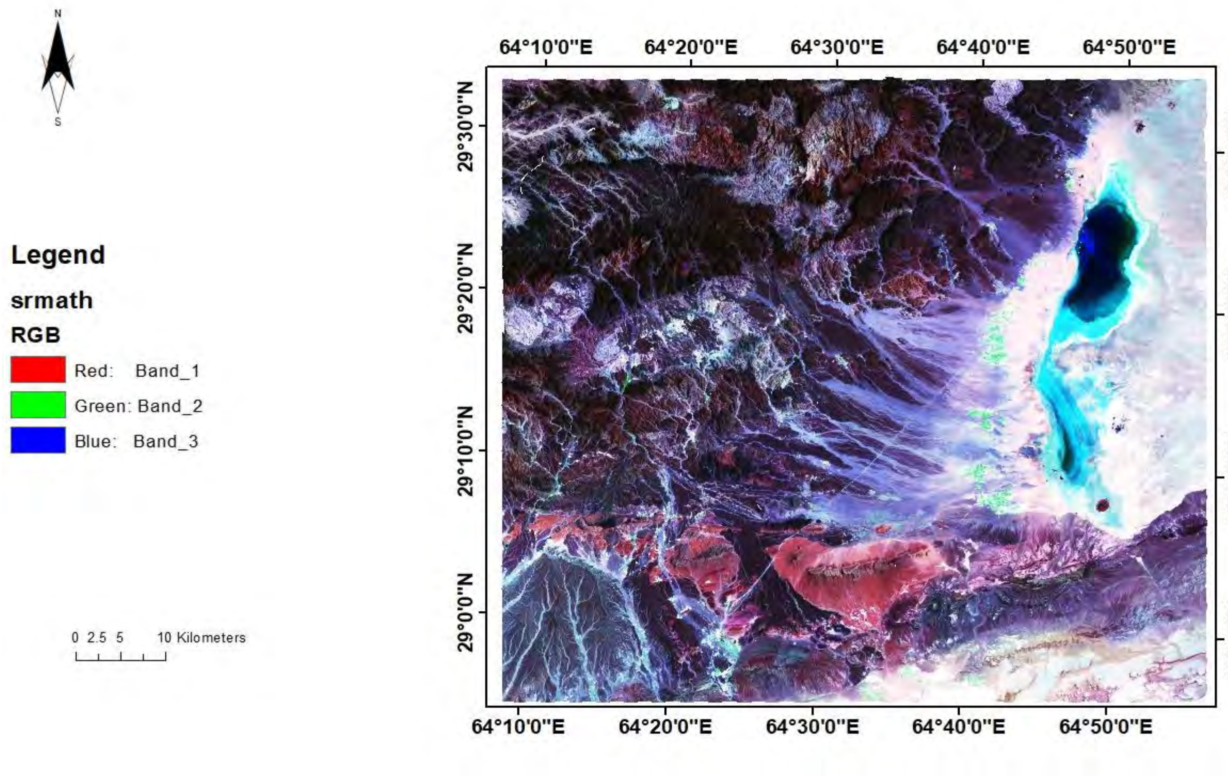


Figure (5.2)

Surface reflectance MATH imagery. Stack bands:1,3,4,5,6,7 and 8.RGB combination :band1,band2,band3.Both are pre-processed image. In this imagery we use image analysis because our imagery looks better ,In Figure (5.2) no image analysis performed.

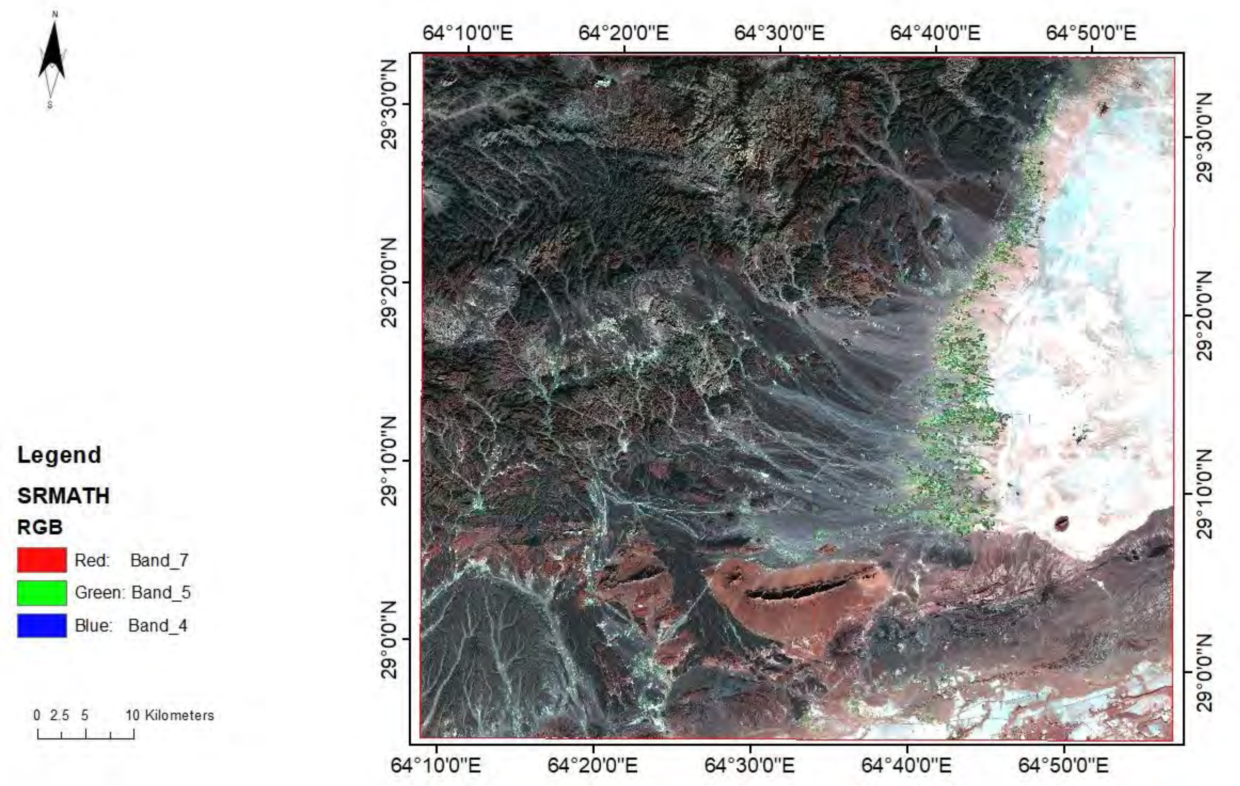


Figure (5.3)

5.3. Lineament mapping

5.3.1. What is lineaments

Lineaments are simply linear or curvilinear edges that may be related to:

1)-Geological structures:

-Faults

-joints

-line weaknesses.

2)-Tonal contrast:

-Vegetations

-Soil Moisture

-Rock Compositions

3) Human Activities:

-Road constructions

-Tracks

- Biuldings

-Mining e.t.c

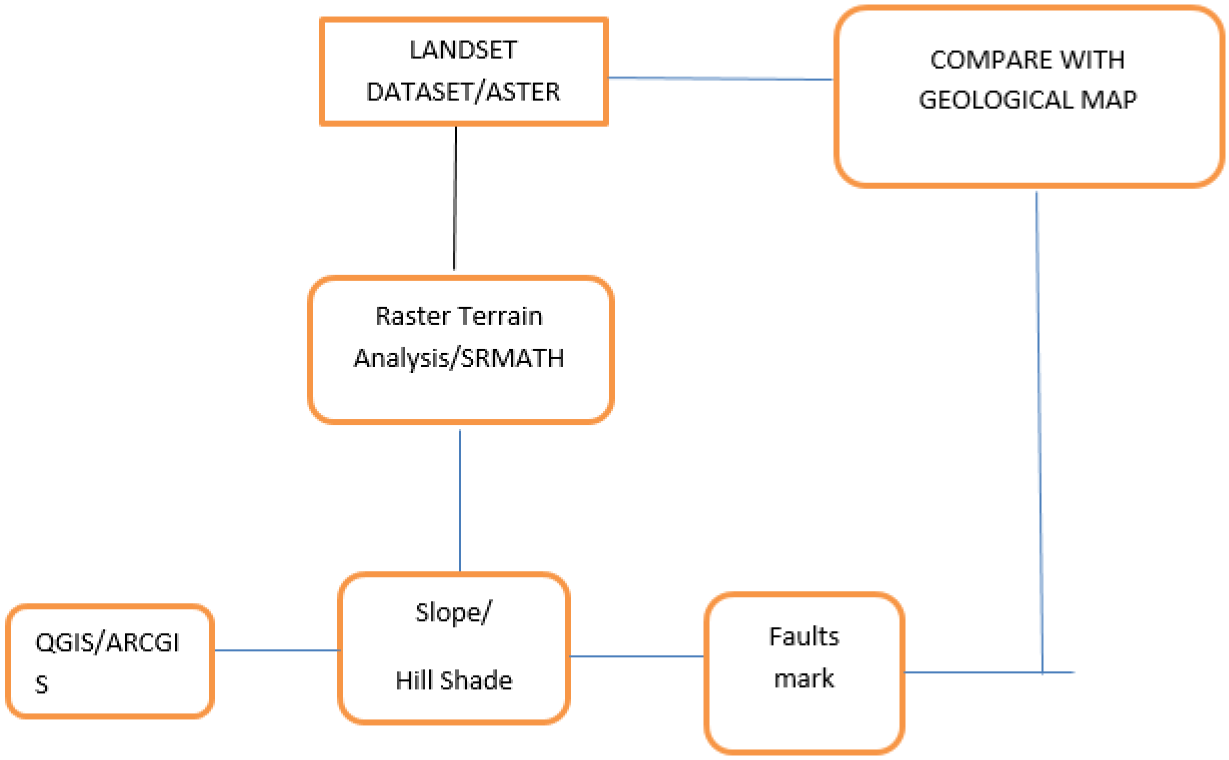
5.3.2. Types of Lineament Mapping

1-Manual Extraction of ineaments.(ALSO USED DEM(SRTM) DATASET).

2-Automatic Extraction of lineaments.

3-Multiband Analysis also used for Extraction of lineaments.

1-Manual Extraction of Lineaments



2-Automatic Extractions

We can use pc1 Geomatica software for this purpose.if we can use that Technique . The most important factor for using Geometica is the ability to extract lineaments from raster images automatically with the LINE option. After we compare with geological map .so that's why its most helpful.

3-Multi band Analysis Extraction of lineaments

In this technique we can used PCS (principal component Analysis) bands, may be its Band 1,2,3. .7.e.t.c.Here we used Multiband Analysis Extraction of lineament,

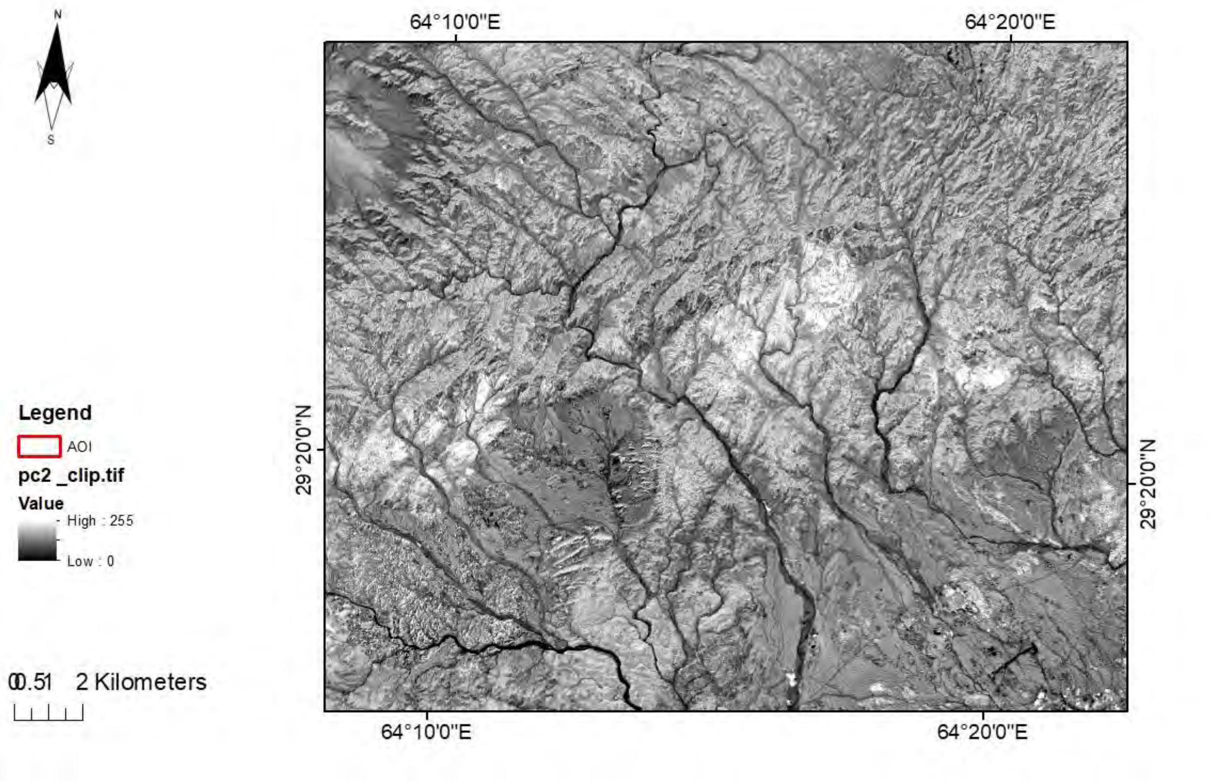


Figure (5.4)

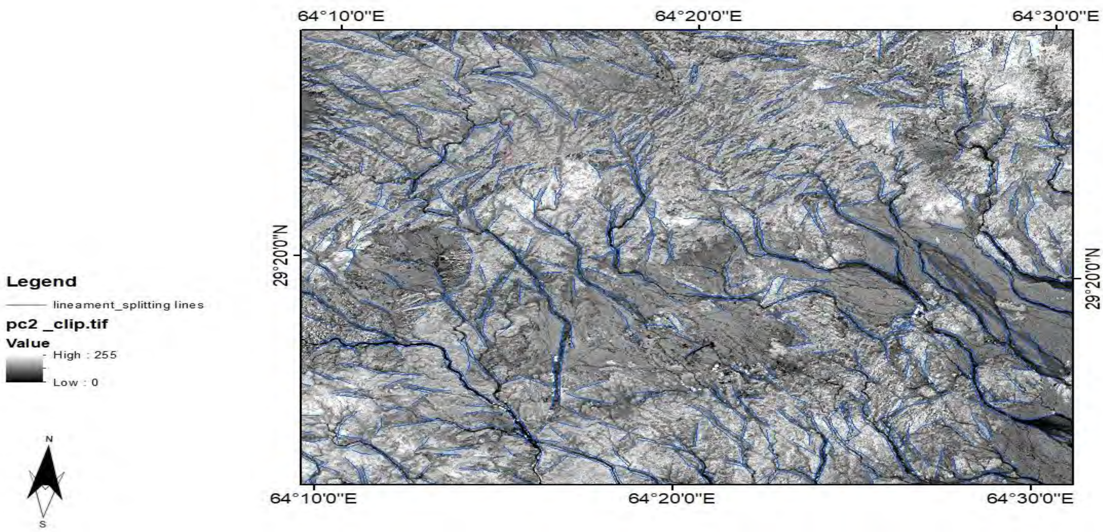


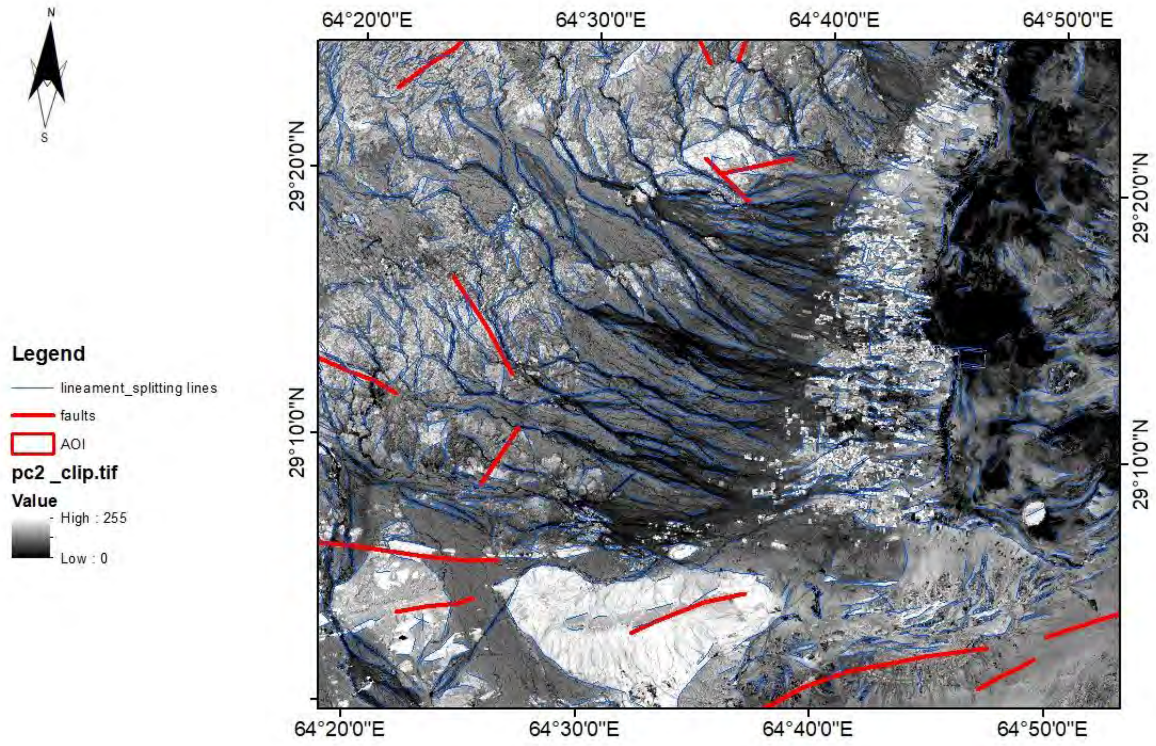
Figure (5.5)

Calculate geometry

X1	Y1	X2	Y2
616185	3200145	616485	3199335
678855	3201885	676635	3201735
671835	3201495	671055	3201465
671055	3201465	670845	3201465
670845	3201465	668445	3201315
656985	3202365	656685	3202185
656685	3202185	656265	3201465
656115	3202755	656985	3202365
653055	3202185	653505	3202155
653505	3202155	654075	3202335
658725	3201915	659115	3202185
659115	3202185	659385	3202365
659385	3202365	659685	3202425
689745	3202395	687045	3202275
687045	3202275	686955	3202245
686955	3202245	686145	3202305
686145	3202305	685935	3202245
685935	3202245	685485	3202305
685485	3202305	685125	3202185
685125	3202185	682065	3202005
654135	3202665	653625	3202605
653625	3202605	653145	3202425
653145	3202425	652155	3201675
635175	3202335	634815	3201915
634815	3201915	633945	3201315
633945	3201315	633105	3200925
624405	3202365	624405	3201795
624405	3201795	624195	3201285
643395	3202455	643575	3201885

Now compare with GSP PROVIDED FAULTS OF THAT AREA:

In figure (5.6) we compare faults with lineament mapping , there is similar between both of them .blue color lineaments splitting lines shows a faults, joint (if present in study area) and fracture points .on the other hand we have faults in red color lines, which is provided by GSP.

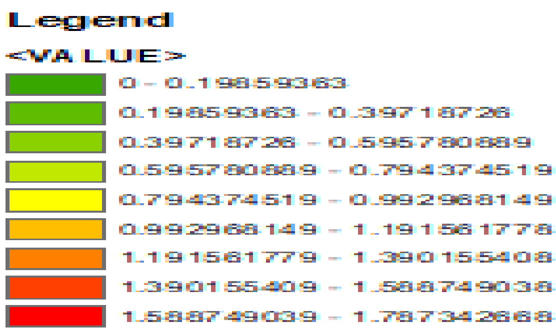


Fault Extraction using Satellite Imagery

Figure(5.6)

5.3.3 Density lineament Map

lineament Density maps ; we calculating density around each grid cells



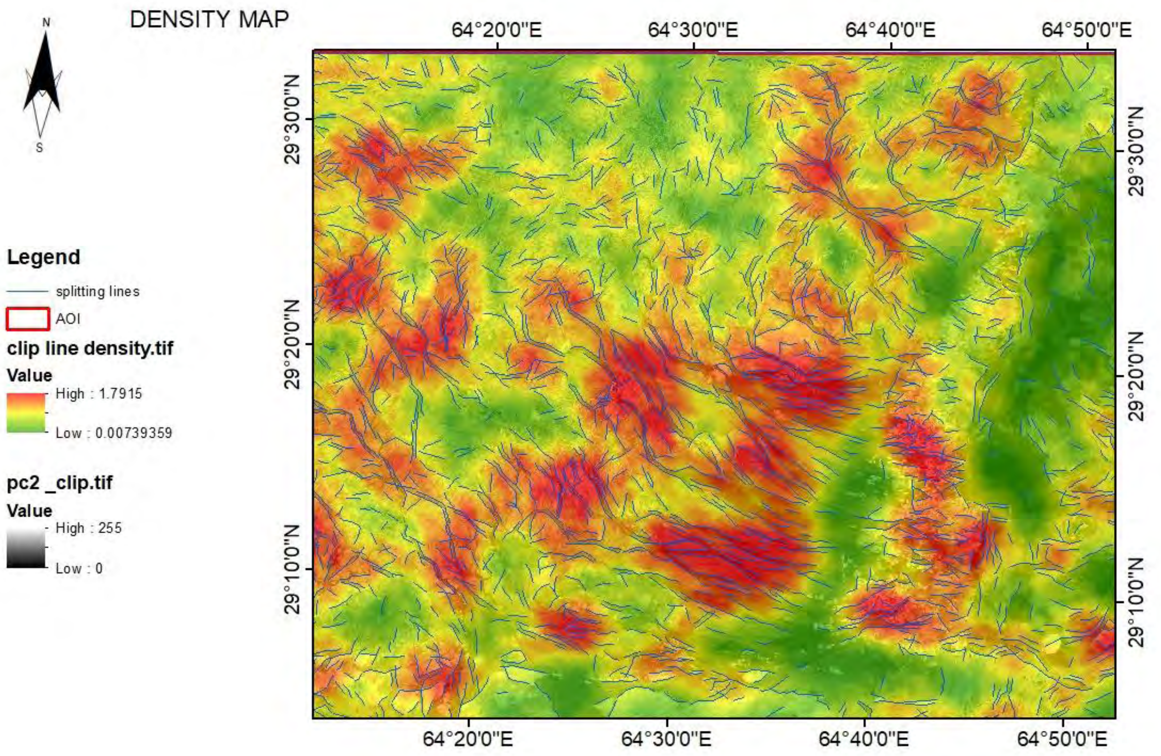


Figure (5.7)

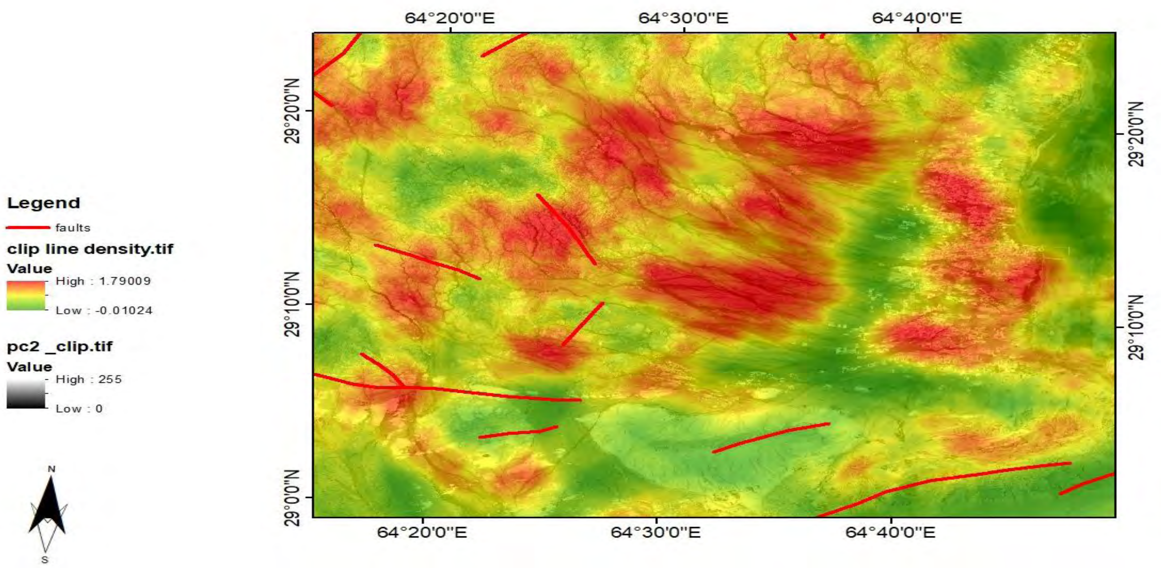


Figure (5.8)

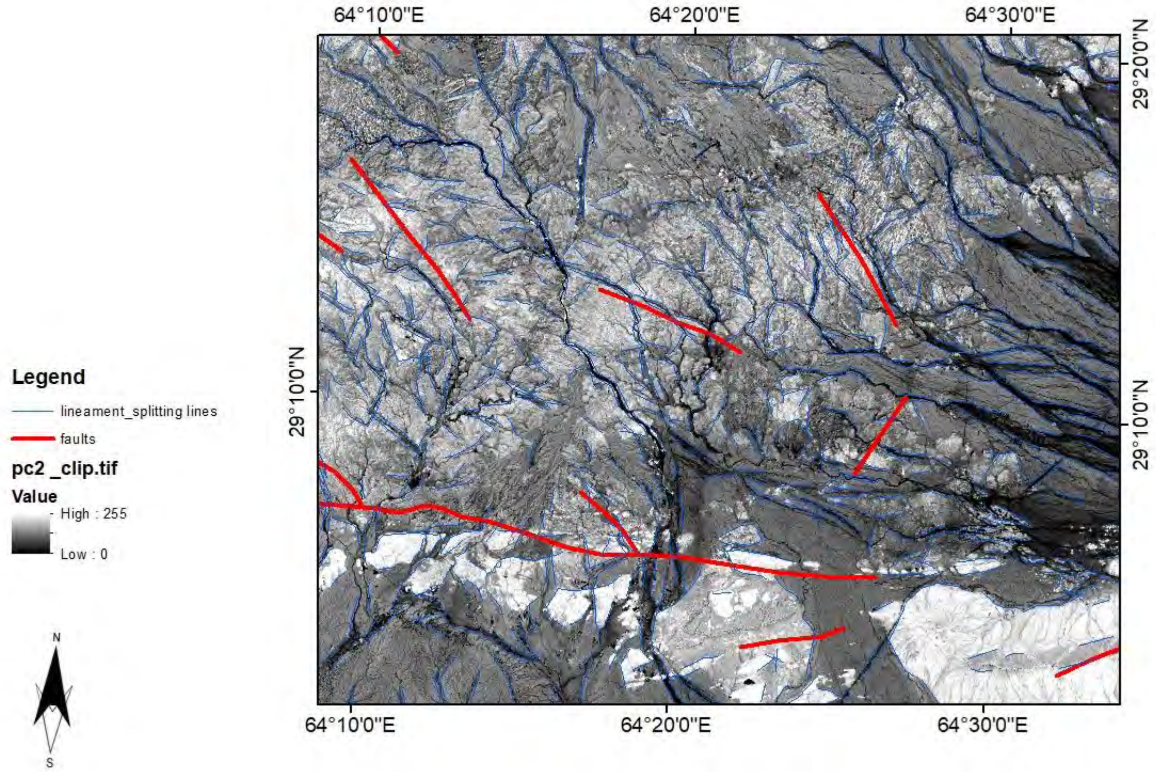


Figure (5.9)

5.4 Faults

5.4.1. Faults

Fault is any surface or zone in the earth across which measurable slip developed. Faults are fractures on which slip develops primarily by brittle deformation processes.

1-Fault splays

Displacement in fault zones involve formation and slip on many small, sub-parallel Brittle faults, fault diverge (called fault splays).

2-listric faults

Faults that have a steep dip close to the Earths surface and have a Shallow dip at depth are called Listric faults, occur because of plastic behavior of rocks at depth.

<u>Shallow Dipping faulting:</u>

Fault with dip between 30 to 60 degree.

3-Vertical faults:

Faults that have a dip of about 90 degree, if fault dip is closest to 80-90 degree than its called Sub vertical faults.

-During fault separation, the vertical component of separation called **throw.**

-A Horizental component during separation called **Heave.**

4-Reverse fault:

If the hanging wall moves up relative to the footwall, the faults are called Reverse faults.

5-Normal fault:

If the hanging wall moves down relative to footwall, the faults are called Normal faults.

Master faults: A faults with major dip.

5.4.2. Recognition of faults:

1-Abrupt change in Topography.

suppose you are travelling on a highway and suddenly encounters an abrupt change in elevation (i.e mountain in front) ,a question hint your mind, You are actually facing Fault scrap.

2-Abrupt change in stream course.

When a stream encounters a fault. It change its direction of flow due to topographic fluctuations.

Example: river indus faces Salt rang thrust from S to SW.

3-Repetition of Stratigraphic Sequences.

If we find repetition of strata in a region, we can conclude that there is thrusting of strata, which is due to faulting in area.

CHAPTER 6

3D MODELS OF CHAGAI

6.1. SRTM DATA SET

The Shuttle Radar Topography Mission (SRTM) was Launched on February (11-22-2000).

Projection	Geographic
Horizontal Datum	WGS84
Vertical Datum	EGM96 (Earth Gravitational Model 1996)
Vertical Units	Meters
Spatial Resolution	1 arc-second for global coverage (~30 meters) 3 arc-seconds for global coverage (~90 meters)
Raster Size	1 degree tiles
C-band Wavelength	5.6 cm

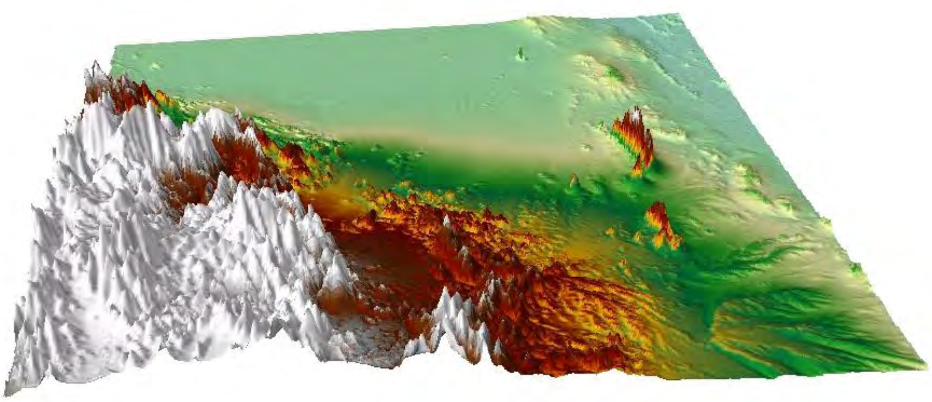


Figure (6.1)

By using SRTM (DEM 30 m) to create 3D model of CHAGAI BALOCHISTAN. In this image you clearly see the rocks of study area by using Raster terrain Analysis to create 3d modles.

Slope: The maximum rate of change in value from that cell to its neighbors. Basically, the maximum change in elevation over the distance between the cell and its eight neighbors identifies the steepest downhill descent from the cell.

1	1	1	1	1	1
1	3	3	2	1	
1	1	3	2	2	2
1	2	2	2	2	2
1	1	1	2	2	2
1	1	1	1	1	2

=

19.5	38.3	41.5	29.2	10.0	0.0
26.6	38.3	32.5	41.5	29.2	
21.6	43.6	21.6	26.6	14.0	10.0
14.0	29.2	29.2	14.0	0.0	0.0
10.0	21.6	29.2	29.2	21.6	10.0
0.0	0.0	10.0	21.6	29.2	14.0

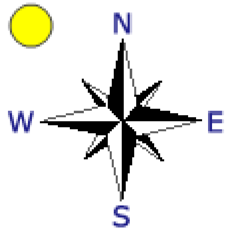
Hillshade: It Creates a shaded relief from a surface raster by considering the illumination source angle and shadows.

Parameters:

Azimuth:

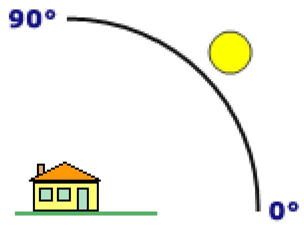
The azimuth is the angular direction of the sun, measured from north in clockwise degrees from

0 to 360.



Altitude:

The altitude is the slope or angle of the illumination source above the horizon.



Curvature: Curvature is the second derivative of the surface, or the slope-of-the-slope.

z-factor: The z-factor is a conversion factor that adjusts the units of measure for the vertical (or elevation) units when they are different from the horizontal coordinate (x,y) units of the input surface. It is the number of ground x,y units in one surface z-unit. Here we see the results of DEM, Hill-shade, Curvature and slope.

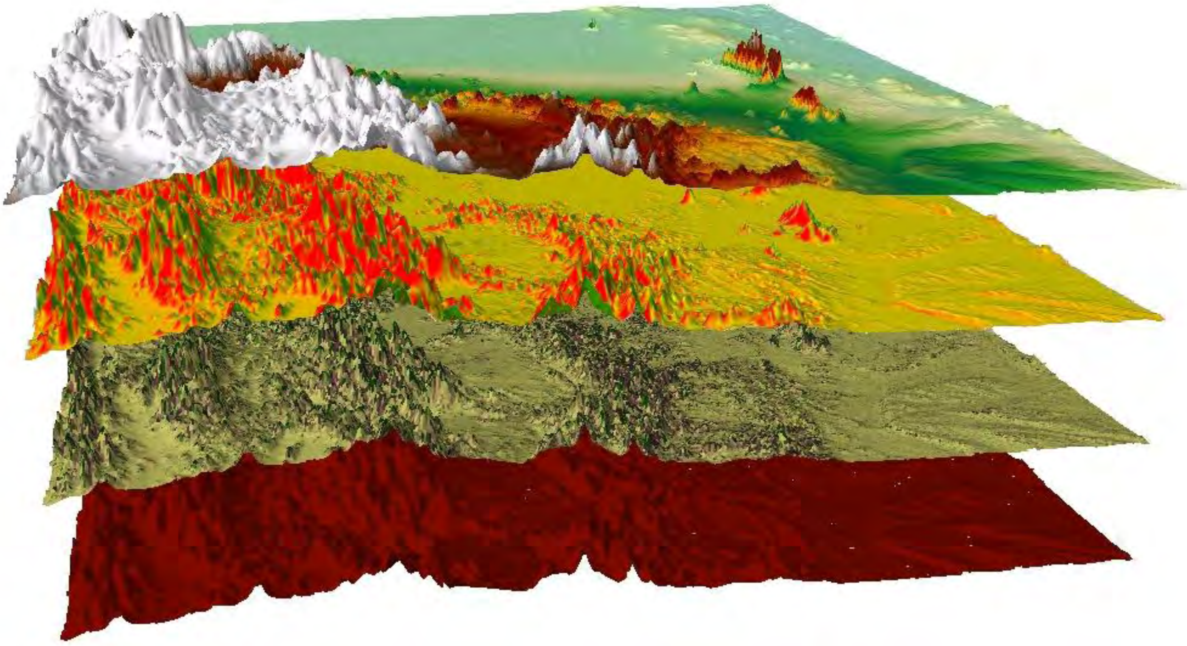


Figure (6.2)

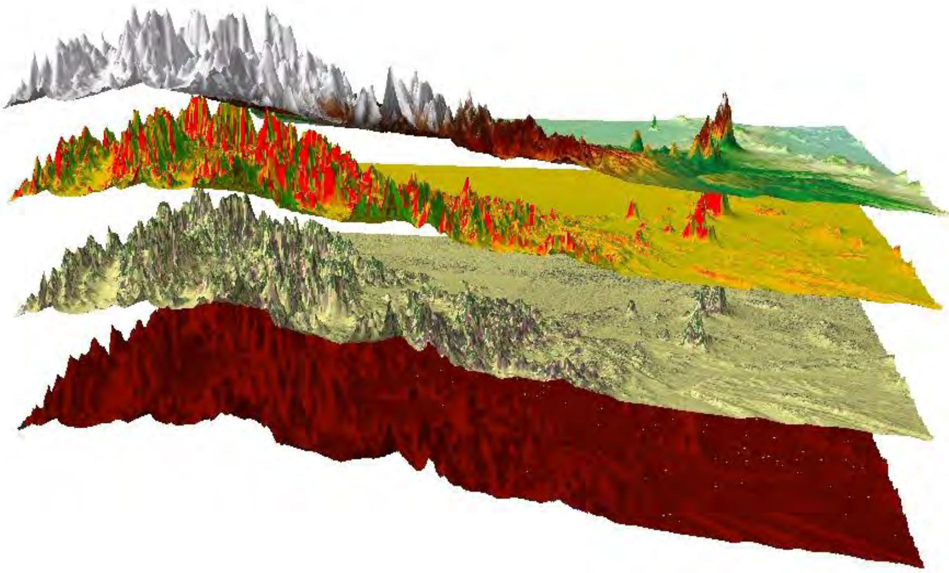


Figure (6.3)

Raster Terrain Anaylsis

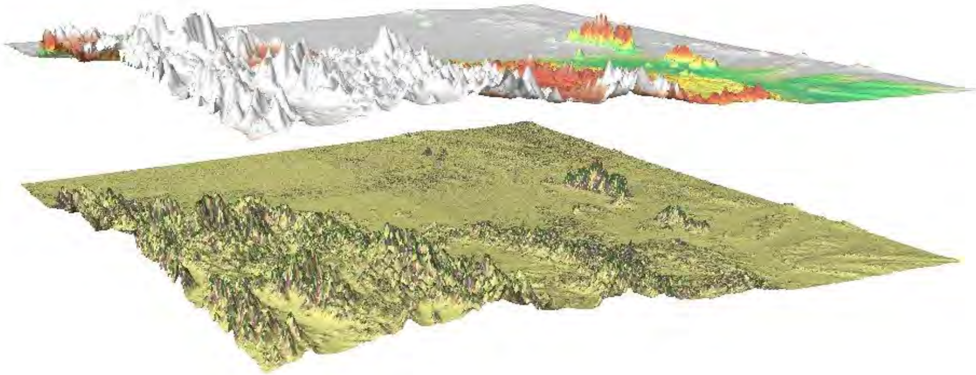


Figure (6.4)

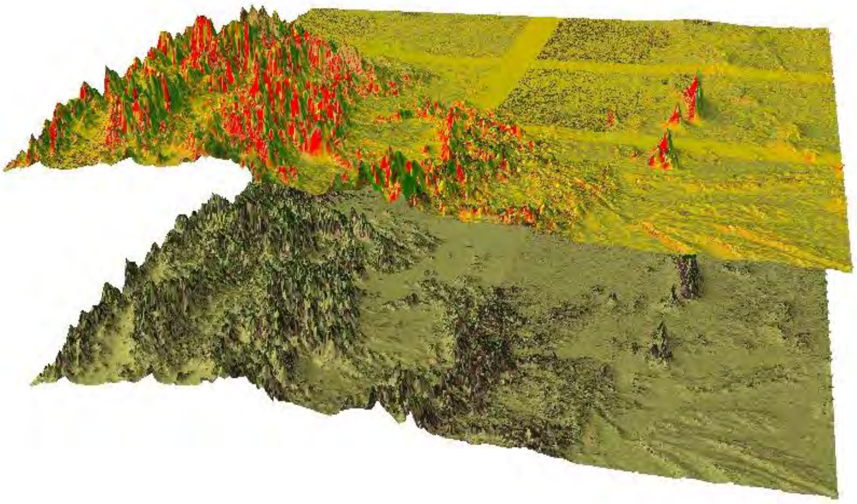


Figure (6.5) Hill shade and curvature.

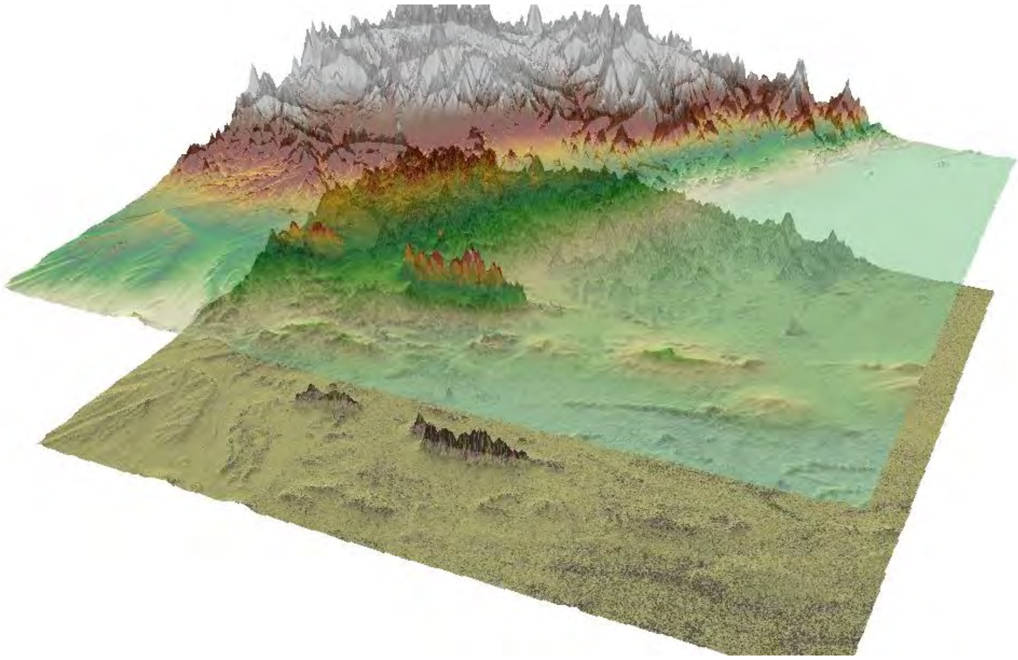
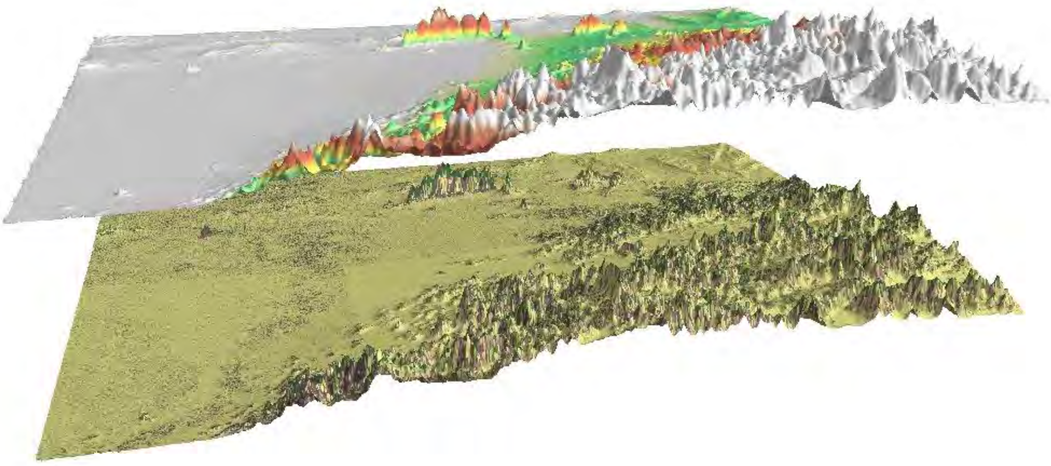


Figure (6.6)

Dem and curvature

1-Dem :Transparecny 50 %   and contrast 0 %,

2-curvature: Transparency 0 % and contrast 0 %



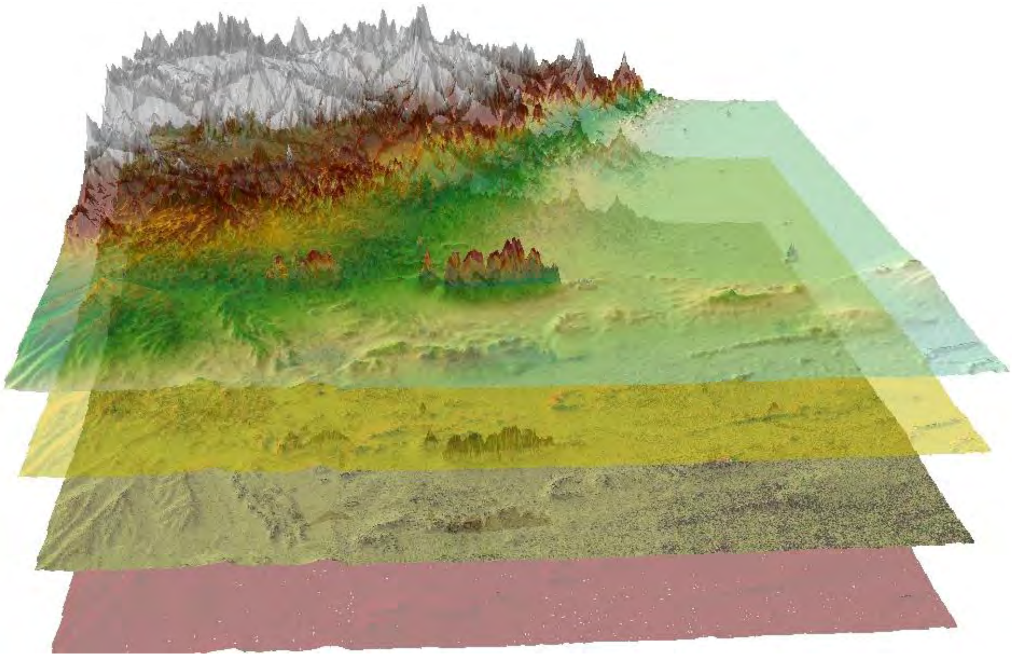
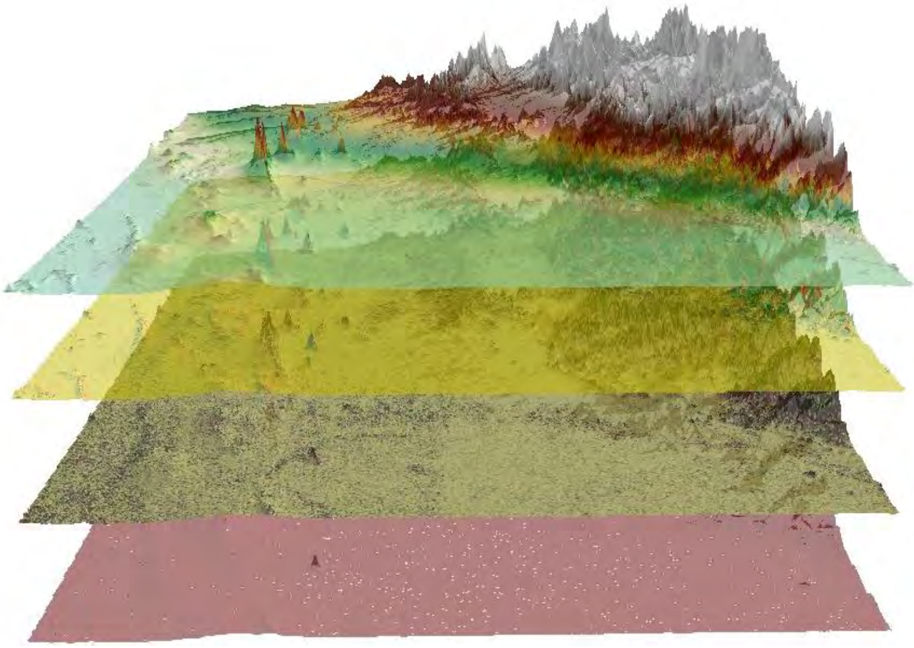


Figure (6.7)

Transparency 50 % and contrast 8 %.



6.2. Conclusion

Spatial data processing, analysis and integration using remote sensing and GIS applications were useful in updating the lithological map of the study area. During the processes of image interpretation, geological map was used as a base map to extract information on major lithologic units. Multispectral image enhancement and interpretations were important in identifying and delineating lithological units in the study area.

The research helped to update the Litho map by using different remote sensing techniques like principal component analysis, forward minimum noise fraction, band ratioing and image classification. Visible near infrared and short -wave infrared bands were used collectively.

6.2.1. RECOMMENDATIONS

NOTE: We corelate Remote sensing and GIS with Geophysics.

If we have Well data of any area , than we used Geo- Statistical Analysis (IDW interpolation) inverse distance weighted interpolation, and Surface trend Analysis to create a Structure maps. To make a GIS Based Structural contour maps on top of each formation (Eocene, Jurassic etc) these GIS based maps Are very effective to have a subsurface look in those areas where no seismic data is available.

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