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Image Processing and Analysis of Mapping Alteration Zones In environmental research, East of Kurdistan, Iran

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Abstract: Hydrothermal alteration zones have significant role in prospecting of epithermal mineral deposits. In this research, hydrothermal alteration zones in east of Kurdistan in Iran have been investigated using image processing of remotely sensed data. The effectiveness of ETM+ data for detecting alteration zones has been assessed. Three band color composite images produced based on optimum Index Factor method and known spectral reflectance properties of rocks and alteration minerals in relation to ETM bands. The color composite of ETM bands, RGB (7,5,1), RGB (7,4,1) and RGB(b1-b2, b4-b2, b5-b7) achieved the most effective method for separation of hydrothermal alteration (high, medium and low) zones. The color composite of ETM bands, 5, 3 and 1 displayed as RGB revealed the best band combination for identification of rock types that hydrothermal alteration affect in widespread region at East of Kurdistan.

Key words: Hydrothermal · Alteration zone · Kurdistan · Remote sensing

INTRODUCTION

Remote sensing provides information on the properties of the surface of exploration targets that is potentially of value in mapping alteration zones and lithology units. Alteration can produce distinctive assemblages of minerals that vary according to the location, degree and longevity of those flow processes. When exposed at the surface of the earth this alteration can be mapped at a zonal pattern, around a core of highest grade alteration and greatest economic interest. In the past, the geological maps are prepared from conventional ground surveys based on field observations. They are made along traverse lines at regular intervals. While plotting such point information collected along the traverse lines on the topographic base and ultimately preparing final maps by extrapolating the details, certain errors are unavoidable and lead to inaccuracy in maps. Since the development of image processing and remote sensing technology, the mapping procedures have undergone continuous change [1-3]. Mapping of lithology and alteration zones in inaccessible mountain and forest terrain has always posed a challenge [4]. There always existed disputes on the accuracy of lithological boundaries and structural details in these maps. Vast area to be surveyed and its inaccessibility, forbids physical investigation of every outcrop. At this juncture, the potential of RS is appreciable [5, 6]. The greatest advantage of RS is the synoptic view that it provides. It gives a regional and integrated perspective of inter-relations between various land features. The availability of multi-spectral and high resolution data as well as the advanced capabilities of digital image processing techniques, in generating enhanced and interpretable image has further enlarged the potential of RS in delineating the lithological contacts and geological structure in great details and with better accuracy. The existing multi spectral satellite systems are designed to investigate natural resources with special focus on vegetation coverage, lithology and mineral exploration. The wide area coverage of the data in connection with their long-term availability allows analysis of the spatial dynamics within larger areas. Most applications of RS in geology involve the delineation of structures, discrimination of different rock and soil types and resource exploration. Following the launch of Landsat Thematic Mapper (TM) in 1982, geologists gained access to better spatial (30m) and spectral resolution, compared to the Multi spectral Scanner (MSS) used, for detailed geological studies. Many geological studies have employed TM and ETM+ data to discriminate the various lithologies, lineaments, alteration zones and minerals by using hyperspectral laboratory [7-9]. The objective of this paper is to carry out a geological and lithological study of as well as exploration for alteration zones using Landsat ETM+ in the East of the Kurdistan area.

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MATERIALS AND METHODS

The Study Area: The studied area is located in between Hamadan and Kurdistan province, Iran and is 35° 00' to 35° 30' N and 47° 20' to 48° 10' E. This region is 400 square km^2 and is bordered of Zanjan from North, on Kermanshah from South, on Hamadan from East (Figure 1).

Geological Setting: In the study area (Western Iran) two distinct volcanic cycles have been recognized. The first, of upper Miocene age, consists of high-K calc-alkaline volcanic rocks interpreted as final products the calc-alkaline Tertiary phase of central Iran. The second volcanic cycle, mostly of Pleistocene age consists of undersaturated, mainly potassic, alkaline products. As the lavas of this last phase are slightly fractionated, the chemical differences shown by these rocks have been interpreted as primitive features related to the physical conditions governing the partial melting in the mantle and/or the mantle heterogeneity. In a volcanic center contemporaneous basic and acid magmas have been found and interpreted as derived from two different and independent sources. The alkaline basic volcanism is considered as an expression of disjunctive processes that have affected the western margin of the Iranian plate after the Pliocene. Mio-Pliocene collection and Quaternary in Bijar, Mio-Pliocene deposits and Quaternary layers almost horizontal surface is covered (Figure 2) [10, 11].

The use of spatial integration of various data sets including Landsat ETM+ and topography maps of scale 1:50,000 and the geological maps of scale 1:100,000 in exploration for alteration zones in the studied district form the essential objective of this work. Landsat Enhanced Thematic Mapper ETM+ has 9 spectral bands. These include three visible bands (1-3) between 0.4 and 0.7 µm and one near infrared NIR band (4) between 0.76-0.90 µm and two infrared IR bands (5 and 7) between 1.55 and 2.35 µm and one panchromatic band 8 between 0.52-9.0 µm; in addition to two thermal infrared bands (61 and 62) between 10.40 and 12.5 µm. Landsat ETM+ spectral bands have a spatial resolution of 30 meters for bands 1 to 5 and band 7. The resolution for band 6 (thermal infrared) is 60 meters and resolution for band (8 panchromatic) is 15 meters. Finally used in this study six bands (bands 1,2,3,4,5 and 7).

Landsat ETM+ image processing tools and soft wars include ERDAS Imagine 9.1, Ilwis and Arc GIS 9.3 on study area. Three scenes (Path 166, Raw 36, Path 167, Raw 35, Path 167, Raw 36, Date 2000) covering the investigated area. The preliminary process of the images includes geometric correction, boundary tracking and radiometric correction. False color composite images for the studied district were used to discriminate alteration zones in study area. Geometric correction has been applied with sufficient number of ground control points taken from 1:50,000 scale topographic maps.

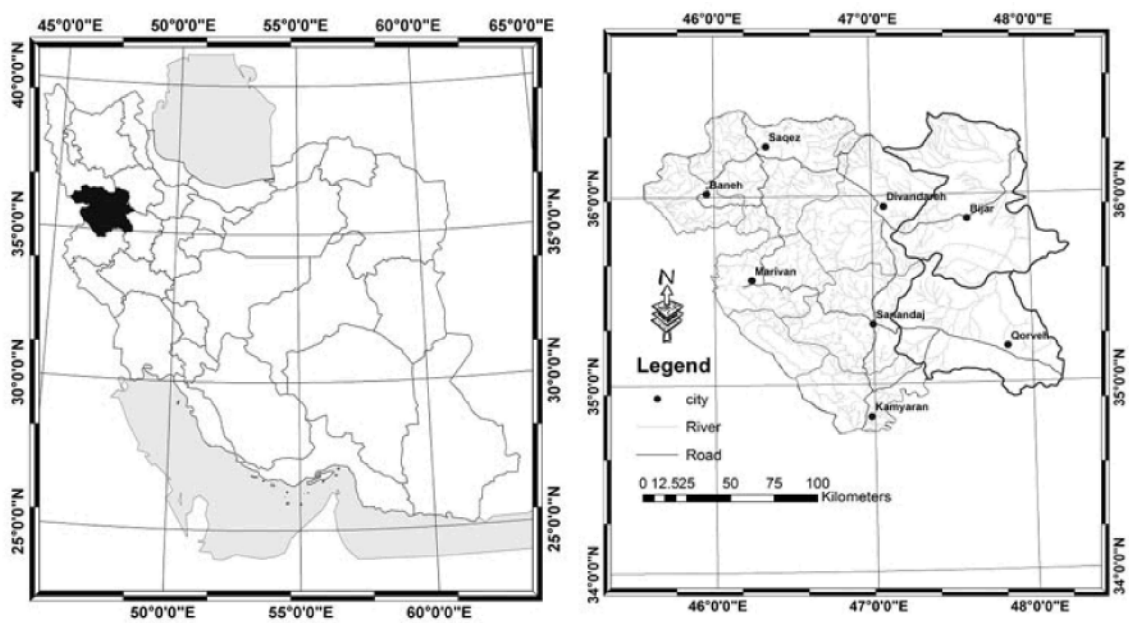

Fig. 1: Location map of the study area

Geology Unit	Description
E1f	Silty shale , sandstone , marl , sandy limestone
Ebv	Andesite and basalt mainly with vesicular texture
Ed.av	Dacitic and andesitic volcanics
JKl	Crystalized limestone and calc- schist
Jugr	Upper Jurassic granite
Jugr-di	Upper Jurassic granite to diorite intrusives
K1m	Limestone , argillaceous limestone
Mav	Massive andesitic to dacitic lavas
Plbv	Basaltic volcanics
Plms	Mudstone , locally gypsiferous and sandstone
Qal	Stream channel , braided channel
Qft1	High level piedmont fan and valley terrces deposits
Qft2	Low level piedmont fan and valley teraces deposite
TRdl	Crystaline limestone and dolomite
TRJvm	Meta - volcanics , phyllites , slate and meta- limestone

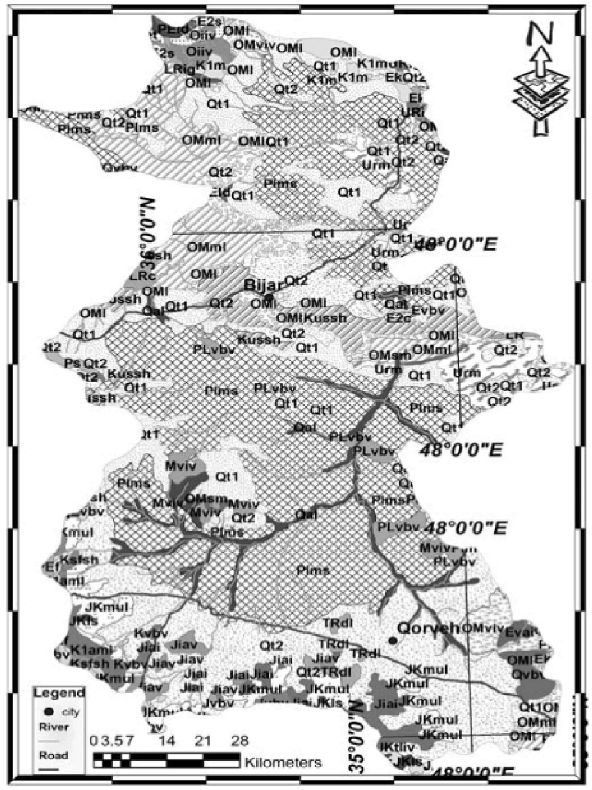

Fig. 2: Geological map of the study area [6, 7]

Cubic convolution resampling technique has been used to project the image according to Universal Transverse Mercator (UTM) system, WSG84, using topographic maps at scales 1:50,000 and 1:100,000 with an output pixel size of 30 meters. Resampling process is carried out to determine the pixel values and to fill into the output image from the original image matrix. Radiometric balancing has been done to achieve homogenous radiometric set of data. Mosaicing between the scenes has been conducted to have one set of composite image that is geometrically corrected and radiometrically balanced. For multispectral data there are several computerized data processing techniques which can be applied to the problem of differentiation of the alteration zones from the country rocks. These techniques include the use of band ratios and supervised classifications.

Landsat ETM multispectral data have been processed to discriminate the different rock types present such as altered and unaltered rocks because different rocks have a characteristic spectral signature as a finger-print. A band ratio image is created by dividing the digital number (DN) in one band by the corresponding DN in another band for each pixel and stretching the resulting value as an image. Each pixel in the image is processed in this way resulting in a band ratio. The use of a band ratio enhances compositional information, while the other types of information about the earth surface such as differences in topographic slope give the same appearance throughout the image [12]. The false color composite ratio image (FCC) was produced by combination the three ETM band ratio images 741, 751, 531 and b1-b2, b4-b2, b5-b7 in red, green and blue (RGB) in one image.

RESULTS AND CONCLUSION

During formation of ore materials, hydrothermal hot solutions interact chemically with the country rocks and alter the mineral composition for considerable distance beyond the site of ore depositions. Hydrothermal altered rocks are lithologic anomaly, which contain distinctive assemblages of secondary minerals, which their reflectance spectra differ from those of the country rocks. Remote sensing methods provide information on properties of this alteration zones and if these minerals are present in sufficient quantities at the surface,

Table 1: Correlation matrix between ETM + bands

	bf11	bf2	bf3	bf4	bf5	bf7
bf11	1.00	1.00	0.99	0.97	0.98	0.98
bf2	1.00	1.00	1.00	0.97	0.99	0.99
bf3	0.99	1.00	1.00	0.96	0.99	0.99
bf4	0.97	0.97	0.96	1.00	0.97	0.95
bf5	0.98	0.99	0.99	0.97	1.00	0.99
bf	0.98	0.99	0.99	0.95	0.99	1.00

can be reflected to the sensors like Landsat Thematic Mapper (ETM). Landsat Thematic Mapper (ETM) is capable of discriminating between rock types such as Iron-rich, Clay-rich lithologies and secondary minerals. During this study the remote sensing techniques have been applied to discriminate, delineate and map of alteration which occur within the volcanic sequence at in the SE Kurdistan, NW of Iran. Results from this study confirm the usefulness of these techniques to discriminate and map these alteration zones were identified in the processed Landsat imagery and verified in the field and mapped using this approach. On the other hand, these techniques show the benefits of these tools in such application. The use of some spectral processing techniques was necessary to prove the efficiency of remote sensing in this field. A linear contrast stretch with atmospheric correction was sufficient to produce an image of high quality. A linear transfer function was used to make full use of the 256-output value. Enhanced images of single band or false-color images comprising three contrast stretched bands can then be interpreted geological data's. The Principal Component Analysis process allowed the extraction of new information. It shows the directions of grey levels distribution in feature space. In general, PC analysis is a statistical technique widely used in RS to choose the suitable bands and to show spectral differences which helps to display clearly the correlation of the spectral values between the different channels. Due to the large number of spectral bands, much information was acquired from Landsat ETM+ images, especially in the infrared region of the spectrum. As result, these data were very useful for alteration zones, lithology, soil and terrain pattern differentiation.

Table 1 shows the correlation matrix between ETM+ bands.

In the study area, Digital image processing generated several products ranging from false color composite bands 741-751-531 and principle components and rationing bands and b1-b2, b4-b2, b5-b7 in red, green and blue (RGB) in one image.

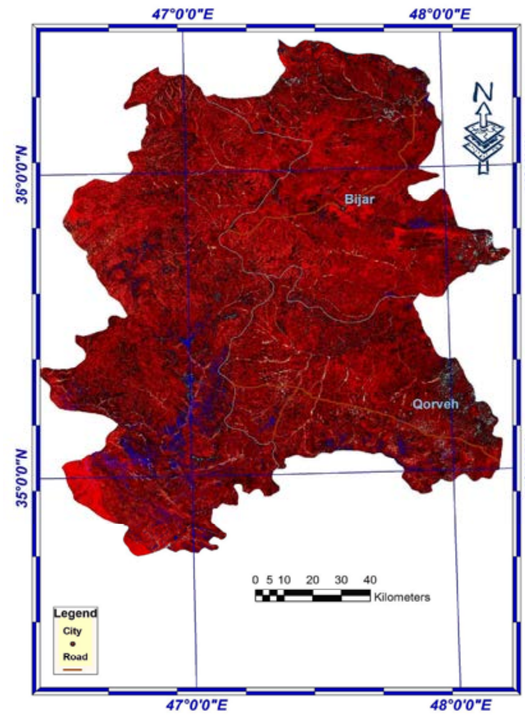

Fig. 3: Landsat ETM ratio image bands (b5-b7), (b4-b2) (b1-b2) in red, green, blue for area A, showing the alteration zone, alteration rocks are white, light pink in the Landsat ETM image

False color composite bands 741 and 751 images have been used in alteration rocks analyses in study area. Figure 5 shows the alteration zone at area, The intrusive rocks are shown in cream, volcanic rocks are purple, alteration rocks are white, light pink and water light green colors in the Landsat ETM image and Figure 4: Red–Green–Blue color composite of Bands 7, 5 and 1, the intrusive rocks are shown in orange, light yellow, volcanic rocks are blue and alteration rocks are white, light pink colors in the Landsat ETM image. Band ratio technique is the most usable technique used to identify and map the alteration zones in several places in the world. In General, Landsat ETM band-ratios b1-b2, b4-b2, b5-b7, 5/7 and 3/1 emphasizes alteration, clay and Fe minerals that have specific spectral reflectance and absorption features in these bands [13, 14]. It is well established that the Landsat ETM band ratio 3/1 effectively maps iron alteration as the iron minerals such as limonite, goethite and hematite have reflectance maxima within Landsat ETM band 3 (visible red light) and reflectance minima within Landsat ETM band 1 (visible blue light). Hence Landsat ETM band ratios 3/1 increase the differences between the digital numbers (DN) of iron alteration zones and those of

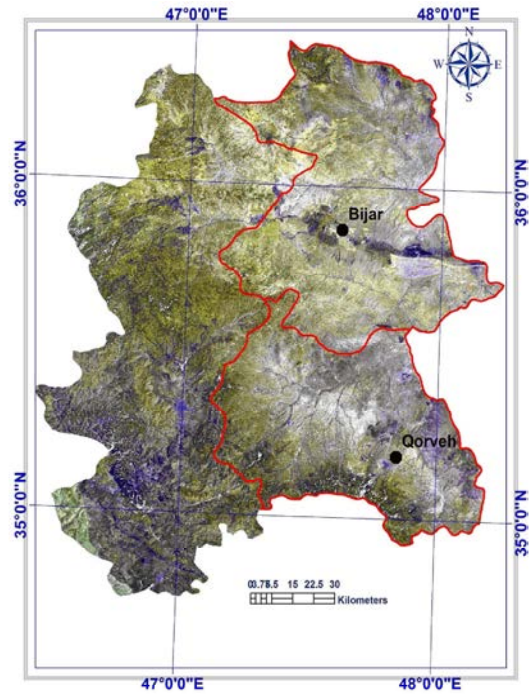

Fig. 4: Red-Green-Blue color composite of Bands 7, 5 and 1, the intrusive rocks are shown in orange, light yellow, volcanic rocks are blue and alteration rocks are white, light pink colors in the Landsat ETM image

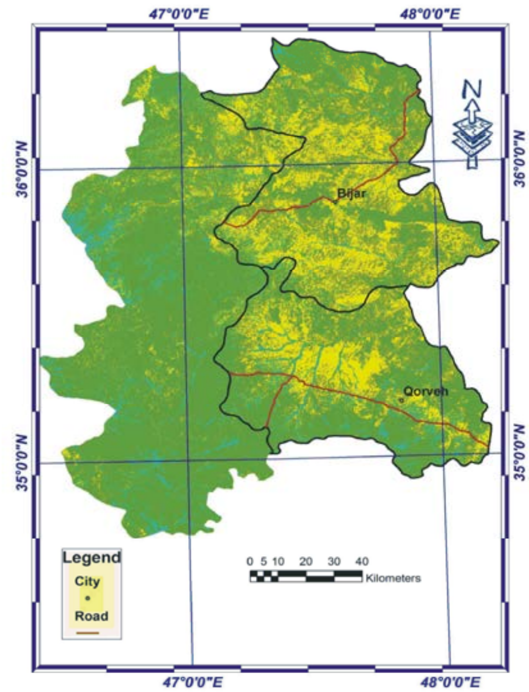

Fig. 6: Supervised classification alteration rock in study area,: Red-Green-Blue color composite, alteration rocks are shown in yellow, non-alteration rocks are green and water and vegetation are green colors in the Landsat ETM image

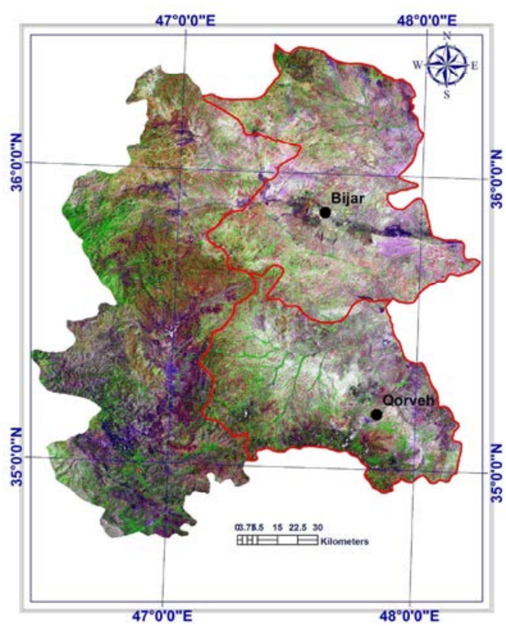

Fig. 5: Red-Green-Blue color composite of Bands 7, 4 and 1, the intrusive rocks are shown in cream, volcanic rocks are purple and alteration rocks are white, light pink and water light green colors in the Landsat ETM image

unaltered rocks respectively. This leads to a better discrimination between hydrothermally altered and unaltered rocks in the present area (Figure 3). Supervised classification helped identify previously unknown alteration zones in study area. This technique involves selecting a pixel, individual pixels, or a cluster of pixels with known geologic significance and using these as training sites to locate regions with similar spectral characteristics. Field survey of alteration zones were chosen as a training site for this purpose. This exercise demonstrates the utility of density slicing and supervised classification for identifying previously unknown alteration zones and related ore deposits in the Southeastern area. The supervised classification also showed many small areas being classified as hydrothermally altered zones. We interpreted these as areas covered with weathering products from the main alteration zones outcrops now deposited on the dry-river beds. Alternatively, these might represent previously unmapped hydrothermally altered zones. These await field confirmation. In study area first get the interpretation criteria with unsupervised classification process; then process the treated remote sensing image by supervised classification process with the revised interpretation criteria. Initial results of the unsupervised classification showed eighth spectral clusters. Based on field visits, the resulted clusters were merged into three major classes of water and vegetable, alteration, non- alteration in study area. The map produced from supervised classifications, Figure 6; show that alteration rocks occupied less than 30 % of the total area.

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