Al-Farouk journal of sciences
Volume (2), Issue (1) (March, 2026)
ISSN: 3135-2359

مجلة الفاروق للعلوم
المجلد (2) العدد 1 مارس 2026
ردمد: 3135-2359

Improved geological mapping using Landsat-5 TM data, Northwest of Yunnan province Weixia area, China: PC and IHSecorrelation stretching

[1] Dr. Tarik B. Benomar, [2] Dr. Hafid Nanis
[1&2] College of Engineering Technology, Zuwara, Libya
hafidnanis@gmail.com

Received: 29/1/2026 Revised: 20/2/2026 Accepted: 28/2/2026 Publication: 5/3/2026

Abstract.
A Landsat-5 TM digital spectral data covers Weixi area which lies in the North West of Yunnan Province, China, which is commonly called as 'three river' . Different image processing algorithms have been evaluated in the context of geological mapping using Landdsat TM data. False color composites, the principal component imagery, and IHS decorrelation stretching method for Landsat-5 TM data have been found useful in delineating the regional geological features, mainly to provide the maximum geological information for area of study. The study testifies that using different image processing yields best results for geological mapping in arid and semiarid regions by preserving morphological and spectral information. Generally, the study area can be divided into three main geological units: Basaltic intrusive rocks, Metamorphic with varying intensities and Sedimentary rocks.

Keywords: False color composites, HIS decorrelation, principal component, Weixi.

1. Introduction

Remote sensing technology has opened a new chapter in geological mapping and related studies. The data from earlier satellite generation sensors like LANDSAT, SPOT, IRS-IA and 1B had limitation of spatial resolution. The data available from new satellites like IRS-1C are more useful in detailed mapping.

The goal of this chapter is to improved visual interpretation in discriminating various lithological units and for detection of structural features using standard image processing algorithms such as selected band composites (Grippen 1989), principal component analysis (Kaufmann 1988) and IHS decorrelation stretching methods. The combination of information extracted from these two methods has been used for producing maps with improved geological data and accuracy.

The study area (weixi) situated in northwest of Yunnan province between Latitude (26 07 to 28 66N) and Longitude (97 92 to 101 89 E), respectively (figure1). The study area lies in the region of high mountains, the study area represent by several different scale of rivers. vegetation in the study are not very high in most parts, so the rocks are by and large well exposed.

Figure 1: Shows the location map of study area

2. Geology

Study area district lies in the northwest part of Yunnan Province, which is commonly called as " three river" area. It is the combined part of Eurasia plate and Gondwana plate.

The three rivers area have complicated the tecto-genesis and magma volcano activities and are praised as the earth dynamic, key for solving global structure problems, especially solution of Tethyan geosyncline.

The main rock associations in the region include variable composites of metavolcanics, principally Meta andesites, metatuff, schist, rhyolites, and sediment rocks such as limestone, sandstone, shale and conglomerate, and igneous rocks . The different kinds of rocks and formations in the study area are concisely described as follow:

Cenozoic Era

This Era represented by conglomerate, mudstone, ryholite include lava breccia and dark micaceous granite.

Mesozoic Era

This era represented by the following kind of rocks, siltstone shale, upper part of Triassic period represented by gray dark oolitic limestone muddy. Early triassic include intrusive volcanic rock and metamorphic rock, Lava body.

Paleozoic Era

Include Permian igneous body, these bodies represented by basalt rock. Devonian period represented by sandstone and siltstone rock.

3. Image processing

A landsat- TM –5 scene, acquired on 1988 and covers most of the study area. The scene was geometrically corrected. The geo-referenced image was corrected for scattered radiation using the method given by (Chavez, 1975). This method is based on the fact that TM band-4(0.76-0.90 um) is almost free from atmospheric scattering whereby the histogram of band-4 has a gain of 0 or 1value.The same pixel is observed for its value in shorter wavelengths and the difference between the two values is thought to represent the haze effect.

Digital data was processed on SUN1000 workstation using ERMAPPER version 5.5 software. On screen drawn vectors using different algorithms have been used for image interpretation, then the Arcview GIS software was used to display and combine the results.

3.1 Processing of False color composites

As only three bands are needed for a color composite, the best suitable false color composite in the present work has been carried out under the following consideration:

1. Using the correlation coefficient concept method (Crippen 1989) for the six reflective bands of Landsat TM (Table 3.1), the best band composites 741, 531, 541 and 751 were evaluated for their visual significance.

Table 3.1: Shows the Correlation matrix

Band No	**1**	**2**	**3**	**4**	**5**	**7**
1	**1.000**	**0.960**	**0.886**	**0.794**	**0.777**	**0.768**
2	**0.960**	**1.000**	**0.968**	**0.839**	**0.881**	**0.878**
3	**0.886**	**0.968**	**1.000**	**0.788**	**0.937**	**0.950**
4	**0.794**	**0.839**	**0.788**	**1.000**	**0.815**	**0.730**
5	**0.777**	**0.881**	**0.937**	**0.815**	**1.000**	**0.797**
7	**0.768**	**0.878**	**0.950**	**0.730**	**0.979**	**1.000**

2. The general statistics of TM raw data bands number 751 have higher standard deviation than other fourth bands. Table (3.2) shows the average standard deviation for the six bands.

Table (3.2) general statistics of raw data

Band No	Standard deviation
1	**14.372**
2	**7.292**
3	**9.552**
4	**20.275**
5	**30.725**
7	**25.670**

3. For the selection of the best possible three-band combination, optimum Index factor OIF (Chavez et al, 1982) was used. OIF is based on total variance within bands correlation approach to rank all possible 3-bands. Three bands combination with high total variance within bands and low correlation coefficient between bands will have high OIF. These combinations are expected to have the maximum extractable lithologoical information since they use bands with the least redundancy in the remotely sensed data. For all possible three bands combinations made from six bands of TM data have been evaluated using the following algorithm:

$$OIF = \frac{\sum_{k=1}^{3} S_k}{\sum_{j=1}^{3} |r_j|}$$

Where, S is the standard deviation of band k and r_j is the correlation coefficient between any two of the three bands being evaluated. Since the estimation of optimum index factor is based on the amount of total variance and correlation within and between various band combinations, the combination with largest optimum index factor will generally have the most information with the least amount of duplication (Jensen, 1996).

Factor values of all possible three bands combination selected for this study were: 741, 531, 541 and 751. Fig (3.1) shows the Landsat TM image color composite 741, 531 in RGB.

Table 3.3: Optimum Index Factor (OIF) for TM image of study area

BBC	$\sum$ Sk *	$\sum$ ABC(rj)**	OIF
754	**75.67**	**2.52**	**30.027**
753	**64.947**	**2.8**	**23.19**
752	**62.687**	**2.7**	**23.21**
751	**69.767**	**2.5**	**27.906**
743	**54.497**	**2.6**	**22.15**
742	**52.237**	**2.44**	**21.408**
741	**59.317**	**2.2**	**26.962**
732	**41.604**	**2.3**	**18.69**
731	**48.594**	**2.6**	**18.69**
543	**60.552**	**2.5**	**24.22**
542	**58.316**	**2.5**	**23.32**
541	**62.372**	**2.6**	**25.14**
532	**47.509**	**2.7**	**17.595**
531	**54.649**	**2.66**	**20.54**
521	**52.389**	**2.6**	**20.14**
532	**47.569**	**2.7**	**17.61**
431	**44.199**	**2.4**	**18.416**
421	**41.199**	**2.5**	**16.775**
321	**31.164**	**2.8**	**11.13**

* $\sum S_k$ =Sum of standard deviation of the bands in the combination

** $\sum |r_j|$ = sum of the absolute values of the correlation coefficient

3.2 principle component analysis:

The Principal component enhancement technique or Principle component analysis (PCA) has been found to be useful for pattern recognition study of an area. It is a spectral enhancement, which can be used to compress the information content of a multi-spectral dataset (Sabin, 1997). PCA uses Mathematical algorithm to transform new statistical independent components based on the covariance matrix (Kuffman, 1988,Soho& Schwartz1978, Corner, 1999).

The method can be applied to any number of bands. Three of the resulting components may be displayed as a color composite.

The first principal component is the PC1 that describes most of the variances of the brightness values for the pixels of the original bands (Jensen,1996). Subsequent components explain less about the data. The final PC usually corresponds to the atmospheric noise in the data rather than any ground features (Sabin,1986 and 1997). By considering various available spectral bands, the user is often interested in information unique to each spectral band as compared to information that is common to all bands involved. The mapping of this spectral differences and understanding what causes the contrast can be important in many applications.

3.3.3 IHS decorrelation stretching

In IHS decorrelation stretching three images that make a composite are converted to intensity (I)-the amount of light, hue (H)-the dominant wave length of the light seen , and saturation (S)-the proportion of pure light of thedominant wavelength. The saturation image is then enhanced. The color transform method has been widely used to display the information in remote sensing (Harris et al 1990, pohl & Van Gendera,1998). The human eye perceives these parameters independently, and therefore each one of them can be manipulated without causing any interfering effect to any of the other two component. For the interest of IHS decorrelation, stretching has been conducted using the selected band 741 in RGB. In IHS coordinates, saturation was stretched, intensity was replaced and stretched by edge enhanced PC1. IHS decorrelation stretching method was used to stretch (uniform distribution stretched) the selected band 741 in RGB.

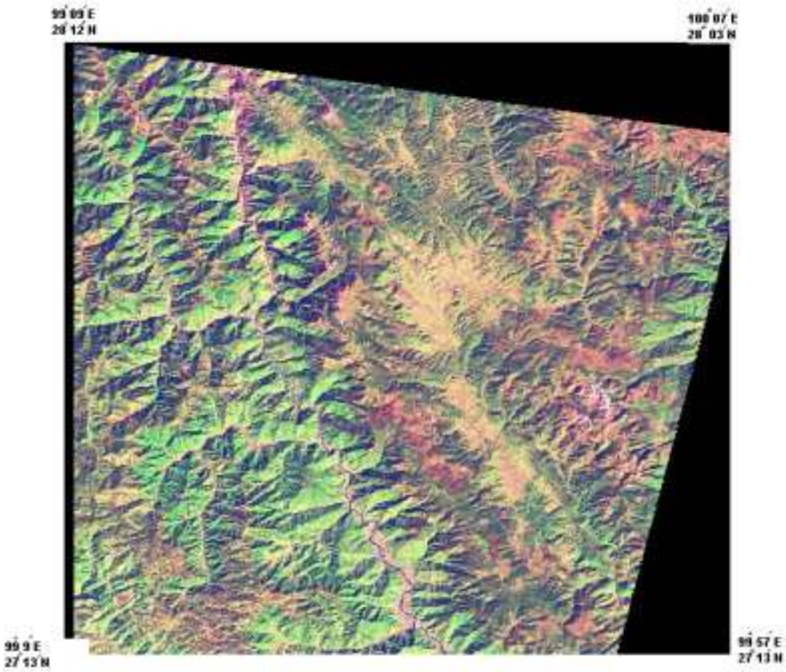

Figure 3.1.A Landsat TM image RGB 741

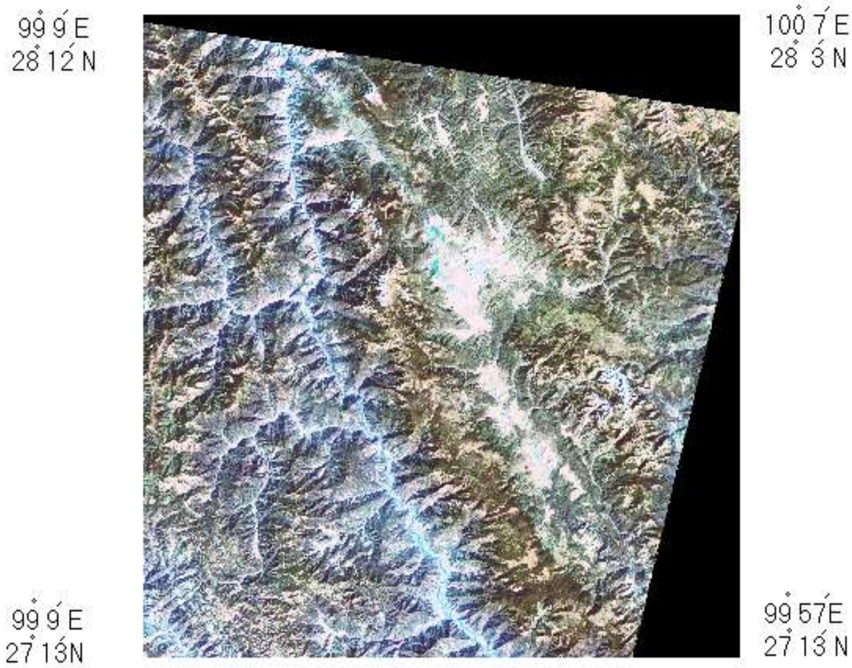

Figure 3.1 B landsat TM image 531 RGB

4. Image interpretation

In the present study at Weixi area, the FCC has been found to be suitable for geological delineation (type of rocks) and this particular band combination can be used for geological mapping.

Depending on the detailed geological study and surface observations, the rock information or units were divided into Nine groups according to the lithology and age of rocks formation. Table (4.1) shows the characteristics and summarized information of these groups. The color composite is somehow limited by the Low degree of color variation which can be attributed by the relatively well balanced reflectance characteristics related to the lack of strong absorption bands associated with most rock surface and width of TM bands. The groups are:

Group A**:** This group consists of the sandstone rock represented by Ran jia wan zu formation and Nanbian Shan zu formation. The formations consist of sandstone and crystalline sandstone and feldspathic quartz.

Group B: Consist of Limestone ,Quartz sandstone and Oolitic Limestone represented by Bazhu lu zu.

Group C: Is represented by Gang da gai zu, Jian chuan zu formations, which consist of coarse Lava breccia, Muddy tuff, Acid lava tuff and Moderate acid lava.

Group D: Represented by Emei shan basalt.

Group E: Represented by Ryholite.

Group F: Represented by Shang lan zu formation that consists of Siltstone at lower part and gray color shale, and gray to dark siltstone and shale at upper part.

Group G: Represented by crystalline Schist, quartz Schist and slate.

Group H: Represented by Granite rock.

Group I: Represented by Ba xing si zu and consists of yellow to brown conglomerate, siltstone and sandy conglomerate of quaternary sediments.

The combination of geological information and field surface observation s with processed satellite image has been used to generate geological map of study area (See Figure 4.1).

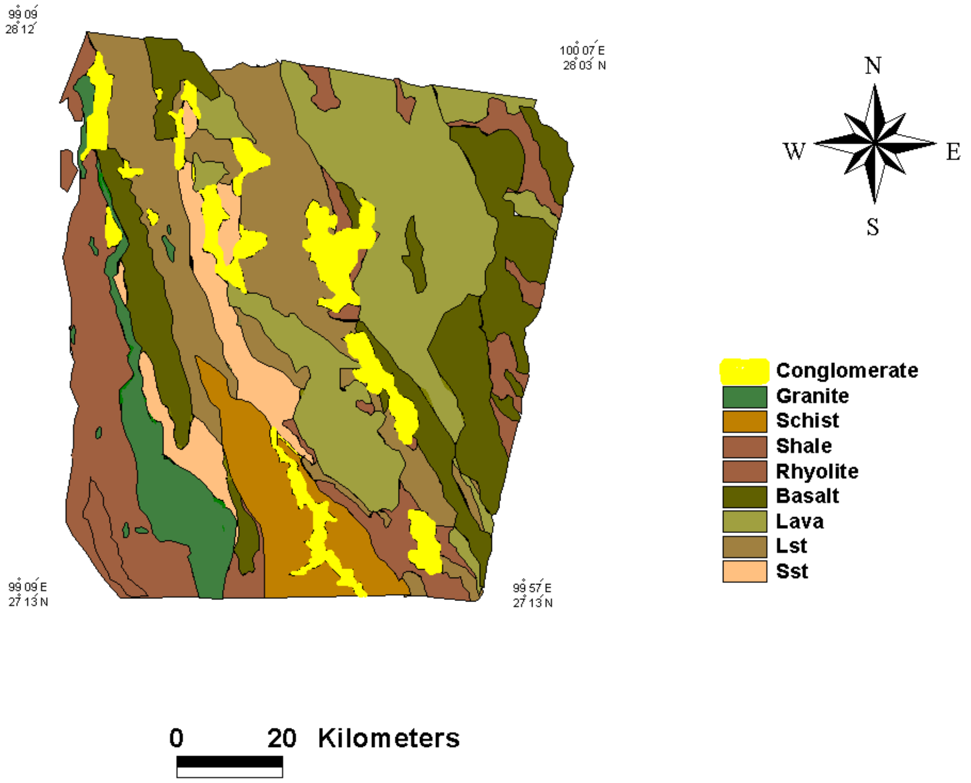

Figure 4.1: Shows the different geologic rocks in the study area

Table 3.4: Shows the different kind of Rocks

GROUP	PCA	IHS	Band Color Composite In RGB			
			741	531	541	751
A	Light greenish	Homogeneous light green	Light green to reddish	Light brownish	Green to yellowish and spots red	Dark rose with dark spot green
B	Dark reddish	Purple	Dark brownish and greenish spot	Brown to light brown	Reddish to light green	Dark green to yellowish orange
C	Green to grayish	Greenish dark	Greenish with reddish to green	Light brown to greenish brown	Light green red brownish spot	Dark greenish yellow
D	Brown to light red	Yellowish light green	Light red to light rose green spot	Medium to dark greenish	Light greenish with light red	Light yellowish to dark orange
E	Light green	Homogen brownish	Light brown to reddish brown	Light green to violet brown spot	Light brown to reddish brown	Dark green rose and light orange

F	Light brown	Dark brown	Yellowish green	Light gray	Greenish to reddish	Light reddish orange spot
G	Green to light gray	Brown purple	Light green with dark brownish spot	Light green	Light to dark green	Dark greenish with orange spot
H	Light orange	Greenish to light gray	Green to light greenish	Gray to reddish gray	Light green with red brownish	Dark greenish with yellowish spot
I	Light brownis h	Green with dark spot	Light brown to light yellowish	Light yellow	Light brown to light reddish	Light rose dark greenish with orange spot

5. Conclusion.

FCC, PC and IHS decorrelation stretching of Landsat TM data have been used some parts of the study area. FCC 741 has been found to be the best for the delineation of study area. In addition to FCC 531 and PC imagery, the FCC 741 are found to be relevant for mapping geological features of the study area. The resulting images are helpful particularly in discriminating rocks with subtle mineralogical difference. Decorrelated images with the highest load are best used in such composites in order to retain the morphological features that are important for visual image interpretation.

Reference

1. Chavez P S, 1975. Atmospheric, solar and TMF correction for ERTS digital imagery. In proceedings of American Society of Photogrametry meeting, falls church, Virginia, U.S.A. (fall church, VA: American Society of Photogrametry).
2. Chavez P S; Berlin Gl and Sowers LB, 1982. Statistical method for selecting landsat MSS ratios. Journal of applied Photographic Engineering.8: 23-30.
3. Grippen R E, 1989. Selection of landsat TM band and band ratio combinations to maximize lithologic information in color composite for Proceedings of the seventh Thematic conference on remote sensing for exploration geology held in Calgary, Alberta on 2-6 October 1989(Ann Arbor Michigan: Environmental Research Institute of Michigan): 917-921.
4. Jensen J R, 1996. Introduction Digital Image Processing. Second edition (Upper Saddle River, NJ: Prentice-Hall).
5. Kaufman H, 1988. Mineral Exploration along the Aqaba-Levant Structure by use of TM data. Concepts, processing and results. International journal of Remote sensing.
6. Sabin F F, 1997. Remote sensing: principles and Interpretation third edition NewYork: Freeman.
7. Davis J C, 1973. Statistics and Data Analysis in Geology.2nd Edition. Singapore: Jhon Wiley and Sons. 646
8. Mo X X, Shen S Y, Zhu Q W.1998. Volcanic Ophiolite and Mineralization of Middle southern Part in Sanjiang Area of Southernwest China. Beijing :Geological publishing house. 128 (in Chinese)
9. Shi Lin. Chen Jichen Wu Shanglong, peng Xingjie, Tang Shangchun. 1989. The Low Tin Mineralization Zone in Dianxi, Yunnan province. Deposit and mineral No 12