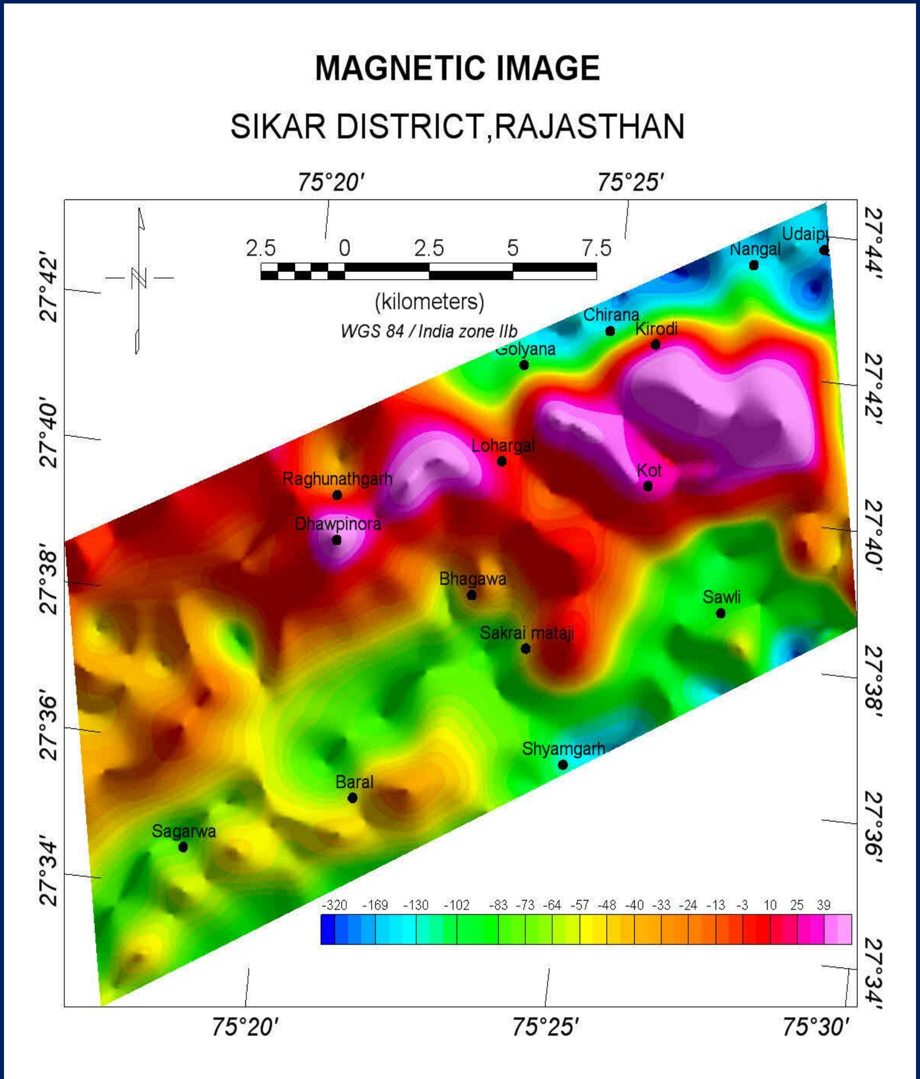
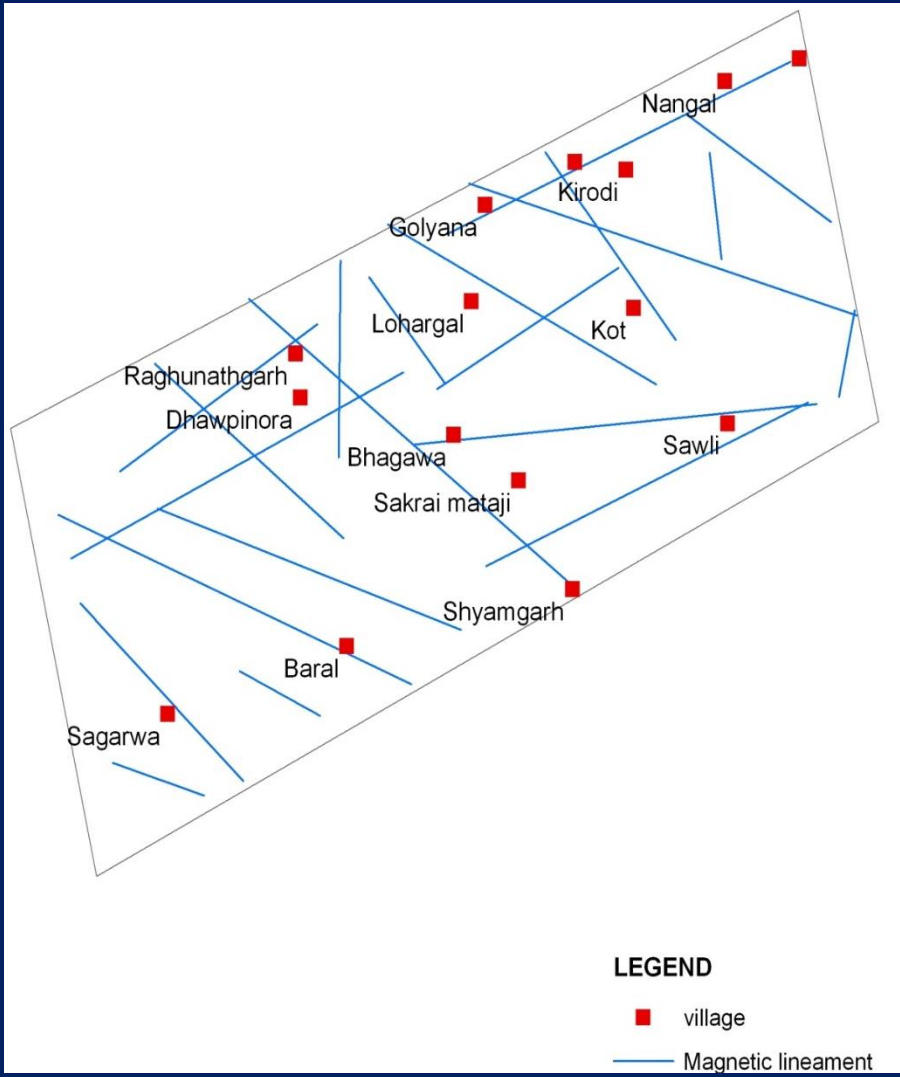
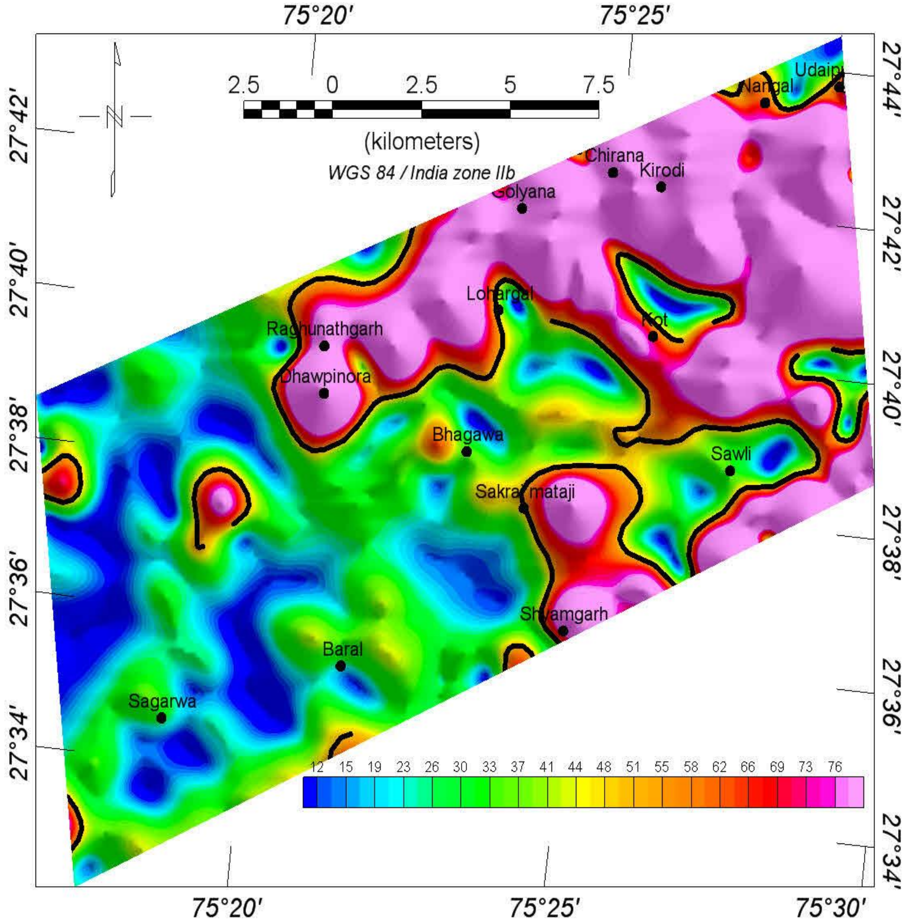
Mineral Exploration
Unit-4


MAGNETIC IMAGE
SIKAR DISTRICT,RAJASTHAN
75°20′
75°25′
75°30′
27°34′
27°36′
27°38′
27°40′
27°42′
27°44′
2.5 0 2.5 5 7.5
(kilometers)
WGS 84 / India zone IIb
Nangal
Chirana
Kirodi
Golyana
Lohargal
Raghunathgarh
Kot
Dhawpinora
Bhagawa
Sawli
Sakrai mataji
Shyamgarh
Baral
Sagarwa
-320 -169 -130 -102 -83 -73 -64 -57 -48 -40 -33 -24 -13 -3 10 25 39


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

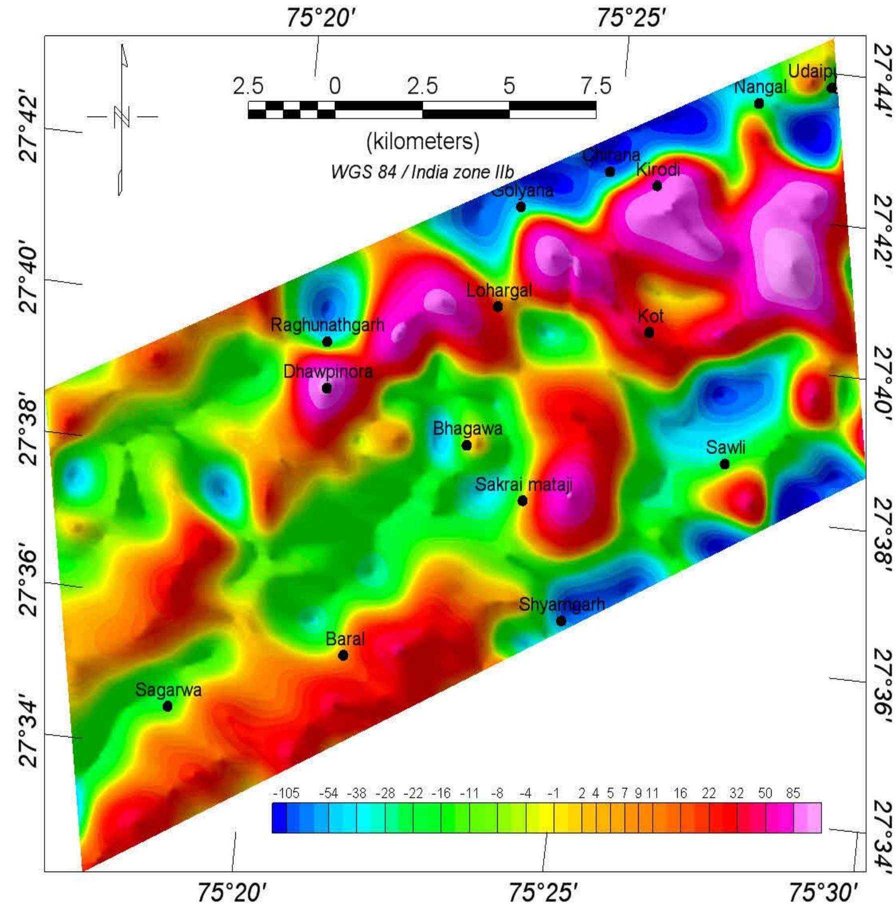
ANALYTICAL SIGNAL IMAGE

SIKAR DISTRICT,RAJASTHAN



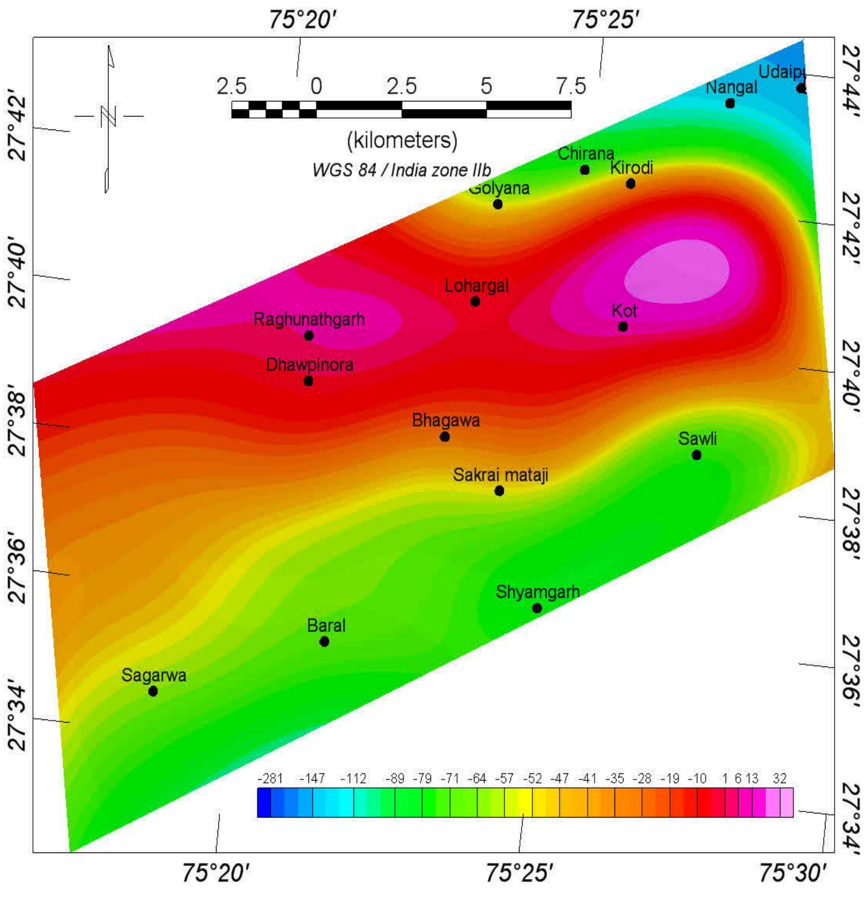
RESIDUAL ANOMALY DERIVED FROM MAGNETIC DATA

SIKAR DISTRICT,RAJASTHAN



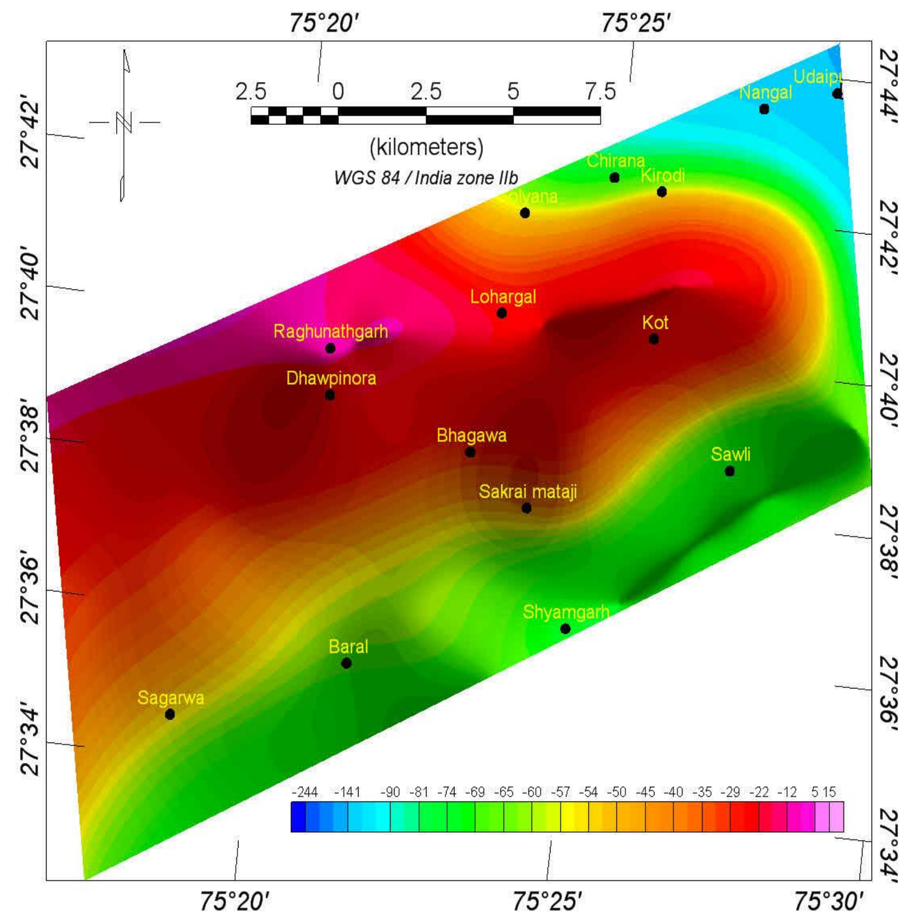
REGIONAL ANOMALY DERIVED FROM MAGNETIC DATA

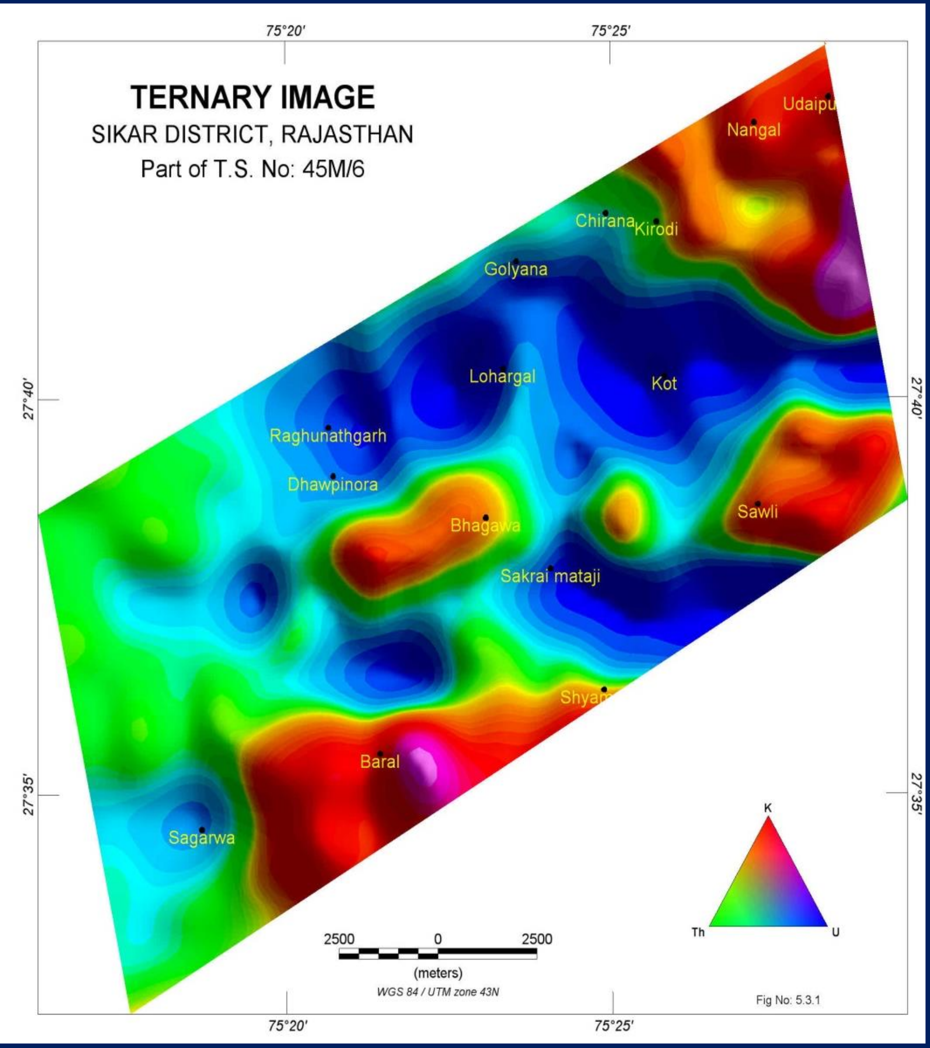
SIKAR DISTRICT,RAJASTHAN



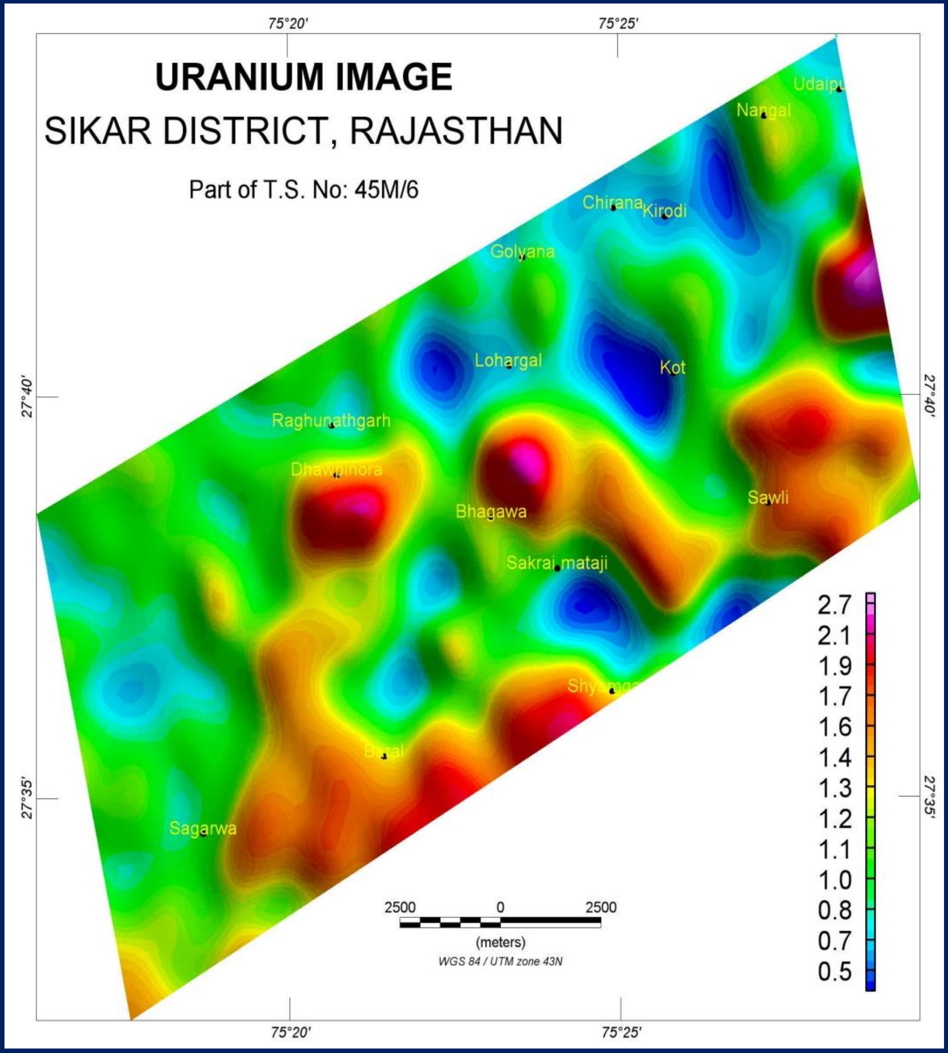
UPWARD CONTINUATION IMAGE

SIKAR DISTRICT,RAJASTHAN

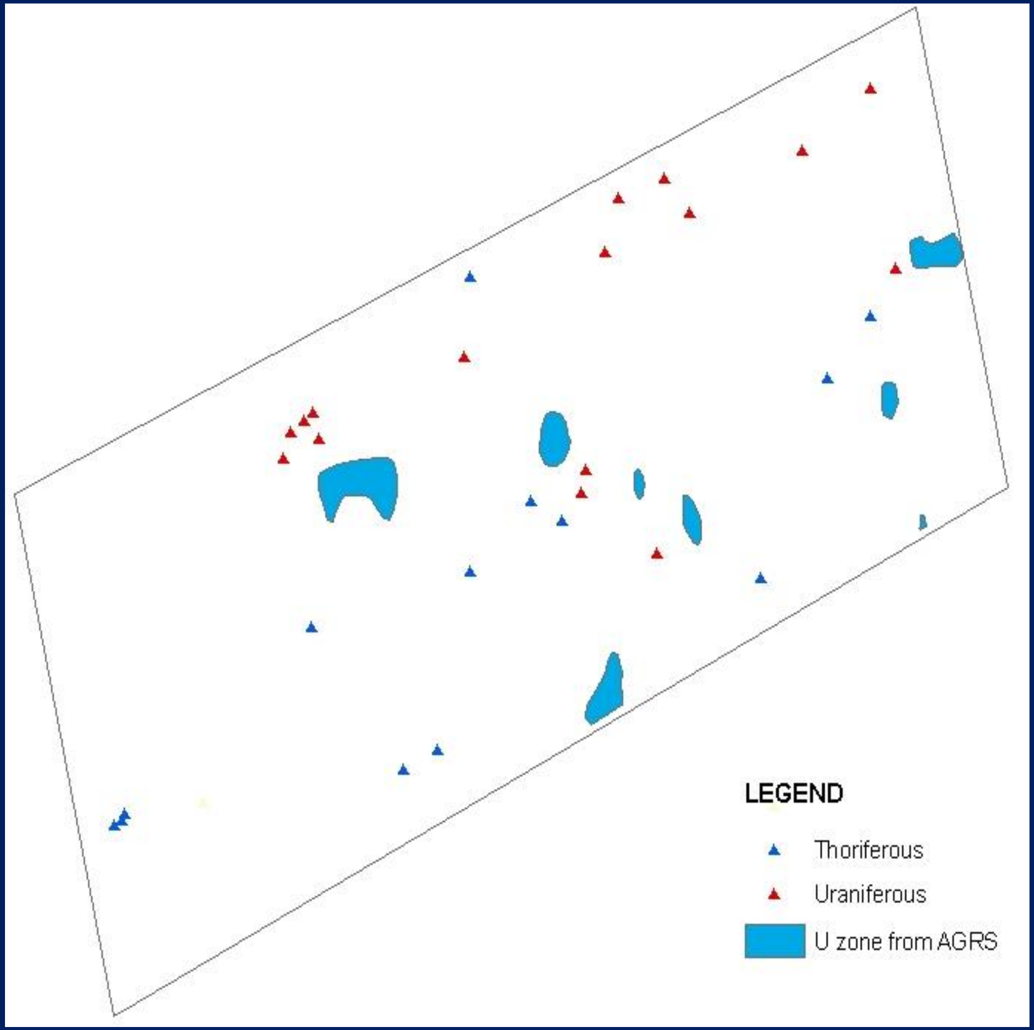


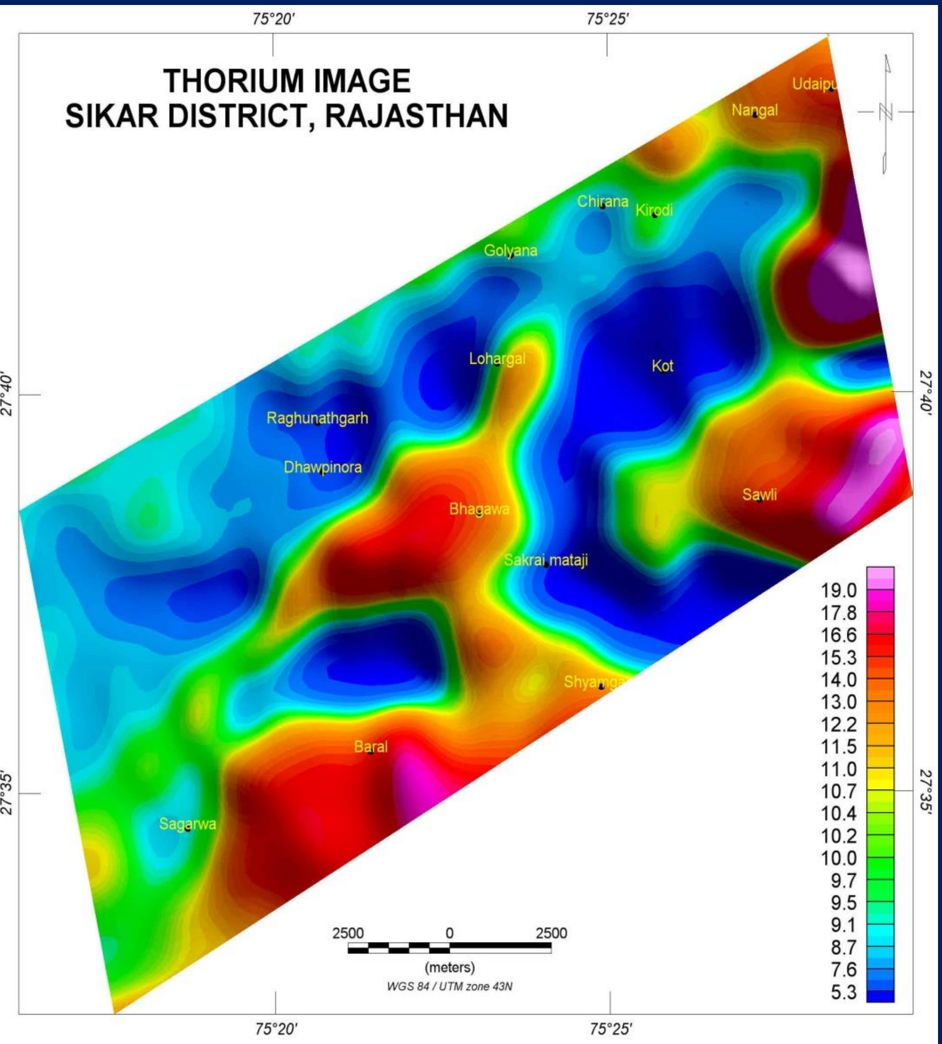


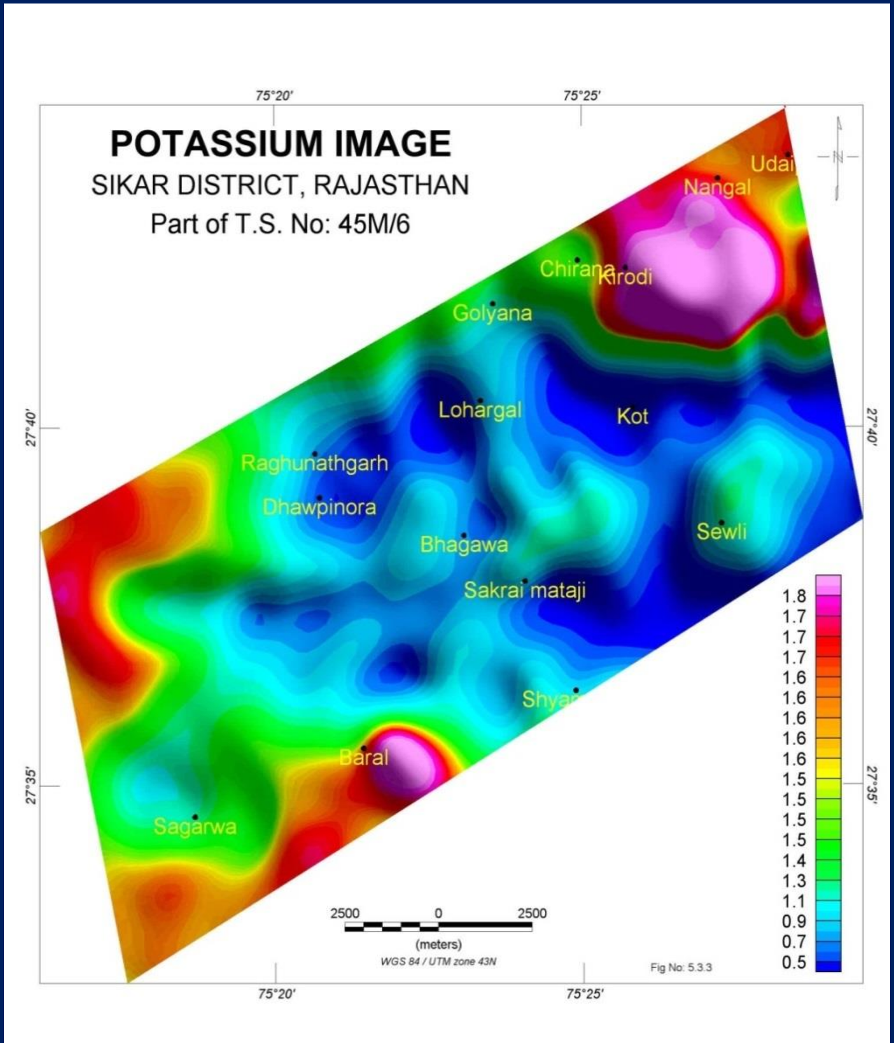
TERNARY IMAGE
SIKAR DISTRICT, RAJASTHAN
Part of T.S. No: 45M/6
75°20′
75°25′
27°40′
27°35′
Udaipu
Nangal
Chirana
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
Sakrai mataji
Shyam
Baral
Sagarwa
K
Th
U
2500
0
2500
(meters)
WGS 84 / UTM zone 43N
Fig No: 5.3.1

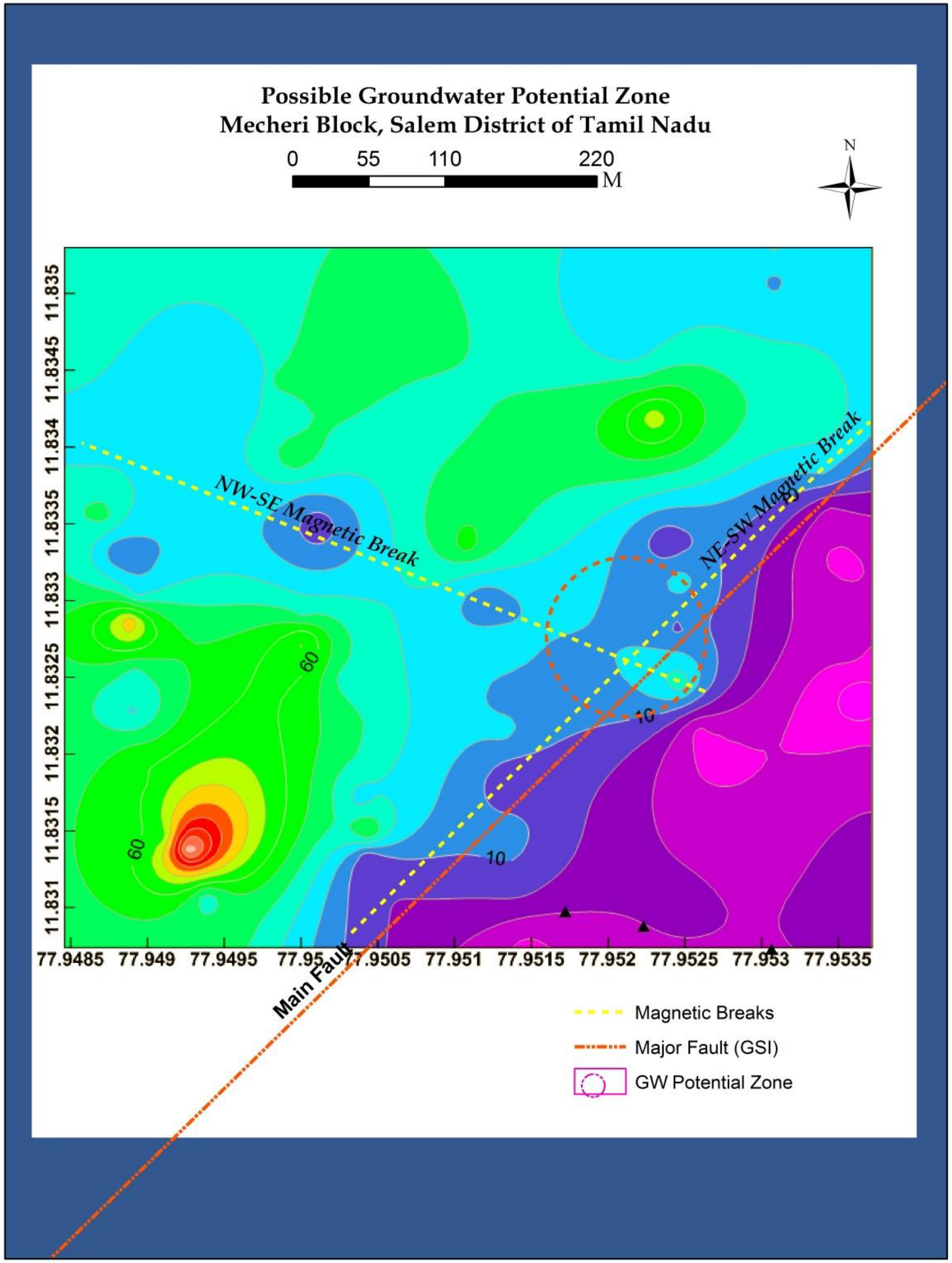


URANIUM IMAGE
SIKAR DISTRICT, RAJASTHAN
Part of T.S. No: 45M/6
75°20′
75°25′
27°40′
27°35′
Udaipu
Nangal
Chirana
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
Sakrai mataji
Baral
Sagarwa
2.7
2.1
1.9
1.7
1.6
1.4
1.3
1.2
1.1
1.0
0.8
0.7
0.5
2500
0
2500
(meters)
WGS 84 / UTM zone 43N

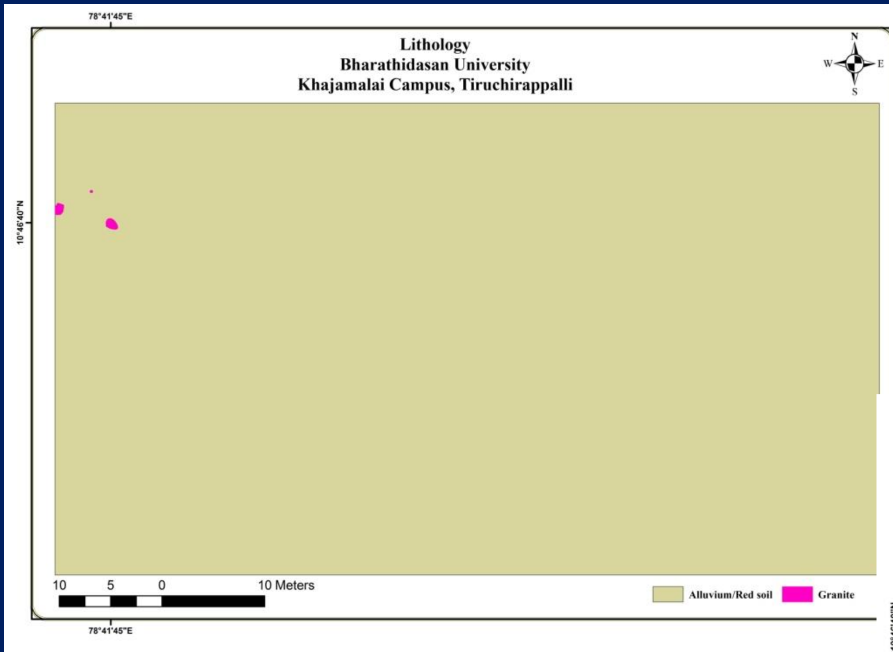

LEGEND
Thoriferous
Uraniferous
U zone from AGRS

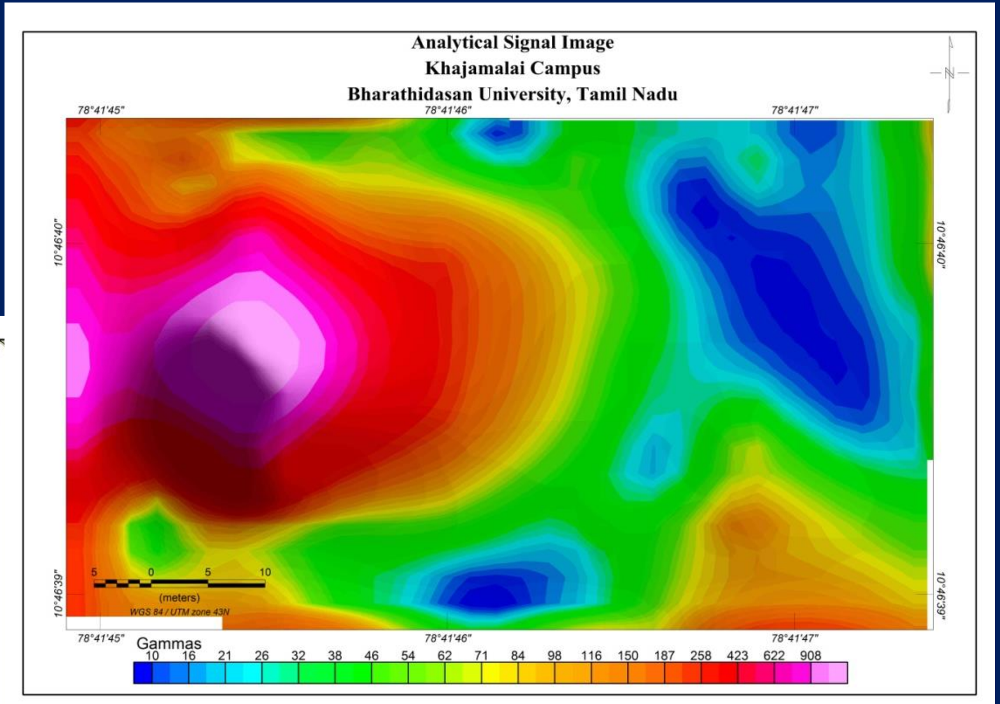

THORIUM IMAGE
SIKAR DISTRICT, RAJASTHAN
75°20'
75°25'
27°40'
27°35'
Udaipu
Nangal
Chirana
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sawli
Sakrai mataji
Shyamga
Baral
Sagarwa
19.0
17.8
16.6
15.3
14.0
13.0
12.2
11.5
11.0
10.7
10.4
10.2
10.0
9.7
9.5
9.1
8.7
7.6
5.3
2500 0 2500
(meters)
WGS 84 / UTM zone 43N

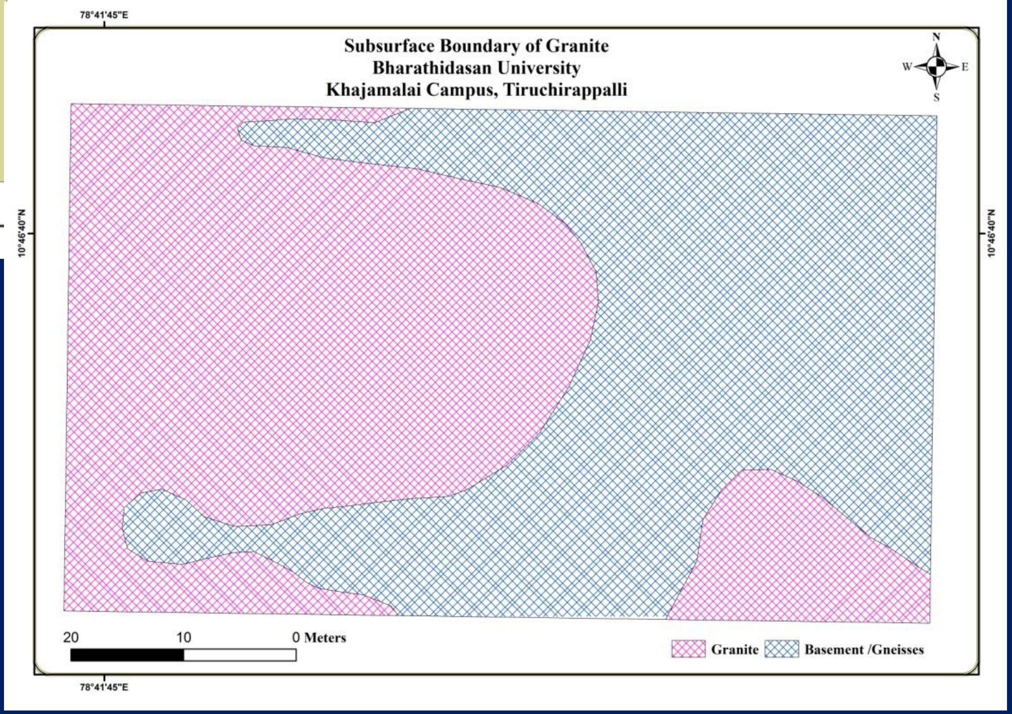

POTASSIUM IMAGE
SIKAR DISTRICT, RAJASTHAN
Part of T.S. No: 45M/6
75°20'
75°25'
27°40'
27°35'
Udai
Nangal
Chirana
Kirodi
Golyana
Lohargal
Kot
Raghunathgarh
Dhawpinora
Bhagawa
Sewli
Sakrai mataji
Shya
Baral
Sagarwa
1.8
1.7
1.7
1.7
1.6
1.6
1.6
1.6
1.6
1.5
1.5
1.5
1.5
1.4
1.3
1.1
0.9
0.7
0.5
2500 0 2500
(meters)
WGS 84 / UTM zone 43N
Fig No: 5.3.3



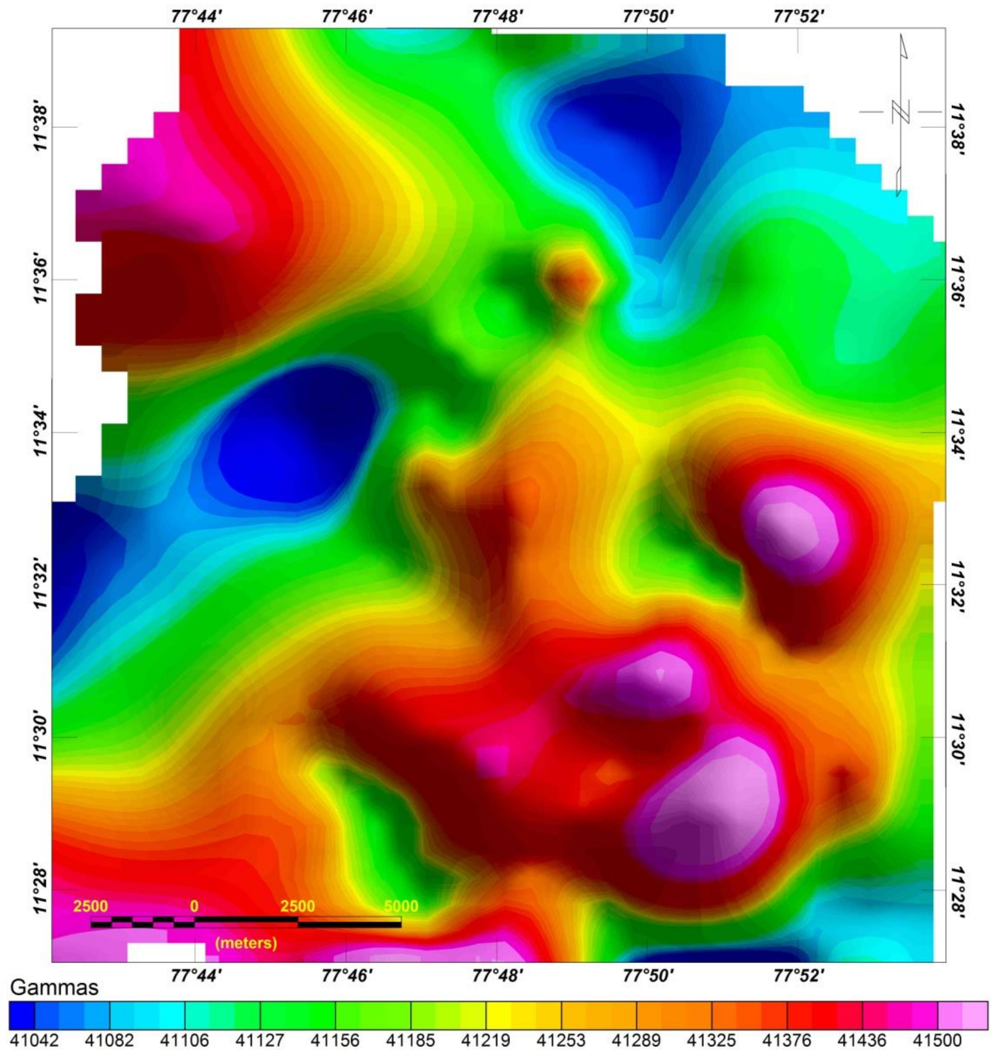
Possible Groundwater Potential Zone
Mecheri Block, Salem District of Tamil Nadu
0
55
110
220
M
N
NW-SE Magnetic Break
NE-SW Magnetic Break
Main Fault
60
10
11.835
11.8345
11.834
11.8335
11.833
11.8325
11.832
11.8315
11.831
77.9485
77.949
77.9495
77.95
77.9505
77.951
77.9515
77.952
77.9525
77.953
77.9535
Magnetic Breaks
Major Fault (GSI)
GW Potential Zone


78°41'45"E
Lithology
Bharathidasan University
Khajamalai Campus, Tiruchirappalli
N
W
E
S
10°46'40"N
10
5
0
10 Meters
Alluvium/Red soil
Granite
78°41'45"E

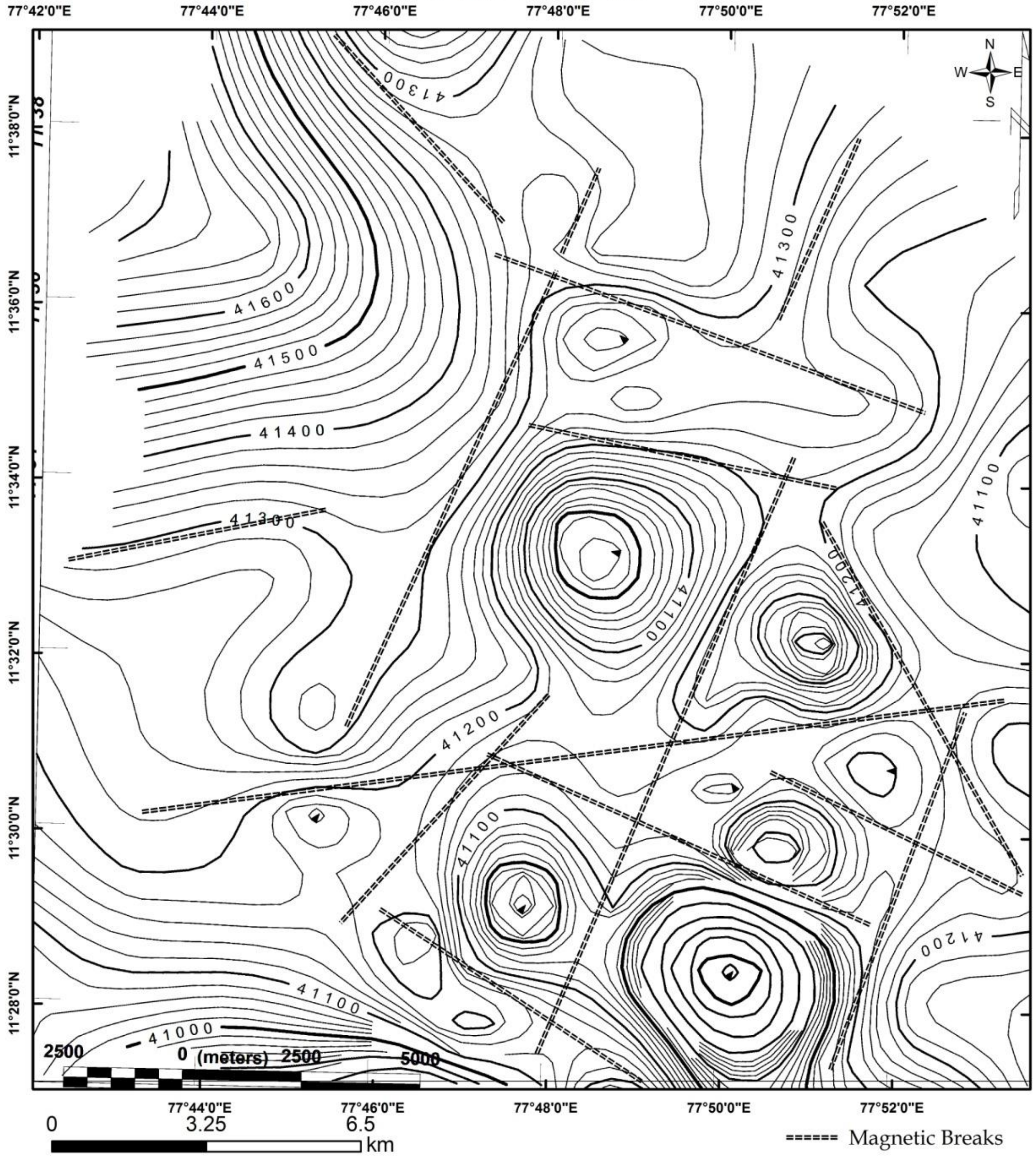

Analytical Signal Image
Khajamalai Campus
Bharathidasan University, Tamil Nadu
78°41'45"
78°41'46"
78°41'47"
10°46'40"
10°46'39"
5
0
5
10
(meters)
WGS 84 / UTM zone 43N
Gammas
10 16 21 26 32 38 46 54 62 71 84 98 116 150 187 258 423 622 908

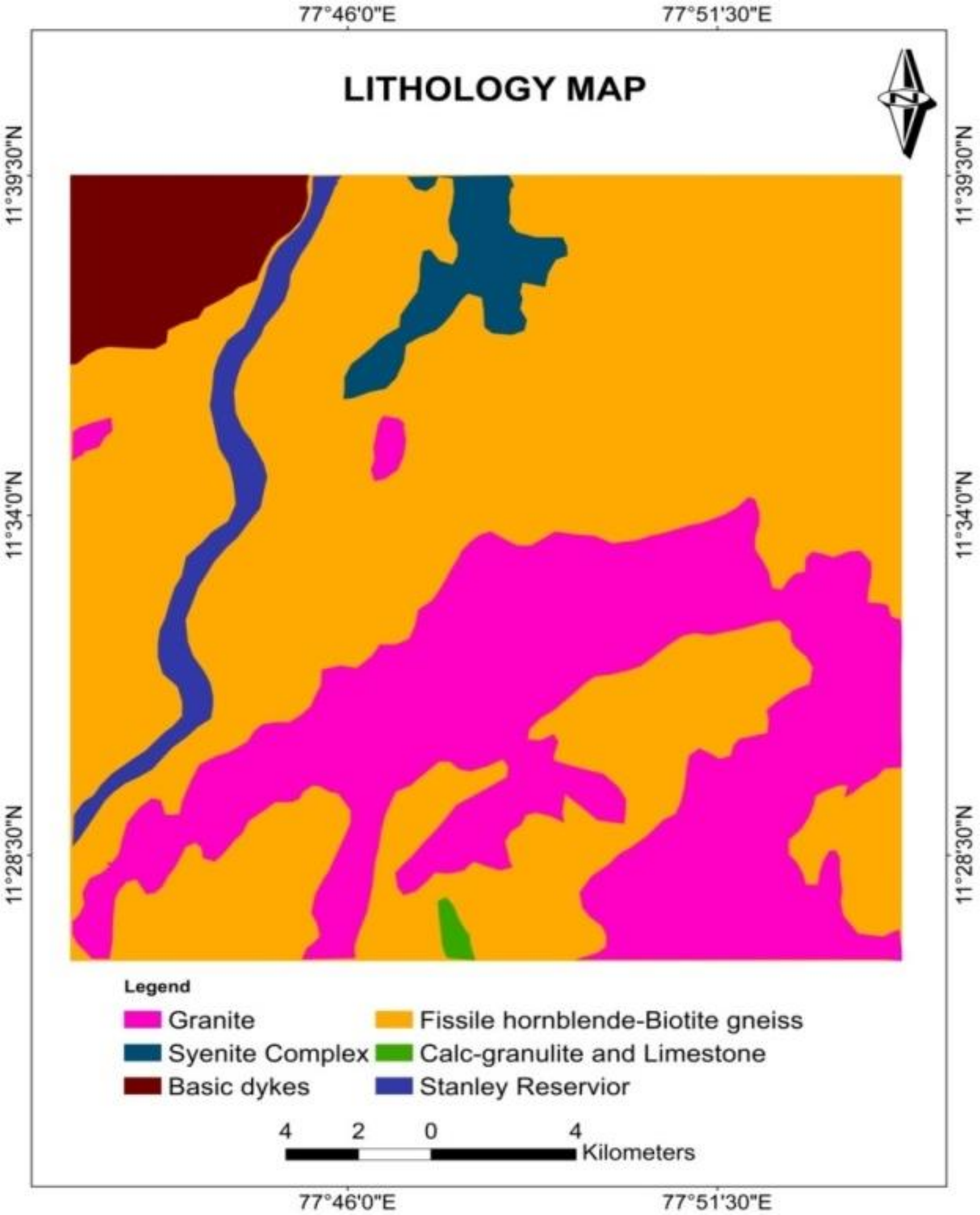

78°41'45"E
Subsurface Boundary of Granite
Bharathidasan University
Khajamalai Campus, Tiruchirappalli
N
W
E
S
10°46'40"N
20
10
0 Meters
Granite
Basement /Gneisses
78°41'45"E

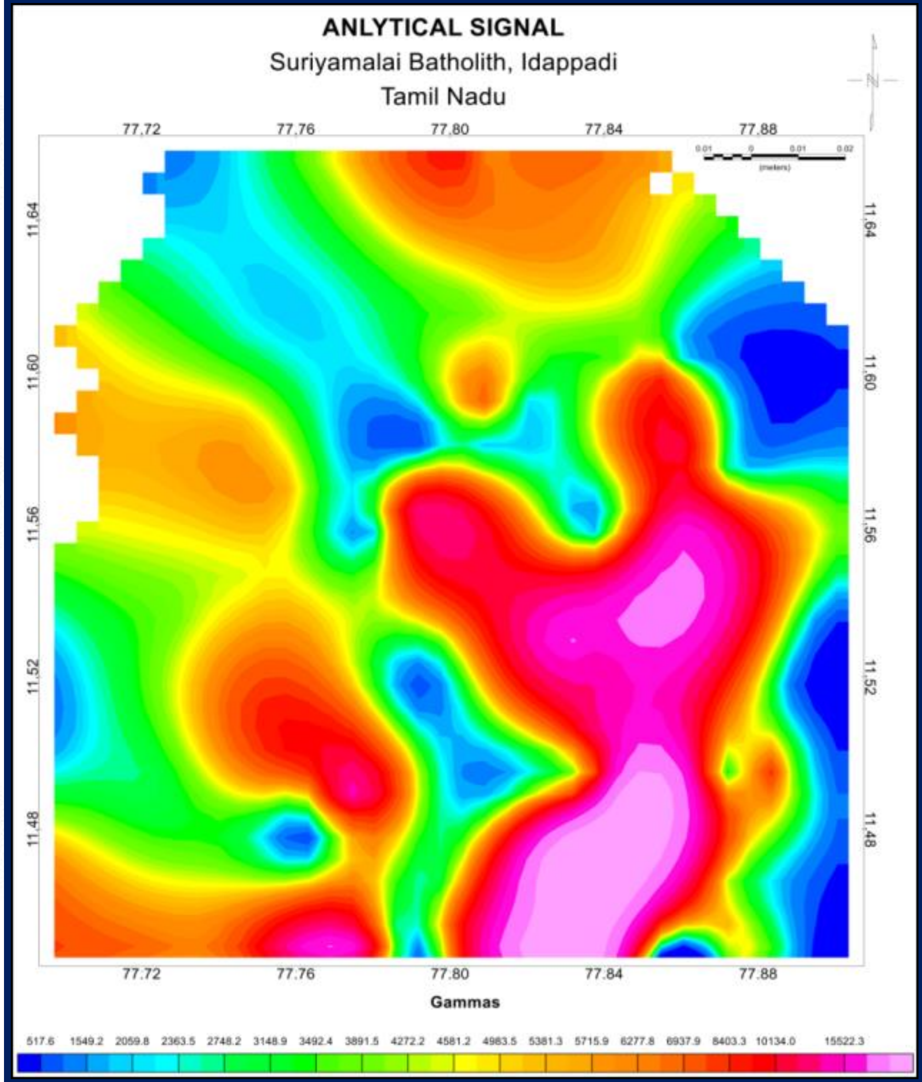
Regional Anomaly
Suriyamalai Batholith, Idappadi

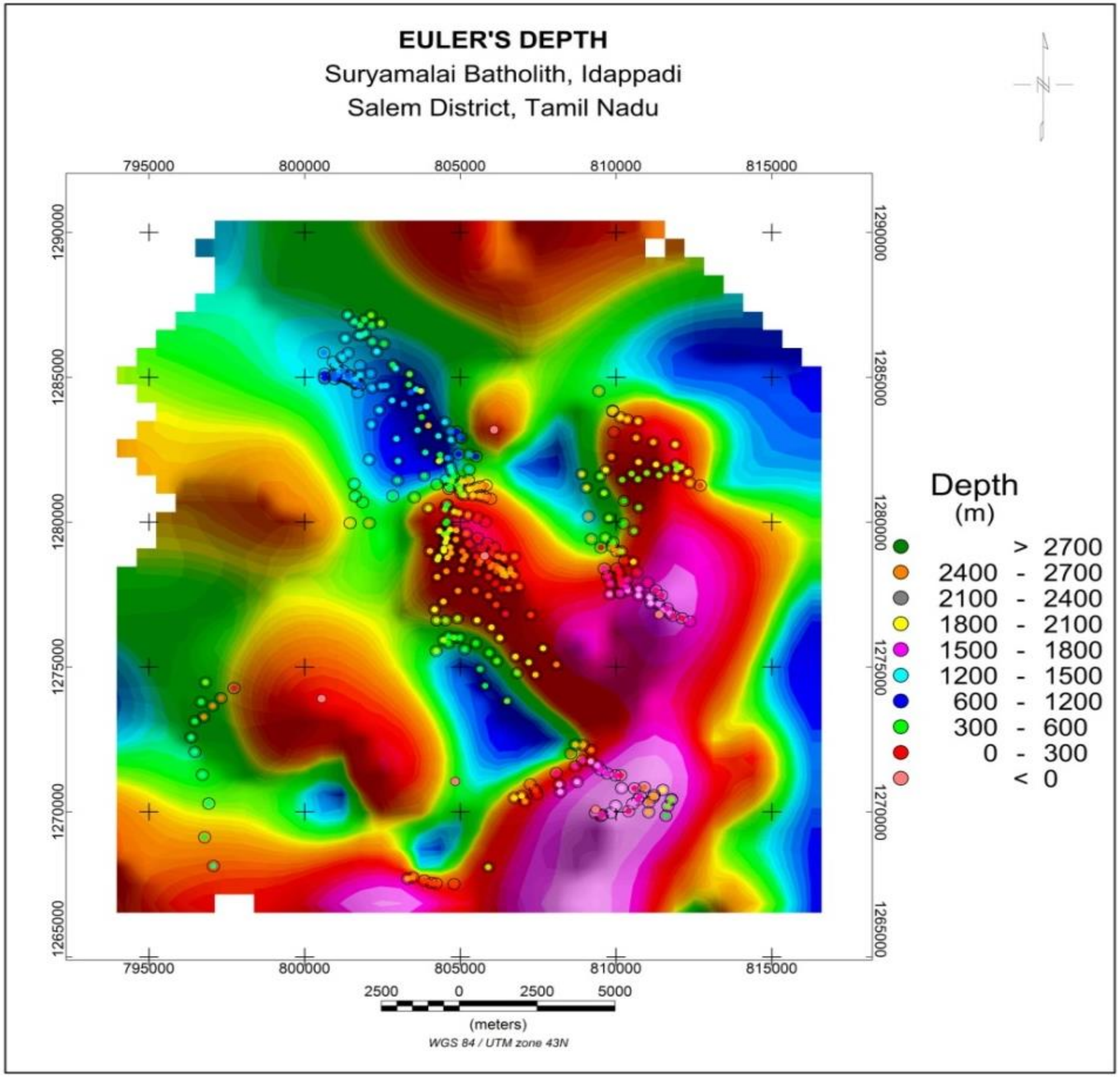


Magnetic Breaks Superimposed Over Contour



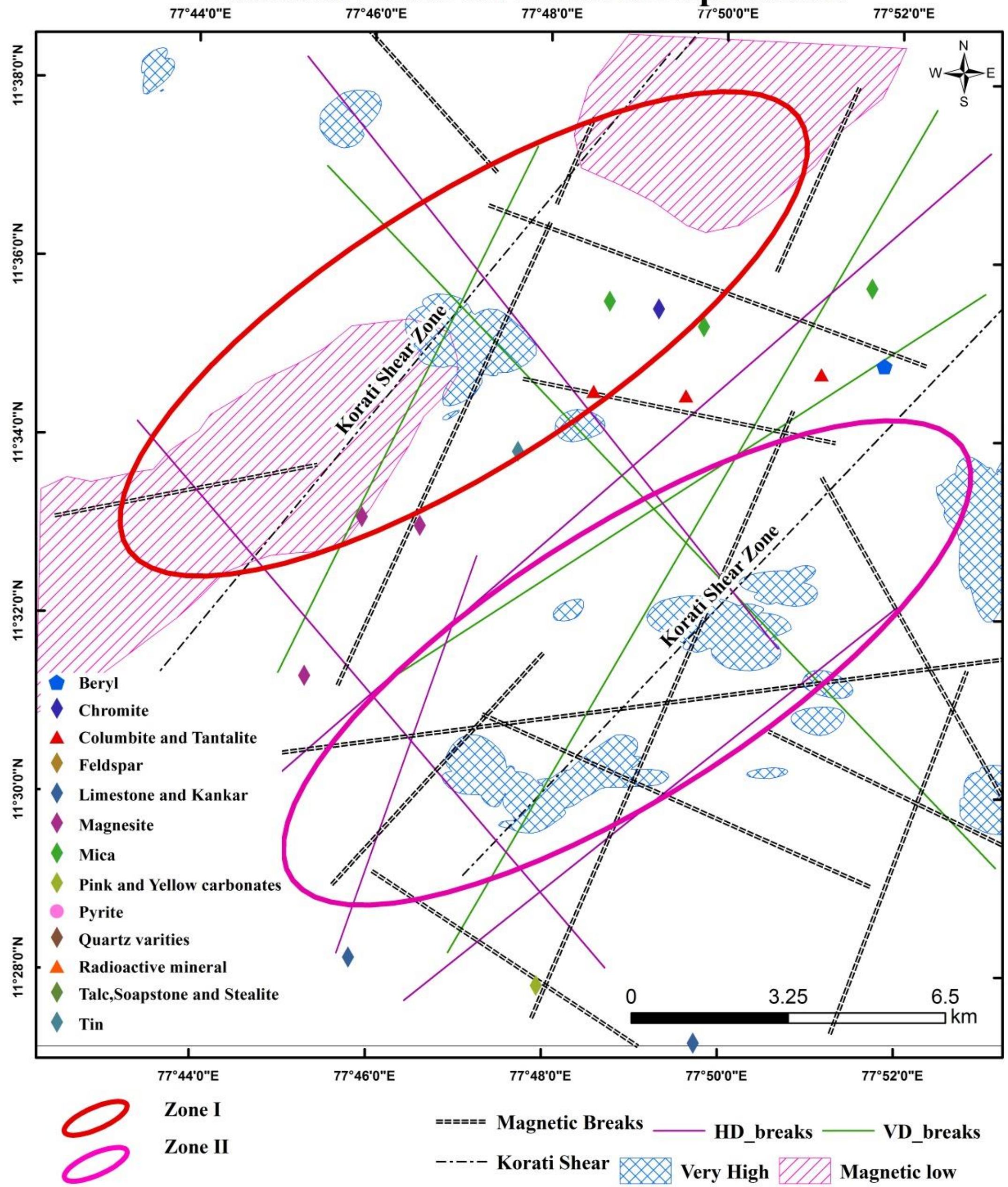

LITHOLOGY MAP
77°46'0"E
77°51'30"E
11°39'30"N
11°34'0"N
11°28'30"N
Legend
Granite
Syenite Complex
Basic dykes
Fissile hornblende-Biotite gneiss
Calc-granulite and Limestone
Stanley Reservior
4 2 0 4
Kilometers

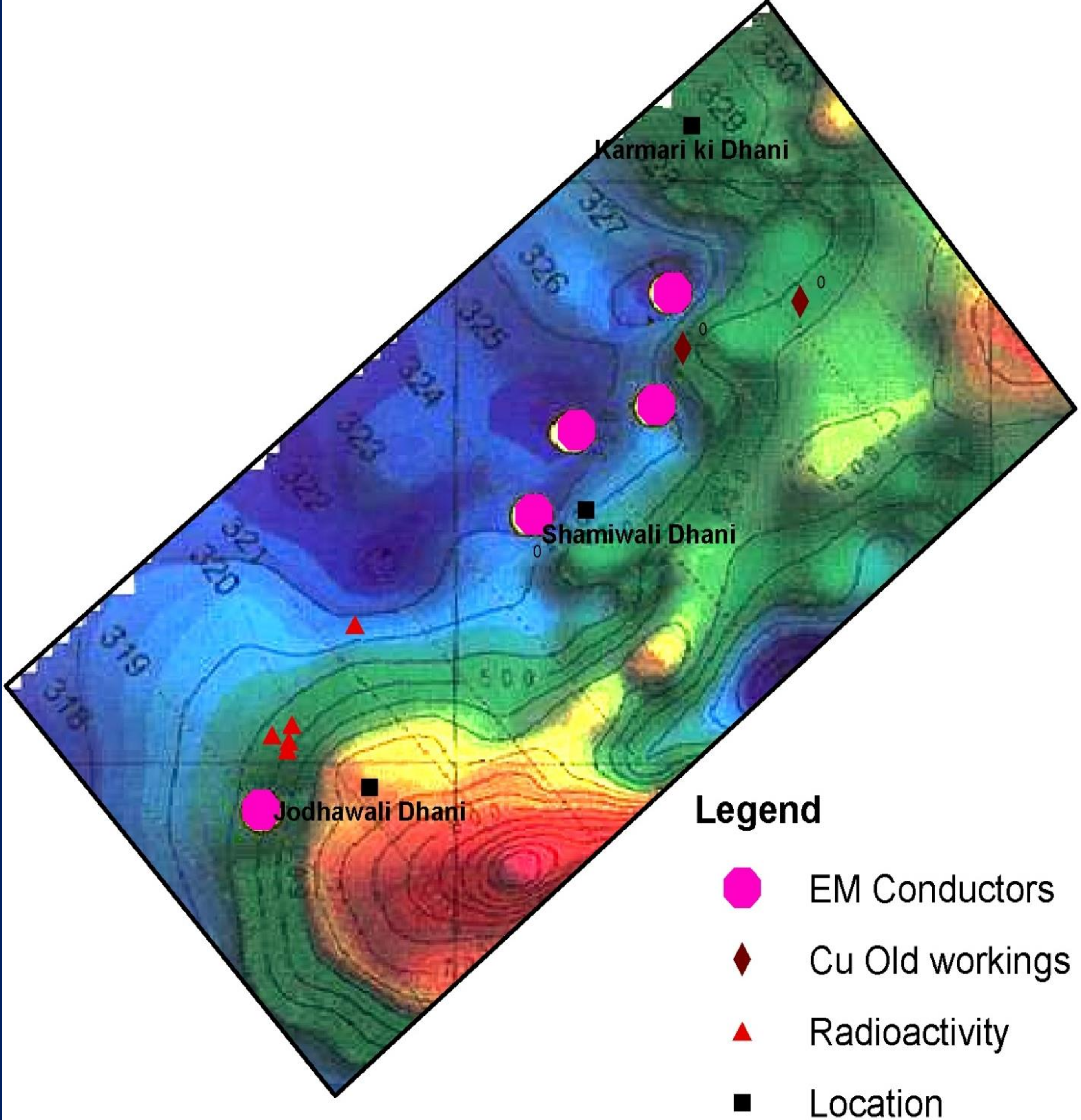

ANLYTICAL SIGNAL
Suriyamalai Batholith, Idappadi
Tamil Nadu
77.72
77.76
77.80
77.84
77.88
11.64
11.60
11.56
11.52
11.48
Gammas
517.6 1549.2 2059.8 2363.5 2748.2 3148.9 3492.4 3891.5 4272.2 4581.2 4983.5 5381.3 5715.9 6277.8 6937.9 8403.3 10134.0 15522.3

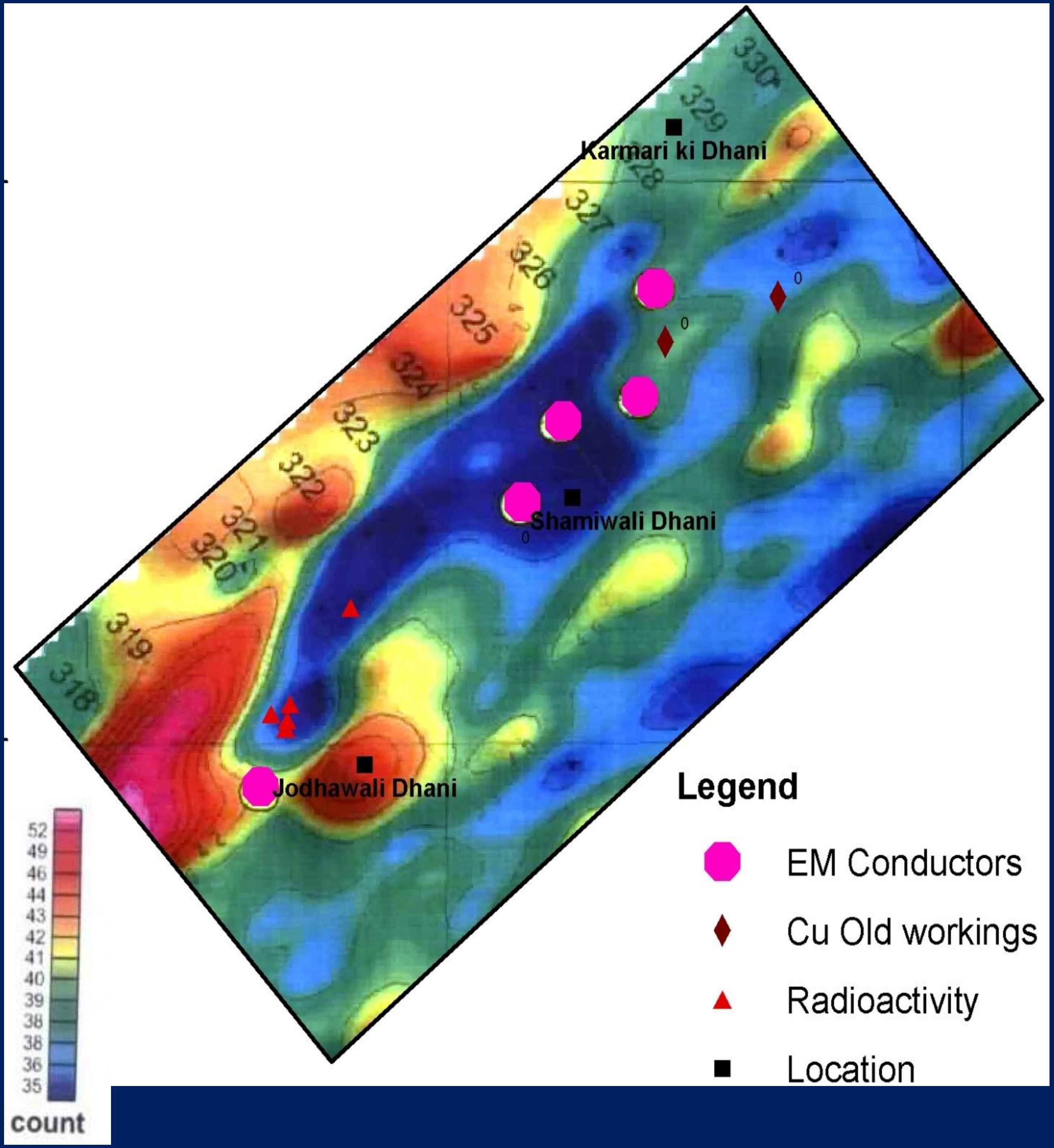


EULER'S DEPTH
Suryamalai Batholith, Idappadi
Salem District, Tamil Nadu
795000
800000
805000
810000
815000
1290000
1285000
1280000
1275000
1270000
1265000
Depth
(m)
> 2700
2400 - 2700
2100 - 2400
1800 - 2100
1500 - 1800
1200 - 1500
600 - 1200
300 - 600
0 - 300
< 0
2500
0
2500
5000
(meters)
WGS 84 / UTM zone 43N

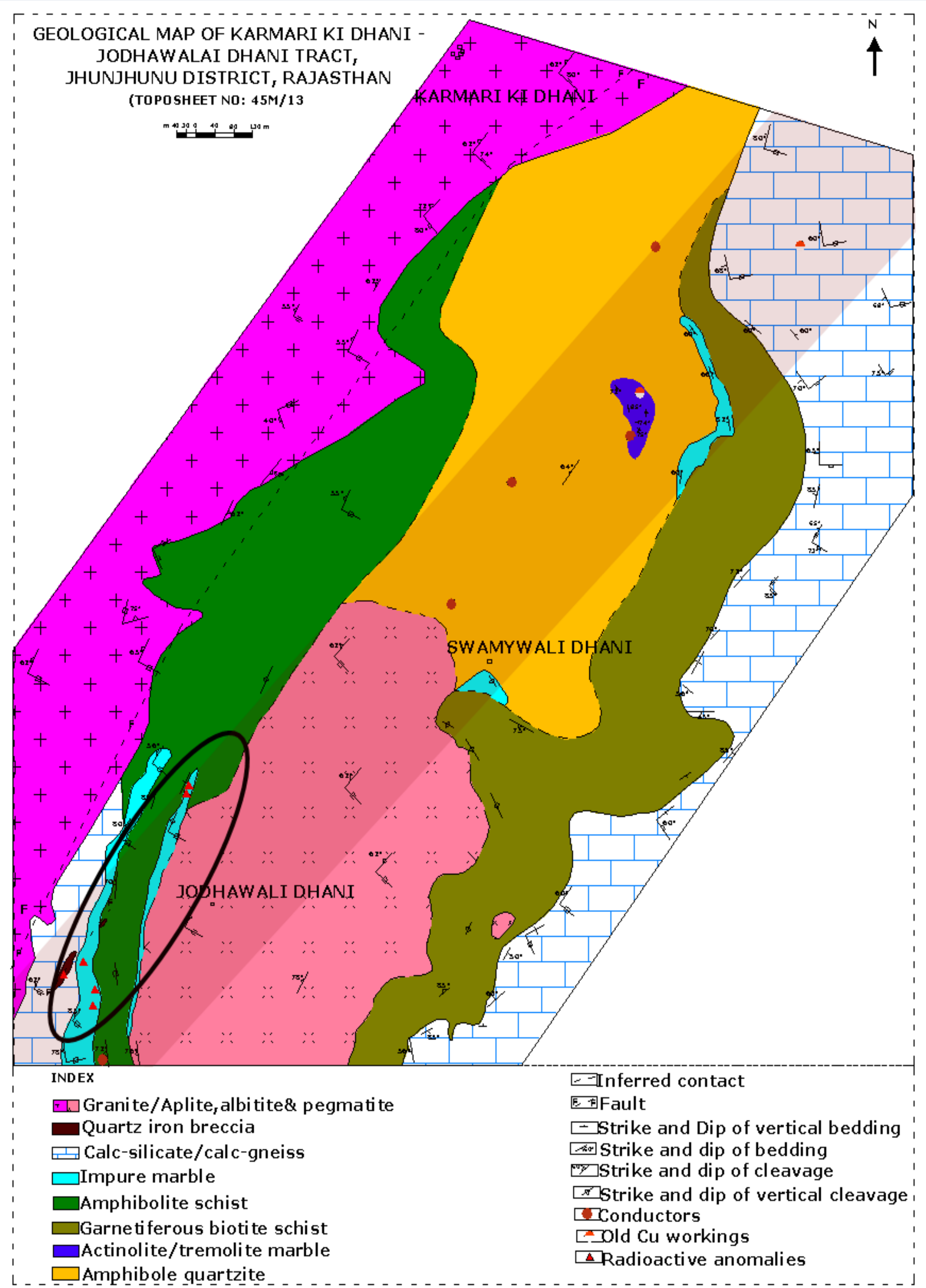
Potential Zones for Mineral Exploration




Karmari ki Dhani
Shamiwali Dhani
Jodhawali Dhani
Legend
EM Conductors
Cu Old workings
Radioactivity
Location



330
329
Karmari ki Dhani
328
327
326
325
324
323
322
321
320
319
318
Shamiwali Dhani
Jodhawali Dhani
52
49
46
44
43
42
41
40
39
38
38
36
35
count
Legend
EM Conductors
Cu Old workings
Radioactivity
Location

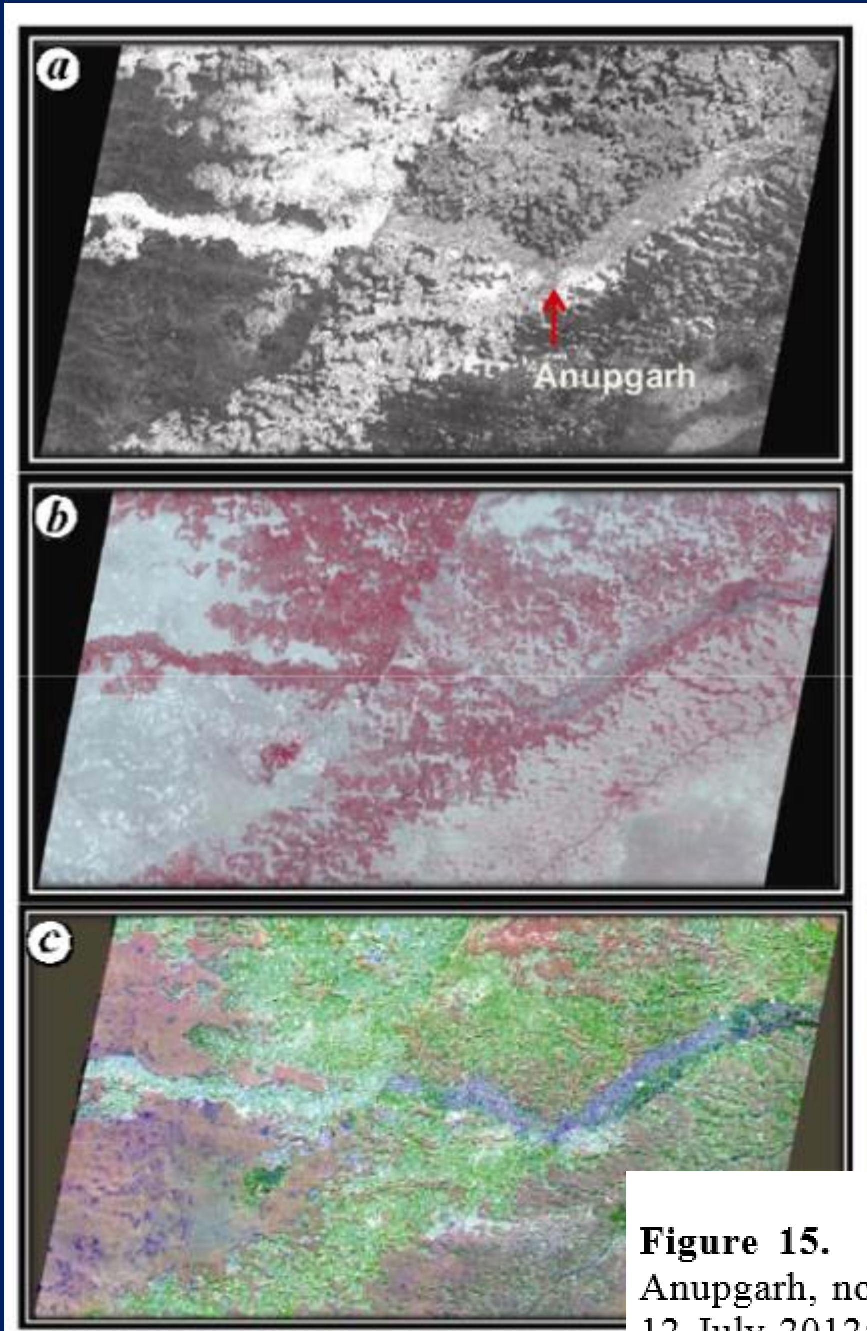

GEOLOGICAL MAP OF KARMARI KI DHANI - JODHAWALAI DHANI TRACT, JHUNJHUNU DISTRICT, RAJASTHAN
(TOPOSHEET NO: 45M/13)
N
KARMARI KI DHANI
SWAMYWALI DHANI
JODHAWALI DHANI
INDEX
Granite/Aplite,albitite& pegmatite
Quartz iron breccia
Calc-silicate/calc-gneiss
Impure marble
Amphibolite schist
Garnetiferous biotite schist
Actinolite/tremolite marble
Amphibole quartzite
Inferred contact
Fault
Strike and Dip of vertical bedding
Strike and dip of bedding
Strike and dip of cleavage
Strike and dip of vertical cleavage
Conductors
Old Cu workings
Radioactive anomalies

Microwave Remote Sensing in Mineral Exploration

- Imaging radars provide information that is fundamentally different from sensors that operate in the visible and infrared portions of the electromagnetic spectrum.
- One of the unique potentials demonstrated by spaceborne radar images is their penetration capability through shallow sand cover in arid regions and detecting subsurface geological and archaeological features, in particular buried river channels and imprints of archaeological sites occurring in the adjoining areas.

- The capability of the L-band (wavelength 24.5 cm) to penetrate 1–2 m of loose sand and return information about geologic and geomorphologic features covered by sand.
- The benefit of radar images to study bedrock features beneath few meters of loose sand.

- Ancient drainage pattern cut in the bedrock is not visible in the optical images because of the sand cover.
- The buried palaeo drainage network appears as dark features due to smoother channel fillings.
- It is also identified due to contrasting brightness of hard substrate of the adjoining region



The analysis of SAR data covering parts of Thar Desert in western Rajasthan led to identification of previously unknown buried channels, relict valleys and shallow, sand-covered limestone areas.

Figure 15. Parts of the palaeochannel of the lost Sarasvati around Anupgarh, northern Rajasthan as seen on (*a*) RISAT SAR acquired on 12 July 2012; (*b*) Landsat ETM FCC and (*c*) FCC of RISAT SAR and Landsat ETM merged product.

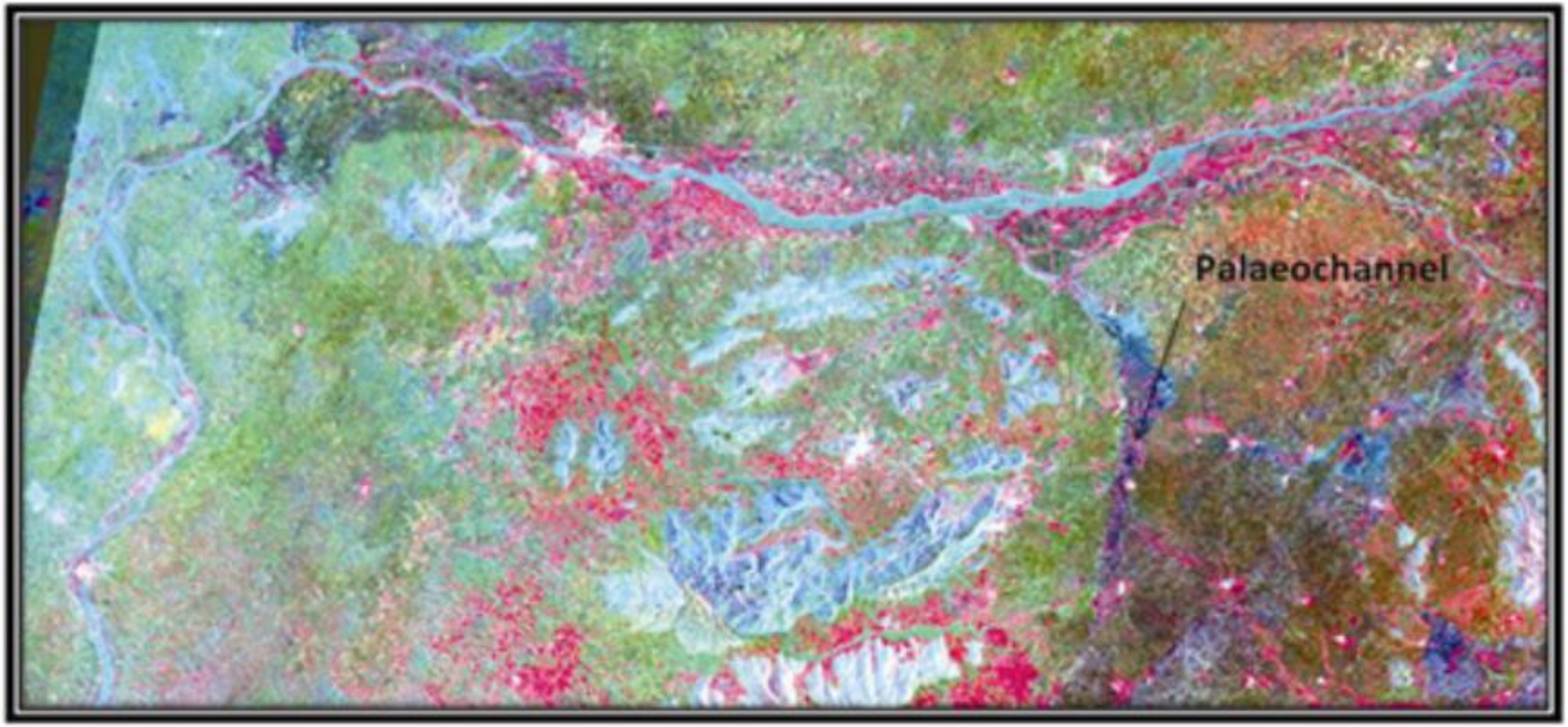
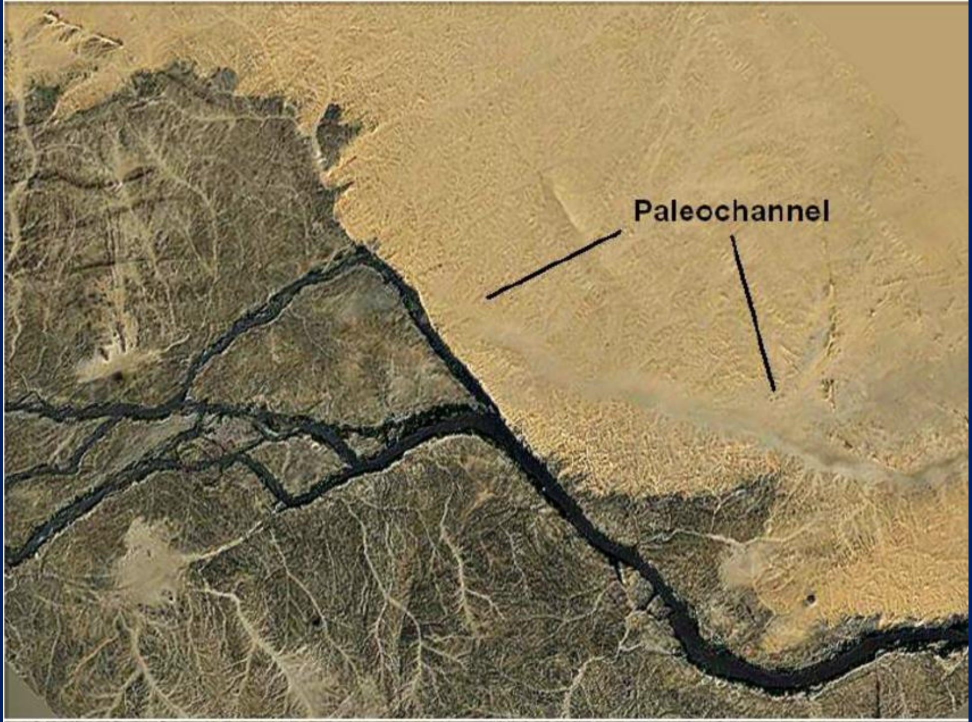
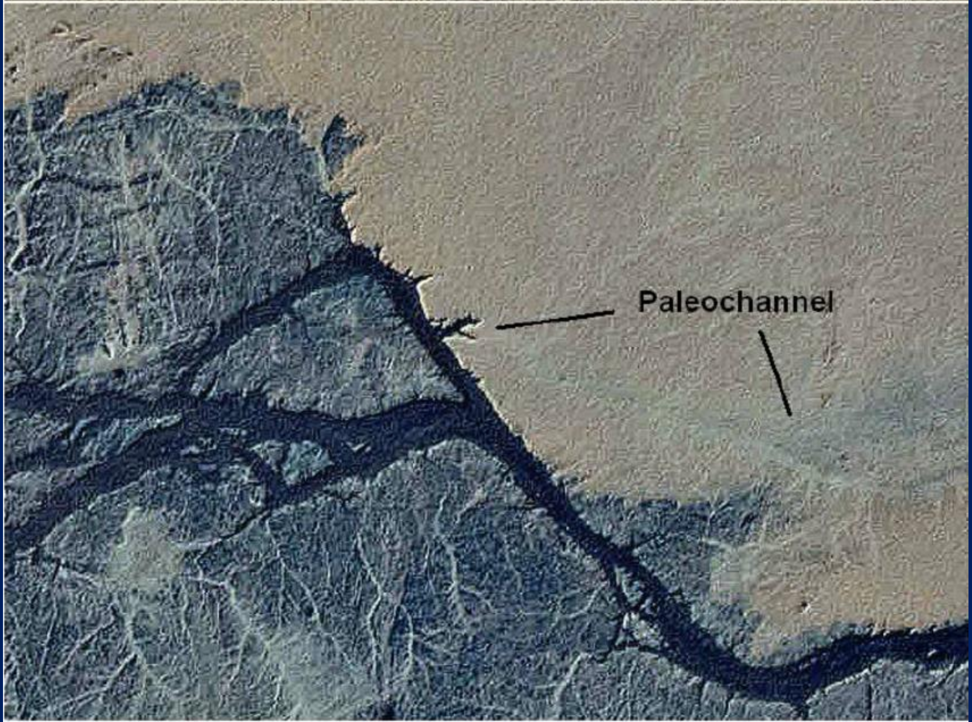
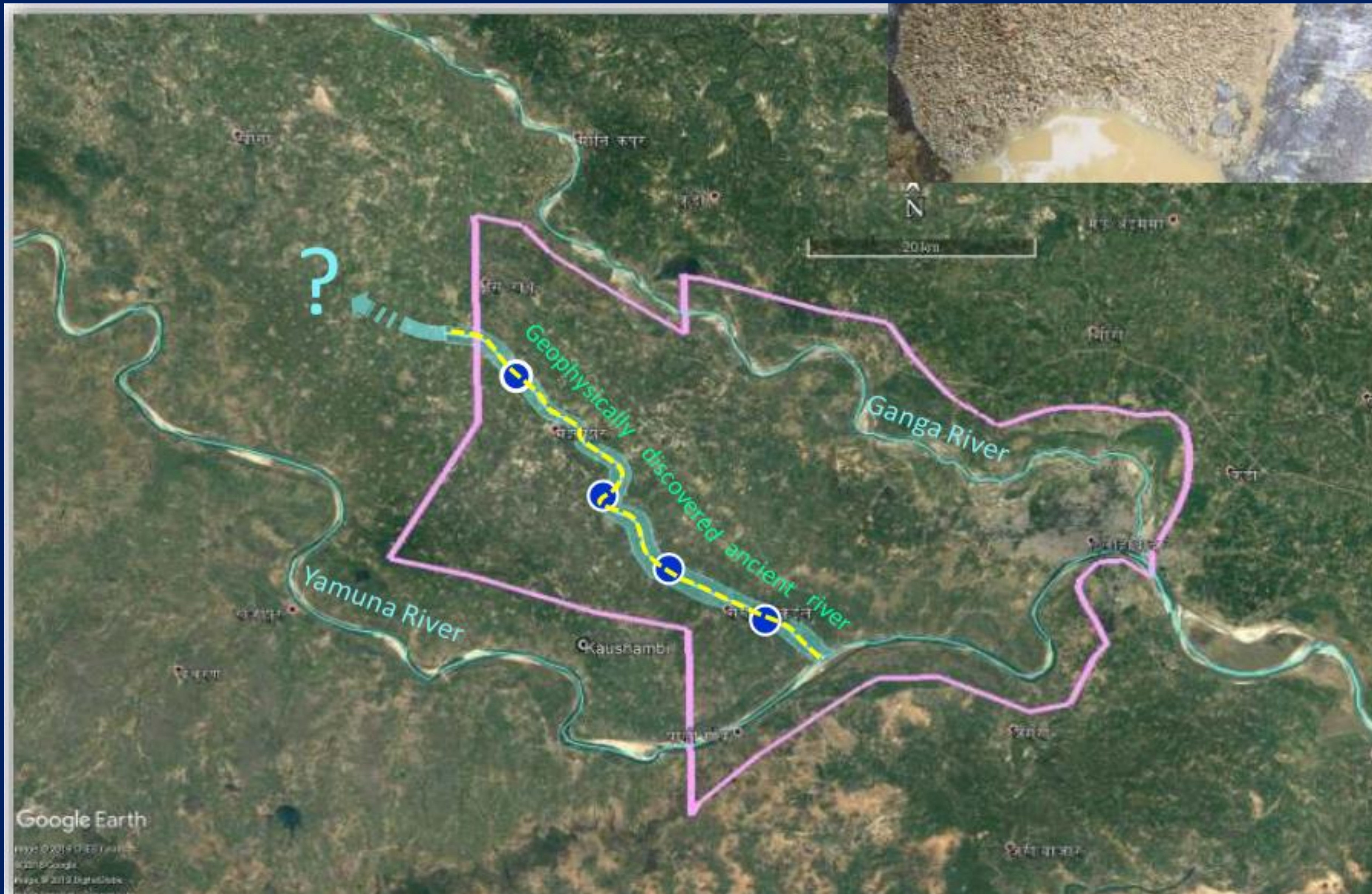


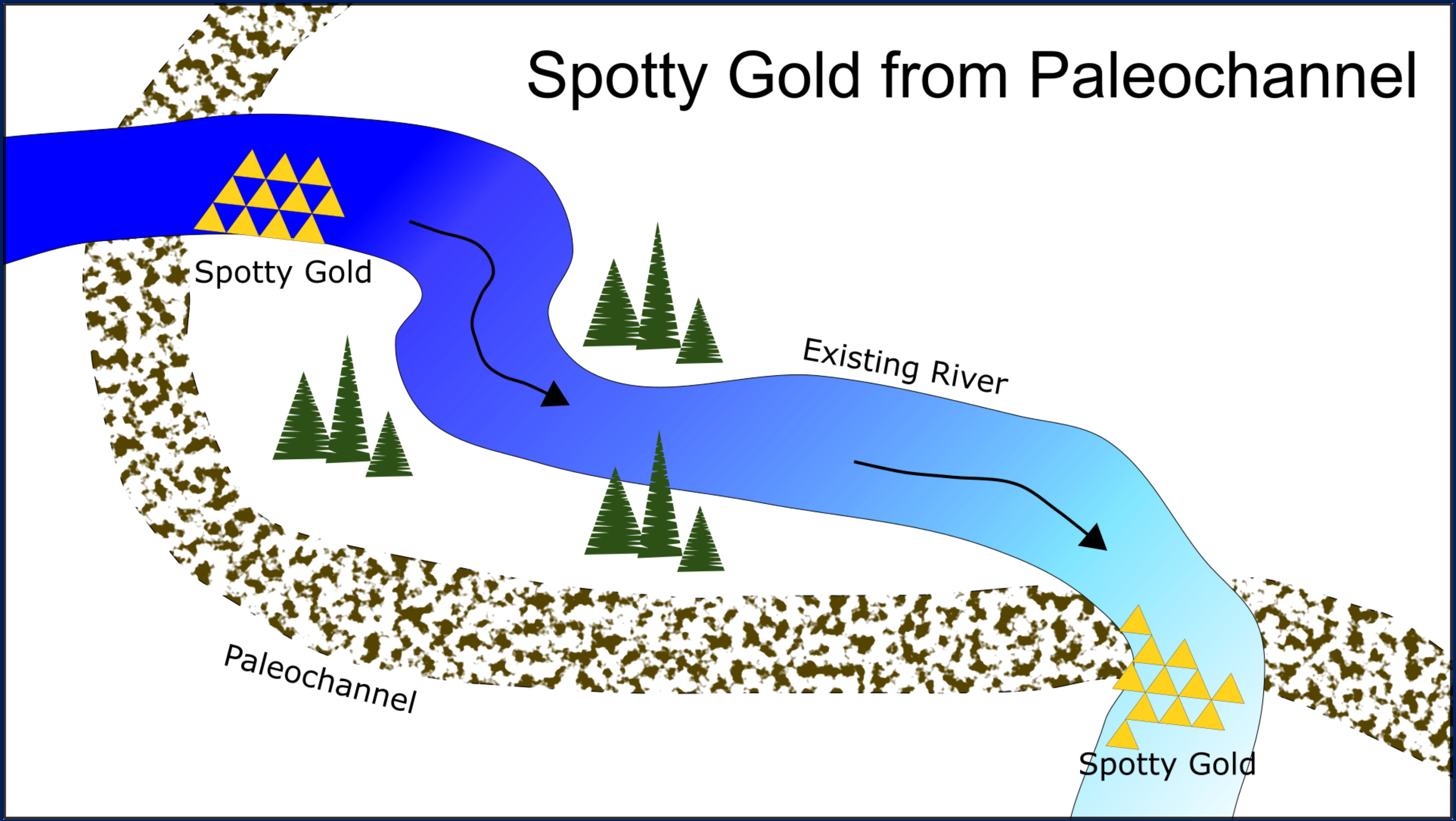
Figure 16. Palaeochannel detected on RISAT SAR and Landsat ETM merged FCC covering parts of Barmer, Jalor and Pali districts in the southern region of Luni River.


Paleochannel


Paleochannel



?
Geophysically discovered ancient river
Ganga River
Yamuna River
Kaushambi
N
20 km
Google Earth


Spotty Gold from Paleochannel
Spotty Gold
Existing River
Paleochannel
Spotty Gold

- **Thermal remote sensing** we measure the radiations 'emitted' from the surface of the target, as opposed to optical remote sensing where we measure the radiations 'reflected' by the target under consideration.
- It is a well known fact that all natural targets reflect as well as emit radiations.
- It is operating on 3-5 µm and 8-14 µm
- Block body is a hypothetical, ideal radiator that totally absorbs and reemits all incident energy upon it.

- The ***thermal inertia*** of a rock is the measure of a surface’s ability to absorb heat during the day and release it at night, and it has been used to determine the mineralogy of rocks present.
- The resistance of a material to temperature change, indicated by the time dependent variations in temperature during a full heating/cooling cycle.
- It is a measure of the response of a material to temperature change. It increases with an increase of conductivity, capacity, density.
- The rock either to absorb or to reflect light depending on the rock’s color.

- Materials with high thermal inertia have more uniform surface temperature through out the day and knight.
- Thermal Conductivity (K): It is a measure of rate at which heat passes through a materials.

Eg. Heat passes through the metal is faster than the rock

- Heat Capacity (C): It is how well the material store the heat.

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.

Imaging Spectroscopy.

- Spectrometers are used in the laboratory, in the field, in aircraft (looking both down at the Earth, and up into space), and on satellites.
- Reflectance and emittance spectroscopy of natural surfaces are sensitive to specific chemical bonds in materials, whether solid, liquid or gas.
- Spectroscopy has the advantage of being sensitive to both crystalline and amorphous materials.
- Spectroscopy's historical disadvantage is that it is too sensitive to small changes in the chemistry and/or structure of a material.
- The variations in material composition often causes shifts in the position and shape of absorption bands in the spectrum.
- Thus, with the vast variety of chemistry typically encountered in the real world, spectral signatures can be quite complex and sometimes unintelligible.

- **With the advances in computer and detector technology, the new field of imaging spectroscopy is developing**

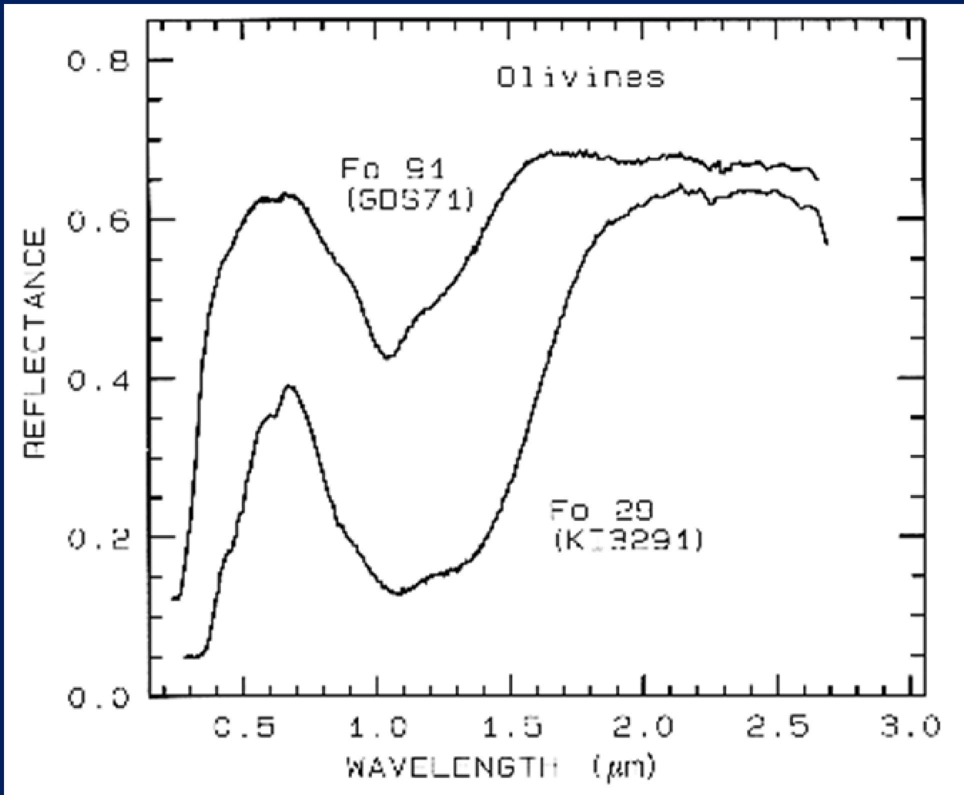
- **Imaging spectroscopy is a new technique for obtaining a spectrum in each position of a large array of spatial positions so that any one spectral wavelength can be used to make a recognizable image.**

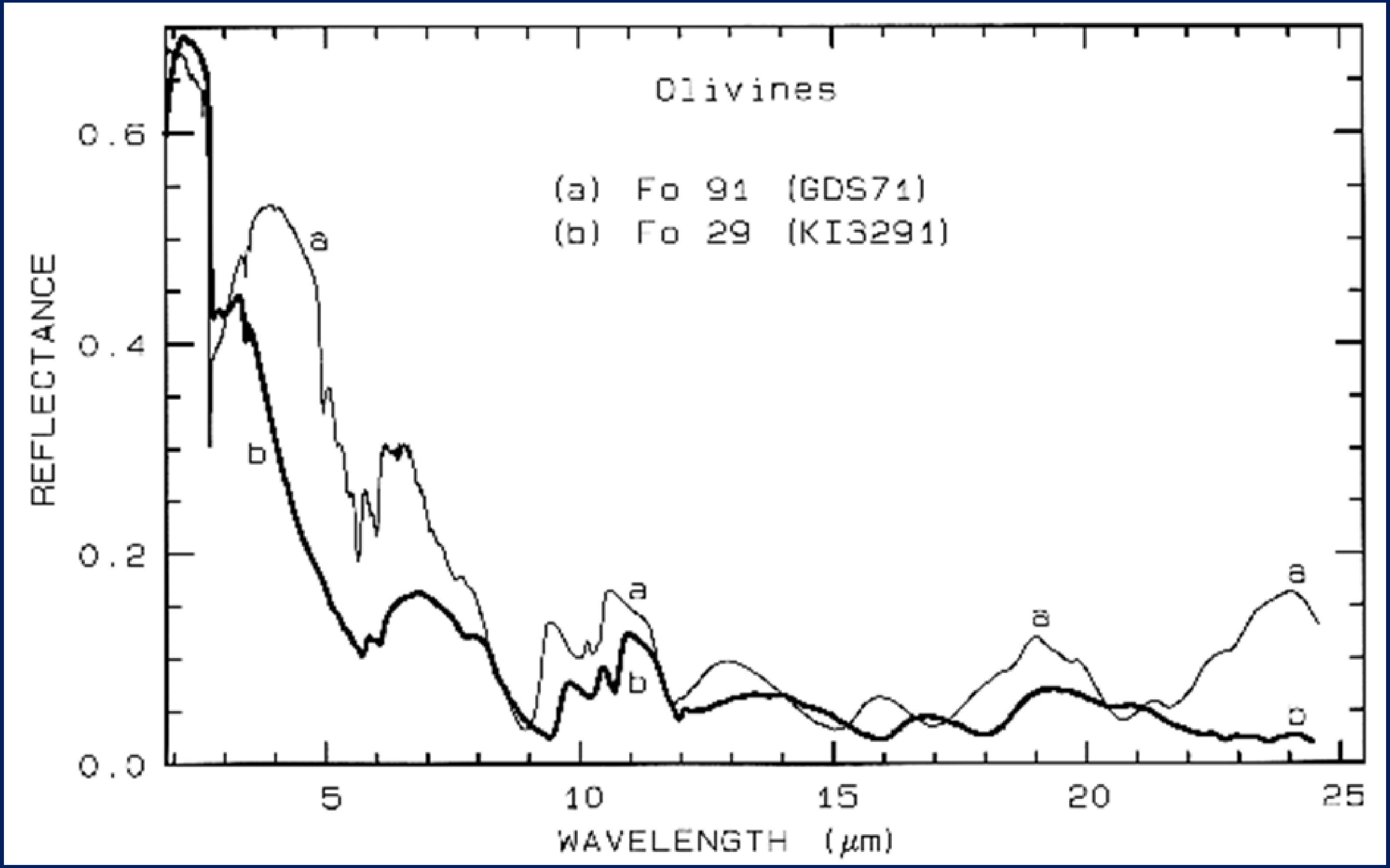
- **Imaging spectroscopy has many names in the remote sensing community, including imaging spectrometry, hyperspectral, and ultraspectral imaging. Spectroscopy is the study of electromagnetic radiation.**

- Spectrometry is derived from spectro-photometry, the measure of photons as a function of wavelength, a term used for years in astronomy.

- Hyper means excessive, but no imaging spectrometer in use can hardly be considered hyper-spectral, after all, a couple of hundred channels stakes in comparison to truly high resolution spectrometer with millions of channels.

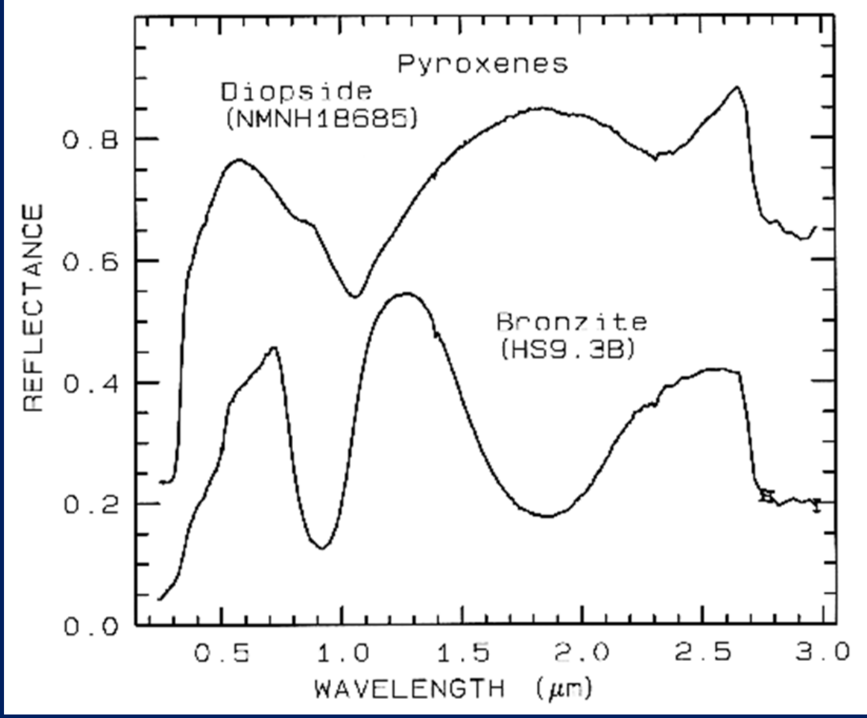
- Reflectance spectra of **two olivines** showing the change in band position and shape with composition.
- The 1-µm absorption band is due to a crystal field absorption of Fe^{2+}. "Fo" stands for forsterite (Mg_2SiO_4) in the forsterite - fayalite ($Fe_2^{2+}SiO_4$) olivine solid solution series.
- The Fo 29 sample (KI3291) has an FeO content of 53.65%, while the Fo 91 sample (GDS 71) has an FeO content of 7.93%. The mean grain size is 30 and 25 µm respectively.
- The 1-µm band position varies from about 1.08 µm at Fo 10 to 1.05 µm at Fo 90

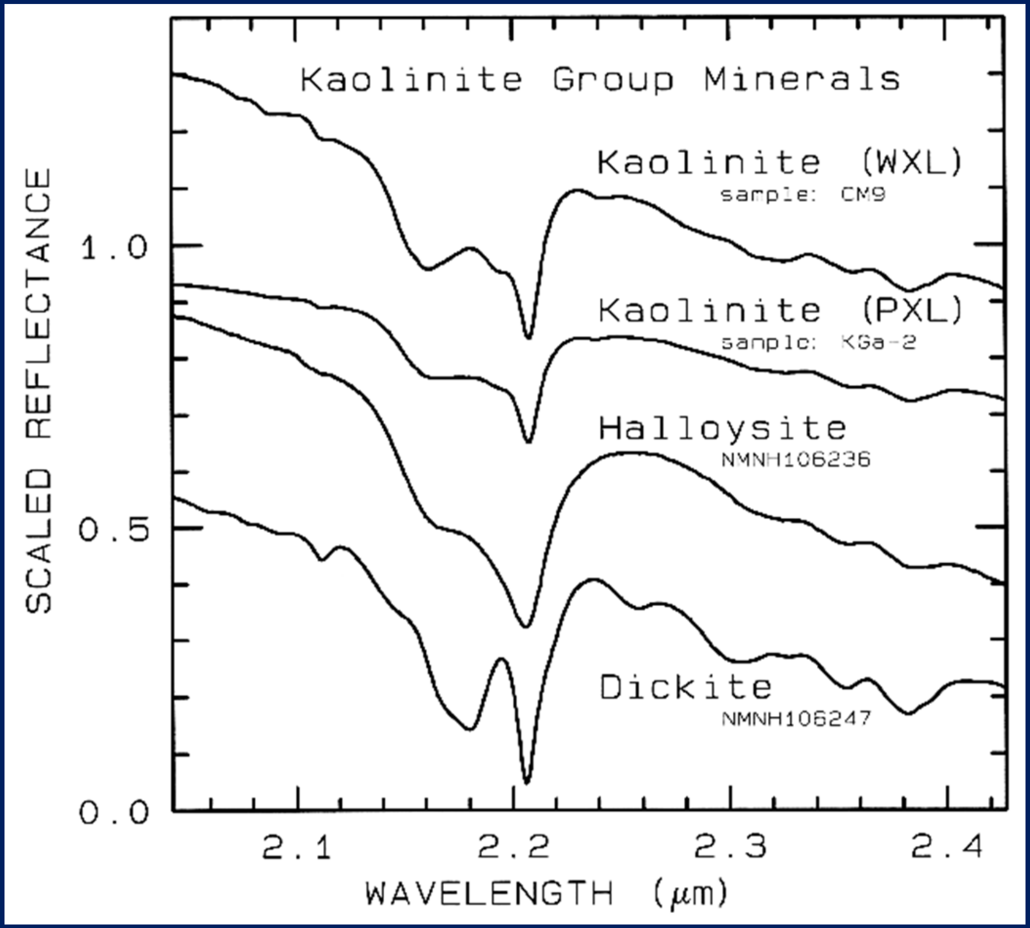




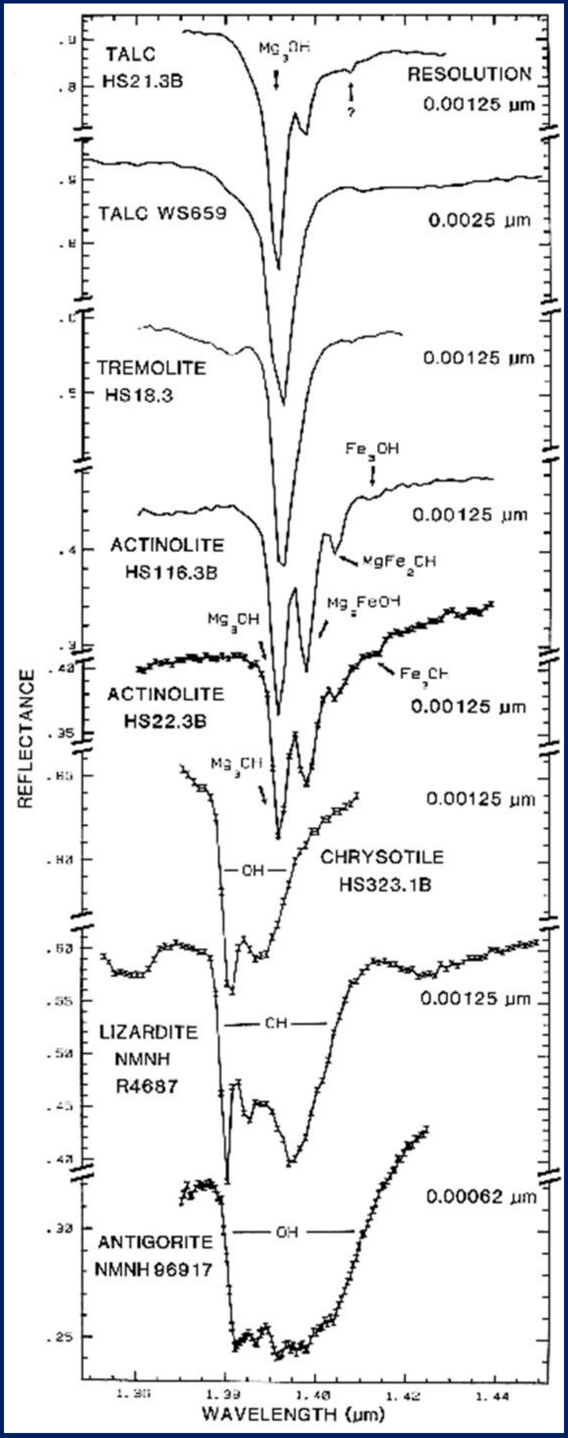
For Mid-infrared wavelengths. Note the shifts in the spectral features due to the change in composition.

- Reflectance spectra of two pyroxenes showing the change in **Fe^{2+}** -absorption band position and shape with composition.
- Diopside, sample NMNH18685, is $CaMgSi_2O_6$, but some Fe^{2+} substitutes for Mg. Bronzite, sample HS9.3B, is $(Mg,Fe)SiO_3$ with mostly Mg.
- The 1-µm versus the 2-µm band position of a pyroxene describes the pyroxene composition.





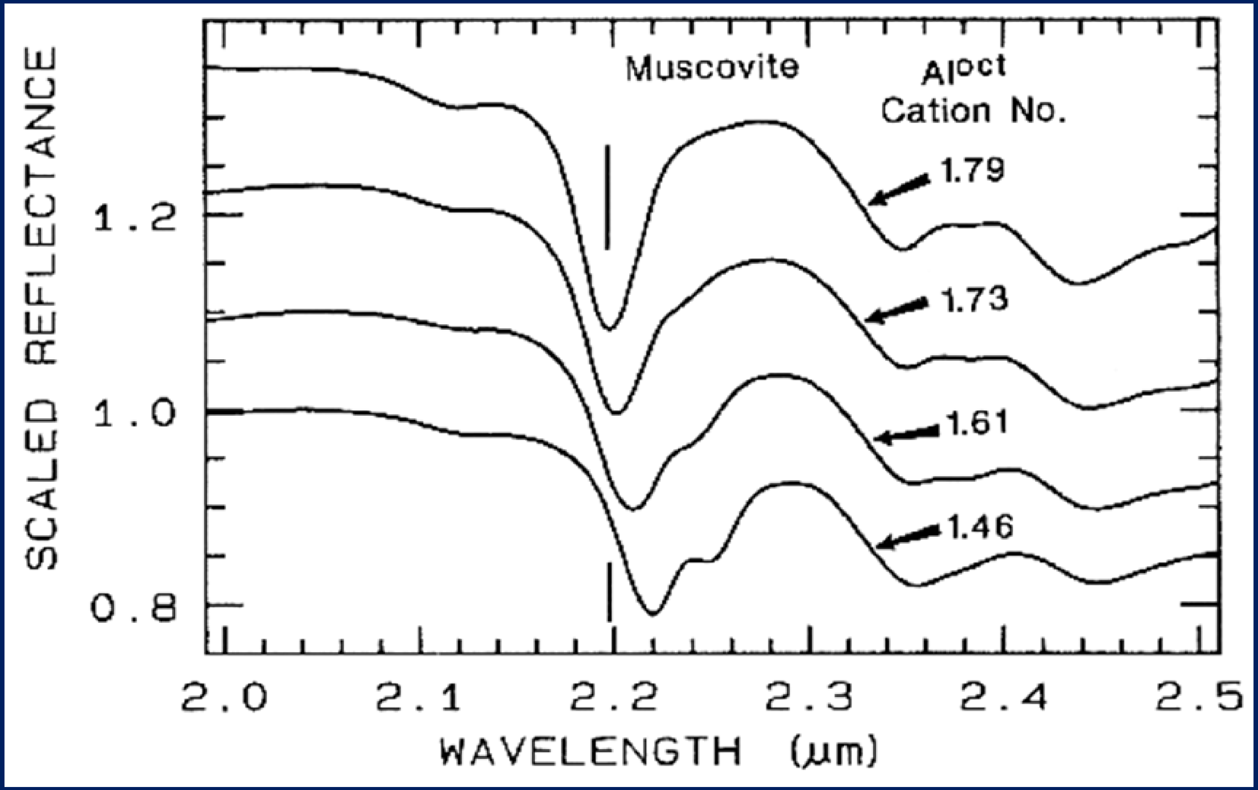
- Subtle spectral differences in the kaolinite group minerals near 2.2-µm.
- Kaolinite CM9 is well crystallized (WXL) while KGa-2 is poorly crystallized (PXL).
- Spectral bandwidth is 1.9 nm and sampling is 0.95 nm. Each spectrum was scaled to 0.7 at 2.1 µm then offset up or down so that the curves to not overlap.
- Original reflectances were between 0.5 and 0.8.



High spectral resolution reflectance spectra of the first overtone of OH in talc, tremolite, actinolite, crysotile, lizardite, and antigorite.

The three sharp absorption bands in talc, tremolite and actinolite are caused by Mg and Fe ions associated with the hydroxyls, causing small band shifts.

The Fe:Fe+Mg ratio can be estimated. In chrysotile, lizardite and antigorite, the absorptions change with small structural differences even though the composition is constant



Reflectance spectra of muscovite showing band shifts due to changing aluminum composition.

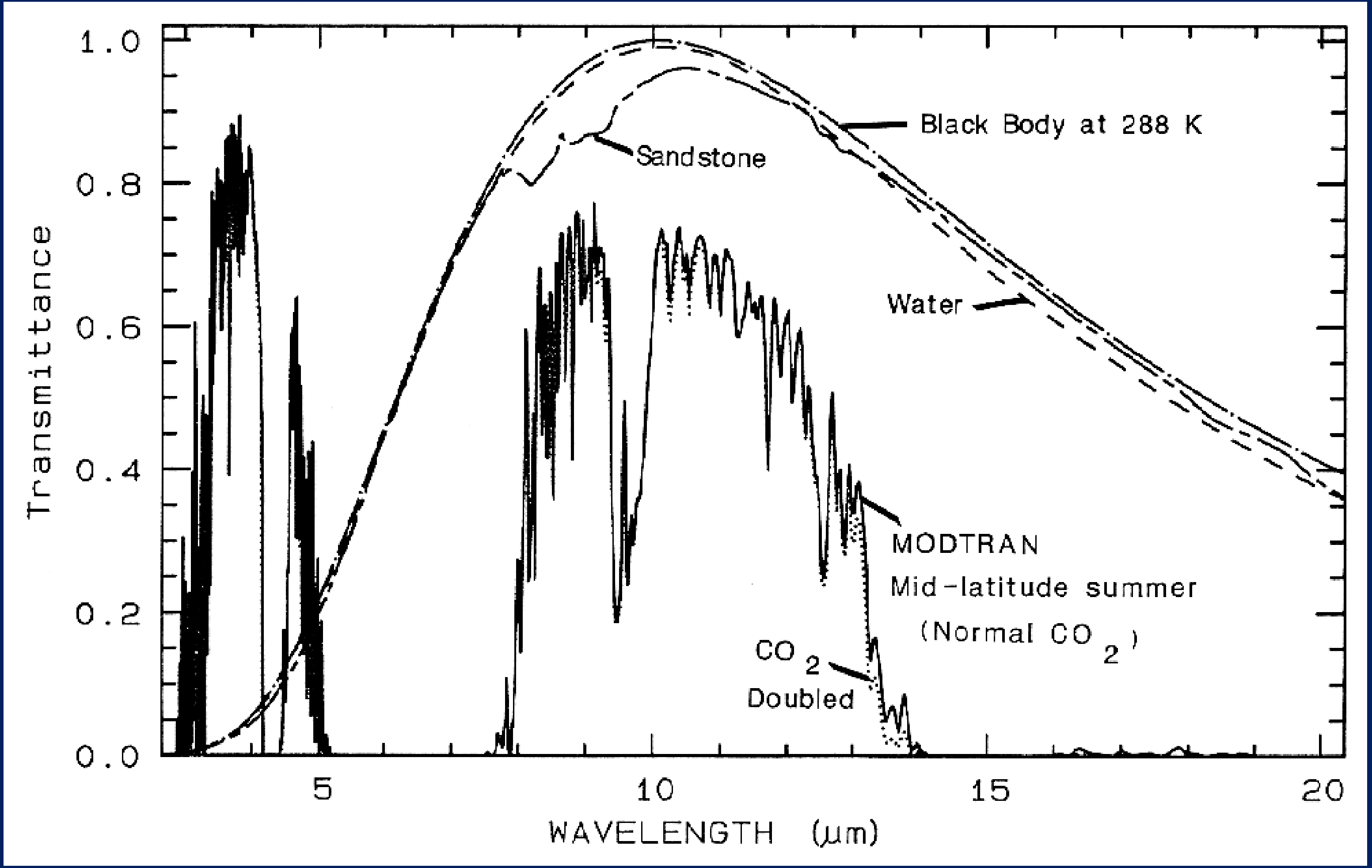
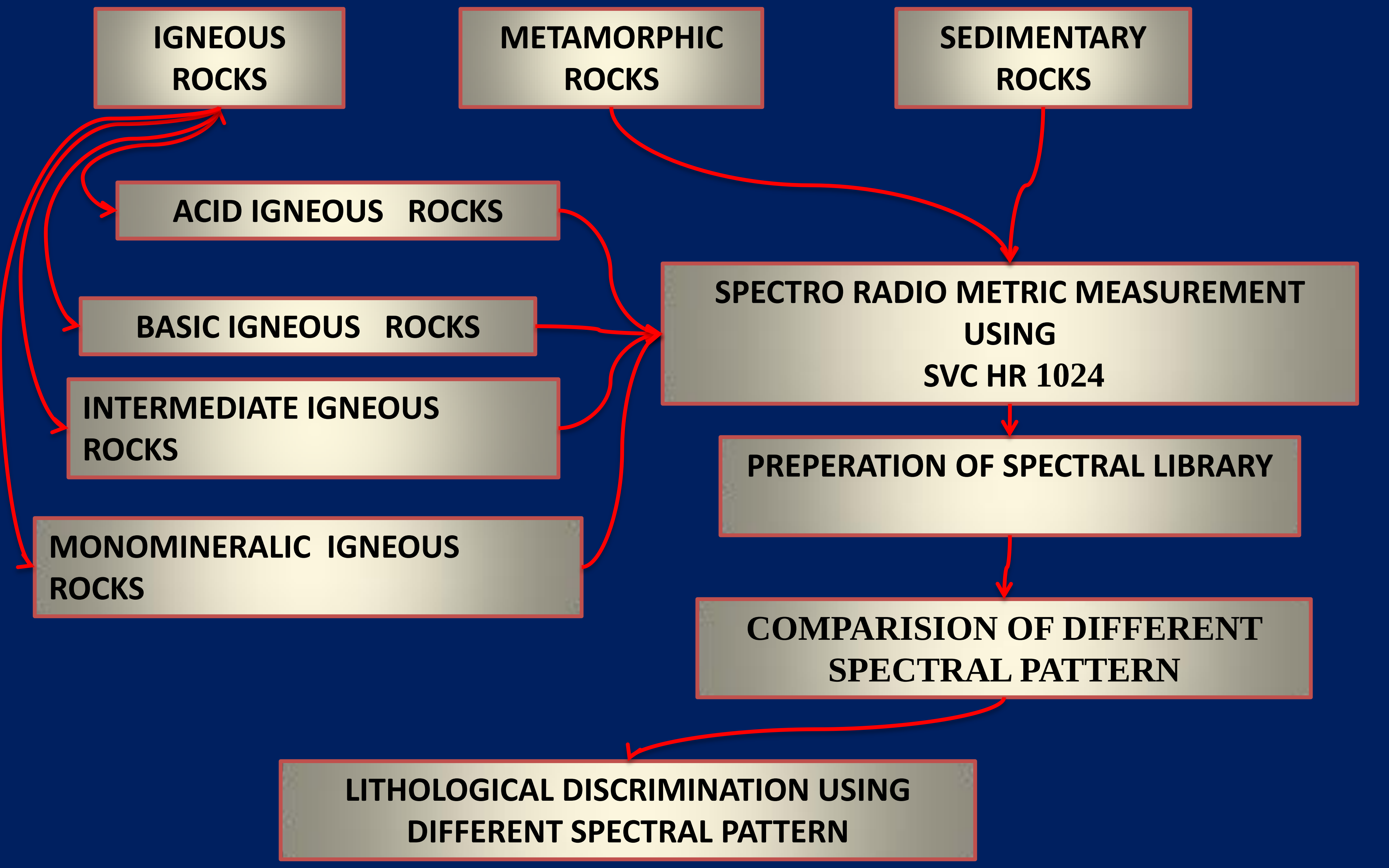


Figure 3b. Atmospheric transmittance, mid-infrared is compared to scaled grey-body spectra. Most of the absorption is due to water.

Carbon dioxide has a strong 15-µm band, and the dotted line shows the increased absorption due to doubling CO_2. Also shown is the black-body emission at 288 K and the grey-body emission from water and a sandstone scaled to fit on this transmittance scale.

The water and sandstone curves were computed from reflectance data using: 1 - reflectance times a black-body at 288 Kelvin.

METHODOLOGY



Interpretation

- The interpretation of magnetic data obtained in ground or airborne surveys made qualitatively and quantitatively, the later involving mathematical procedure.
- Magnetic anomalies are mainly attribute to the changes in the susceptibility and/or the remnant magnetism of rocks and minerals.
- The qualitative study yields information about the bodies causing the anomalies in the areas such as strike trends, faults etc.
- The quantitative analysis deals with individual anomalies and deduce the shape, size and depth of the causative bodies.
- The **quantitative** method of interpretations are half-anomaly width relation, Peters's slope method, upward and downward continuation method, derivative methods, RTP etc.

Qualitative study

- By visual inspection one may obtain information such as strike of the causative bodies from the trend of the contour.
- The intensity of the anomaly suggest whether one is dealing with strongly magnetic bodies weaker anomalies denoting structural features in the subsurface.
- If the anomaly is localized and the contours are crowded, the causative bodies may be inferred as shallow depth.
- Abrupt change in the contour pattern suggest the existence of fault.

- In mining field, it is very helpful to locate certain igneous body in the form of dyke, plugs and laccolith and other structural feature such as contact zones may also be noted.
- In oil exploration, the magnetic anomaly map show the margins of sedimentary basins.
- It also gives information about the deeper part of the basin with sediment thickness.

Application:

- It is used to map the sub surface geological structures.
- Geological mapping
- It is used to map the topographic features of the basement that might influence the structure of the overlying sediments
- Ground water exploitation are made more successful through knowledge of fracture system in crystalline rocks and bed rock aquifer under alluvial cover.
- It is used to map the volcanic areas which generally has large susceptibility and often remnants.

- It has an important role in mineral exploration because many mineral deposits are associated with magnetite concentration.
- Kimberlitic pipe are often directly detected by magnetic surveys at close sample spacing.
- Application in archeological survey.
- It has a great advantage in the exploration of massive sulphide ore.
- In oil exploration, it gives information from which one can determine the depth to basement and thus locate and define the extent of sedimentary basin.

Magnetic	Gravity
Elevation makes no differences	It cause serious affects
Topography will not make any differences	It will make great difference
Interpretation is more complicated	Less
Vector (both direction & intensity)	Scalar
Anomaly due to magnetization of rock	It is due to density variation
Elements of magnetization has attractive and repulsive	All the elements of mass attractive only
It measures total component	It measures only vertical component

Gravity: Field Procedure

- Precious location and elevation of the each stations is very important in this gravity prospecting.
- Elevation of each station locations should be obtained accurate to 0.05m.
- 1m error in elevation will cause 0.33mgal in gravity value.
- Locations of each point should not more than 20-25m along the north and south directions.
- The error of 50m either in north or south direction will cause 0.02mgals.

- Leveling instruments or DGPS must be used to get the elevation values.
- For mining exploration, the survey area in general not very large and stations should be carried out very close intervals.
- For long narrow type of ore body, survey should be taken up across the mineralization.
- For the ore body of 100m length, traverse should be made on 10m interval to get the accurate picture of the ore body.
- In case of massive irregular ore bodies, a regular grid pattern with spacing of one third of expected depth of mineralization may be adopted.
- The layout should be planned by taking into the account of nature of topography, available aerial photographic study and existence of road and the transport facilities.

- During the survey, the instrument is kept directly on tripod over the stations marked by the surveyor.
- Leveling of the instrument has to be done using the screws at the bottom.
- After one or two hours of survey, the instrument should brought back the base station to check the drift of the instrument.
- Even the best instruments are susceptible to creep because of the springs or torsion fibres. It is mainly depends on temperature change, mechanical jolts and other factors like shocks during the transport.
- Drift curve is generated by plotting the gravity values with respect to time.
- Some times the reading at one place may be repeated to three to four times when the base station is far away from the survey area.

Interpretation

- Gravity anomaly map generally indicates lateral changes in density of the subsurface rock formations. The variations of density in vertical direction is depth wise change in rocks formation.
- The depth of the ore body can not be predicted directly from the data obtained in surface measurement.
- The geological and geophysical interpretation of a gravity data is more of an art than a science.
- Knowledge and experience of the interpreter plays an important role in these interpretations.
- To interpret the gravity data both physical and geological knowledge must be required. Besides, other type of geophysical data also help to solve the problem

Interpretation

- Interpretation of gravity data properly begins at the very early stage of survey planning and survey must be designed with desired goal really in the mind.
- The critical factors of survey design are the accuracy and spatial distributions. (limiting the survey area for accuracy). These things can be done with prior knowledge of the area and buried sources.
- The accuracy of the gravity data for geological intepretations depends both on the accuracy of the gravity observation themselves and on the accuracy of the other quantities namely station location, elevation, density of the near surface rocks that must be used to reduce the gravity observations to form a suitable interpretaions.

Interpretation

- Generally, the first step in interpretation is the removal of regional field to isolate the residual anomalies. Because, in gravity survey, residual anomalies are prime interest.

Regional and Residual

- Regional and Residual separation may be performed by graphically by sketching in a linear and curvi-linear field by eye. Such method is biased by the interpreter however it is based on the prior knowledge only.
- Other than Graphical, several analytical and graphical methods are available to isolate the Residual from Regional.
- The noise free anomalies contain two components called Regional and Residuals. Due to their deep seated origin, the regional components are broad and have a uniform varying gradient in contrast.

Regional and Residual

- Regional anomalies are sharp and narrow
- Both regional and residual can be separately interpreted for a possible geological information. However, residuals area always analyzed more systematically then the regionals.

➢Interpretation of EM data

➢EM survey gives the information about the geometrical disposition and conductivities of the causative bodies and the nature of the overburden.

➢Qualitative interpretation of data in lateral exploration may often enough.

➢Quantitative determination as estimations of depth, shape, dip etc of the indicating ore body interpretation.

➢Interpretation should be carried out based on the loop orientation and by keeping the instrument in mind.

➢Modeling will be very useful for different geometrical types of ore bodies.

➢Horizontal loop will give better information about the vertical body similarly vertical loop will give much information about horizontal body.

- **Effective Depth of E.M Surveys**
- The depth to which an E.M method is effective depends on the resistivity of the ground, the frequency employed and the separation transmitting loop and the receiving coil.
- The resistivity of the ground and the frequency of the current employed in a system should be taken together for consideration to evaluate the effective depth of penetration.
- The higher the resistivity of the ground, the greater will be the depth of penetration for a particular frequency. But an increase in frequency will reduce the depth of penetration.
- If the ground if highly insulating, the E.M waves will penetrate large depths.

Skin Deth:

The maximum depth of transmission of EM wave into the subsurface, called Skin Depth (d).

$$d=500 \sqrt{\rho/f}$$

Where d is in meter, ρ the resistivity in ohm.m and ‘f’ is in Hz or c.p.s.

- Although the depth of penetration of E.M waves may be calculated from formula, the depth of exploration in most of the EM units would probably be only half of the calculated depth of penetration.
- In the horizontal coplanar system has a depth of exploration about one half or two-thirds the distance between transmitting and receiving coils