Sindh Univ. Res. Jour. (Sci. Ser.) Vol. 50 (003) 385-392 (2018)

http://doi.org/10.26692/sujo/2018.09.0064

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Lithological Mapping of Sedimentary Rocks in Southern Laki Range, Lower Indus Basin Using Satellite Remote Sensing Data

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Received 21st October 2017 and Revised 15th September 2018

Abstract: Lithological mapping of rocks by using Landsat7 Images is carried out in Thano Bula Khan area in southern Indus Basin. The area is mainly composed of various sedimentary rocks of various formations are well exposed in Thano Bula Khan area. The areas composed of the exposed different geologically formations include Dada Conglomerate, Manchar Fm, Gaj Fm, Nari Fm, Tiyon Fm and Laki Fm. To process data, we used band rationing technique such as false color composite band ratio for identifying lithological features of the study area. Our processed data revealed the exposed formations of sedimentary rocks in the study area. The Landsat7 Satellite imagery is proved to be very useful in discriminating the lithology of various formations of the selected area. The data band ratio pairs (5/7, 5/4, 3/1) as well as RGB composite images (4/5, 5/7, 7/5) and (5/7, 3/1, 4/3) played an important role in discriminating different formations of sedimentary rocks in the area. The method using ratios of color band is significant approach for the study of different types of rocks as well as for the identification of minerals.

Keywords: Satellite Remote Sensing, Thano Bula Khan, Sedimentary Rocks

1. INTRODUCTION

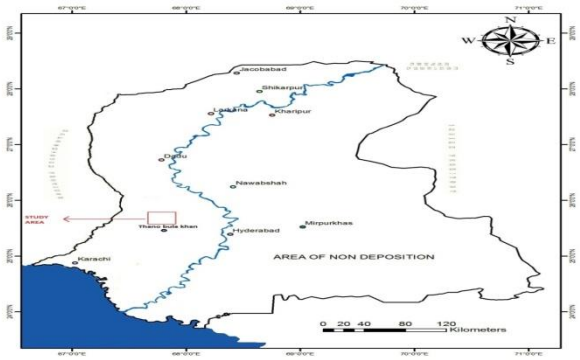
Geological mapping takes place across the field, that is, moving, but technological things have gone away for other useful methods that made things possible among customary geological mapping. Satellite imagery is widely used for the study of geological aspects. For example; study of structural styles, lithological sequences, age of formations, transportation pattern of sediments, type of soil, etc. (Drury, 1993). This method if used in combination with field mapping, the study will be more significant.(Landsat-5) is used to quantify basaltic outcrops Moore et al. (2007). Furthermore; remote sensing is now intensely used in mineral exploration, lithological discrimination, soil composition, and surface deposition. Geological exploration and mapping of hydrothermal alteration areas used through frequently remote sensing data, i.e Landsat maping and ASTER (Sommer and Buckingham 1983, Hunt and Drury 1989, Kaufmann 1988, Carranza and Hale 1999, Crosta and Filho 2003, Warner and Farmer 2008, Assiri et al., 2008,). Geologically analysis some waves are very useful in remote sensing are NIR (infrared), MIR (medium infrared) and SWIR (short-wave infrared). For instance, band 5 and band 7 has been more efficient in specifying the distinct types of rocks and hydrothermal modification in the hydrothermal alteration data Landsat (Crosta and Moore 1989, Drury 1993, Carrier et al., Crosta, Moore et al., 2007 and Filho 2002-2003,). The objective of the current research is to carry out geological mapping of Thano Bula Khan Area using Lansat7 satellite images and also testify the ability of remote sensing techniques to different rock types. The specific objectives include applications of different combinations of band ratio pairs (5/7, 5/4, 3/1) as well as RGB composite images (4/5, 5/7, 7/5) and (5/7, 3/1, 4/3) in discriminating sedimentary rocks of different lithology.

2. STUDY AREA

The preferred field is located in Sindh district; the area is located in South most Laki range. However, the geology of Thano Bula Khan area was first mapped and described by Blanford in (1876). The area can be easily contacted by the main road led by Motorway M9. The area for the study purpose is suitable in November to March around the calendar year. The study area lies on Topo sheet No 35 O/15 prepared by GSP, Pakistan, within 25° 19' 08" to 25° 21' 39" N and Longitude 67° 51' 30" to 67° 56' 56" (Fig. 1). Distinctive rocks of lithological units have the common existence of mega- and microfossils. Age of formation at places in rock unit in study area assigned by hunting survey of Pakistan 1960. On the base of an abundance of fossils and sometimes they grow coquina.

3. GEOLOGICAL SETTING

Tectonically Pakistan is located lithosphere plates,



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the Indian, Arabian, and Eurasian plates (Kazmi and Jan, 1997). Indus Basin is settled lying on the northwest edge of Indian plate. After separating Indian plate starting African plate during Jurassic geologically time started drifting in Cretaceous and moves to the northeast direction and collided with Eurasian plates in Paleocene to early Eocene. The prototype Alpine-Himalayan orogeny considered (Powell, 1979) determined continent to the continent collision, obduction, and thrusting. Pakistan consists of two sedimentary basin Indus and Baluchistan basin. These basins separated a major fracture zone i.e axial belt the total area cover an about 828000 km2 (shah 1977). Indus basin further divided upper middle and lower Indus basin. The study area arise in lower Indus basin.

4, DATA SET

The area of Thano Bula Khan is mostly composed of sedimentary rocks i.e. Limestone, sandstone, shale and clay etc. in the study area exposed formations are Laki Fm of Early Eocene age, Tiyon Fm of Middle Eocene age, Nari Fm of Oligocene age, Gaj Fm of Miocene age, Manchar Fm of Upper Miocene age and Dada Conglomerate of Pleistocene age. The area is chiefly formed of detrital and non-detrital rocks modifying from Early Eocene age to Pleistocene age. The limestone is a major component rock at study area, which signifies the non-detrital type of origin while shale and sandstone belong to detrital sediments. in the study area, the formation steeply dipping is nearby (40° - 45°) to eastern flank and gently dipping (5° - 8°) western flank. The strike is in the northeast direction.

Investigate example for an aforementioned study is Sub-view of passage 154 Row 45 Landsat 7 imagery acquired on 01 May 2003. The software utilized in the review is (Exiles Visualize Information Solution) ENVI 4.7.

A. Data Used for the Study:

- Landsat 7 TM (NIR), (MIR), (SWIR)
- Geological Map

Landsat data use for the purpose of lithological mapping of study area. Initially Landsat data was managed by NASA, later on, responsibility for the management of Landsat program was transfer to NOAA in 1983. In 1985, the program became commercialized, then data was provided to civilian researchers and university students also. The reason of success in Landsat's data used for significant geological studies is due to the number of factors for examples the arrangement of sensors with spectral bands modified to earth scrutiny, useful for spatial resolution and good areal coverage. Every Landsat satellites are positioned in near-polar, sun-synchronous orbits. The first three satellites (Landsats 1-3) are at altitudes of approximately 900 km and the re-observation period is 18 days. Then satellites are at more or less 700 km and have revisit periods of 16 days. In the early days of Landsat, Multispectral Scanner (MSS) and later the Thematic Mapper (TM) were introduced. The functions MSS and TM are to collect the data over a swath width of 185 km, with a full scene as 185 km x 185 km of area. Spectral Resolution, Thematic Mapper and their some useful applications are given in **(Table 1).**

Tab1e 1: Description of Bands of Landsat 7

TM Bands		
BANDS	**Wavelength array (µm)**	**Application**
BAND1	0.45 - 0.52 (blue)	Band number 1 is helpful in soil/flora favoritism; bathymetry/coastal mapping; cultural/urban feature detection
BAND2	0.52 - 0.60 (green)	Band number 2 represents green vegetation mapping (measures reflectance peak); cultural/urban feature identification
BAND3	0.63 - 0.69 (red)	Band number 3 helps to investigate vegetated vs. non-vegetated and plant species discrimination (plant chlorophyll absorption); cultural/urban feature identification
BAND4	0.76 - 0.90 (near IR)	Band number 4 is helpful in identification of plant/vegetation types, health, and biomass content; water body delineation; soil moisture
BAND5	1.55 - 1.75 (short wave IR)	Band number 5 is very sensitive to identify the moisture in soil and vegetation; discriminating snow and cloud-covered areas
BAND6	10.4 - 12.5 (thermal IR)	Band number 6 is capable for vegetation stress and soil moisture discrimination related to thermal radiation; thermal mapping (urban, water)
BAND7	2.08 - 2.35 (short wave IR)	Band number 7 is used for the identification of moisture in soil or in plants.

5. METHODOLOGY

Landsat cloud free images were selected to ensure maximum spectral responses from the lithologies. The results from satellite data processing were then compared with published studies and Geological Survey of Pakistan (GSP). Image processing techniques including Band Ratios were applied for mapping different rock units present in the study area.

6. RESULTS AND DISCUSSION

The results obtained from spectral indices techniques were compared with the existing reports and maps of the study area. Laki formation, Tiyon formation, Bara formation, Lakhra formation and Manchhar formation constitutes the bulk composition of the area. The landsat7 Satellite images are proved to be very useful data in modeling the lithological variations of the given area. Imageries produced from Spectral Indices comprise for 30-bit DN values. In order to segregate desired lithological components from surrounding material a threshold value was given for each resultant imagery. These threshold values were computed statistically using standard deviation and mean values. Landsat 7 band 5/7, 5/4, $^{3}/_{1}$ were applied to discriminate the rocks such as Limestone, Sandstone and Shale in the study area. Whereas band 4/5, 5/7, 7/5 showed the major lithology of the study area. Landsat 7 band in RGB combination 5/7, 3/1, 4/3 discriminates the different rock types of the area.

7. BAND RATIO

Based on the spectral properties of rock types as described in **(Fig.2, 3 and 4).** different band ratios/combinations were generated to demarcate the lithology in the study area.

The Sedimentary rocks are well recognized in the RGB composite images whereby in composite 5/7, 5/4, 3/1 showing a comparable difference between rocks and other lithological material fig. 2. Further, in 5/7, 5/4, 3/1 image showing limestones are more significantly represented in green color. Similarly, sandstones are also identified as shown in Fig. 2 and in 5/7, 5/4, 3/1 the sandstone appear pink color. The Lakhra formation (mainly limestone) appears in gray tone with clear boundaries. The Gaj and Nari formations appear with mixing of Orange and Yellow colors.

The lithological map shows the major rock types of the study area in the RGB composite 4/5, /5/7, 7/5. The rock types highlighted in this image are Limestones, Sandstones, Clays, Shales and small amount of Conglomerates in varying colors. The limestone of Gaj formation appeared in light blue, Bara formation in pink, Lakhra formation in gray and Khirthar formation in bright yellow colors. The River Indus also appeared in black tone (Fig.3) the stream bed deposits are highlighted in blue color.

The Landsat band ratio in RGB 5/7, 3/1, 4/3 composite image discriminates the distinctive lithology in the study area. The different formations have been identified by the different color tones such as, Bara formation in green color appeared with clear boundary, Manchar formation in yellow color and Lakhra formation in gray color reflectance. Besides discriminating the major lithologies in the area the RGB 5/7, 3/1, 4/3 \composite image further discriminates the other geological features in different color tones i.e. Eolian sand as shown in upper-right corner of the image (Fig_4) in dark-green color. Eolian sand is mostly presents besides major rivers that left at the shore which bring by river its self; non-presence of this green color in rest of the image is authentic that this is deferent geologic feature from sedimentary structure. Unconsolidated surficial deposits in light blue and vegetation in dark-red color can be seen in **(Fig.4).**

According to Gupta, 1999 the ferric iron show pronounced absorption characteristics of about 0.82µm and 0.35 µm, whereas ferrous iron has 1.0, 4.8-2.0 and 0.55-0.45.H hydroxyl-bearing minerals like clays have a major absorption around 1.9,2.35 and 2.5. According to Segal, 1983; Kenea, 1994 ratios images are mostly used for the study and mapping of sedimentary zones.

Band ratio of TM data 5/7, 5/4, 3/1, 4/5, /5/7, 7/5 and 5/7, 3/1, 4/3 were selected for different sedimentary rocks such as Limestone (CaCO3), Sandstone, Shale, Clay and Conglomerate respectively **(Fig.2, 3 and 4).**

Spectral features of sedimentary rocks are used to produce a false color image by varying different combination of bands (5/7, 5/4, 3/1or Abrahm's ratio) in R, G and B respectively as shown in fig. 2. Another image was produced by using color bands 5/7, 3/1 and 4/3 in R,G and B respectively as shown in Fig. 4. This combination appears to be better from the previous one.

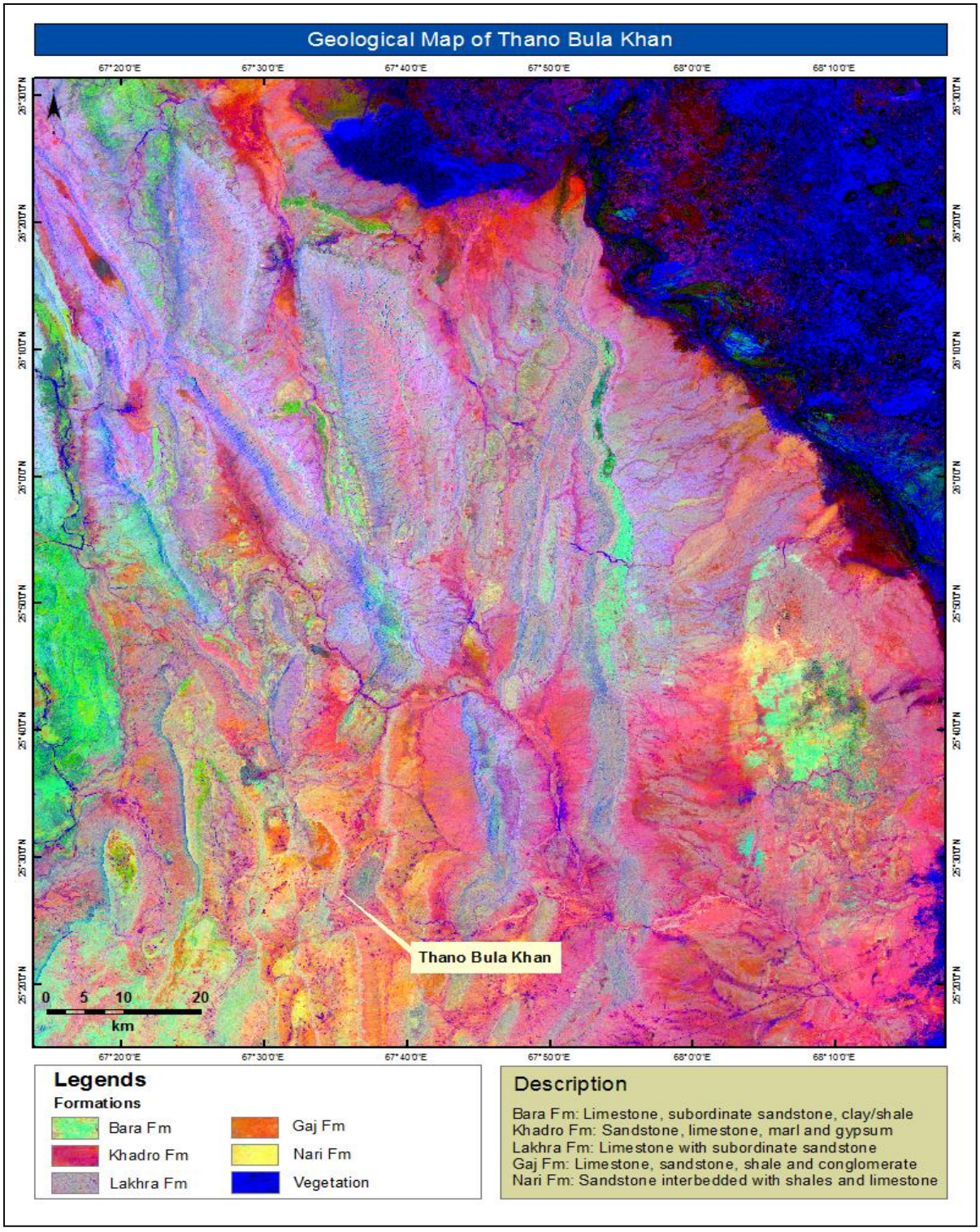

Fig 2: LANDSAT band ratio (5/7, 5/4, 3/1 or Abrahm's ratio) produced the most enhanced spectral discrimination of different rock types such as limestone, sandstone, shale and clay.

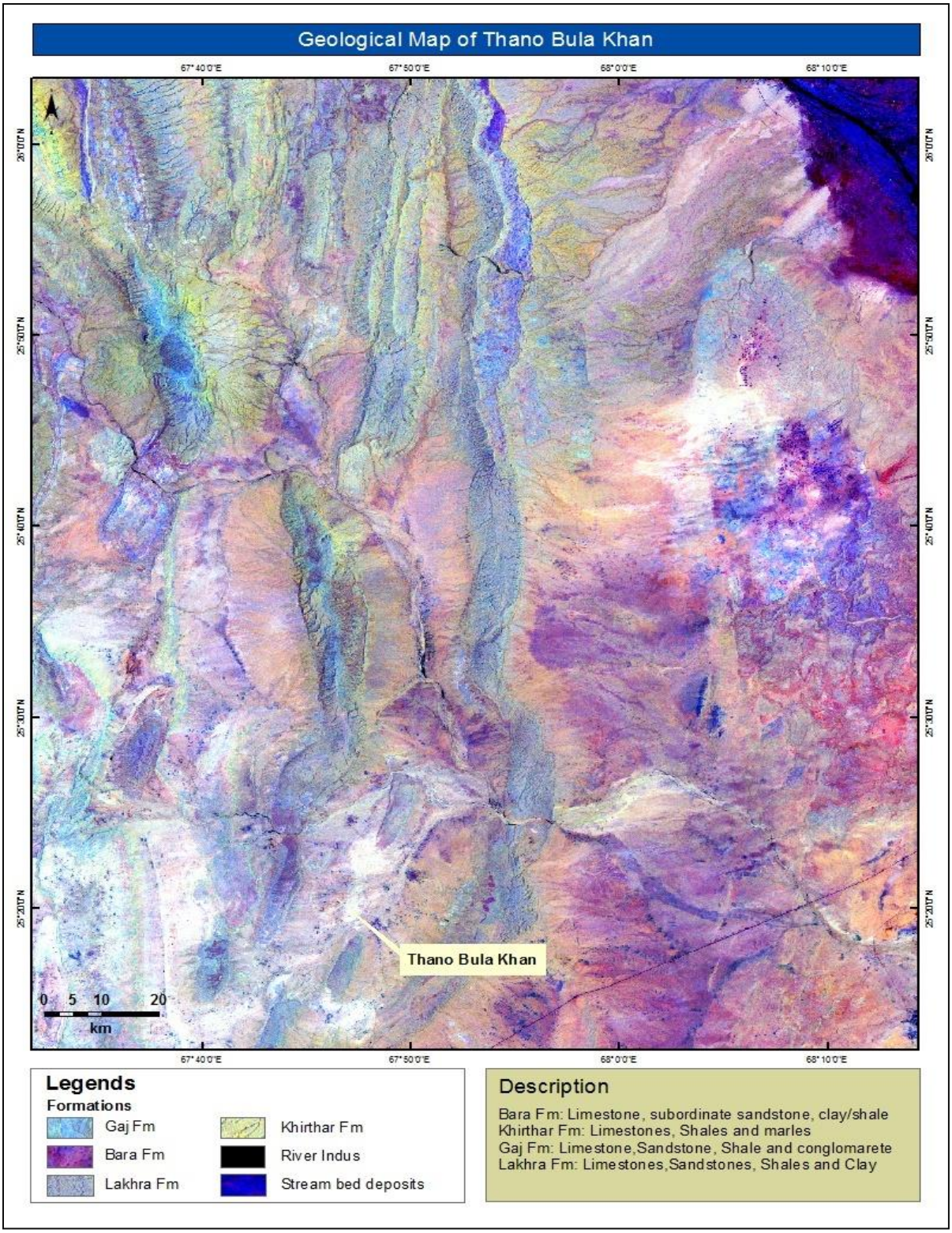

Fig 3: It is a lithological map which is resultant of LANDSAT band ratio (4/5, 5/7, 7/5or Krit Won-In ratio) that shows the major rock types present i.e. limestone, Sandstone and shale/clay.

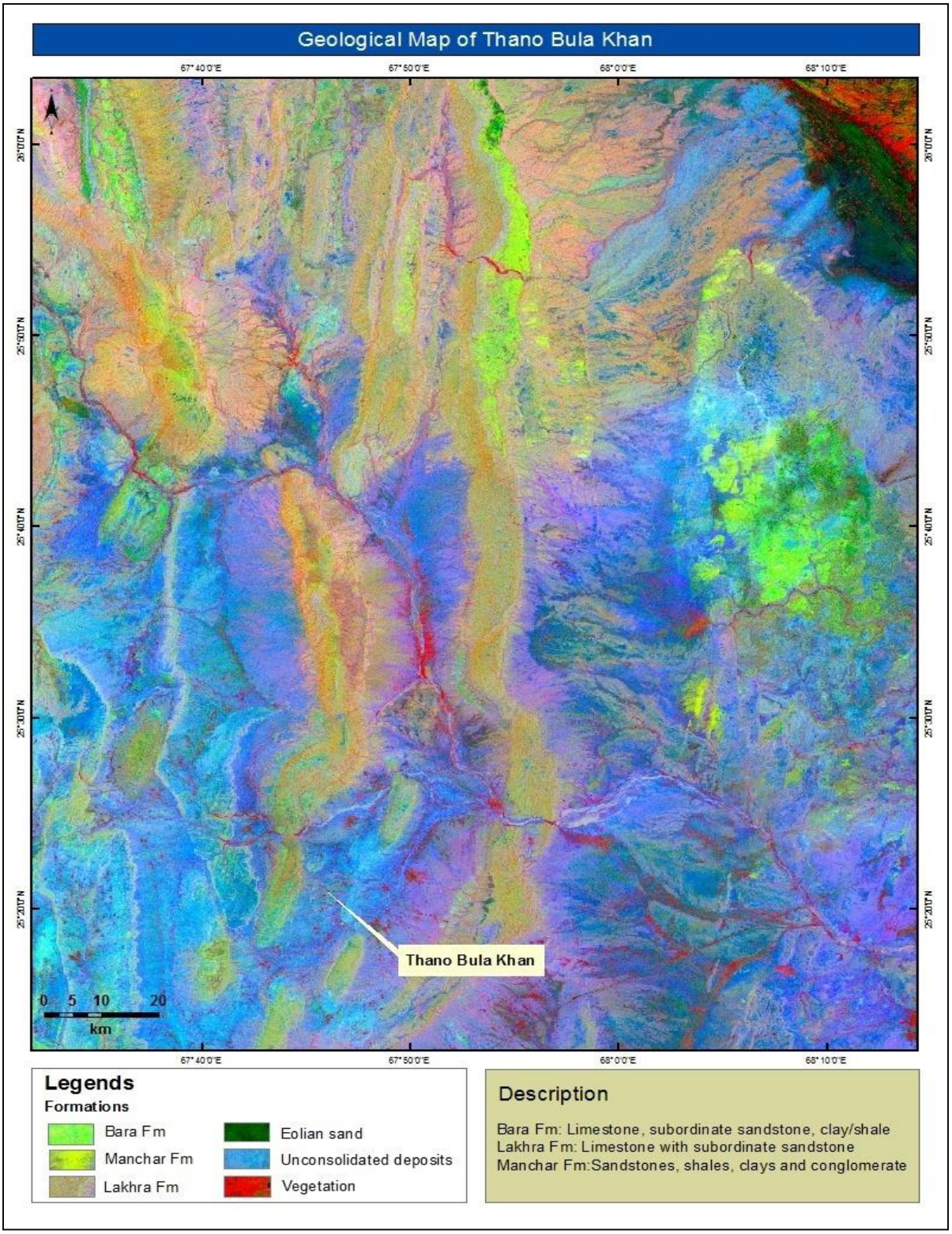

Fig 4: Landsat band ratio in RGB combination (5/7, 3/1, 4/3or Krit Won-In ratio) was successful in highlighting the different rock types in the study area.

8. CONCLUSIONS

Satellite remote sensing techniques proved to be useful in mapping rock types. Spectral Indices on LANDSAT dataset proves to be a valuable image processing technique for discriminating different rock types. Based on the analysis of results following conclusion can be made:

1. Sedimentary rocks can be discriminated using RGB composite images whereby in composite 5/7, 5/4, 3/1 image shows clear difference between various lithologies.

2. In 5/7, 5/4, 3/1 lithologies are more distinctively represented in green colors. Similar phenomenon happened on Sandstones and I 5/7, 5/4, 3/1 the Sandstone appear pink color. The Gaj and Nari formations appear with mixing of orange and yellow colors.

3. Lithological map shows the major rock types of the study area in the RGB composite 4/5, 5/7, 7/5. The River Indus appears in black tone whereas the stream bed deposits are highlighted in blue color.

4. The RGB 5/7, 3/1, 4/3 composite image further discriminates the other geological features in different color tones i.e. Eolian sand is seen as dark-green in color. Unconsolidated surficial deposits in light blue and vegetation in dark-red color can be seen.

5. Band ratio of TM data 5/7, 5/4, 3/1, 4/5, 5/7, 7/5 and 5/7, 3/1, 4/3 effectively differentiates various rocks such as Limestone, Sandstone, Shale, Clay and Conglomerate.

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