Mineral Exploration
Unit-3

Remote Sensing Based Mineral Targeting:

Mapping of Lithologically, Structurally and Geomorphologically Controlled Mineral Deposits Using Raw and Digitally Enhanced Data.

RS is largely used for mineral exploration, especially for

(i) Mapping regional lineaments,

(ii) Mapping local fracture patterns that may control individual ore deposits,

(iii) Detecting hydro-thermally altered rocks associated with ore deposits, and

(iv) Providing basic geologic data.

- Various digital image processing procedures were applied such as ratioing, PC analysis. Band Ratio: It is used mainly to suppress the topographic variations and the brightness variation related to the grain size variations.
- The ratio of ETM+ Band 3 to Band 1 (3/1) renders most of the area in rather dark gray or bright grey, which corresponds to zones of strong hematitic alteration.
- The Spectral response of the weathered iron minerals has weak reflectance in the blue region (band1) and strong reflectance in the red region (band 3), so the ratio 3/1, which has high values can be used for iron oxide.

- Absorption caused by kaolinite, montmorillonite and clay minerals results in low reflectance in band 7 and high reflectance in band 5. So, the ratio image 5/7 would have bright signatures for clay minerals. Unaltered rock in bands 5 and 7 are identical in brightness.

- Mapping of different rock type using remote sensing images have been carried out by different techniques one of which is band ratio method.
- In this technique, spectral information has been enhanced.
- Ratio of 3/1, 5/7 & 5/4 used for arid to semi-arid regions.
- These ratio generally are directly related to the presence of ferric iron (3/1), ferrous iron and hydroxyl bearing minerals (5/7)

- Material with high content of iron oxides have their maximum reflectance in band 3, thus in ratio of 3/1(red/blue) the ferruginous or iron –rich materials should have very bright signature.
- Band ratio 5/3 Reflected IR/Red) was selected due to its colour clearly distinguish most terrain type and geologic formations.
- Band ratio 7/5 has distinctive bright signatures associated with hydrothermally altered rocks.

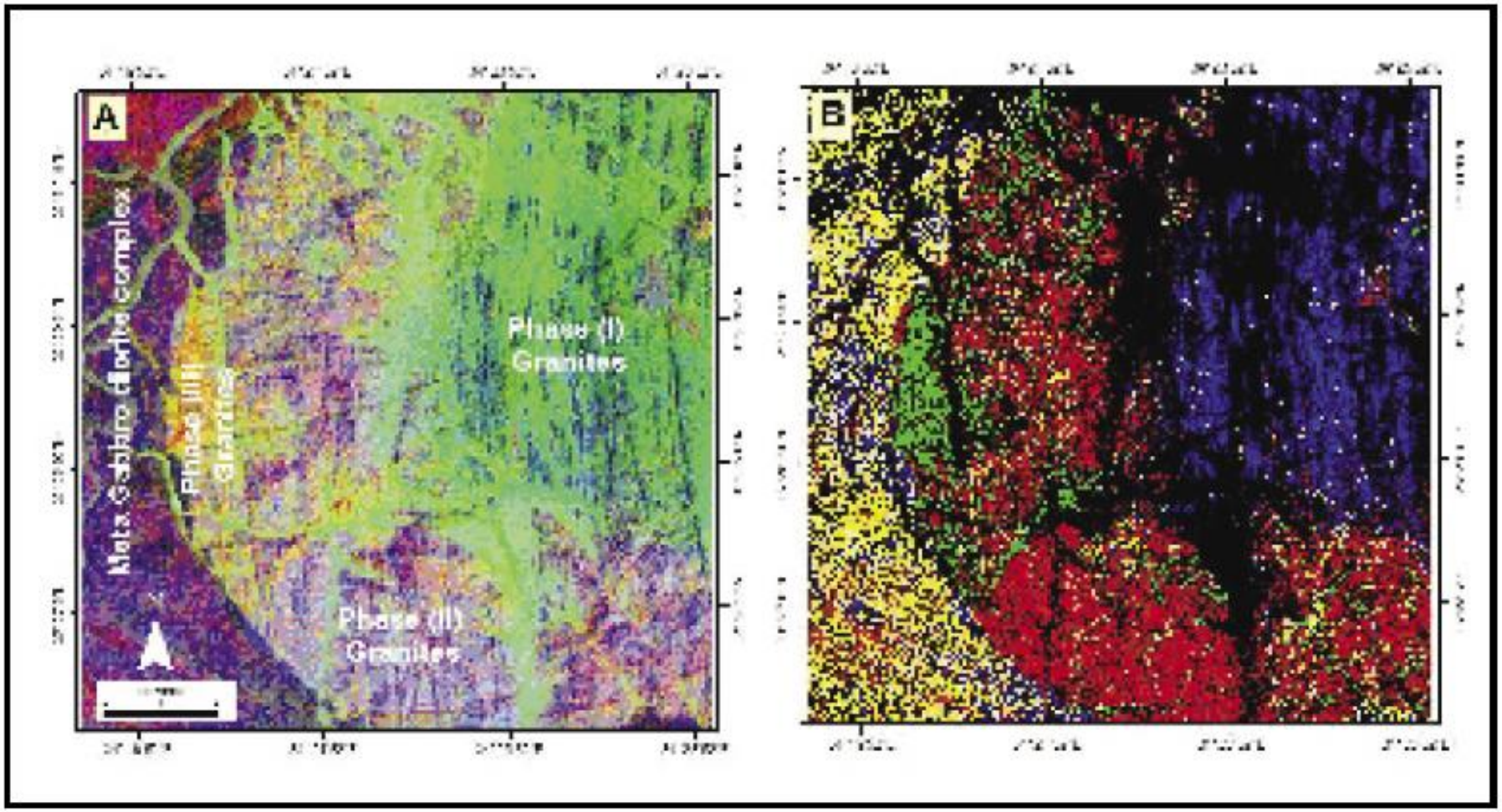


Figure 5: A) Band ratio image and B): Supervised classification for the band ratio image for Kadabora area showing Phase (I) Granites in blue; Phase (II) Granites in red, Phase (III) Granites in green; Metagabbro Diorite complex in yellow; and unclassified areas have black color.

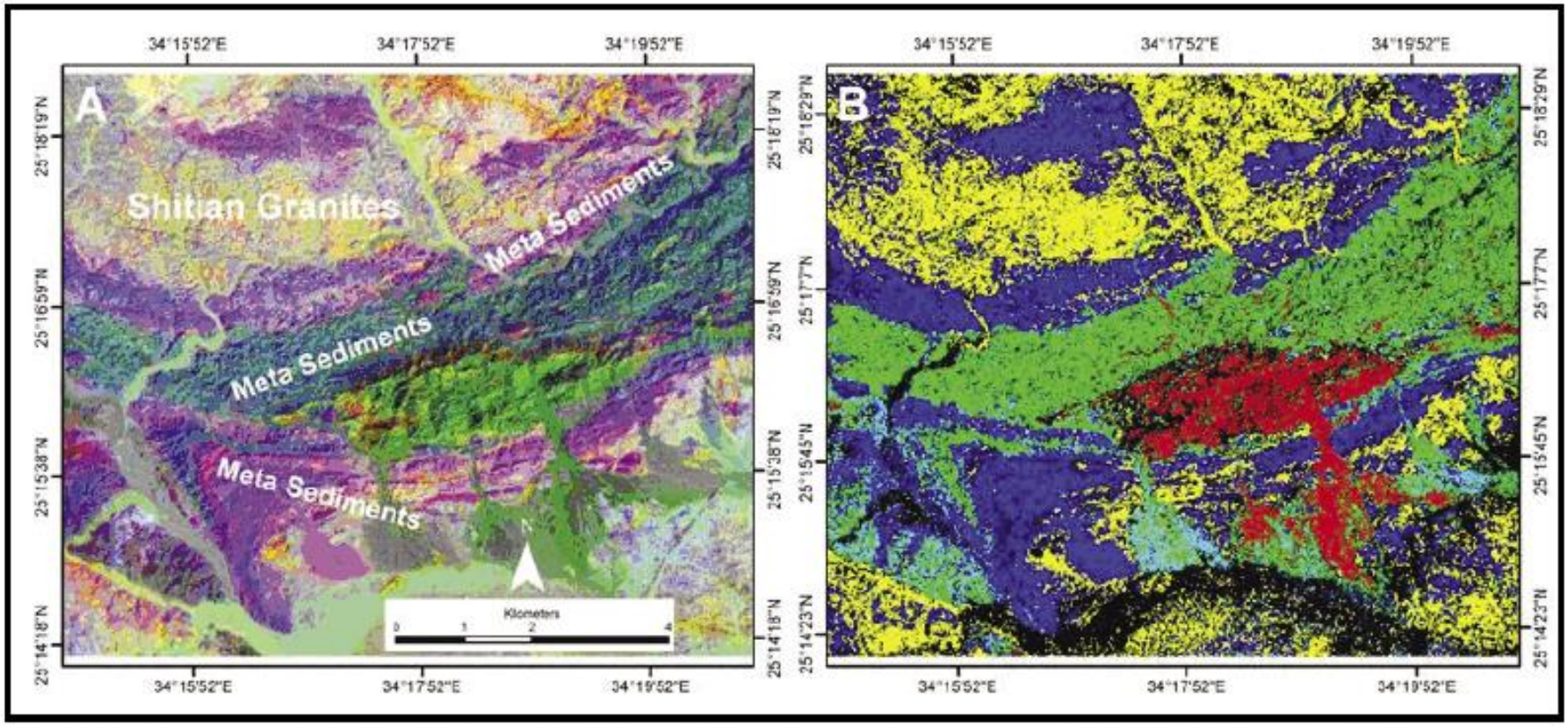
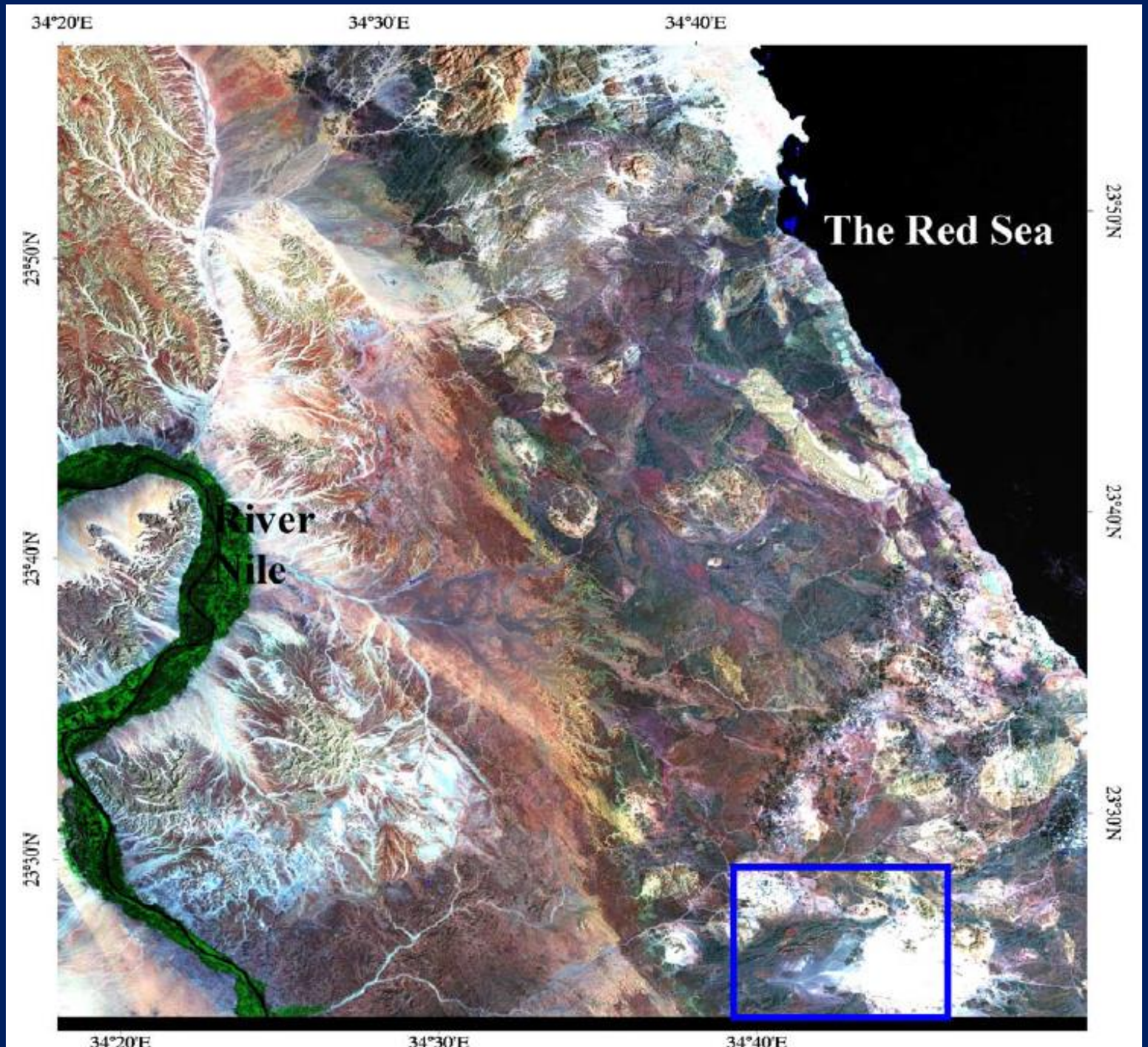


Figure 6: A) Band ratio image and previous geological map for Al Mayyit region. B) Supervised classification image showing that Serpentinites have a red color; metasediments with a green and blue color; Granites have a yellow color; and the unclassified areas have a black color.


34°20'E
34°30'E
34°40'E
23°50'N
23°40'N
23°30'N
The Red Sea
River
Nile

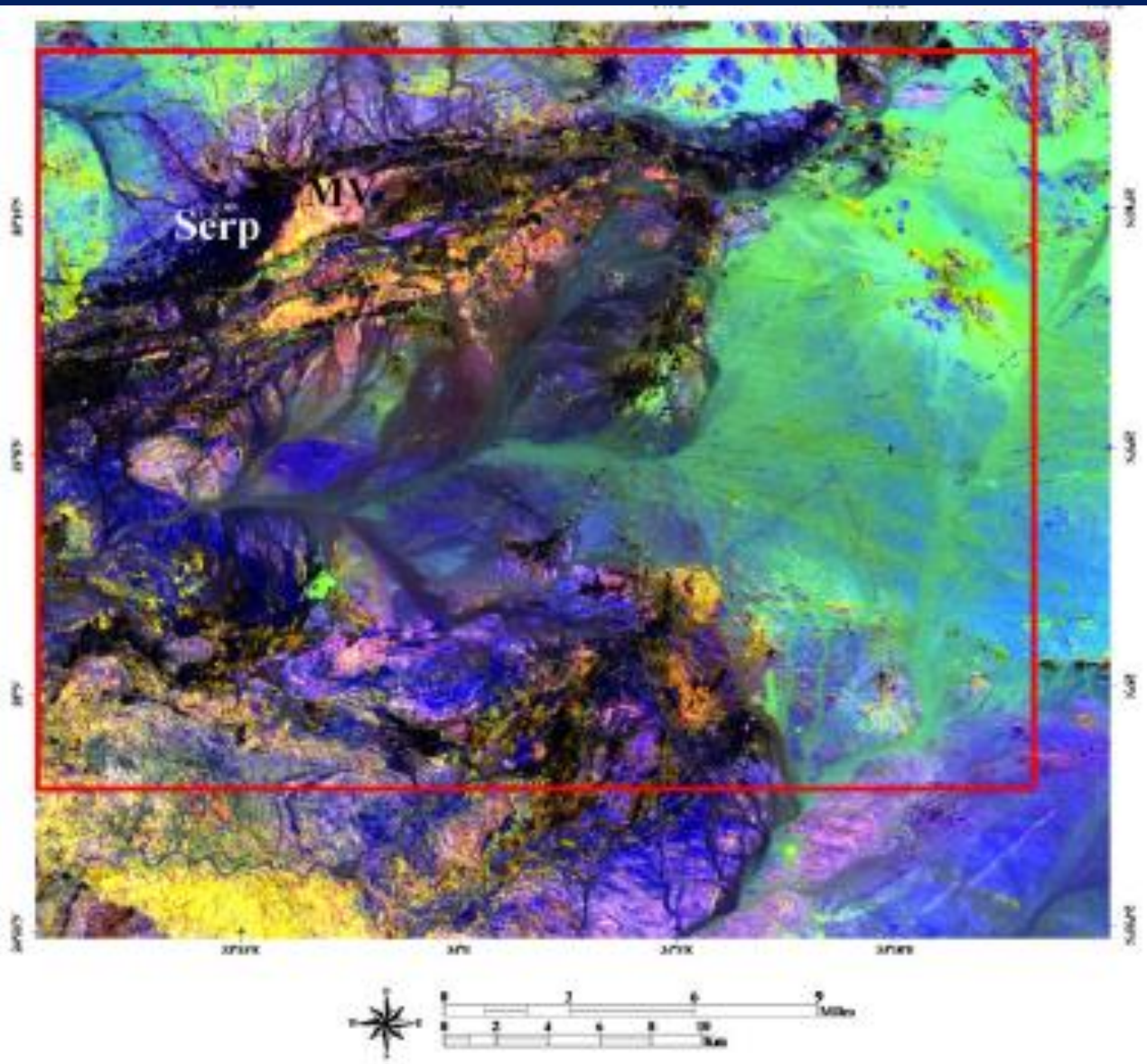


Fig. 4. Landsat TM RGB band ratio color image (5/3, 5/1, 7/5) for the study area. Serp: serpentinites and MV: metavolcanics.

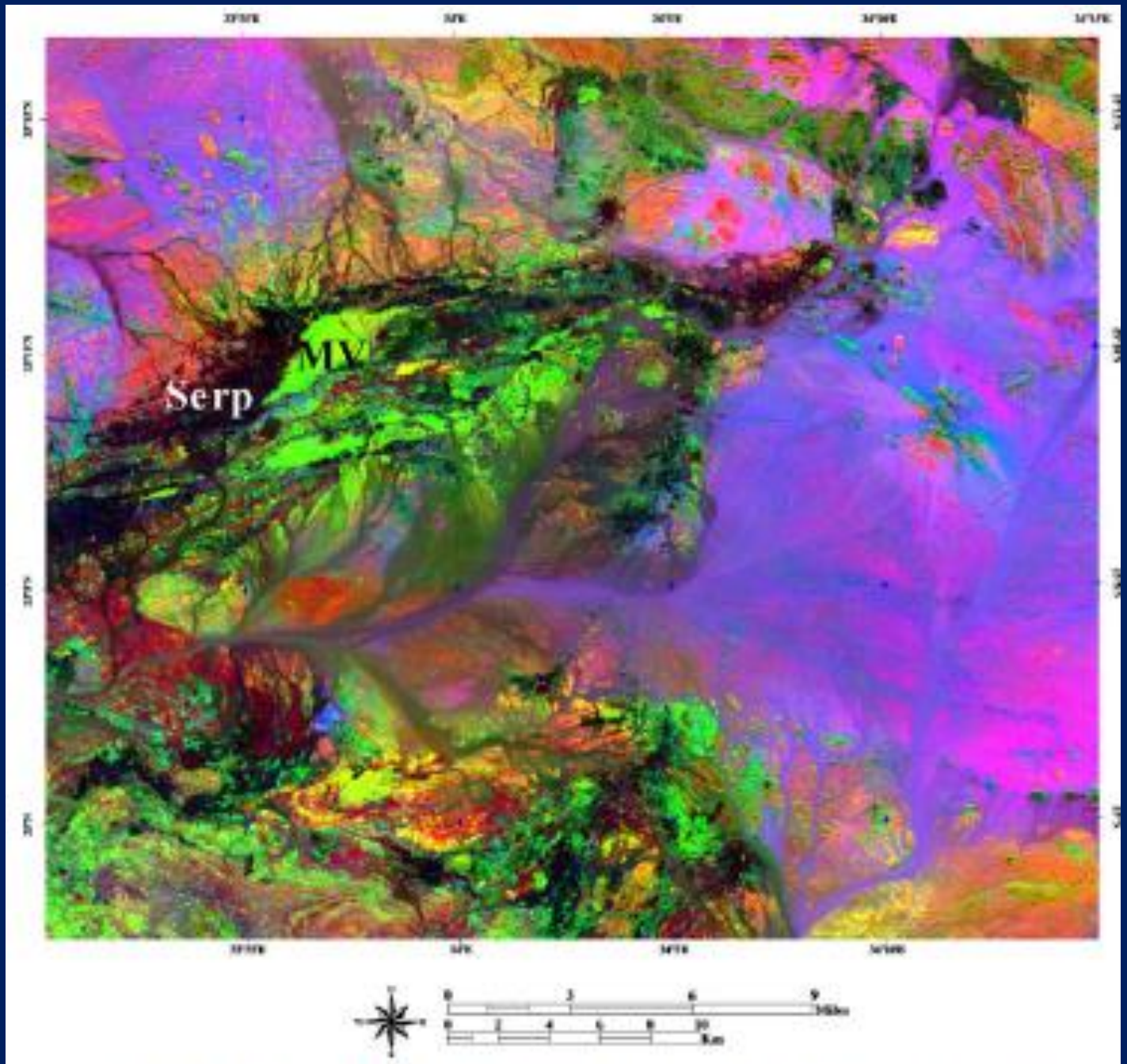
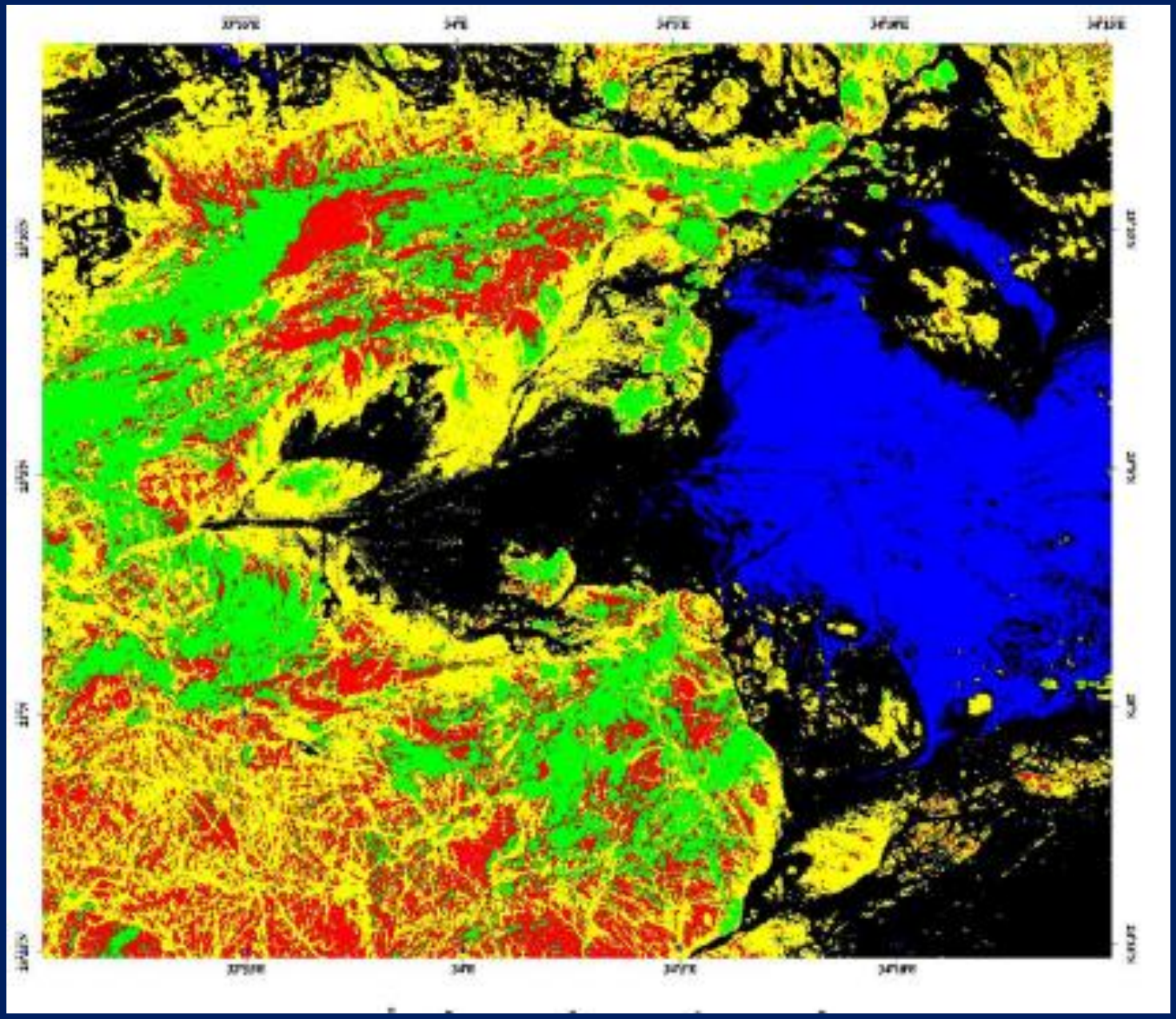
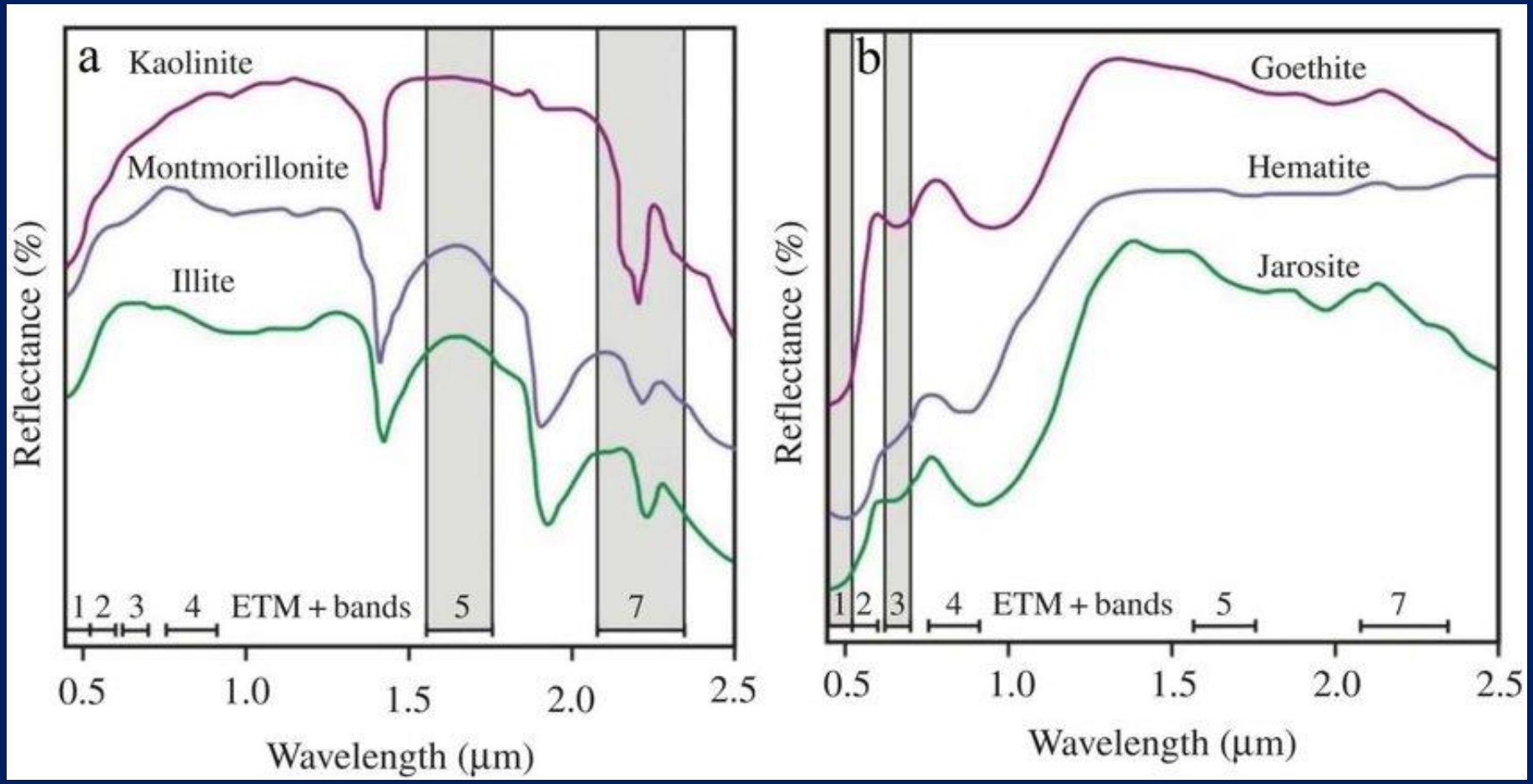


Fig. 5. Landsat TM RGB band ratio image (7/5, 5/4, 3/1) for the study area.

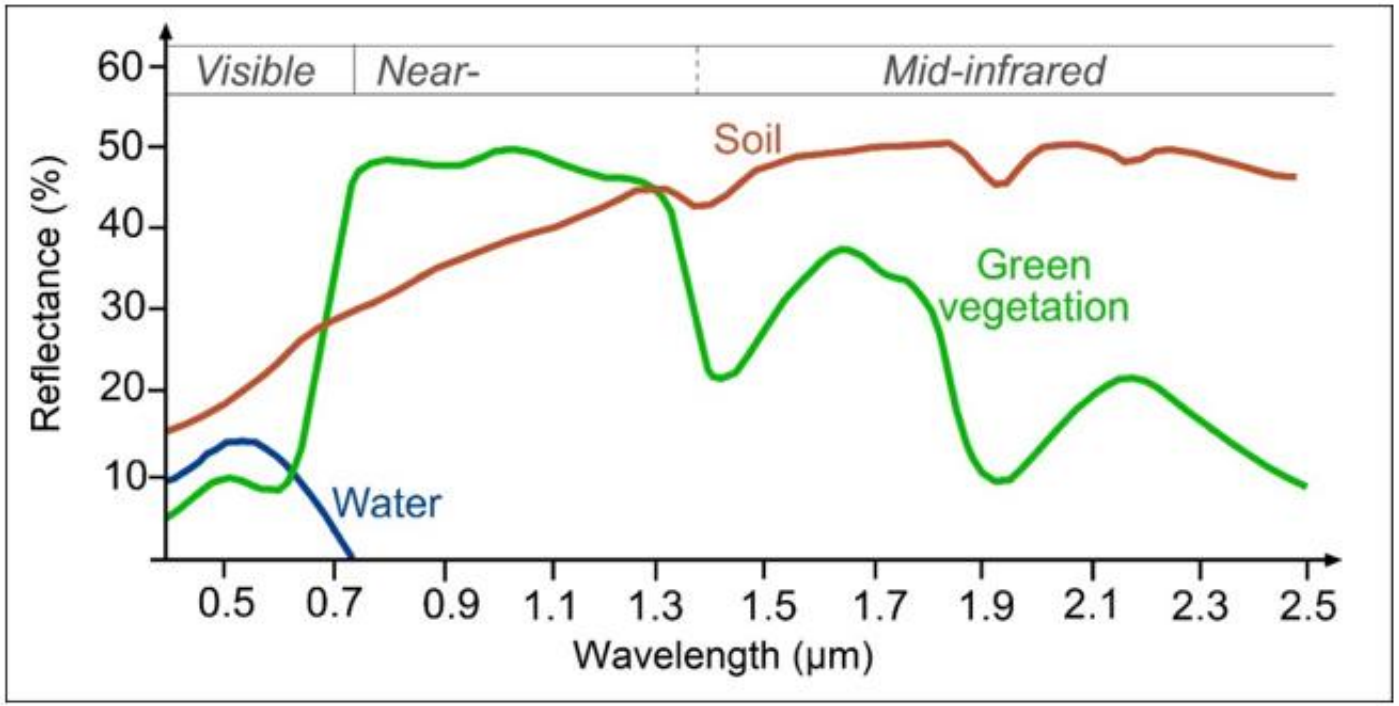


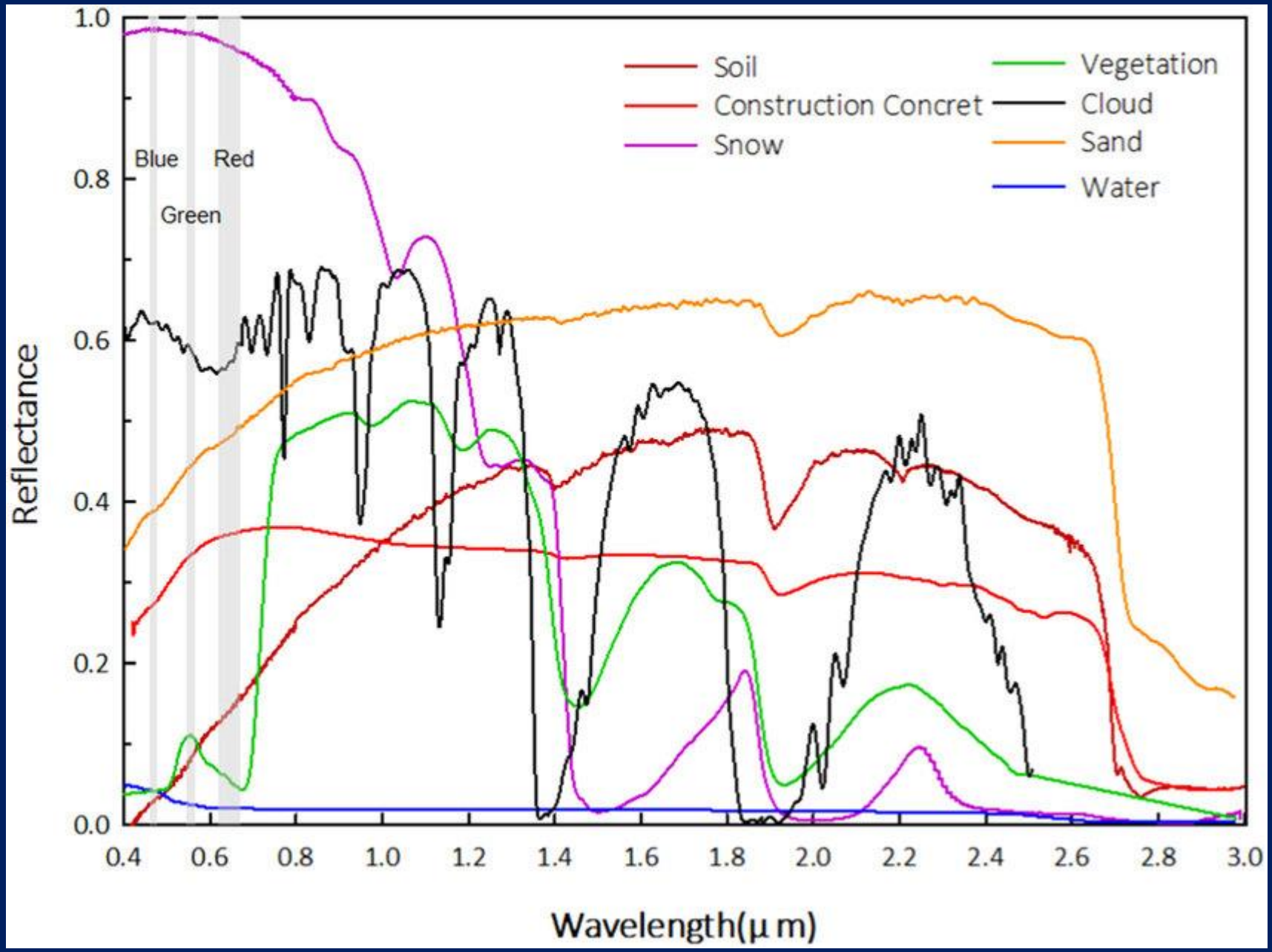

a
Kaolinite
Montmorillonite
Illite
Reflectance (%)
1 2 3 4 ETM + bands 5 7
0.5 1.0 1.5 2.0 2.5
Wavelength (μm)
b
Goethite
Hematite
Jarosite
Reflectance (%)
1 2 3 4 ETM + bands 5 7
0.5 1.0 1.5 2.0 2.5
Wavelength (μm)

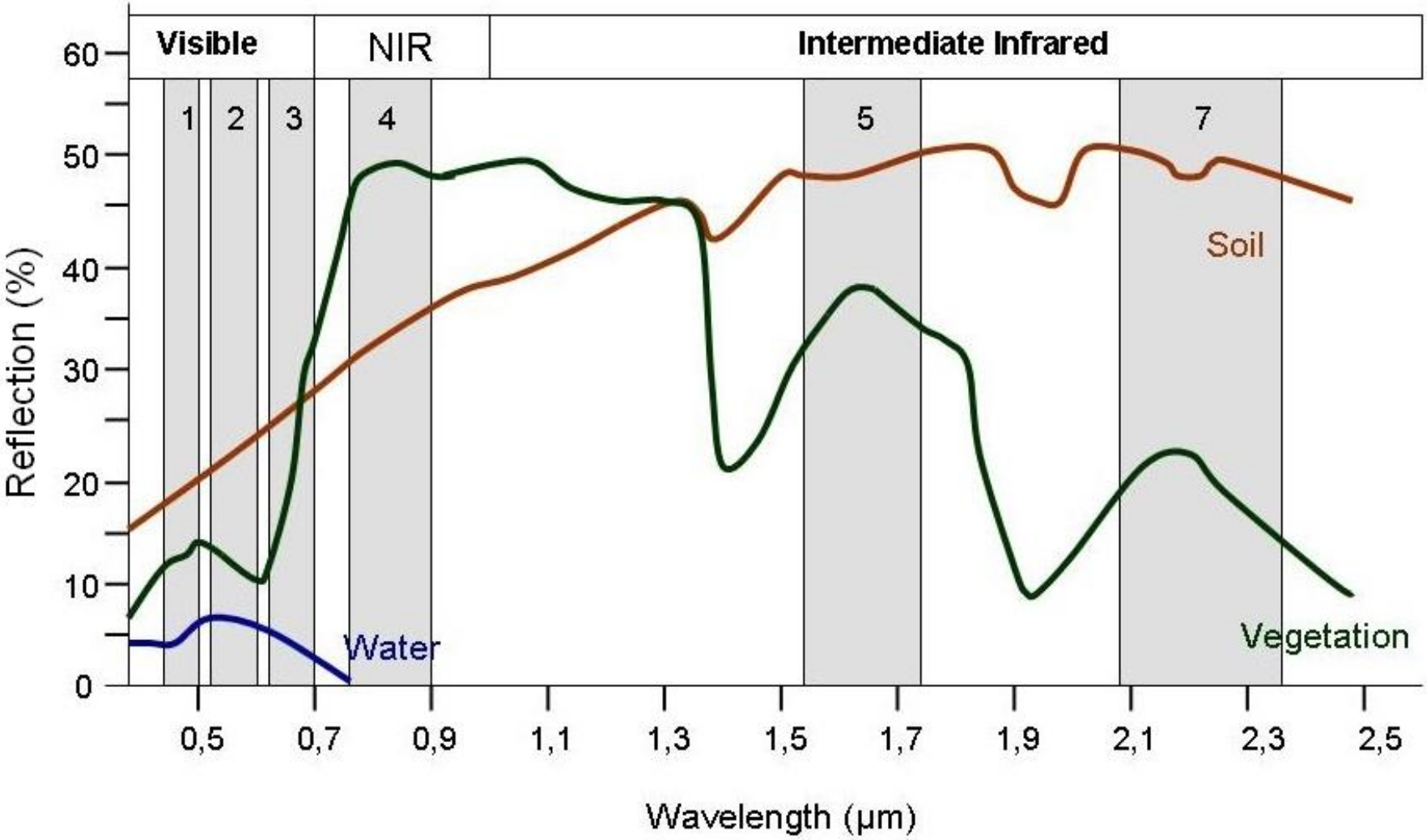
Having the spectral reflectance curves for water, soil and green vegetation as shown in the graph below:

a- What wavelengths are not suitable to distinguish between soil and green vegetation and why?

b- In what wavelengths water looks black on the image and why?




Soil
Construction Concret
Snow
Vegetation
Cloud
Sand
Water
Blue
Green
Red
Reflectance
Wavelength(μm)
1.0
0.8
0.6
0.4
0.2
0.0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0


Visible
NIR
Intermediate Infrared
1
2
3
4
5
7
Soil
Water
Vegetation
Reflection (%)
60
50
40
30
20
10
0
0,5
0,7
0,9
1,1
1,3
1,5
1,7
1,9
2,1
2,3
2,5
Wavelength (µm)

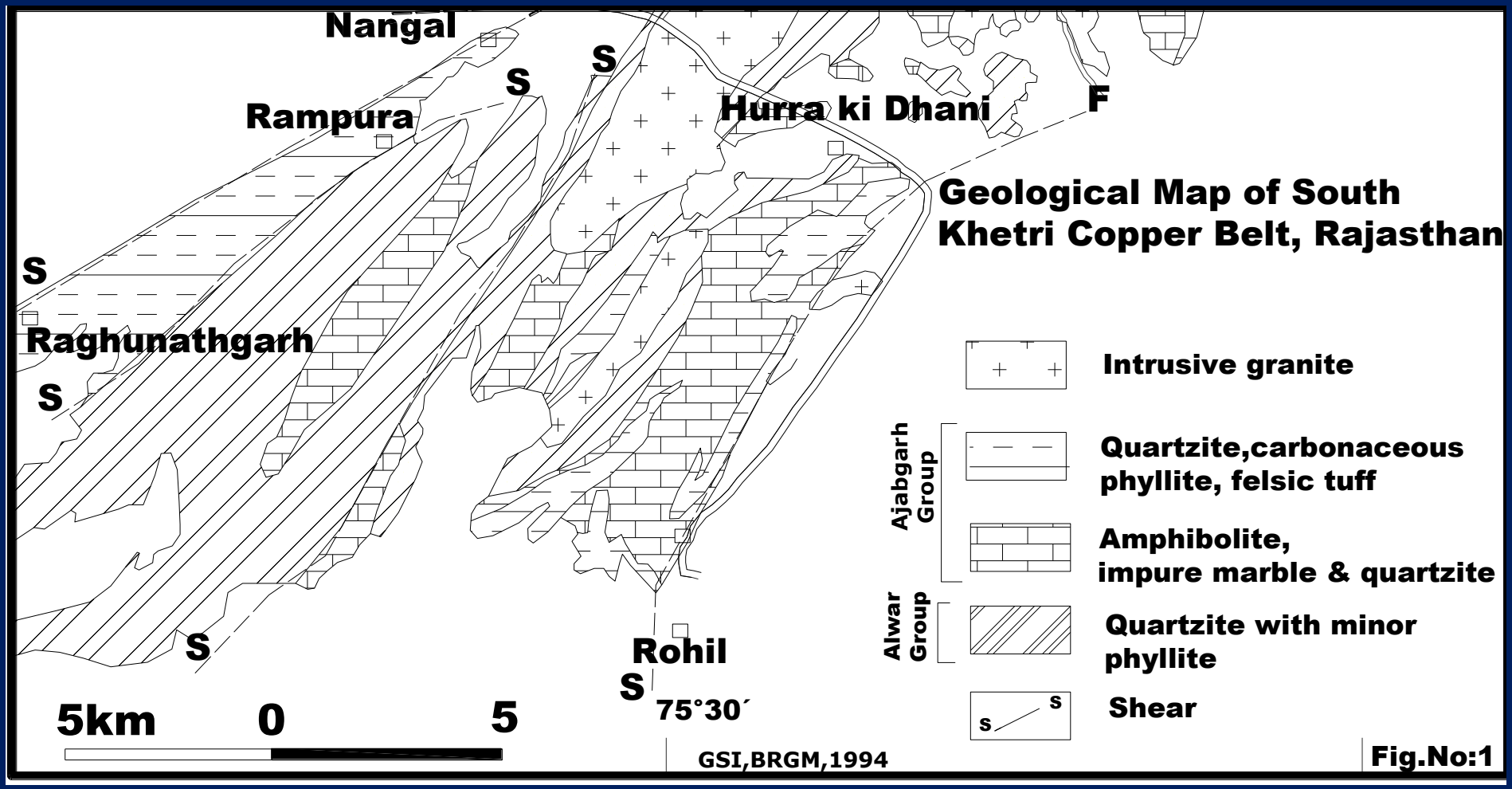
RESOLUTION MERGE

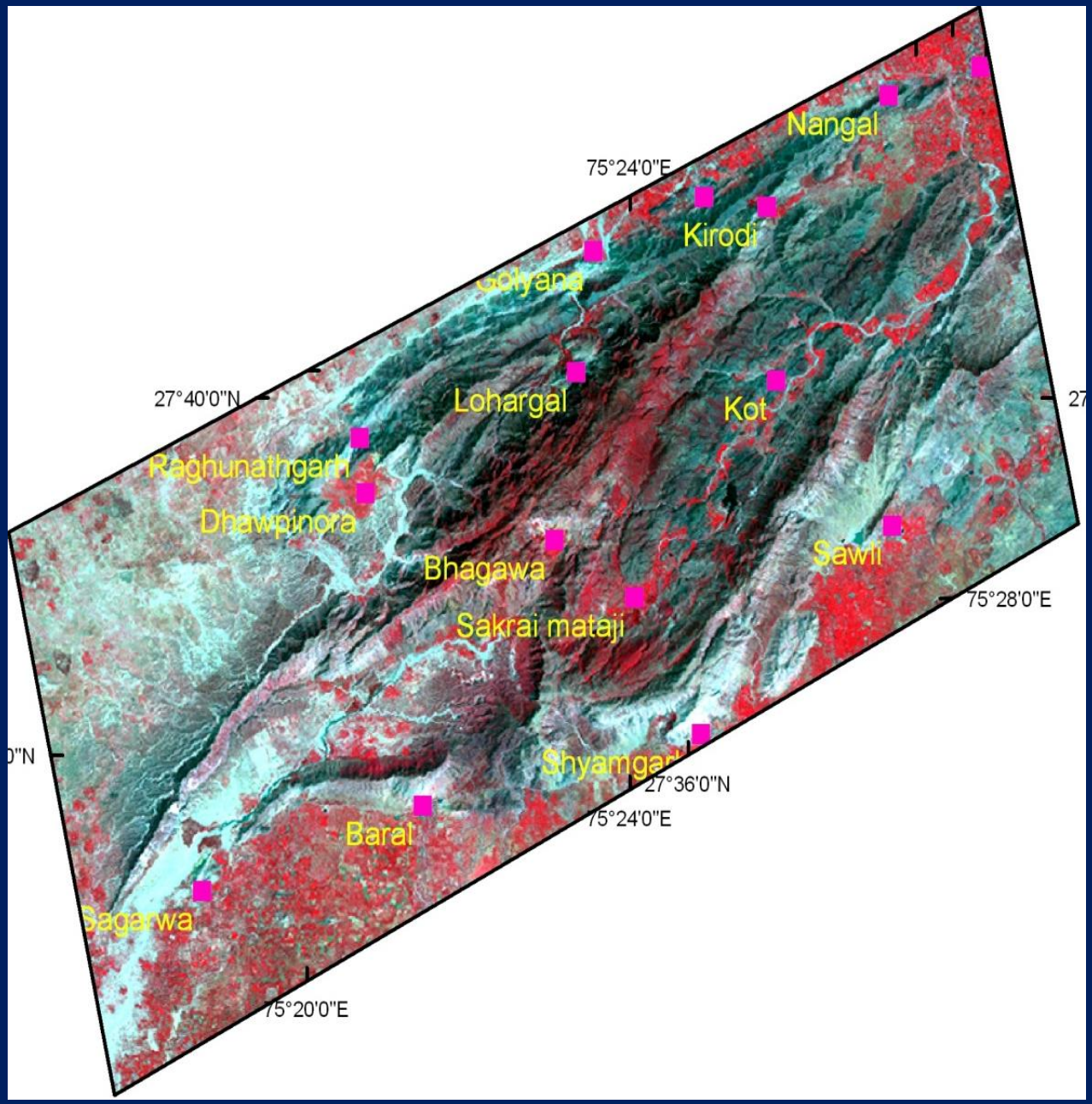
- Resolution merge is one of the enhancement techniques done in Digital Image Processing (DIP).
- In this analysis, spatial information has been taken from the higher resolution data such as PAN (~15 m) and spectral information has been taken from the lower resolution data (MSS) such as Landsat ETM+ (30 m).
- Resulted output is known as resolution merged MSS data with ~15 m spatial resolution.

THERMAL DATA OF LANDSAT ETM+

- Landsat ETM+ thermal data is a black and white image having 60m spatial resolution and 10.4 - 12.5 µm of spectral range.
- It was used to map the structural features like fold, fault and fractures / shears on 1:50,000 scales.
- Thermal data gives information about earth features based on the electromagnetic radiation, which is emitted by the earth system.

- Interpretation of this data was done on the basis of tonal and textural variation.
- Fractures can be mapped on the basis of cool linear anomalies.
- Lineaments mapped from the FCC and PAN can be modified with the help of thermal image.


Nangal
Rampura
Hurra ki Dhani
F
S
Raghunathgarh
Rohil
75°30´
5km 0 5
Geological Map of South
Khetri Copper Belt, Rajasthan
Intrusive granite
Ajabgarh Group
Quartzite,carbonaceous phyllite, felsic tuff
Amphibolite, impure marble & quartzite
Alwar Group
Quartzite with minor phyllite
Shear
GSI,BRGM,1994
Fig.No:1


Nangal
75°24'0"E
Kirodi
Goiyana
27°40'0"N
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
75°28'0"E
Sakrai mataji
Shyamgarh
27°36'0"N
75°24'0"E
Barat
Sagarwa
75°20'0"E

Supervised Classification

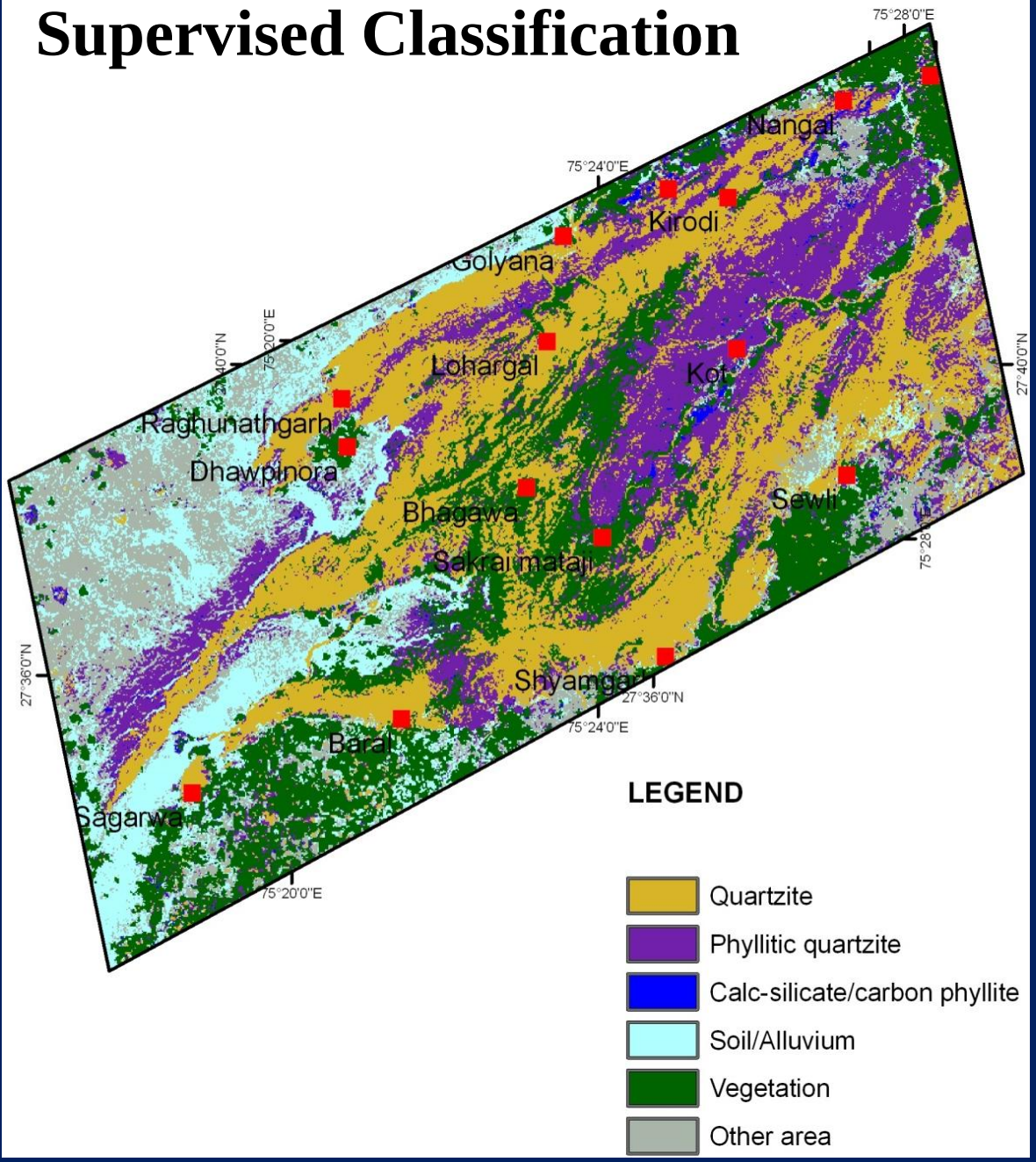


Fig No: 2.6

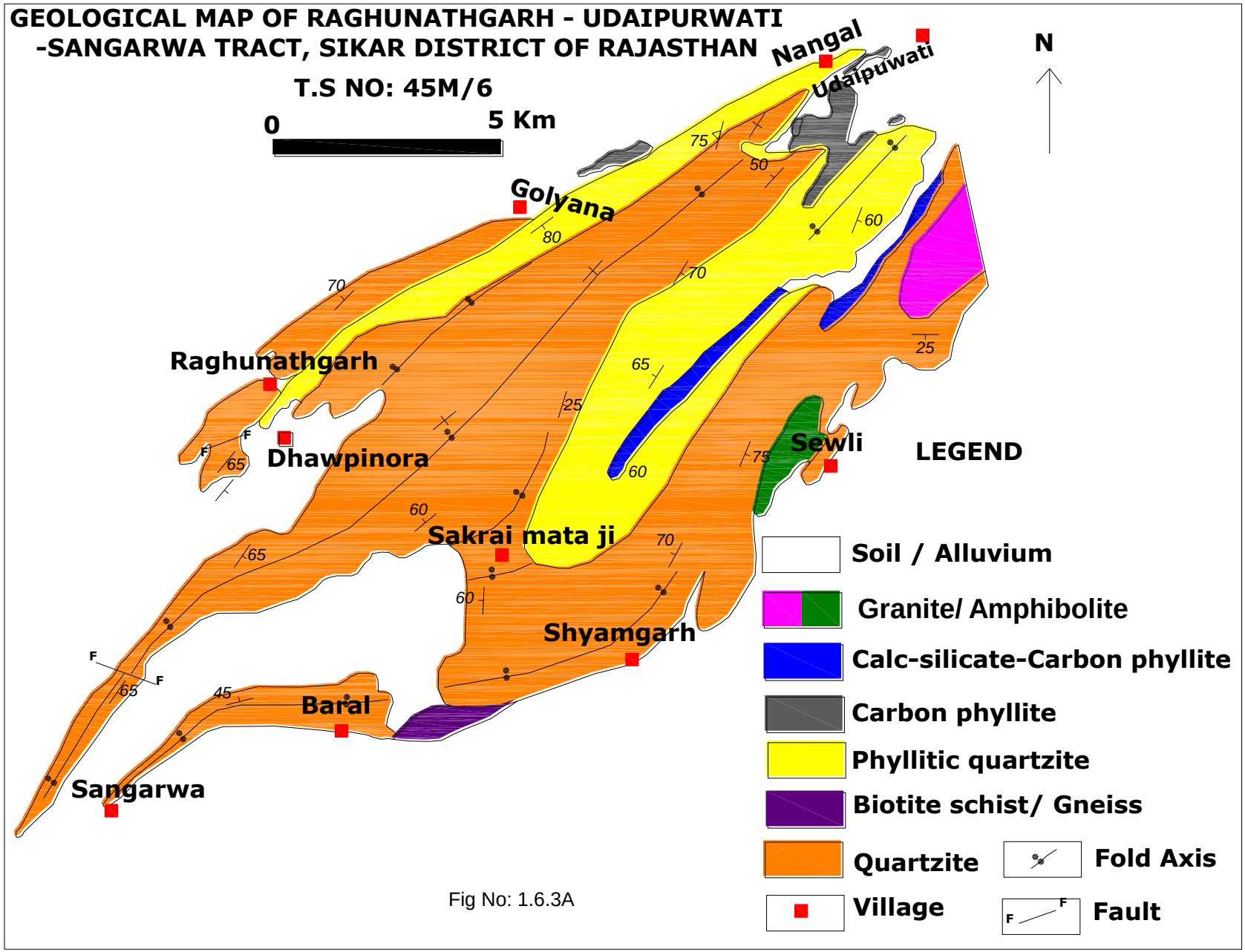
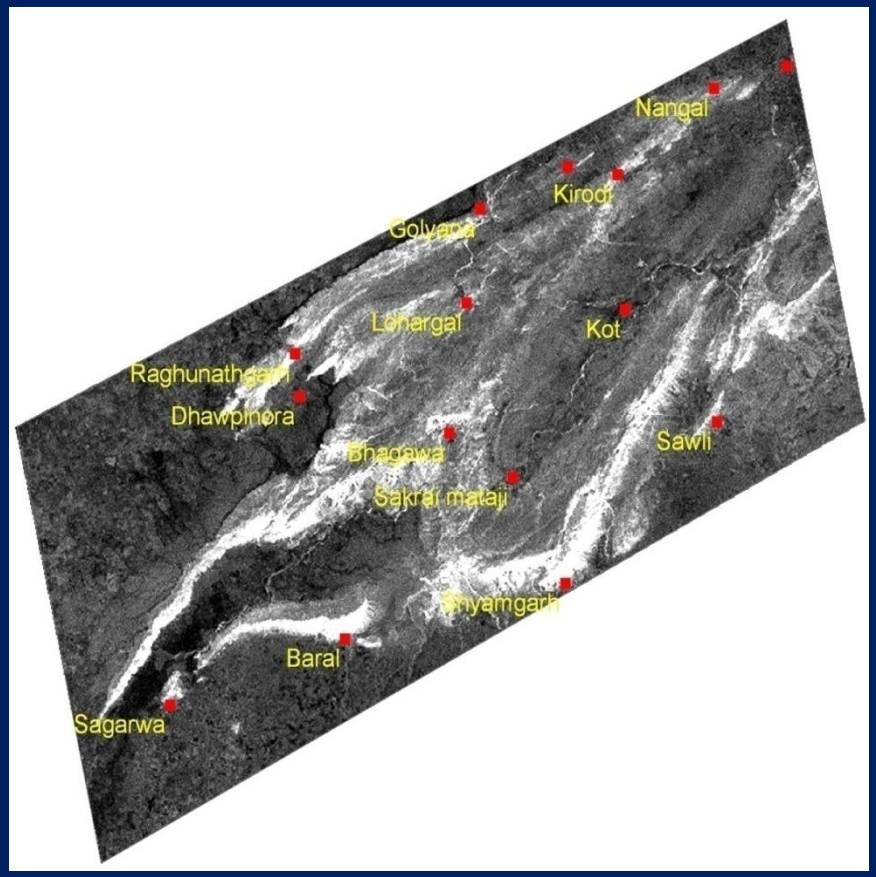

GEOLOGICAL MAP OF RAGHUNATHGARH - UDAIPURWATI
-SANGARWA TRACT, SIKAR DISTRICT OF RAJASTHAN
T.S NO: 45M/6
0
5 Km
N
Nangal
Udaipuwati
Golyana
Raghunathgarh
Dhawpinora
Sewli
Sakrai mata ji
Shyamgarh
Baral
Sangarwa
75
50
60
80
70
25
65
45
F
LEGEND
Soil / Alluvium
Granite/ Amphibolite
Calc-silicate-Carbon phyllite
Carbon phyllite
Phyllitic quartzite
Biotite schist/ Gneiss
Quartzite
Fold Axis
Village
Fault

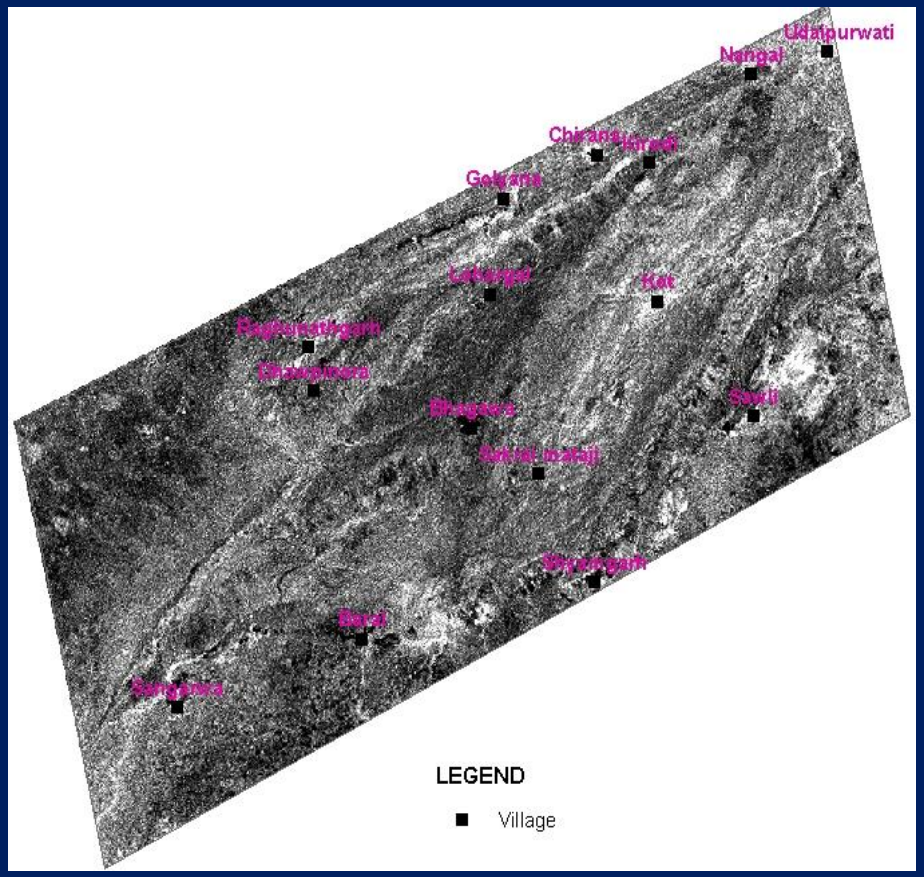
Fig No: 1.6.3A

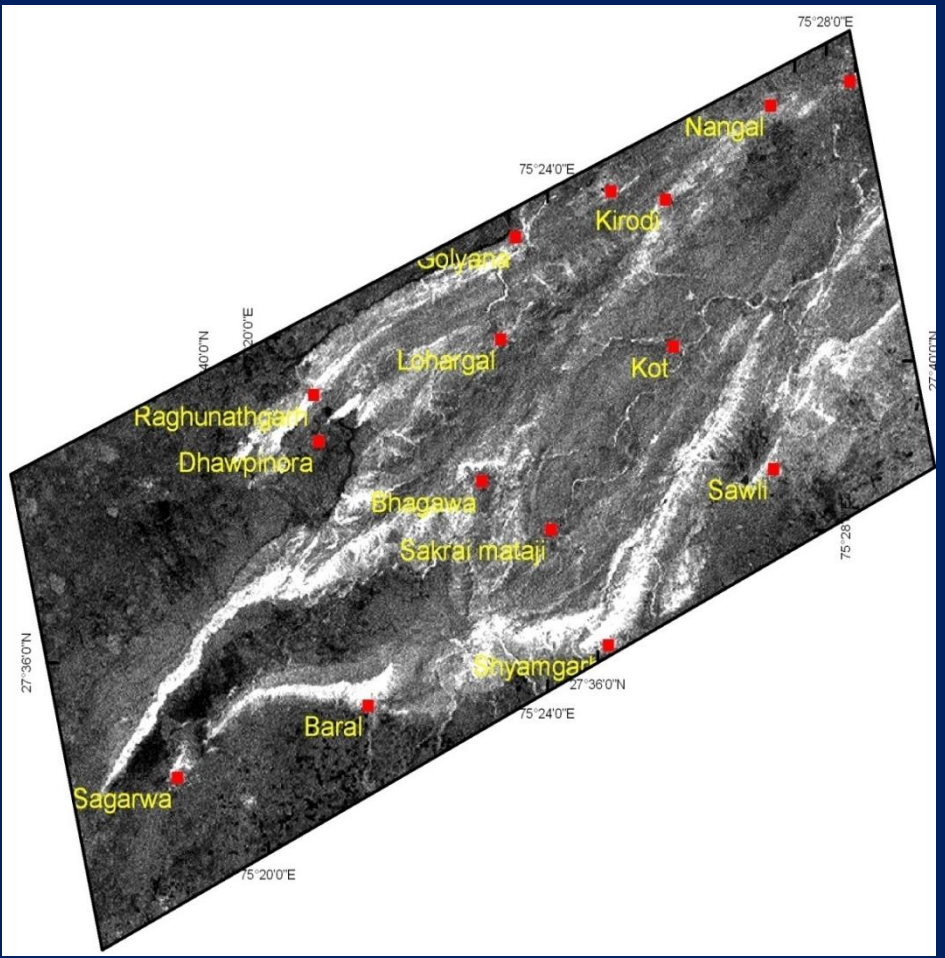
- Crosta technique is applied to find lithological variations. In this technique, principal component analysis (PCA) of 4, 5 and average of 4 & 5 have been used and data were stacked to get a composite image.
- This PCA technique is designed to remove or reduce the redundancy in the multispectral data.
- PCA4 enhances hydroxyl mineral for alteration zones by bright colour.

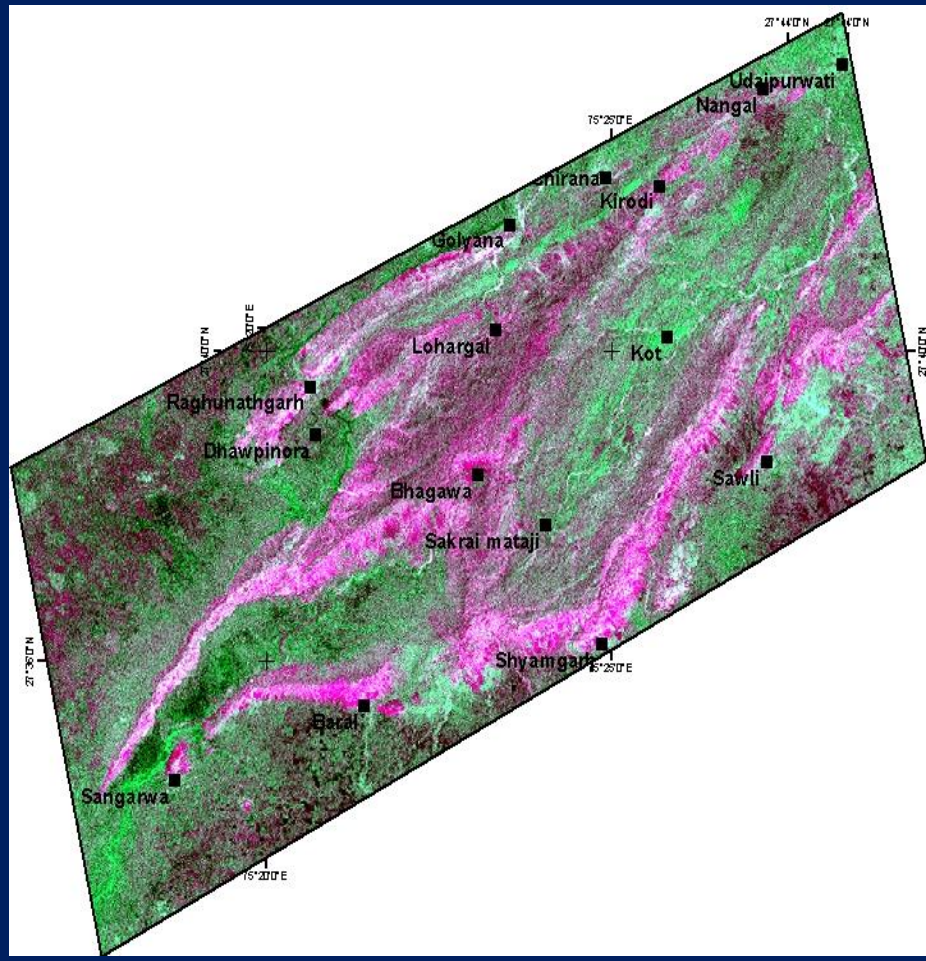
- PCA5 enhances iron oxide mineral for alteration zones showing bright colour.
- This technique was adopted to find the alteration zones but it in the study area failed because of the quartzite rock that contains silica ranging from 76% to 96%.
- But this technique was of immense help to modify the boundary between quartzite and phyllitic quartzite.

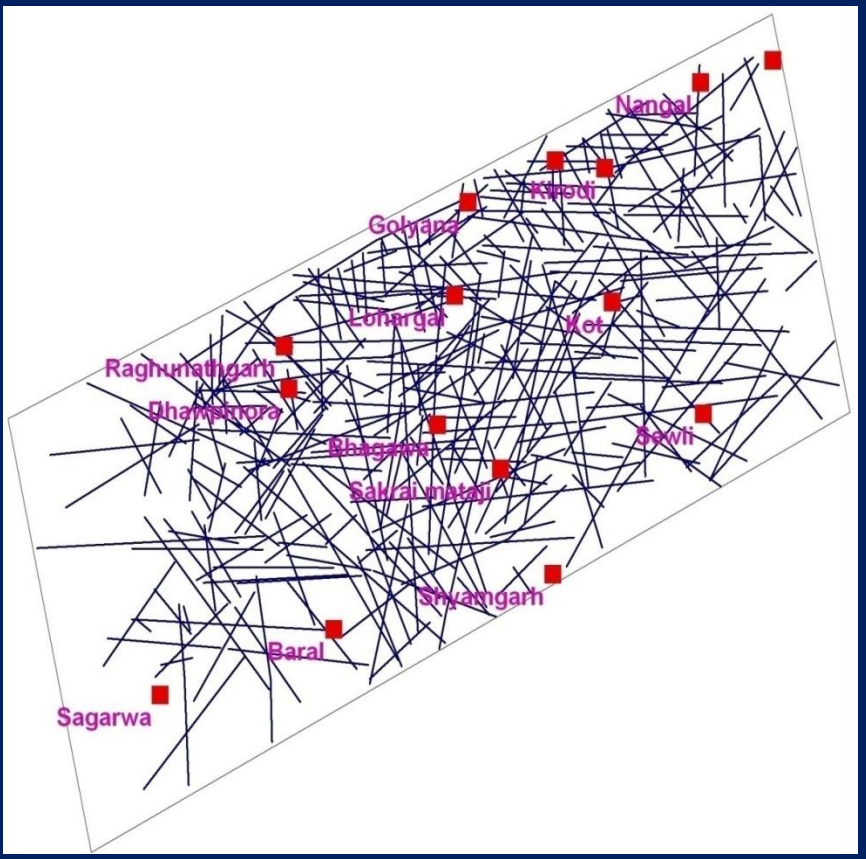
Crosta Analysis:
PCA4, PCA5 and Average of PCA4 and PCA5

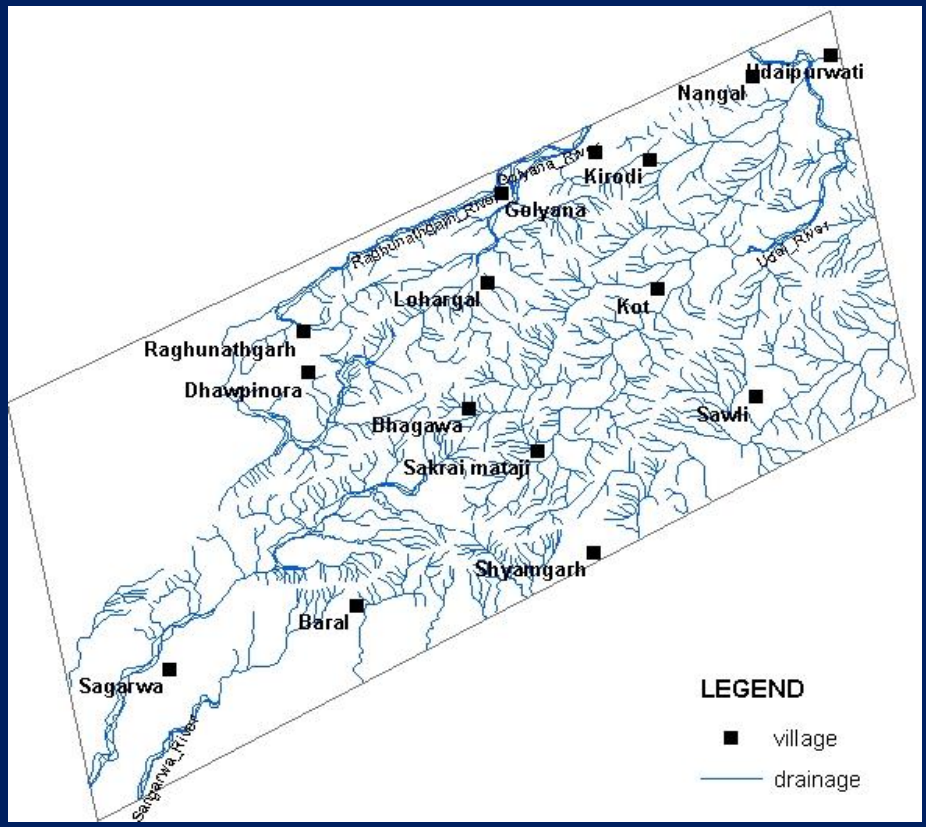


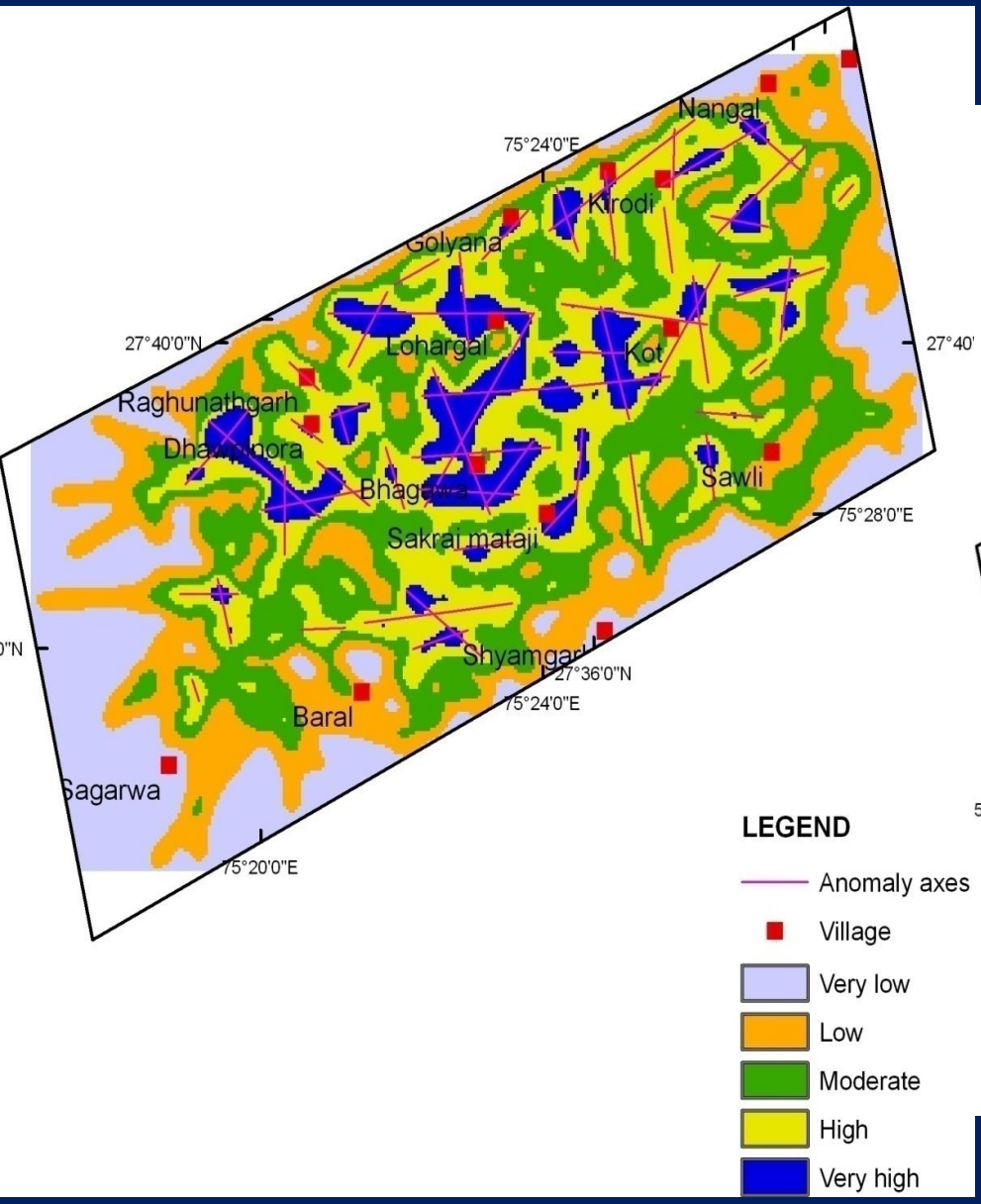


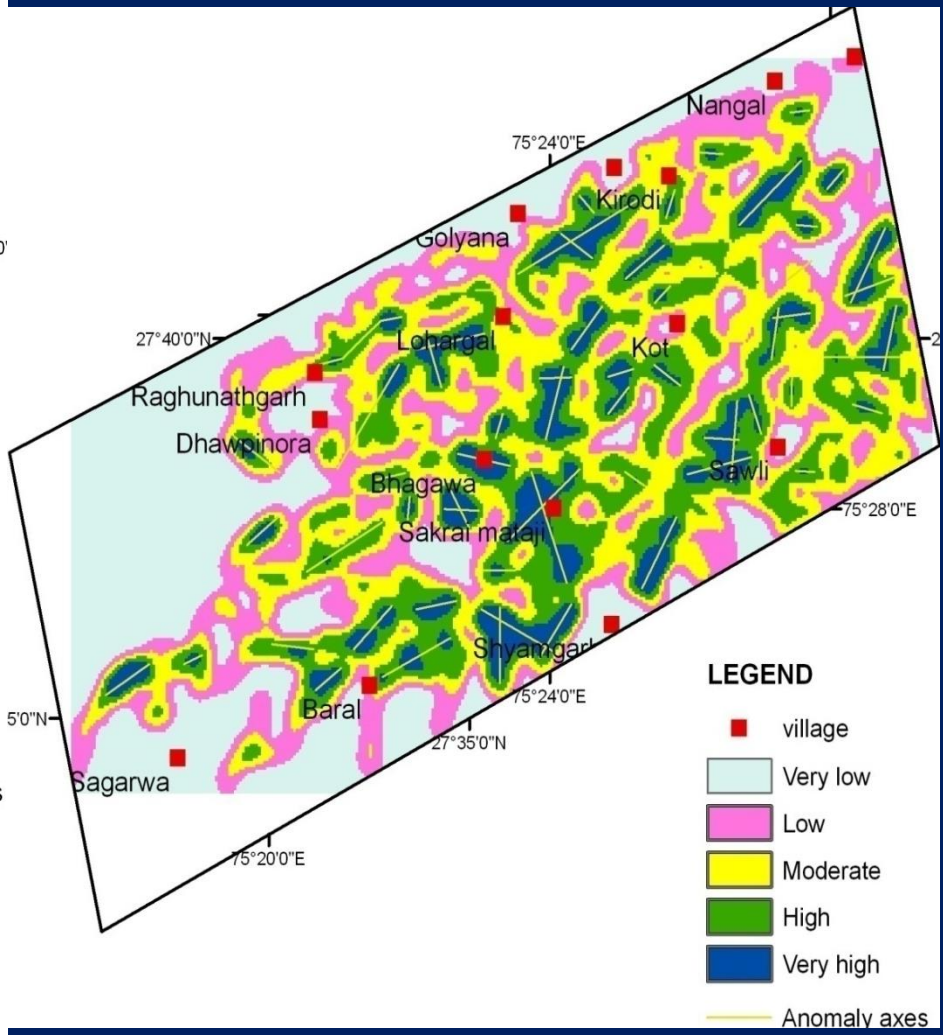

75°28'0"E
75°24'0"E
75°20'0"E
27°40'0"N
27°36'0"N
Nangal
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
Sakrai mataji
Shyamgarh
Baral
Sagarwa

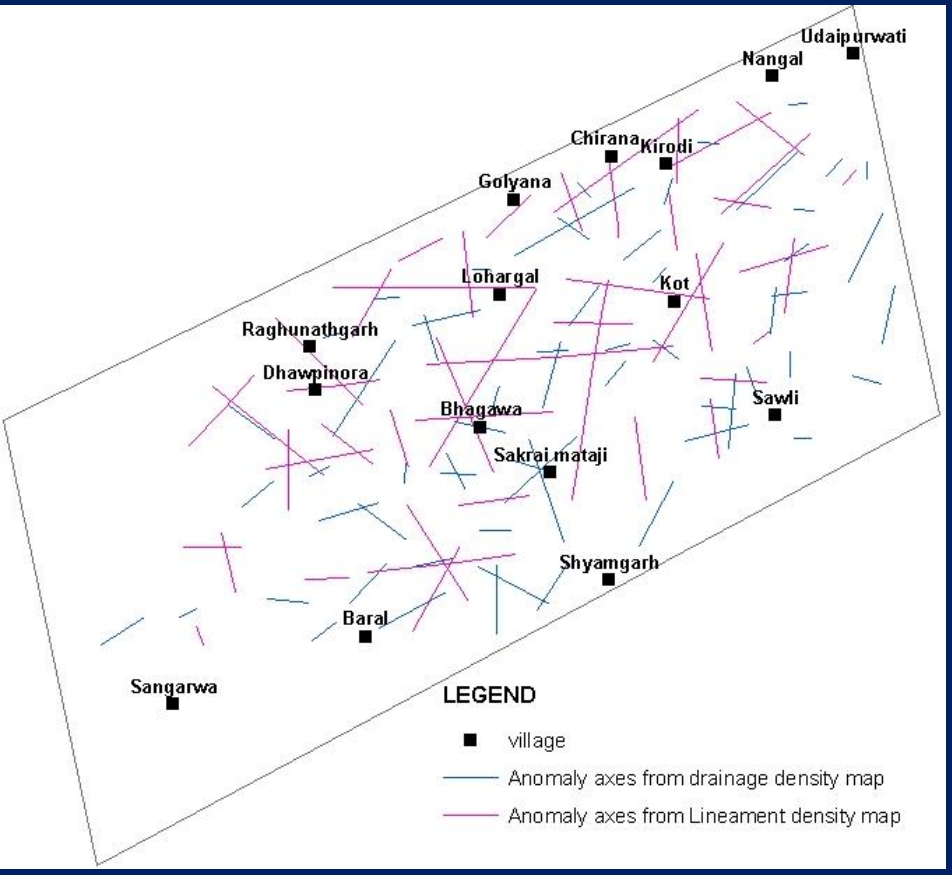

Udaipurwati
Nangal
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
Sakrai mataji
Shyamgarh
Baral
Sangarwa

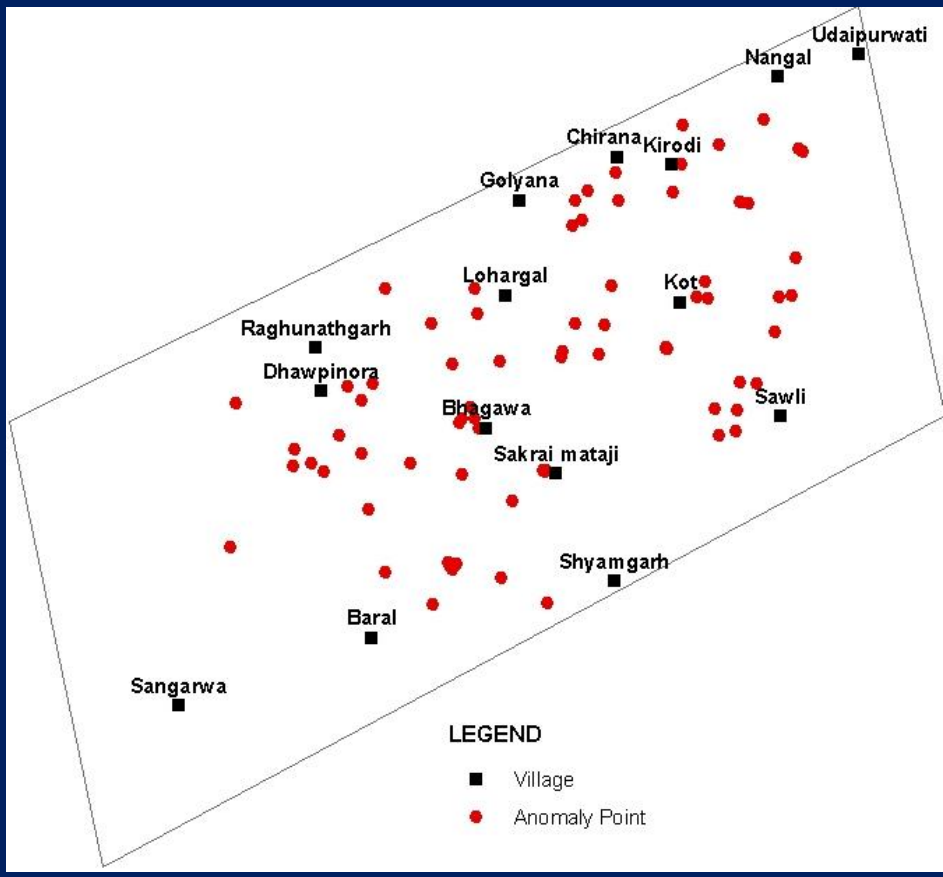

Nangal
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
Sakrai mataji
Shyamgarh
Baral
Sagarwa

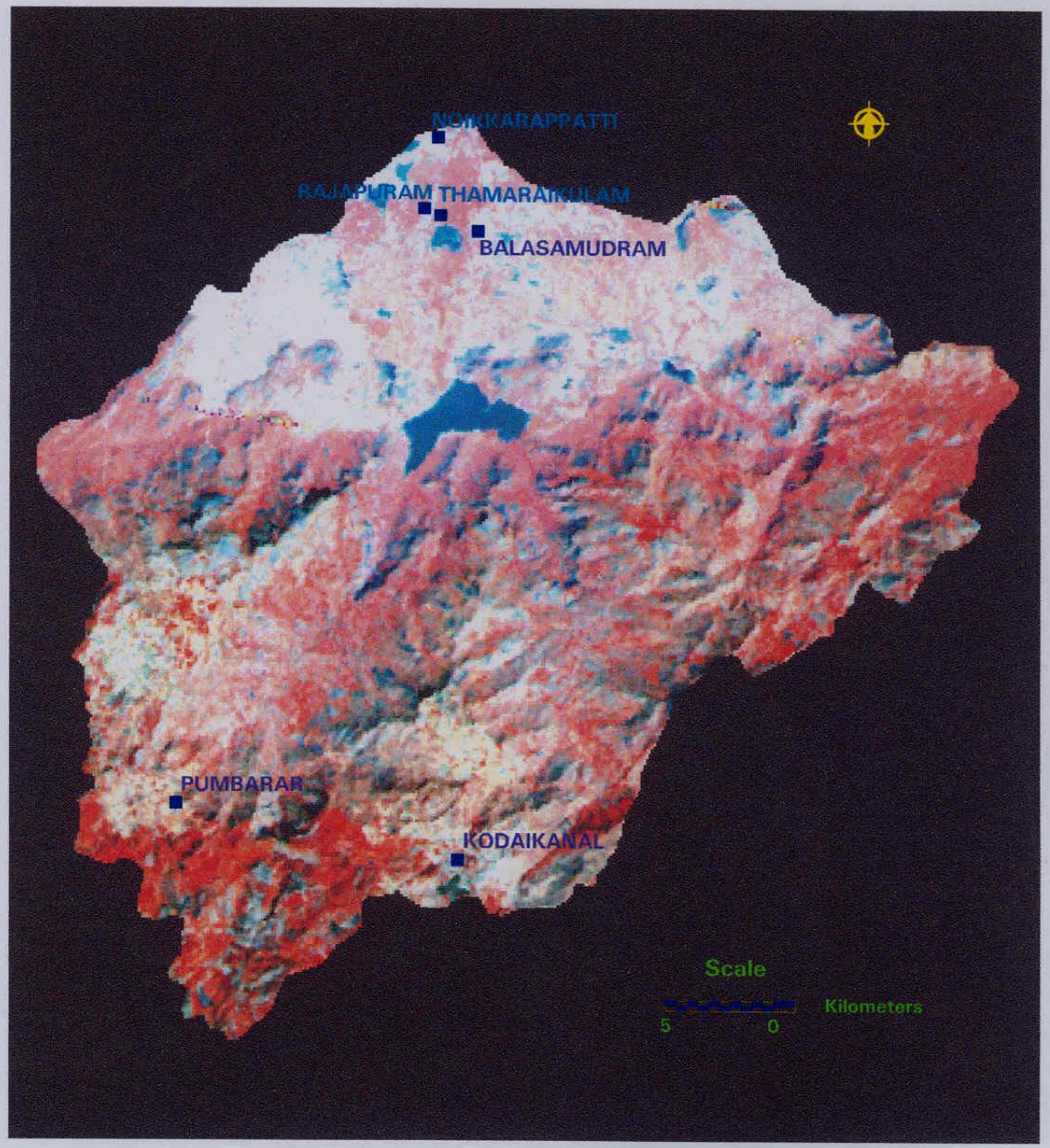

Udaipurwati
Nangal
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
Sakrai mataji
Shyamgarh
Baral
Sagarwa
LEGEND
village
drainage

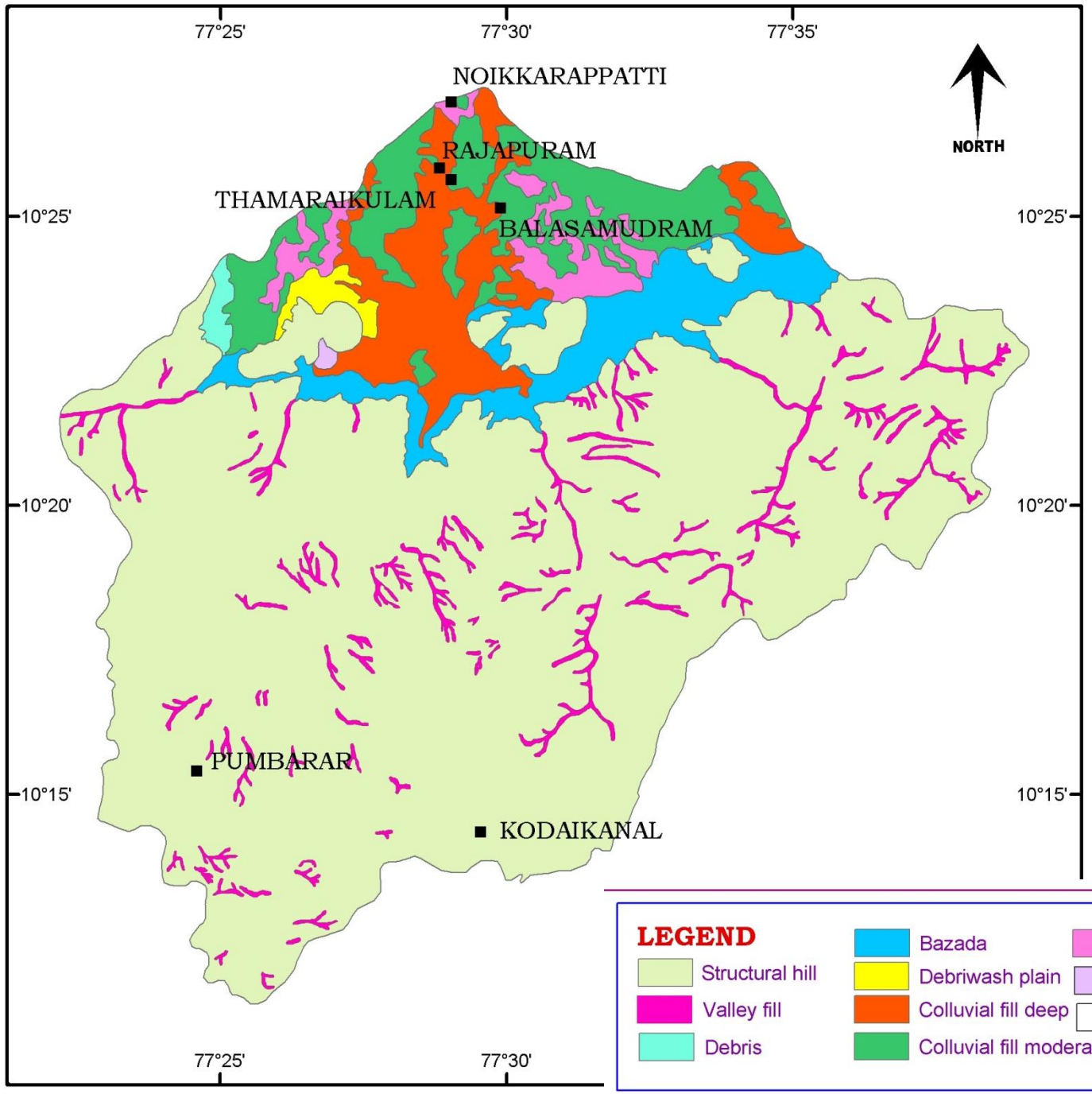

Nangal
75°24'0"E
Kirodi
Golyana
27°40'0"N
Lohargal
Kot
27°40'
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
75°28'0"E
Sakrai mataji
Shyamgarh
27°36'0"N
75°24'0"E
Baral
Sagarwa
75°20'0"E
LEGEND
Anomaly axes
Village
Very low
Low
Moderate
High
Very high


Nangal
75°24'0"E
Kirodi
Golyana
27°40'0"N
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
75°28'0"E
Sakrai mataji
Shyamgarh
5'0"N
75°24'0"E
27°35'0"N
Baral
Sagarwa
75°20'0"E
LEGEND
village
Very low
Low
Moderate
High
Very high
Anomaly axes


Udaipurwati
Nangal
Chirana
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Sawli
Bhagawa
Sakrai mataji
Shyamgarh
Baral
Sangarwa
LEGEND
village
Anomaly axes from drainage density map
Anomaly axes from Lineament density map


Udaipurwati
Nangal
Chirana
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Sawli
Bhagawa
Sakrai mataji
Shyamgarh
Baral
Sangarwa
LEGEND
Village
Anomaly Point


NOKKARAPPATTI
RAJAPURAM
THAMARAIKULAM
BALASAMUDRAM
PUMBARAR
KODAIKANAL
Scale
5
0
Kilometers


77°25'
77°30'
77°35'
NOIKKARAPPATTI
RAJAPURAM
THAMARAIKULAM
BALASAMUDRAM
NORTH
10°25'
10°20'
10°15'
PUMBARAR
KODAIKANAL
LEGEND
Structural hill
Valley fill
Debris
Bazada
Debriwash plain
Colluvial fill deep
Colluvial fill moderate
Colluvial fill shallow
Alluvial fan
Settelment

‘Colluvial’ vs. ‘Alluvial’

Colluvial: unorganized and poorly sorted deposits at the base of a hillslope, formed by gravity.

Alluvial: formed by the action of flowing water, indicated by rounded rocks, distinct channel banks, and organized bed forms.