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Assessing Utilization of Multi-Resolution Satellite Imageries in Geological Mapping, A Case Study of Jabal Bani Malik Area, Eastern Jeddah City, Kingdom of Saudi Arabia

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Abstract. The different types of satellite imageries are considered as one of important useful source of data for the lithologicl discriminations and geological mapping. The modern and high advanced remote sensing technique supplies huge amounts of satellite imageries of different resolutions. This work aimed to assess utilization of the different satellite imagers of different resolutions in the geological mapping. Jabal Bani Malik area which is located to the east of Jeddah city in the Middle Eastern Red Sea is chosen as a case study for this work. This area is composed of different igneous and metamorphosed rocks of the Arabian shield. It is geologically complicated, sheared, fractured and weathered.

Different types of digital satellite imageries for the study area were used in this work, which comprises: Landsat MSS of 80 m resolution, Landsat TM of 30 m resolution, Landsat TM of 25 m resolution, Landsat ETM+ of 30 m resolution, Landsat ETM+ panchromatic of 15 m resolution, SPOT panchromatic of 10 m resolution and the Indian Remote Sensing Satellite IRS panchromatic data of 5 m resolution. These data are classified into three sets concerning the spatial resolutions: 1- Satellite imagery data of low spatial resolutions (LSR): which have a spatial resolution of 25 m or smaller, 2- Satellite imagery of moderate spatial resolutions (MSR): Which have a spatial resolutions ranging between 25 m to 10 m, and 3- Satellite imagery of high spatial resolutions (HSR): which are characterized by a spatial resolution greater than 10 m.

The processed satellite imagers produced from the three data sets were used in the geological mapping of the investigated area. Satellite imagery data of low spatial resolutions (LSR) are used for the regional studies and producing geological maps of scale 1:100,000 or smaller. Satellite imagery of moderate spatial resolutions (MSR) are used for the semi-regional studies and producing geological maps of scale ranging between 1:100,000 to 1:20,000. Satellite imagery of high spatial resolutions (HSR) are used for the detailed studies and producing geological maps of scale 1:20,000 or larger. The processed HSR imageries were used for the geological and structural interpretation and producing a detailed geological and structural maps of the investigated area. These maps are larger in scale and containing more information than the previous studies.

Introduction

Using of remote sensing data in geological mapping is an important approach for geological and structural studies. The geological mapping using remotely sensed data and image processing techniques has been used increasingly by several authors (*e.g.*, Sultan *et al.,* 1986, Richards, 1995, Meguid *et al.,* 1996, Sabins, 1999, Mostafa and Bishta, 2004, and Bishta, 2005). In this work, the imagery data of different spectral and spatial resolution are employed in the geological mapping to test the different image processing techniques for the regional, semi detailed and detailed studies. Jabal (J) Bani Malik area which is located to the east of Jeddah city in the Middle Eastern Red Sea (Fig. 1) is chosen as a case study for this investigation.

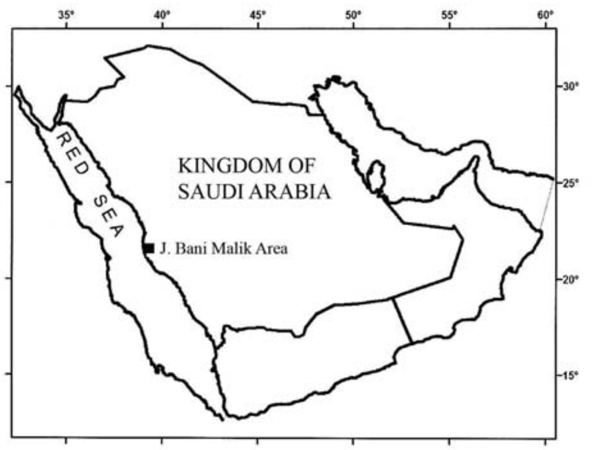

Fig. 1. Location map.

Seven types of digital satellite imageries data for the study area were used in this study. These data were classified in this work into three sets concerning the spatial resolutions:

1- Satellite imagery data of low spatial resolutions (LSR): This type of data include all satellite imageries which have a spatial resolution of 25 m and more. In this work the LSR type comprises: Landsat MSS of 80 m resolution, Landsat TM of 30 m resolution and Landsat TM of 25 m resolution.

2- Satellite imagery of moderate spatial resolutions (MSR): This type of data include all satellite imageries which have a spatial resolution ranging between 25 m to 10 m. In this work the MSR type comprises Landsat ETM+ panchromatic of 15 m resolution and SPOT panchromatic of 10 m resolution.

3- Satellite imagery of high spatial resolutions (HSR): The satellite imageries of this type of data is characterized by a spatial resolution greater than 10 m (higher than both LSR and MSR). The HSR type is exampled in this investigation by the Indian Remote Sensing Satellite IRS panchromatic data of 5 m resolution.

Methodology

The pre-processing procedures of image processing techniques were carried out first on the used satellite imageries of different resolutions such as subsets for the study area, geometric corrections and some contrast stretching enhancements. All satellite imageries were geometrically corrected and rectified by the author using the topographic maps (image to map method) or using another rectified image (image to image method) of the study area. The first order affine transformation was applied and the root mean square error (sigma) was about 0.5 during rectification processes.

The suitable image processing techniques are applied for each type of imagery resolution. Table 1 shows the main image processing techniques suitable and were applied for each data sets of certain spatial resolution (LSR, MSR & HSR). The main image processing techniques applied for the satellite imagery data of low spatial resolution (LSR) are: 1- False color composite (FCC) images, 2- Band ratio images, 3- Color composite principal component analysis (PCA) images, 4- Multispectral image classification, 5- Regional mapping. While, the main image processing techniques applied for the satellite imagery data of moderate spatial resolution (MSR) are: 1- Fusion between Landsat ETM+ Multispectral and panchromatic data, 2- Lineaments extraction from digital satellite data, and, 3- semi-detailed mapping. The main image processing techniques applied for the satellite imagery data of high spatial resolution (HSR) are: 1- Fusion between, multispectral (ETM data) and high resolution panchromatic IRS data, and 2- Detailed geological mapping.

Table 1. Imageries satellite data of different spectral and spatial resolutions (LSR, MSR & HSR) with suitable image processing techniques and the produced geological maps.

Type	Data	Spectral Resolution	Spatial Resolution	Suitable Image Processing Technique	Geological Map Scale
LSR	MSS	4- bands	80 m	1- FCC images 2- Band ratio images 3- Color composite PCA images 4- Image classification 5- Regional mapping	1: 100,000 & Smaller scales (for regional studies)
	TM	6 -bands	30 m		
	ETM+	6- bands	30 m		
	TM	6- bands	25 m		
MSR	ETM+ Pan.	1-band	15 m	1- Fusion between multispectral & MSR Pan Data 2- Lineaments extraction 3- semi-detailed mapping	1: 100,000 to 1: 20,000 (for semi-detailed studies)
	Spot Pan.	1-band	10 m		
HSR	IRS Pan.	1-band	5 m	1- Fusion between Multispectral & HSR Pan Data 2- Detailed mapping	1: 20,000 & Larger scales (for detailed studies)

The seven satellite imageries data of the different spatial resolutions (LSR, MSR and HSR) are used in this work for applying the suitable processing techniques (Table 1) and producing the lithological and structural maps of the study area. Subsets of the study area have been carried out for these data sets. These subsets of satellite imageries for the investigated area were geometrically corrected and enhanced. The suitable enhancements of image processing techniques are applied for each imagery type as shown in the following paragraphs.

Image Processing of Satellite Imagery Data of Low Spatial Resolution (LSR)

The imageries of LSR used in this work include three data sets: The Landsat MSS data of 80 m resolution, the Landsat TM data of 30 m resolution and the Landsat TM data of 25 m resolution. The multispectral

MSS data of Landsat 4 composed of four spectral bands (b1-visible green, b2- visible red, b3-near infrared, & b4- near infrared) with 80 m special resolution. The used remotely sensed raw data of Landsat–5 thematic mapper (TM) data consisting seven broad spectral bands. The TM scene covers about 185 by 185 km. The 6 multispectral bands of TM data (exception the thermal band 6) were selected as the basis for image processing technique in LSR imagery. These data were characterized by their spectral resolution of 6-bands and with a spatial resolution of 30 m. The Landsat 7 ETM+ data have the same spectral bands like TM data, but with additional panchromatic band-8 of 15 m spatial resolution (will be used as MSR). The following enhancement techniques were suitable and applied to these LSR data:

1- False Color Composite (FCC) Images

The digital data sets of LSR are used in this work for constructing the false color composite images displayed in red, green and blue (Fig. 2), composed of MSS (80 m resolution) data bands 4, 3, 1, and TM (30 m resolution) data bands 7, 4, 2 and TM (25 m resolution) data bands 7, 4, 2 in RGB.

These false color composite images of LSR are very useful in the geological and structural interpretations. They are used in the regional geological studies and in the construction of the regional lithological and structural maps in different scales such as 1 : 100,000 from the image of Landsat TM (Fig. 2 b & c) or smaller scales 1 : 250,000 from MSS image (Fig. 2a).

2- Color Composite Ratio (CCR) Images

The color composite ratio images could be constructed using the data sets of LSR. The ratio images are prepared simply by dividing the digital number (DN) value of each pixel in one band by the DN value of the other band (Drury, 1993). Some of these ratios are very useful in mineral exploration such as ETM ratios 5/7, 3/1 & 4/3 which are used to detect some alteration (Fig. 3). The Landsat ratio 5/7 band (Fig. 3a) is used to detect the hydroxyl contents of rocks. The reflectance values in band 7 (2.08 to 2.35 µm) of ETM data are depending mainly on the hydroxyl content of the rocks. The ratio of band 5 to band 7 was used as a measure of the intensity of the hydroxyl absorption (in the 2.2 to 2.4

µm region). This ratio was used because band 5 is not within theconfines of the Fe –bearing aluminosilicate related or hydroxyl-related absorption features, whereas band 7 is within the hydroxyl absorption wave lengths (Sultan *et al.,* 1986).

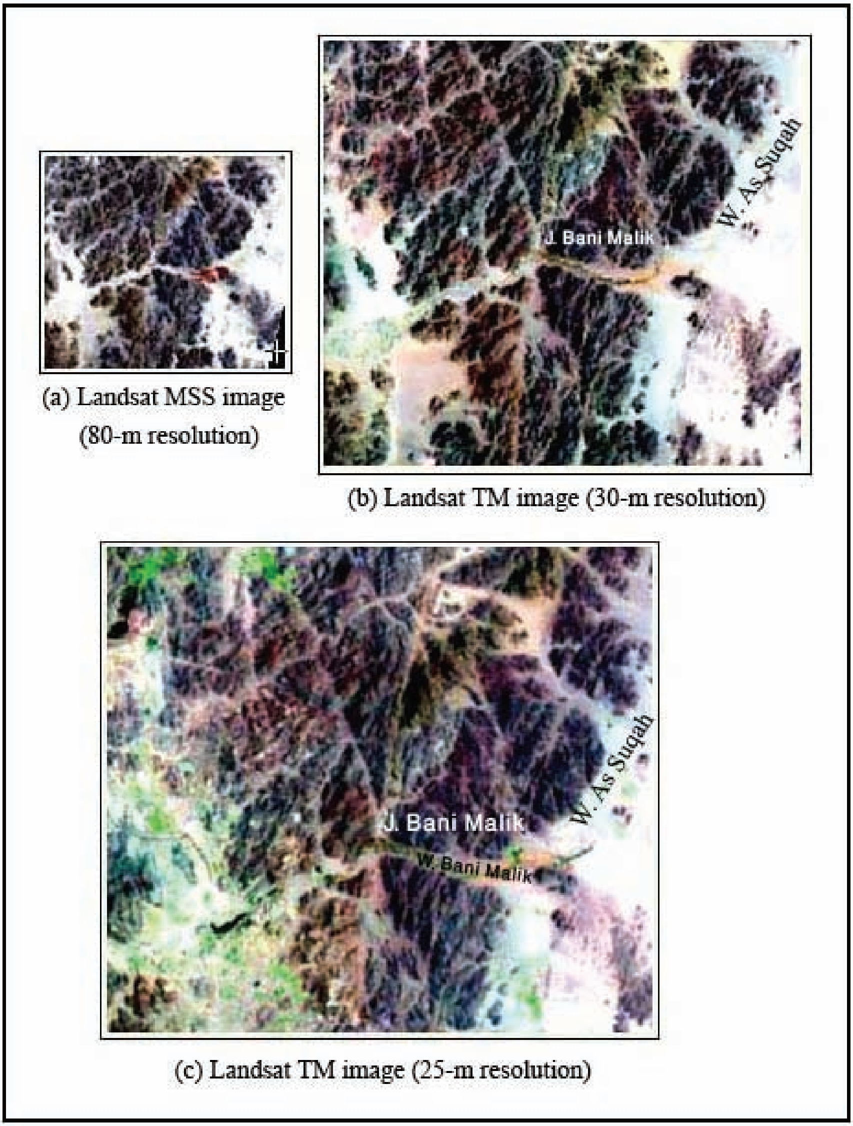

Fig. 2. False color composite imageries of LSR data for the study area: (a) Landsat MSS Image (80-m resolution), (b) Landsat TM image (30-m resolution), and (c) Landsat TM image (25-m resolution).

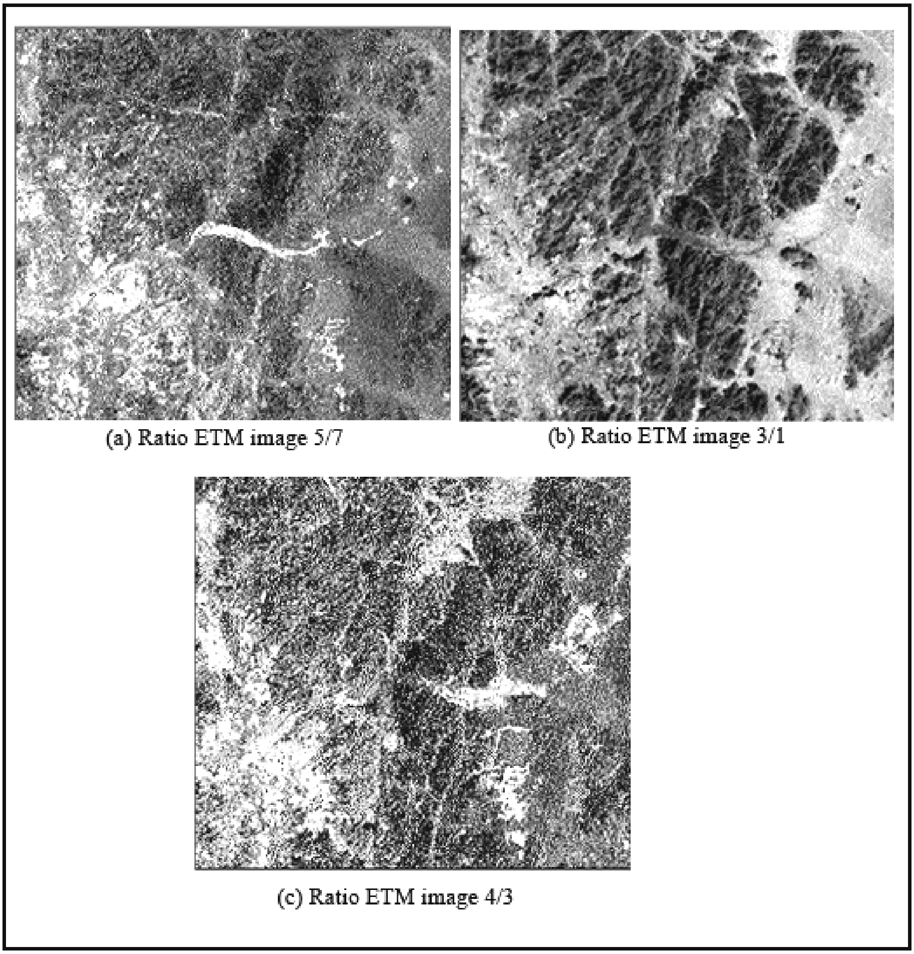

Fig. 3. Landsat ratio ETM images of LSR imagery.

In addition to the use of ratio images separately, they can also be used to generate color composite ratio (CCR) image by combining three monochromatic ratio data sets (Fig. 4). Such composites have the two fold advantages of combining data from more than two bands and presenting the data in color, which further facilitates the interpretation of subtle spectral reflectance differences. Color composite ratio images have been constructed using combination of different ETM band ratios to select the optimum combination which can be helpful in the mineral exploration and/or in the lithological discrimination of the mapped area. These ratio images (Fig. 3) were used for preparing the CCR image (Fig. 4) which was prepared in scale 1 : 100,000 in which the band 5/7 image is assigned by the red component, the band 3/1 image by the green component and the band 4/3 image by the blue component.

3- Color Composite Principal Component Analysis (CCPC) Images

Images generated by digital data from various wavelength bands often appear similar and convey essentially the same information. Principal and canonical component transformations are two techniques designed to reduce such redundancy in multispectral data (Lillesand *et al.,* 2004).

Principal component analysis is often used as a method of data compression by which most of the information contained in the original data will be transformed into the first few principal components. The direction of the first principal component is the first eigen value. The second principal component is orthogonal to the first principal component. It describes the largest amount of variance in the data that is not already described by the first principal component.

The most important advantage of principal component analysis is that most of the information within all the bands can be compressed into a much smaller number of bands with little loss of information.

The color composite Landsat ETM principal component image (Fig. 5) was generated from the first principal component (PC1), the second principal component (PC2) and the third principal component (PC3), displayed in red, green and blue respectively. This CC PC image is very useful to discriminate the rock units exposed in the study area and in the regional mapping in scale 1 : 100,000.

4- Multispectral Image Classification

Multispectral image Classification is an important step in the production of geological maps or other thematic maps from satellite images. It is possible to base a classification on a single spectral band of a remote sensing image (*eg.* ETM Pan), but much better results could be obtained by using more bands at the same time such as the multispectral bands of the data sets of LSR imagery (*eg.* TM or ETM+ Multispectral data). There are two main types of classifications, supervised and unsupervised classifications.

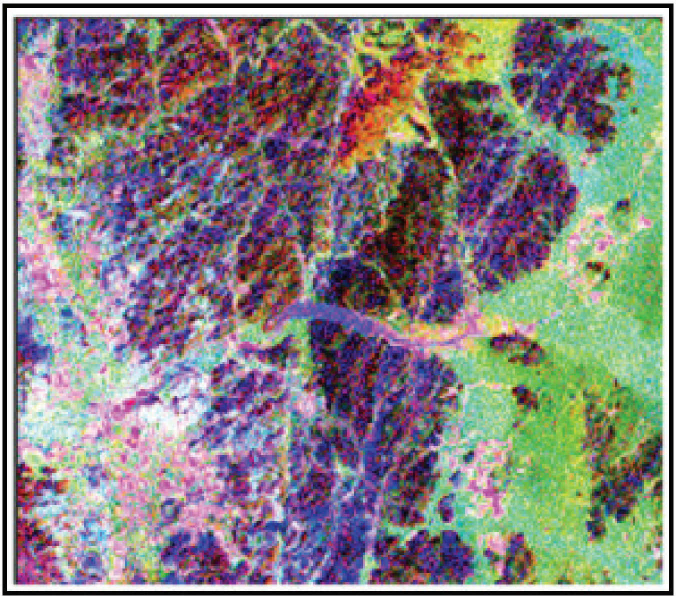

Fig. 4. Color composite ETM image of ratio bands 5/7, 3/1 & 4/3 displayed in RGB respectively.

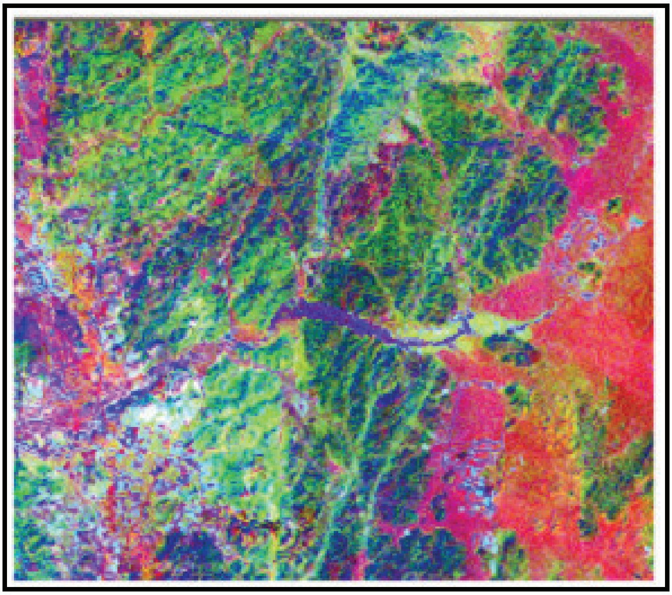

Fig. 5. Color composite ETM image of principal component bands PC1, PC2 &bPC3 displayed in RGB respectively.

The unsupervised classification (clusters) method is performed in this work on the LSR satellite imageries (MSS and ETM) of the study area. The unsupervised classification is performed automatically in this work using Erdas Imagin software package to plot all pixels (all feature vectors) of the image in a feature space, and then to analyze the feature space and to group the feature vectors into clusters (Fig. 6). This type of classification is not completely automatic, but the user specifies some parameters, such as the number of clusters, the maximum cluster size, and the minimum distance that is allowed between different clusters. The result of this classification gave a classified image of 6-different classes for the study area (Fig. 6): These classes or clusters could be useful in the lithological interpretation to delineate and identify some rock units during the geological mapping.

Image Processing of Satellite Imagery Data of Moderate Spatial Resolution (MSR)

The moderate spatial resolution MSR data in this work includes two imageries, the Landsat ETM panchromatic (pan) data of 15 m resolution and the SPOT pan data of 10 m resolution. These MSR data were characterized by their higher spatial resolution than the first type (LSR). The imageries data of MSR in this work are displayed in black and white Landsat ETM panchromatic image (Fig. 7) and black and white SPOT panchromatic image (Fig. 8). The following image processing techniques were suitable and were applied to these MSR data:

1- Fusion Between Multispectral ETM Data (LSR) and SPOT Panchromatic Data (MSR)

The largest resolution of MSR type in this work is the SPOT panchromatic image (10 m resolution), (Fig. 8). It is possible to apply the fusion technique between the SPOT panchromatic image (MSR) and another multispectral colored image of the lower resolution such as ETM+ image (LSR) to get a color MSR image. Fusion processing has been carried out using PCI Geomatica package through the following steps:

1- Image subsets covering the study area have been prepared from multispectral ETM data, and the SPOT pan image.

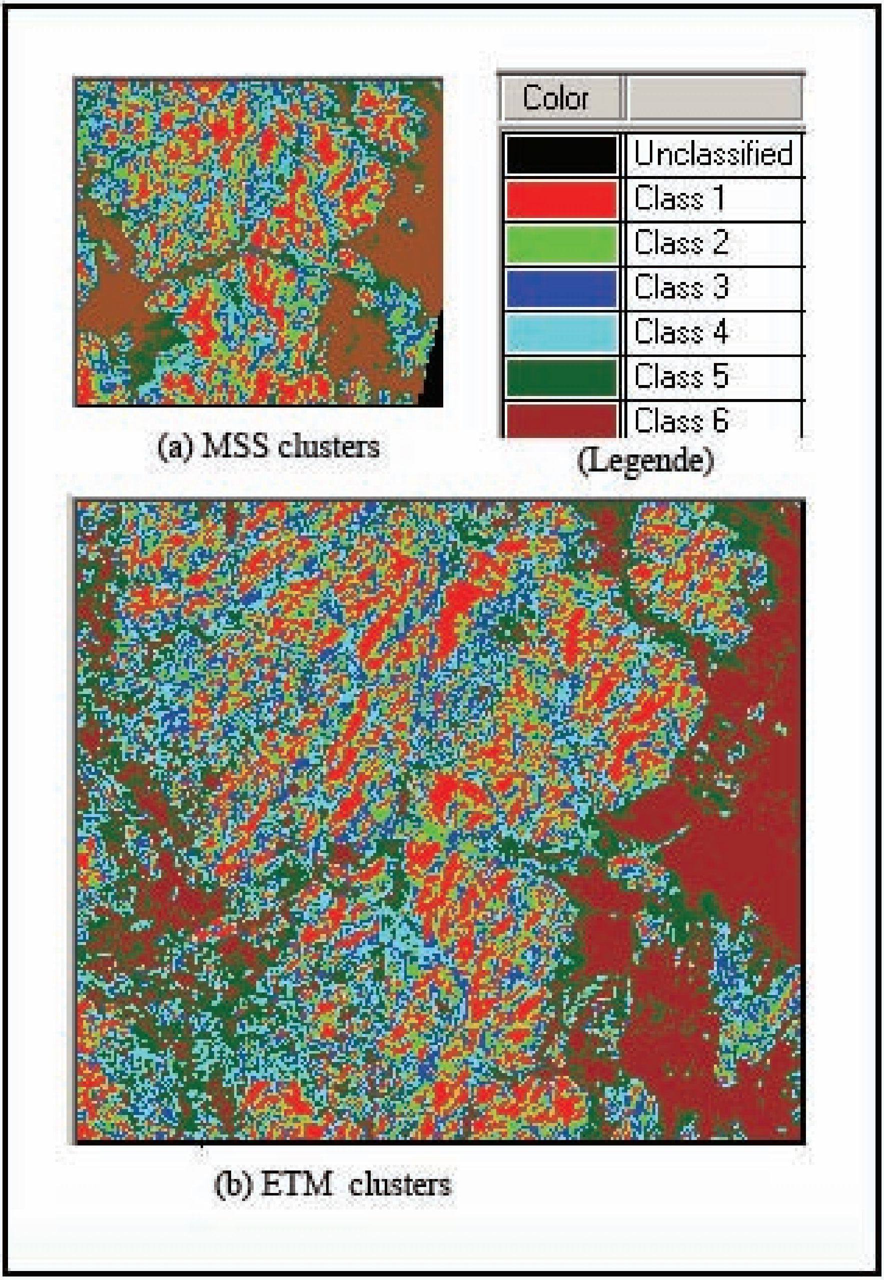

Fig. 6. Unsupervised classification of: (a) Landsat MSS data, and (b) Landsat ETM data.

Fig. 7. Landsat ETM panchromatic image (15-m resolution) of MSR type.

2- The geometric corrections of the ETM data and the spot image have been carried out, as discussed earlier.

3- The false color composite (FCC) ETM image (bands 7, 4 & 2 in red, green and blue RGB) has been constructed in scale 1 : 100,000.

4- The FCC – ETM image (of resolution 30 m) was then merged with the SPOT panchromatic band (Fig. 8, of higher resolution 10 m) using Intensity, Hue and Saturation (IHS) processing in PCI package to produce a color fused image of 10 m spatial resolution and in scale 1 : 20,000 for the study area (Fig. 9).

5- The result of the fused image (Fig. 9) was then used in the geological interpretation of the study area. A large scale of 1 : 20,000 geological image map of the study area could be interpreted from the fused color composite image.

Fig. 8. Spot panchromatic image (10-m resolution) of MSR type.

2- Lineament Extraction from MSR Data

Lineaments can be defined as "mappable, simple or composite linear features of a surface, whose parts are aligned in a rectilinear or slightly curvilinear relationship and which differs distinctly from the pattern of adjacent features and presumably reflect a subsurface phenomenon" (O'Leary *et al.,* 1976).

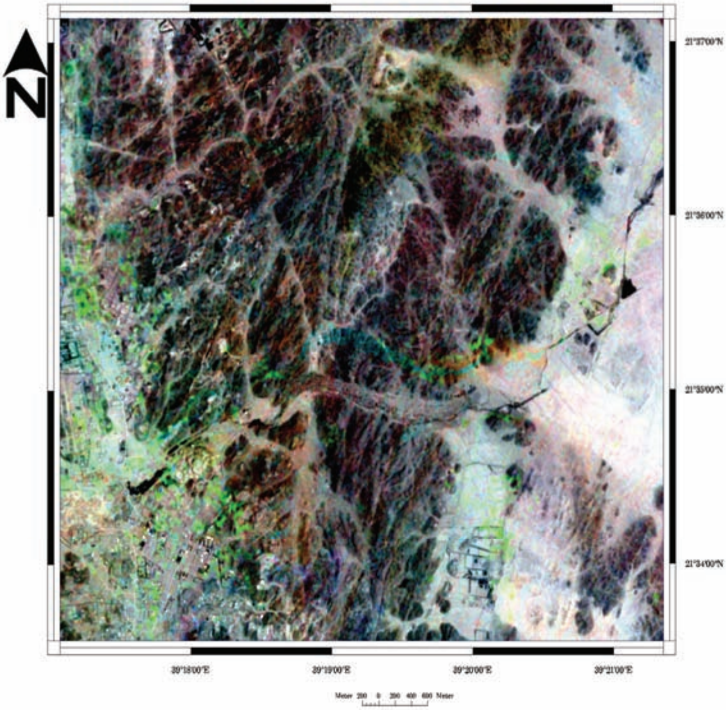

Fig. 9. Fused color composite image created by the fusion between Landsat ETM multispectral bands (30-m resolution) and SPOT panchromatic band (10-m resolution).

Extraction of lineaments from satellite imagery is very important for many purposes such as geological mapping, mineral explorations (Rowan and Lathram, 1980) and seismic and landslide risk assessment (Stefouli *et al.,* 1996). Lineaments may reflect surfaces of discontinuity in the rocks or may reflect a geological structures or topographic features or human made features. The lineaments are usually extracted and interpreted from the satellite imagery manually or automatically. Many authors are manually extracting lineaments from satellite imagery or from aerial photographs such as Chang *et al.*, 1998, Suzen and Toprak, 1998, Leech *et al* ., 2003, Cortes *et al.*, 2003, and Nama, 2004. Many other authors interpreted the structural lineaments from the digital satellite imagery using the automatic extraction technique such as Koike *et al*., 1998, Casas *et al.*, 2000, Costa and Starkey, 2001, Vassilas *et al*., 2002, and Mostafa and Bishta, 2004. The extraction of lineaments from digital satellite imageries (using PCI Geomatica, 2004) of different spatial resolutions for construction of the structural mapping will be tested in this work.

The lineaments extraction for the study area was automatically extracted from Spot panchromatic-10 m (MSR) satellite imagery. These extracted lineaments were edited by visual interpretation to construct the structural lineaments map and determine the main structural trends affecting the investigated area (Fig. 10). The extraction of the lineaments in this work was done under the user defined parameters of PCI Geomatica software Package, which are:

1- Edge filter radius = 3,
2- minimum edge gradient = 15,
3- minimum line length = 10,
4- line – fitting tolerance = 2,
5- maximum angular difference = 10, and
6- maximum linking distance = 30

Image Processing of Satellite Imagery Data of High Spatial Resolution (HSR)

The imageries data of high spatial resolution HSR are characterized by higher spatial resolution than the previous types (LSR and MSR). The Indian satellite remote sensing imagery IRS panchromatic data of 5 m resolution is used in this work as an example of the HSR data (Fig. 11). The best enhancement techniques which are suitable and applied to these HSR data were mainly the fusion and automatic extraction of lineaments**.**

1- Fusion between Multispectral ETM Data and IRS Panchromatic Data

Fusion processing has been carried out using PCI Geomatica through the same steps mentioned before (in 4-1). The fusion was carried out between IRS panchromatic data of subset area showing as a square in Fig. 11 of high spatial resolution HSR (5-m), and the corresponding area of a false color composite Landsat ETM image of lower resolution (LSR) 30 m. The fusion processing produced a fused color composite image of high resolution (5 m) in scale 1 : 5,000 for the subset area as shown in Fig. 12. The result of the fused color image was then used in the geological interpretation to produce a large-scale geological map.

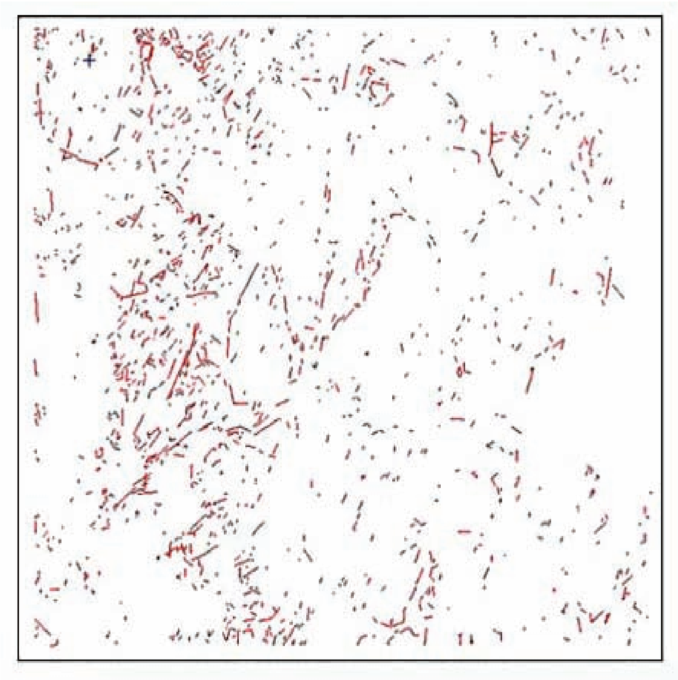

Fig. 10. Structural lineaments for the study area, automatically extracted from satellite imagery of moderate spatial resolution, MSR, (Spot Pan-10 m).

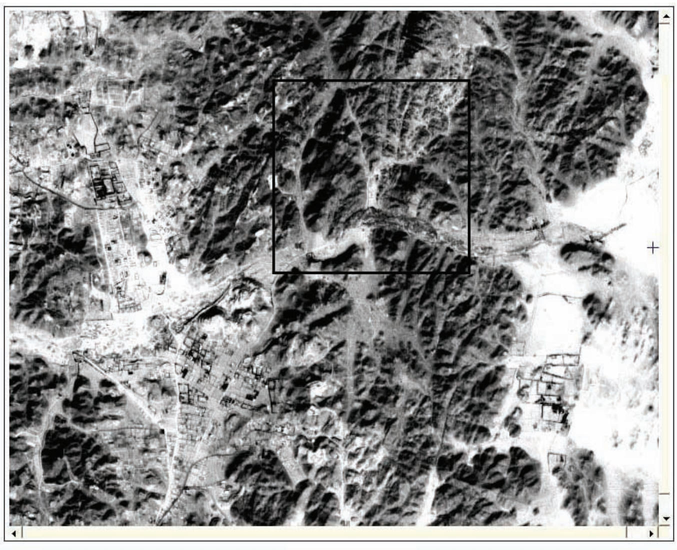

Fig. 11. Indian IRS panchromatic image (5-m resolution) of HSR imagery. The squared area is a subset for applying the fusion technique (original scale is 1 : 5000).

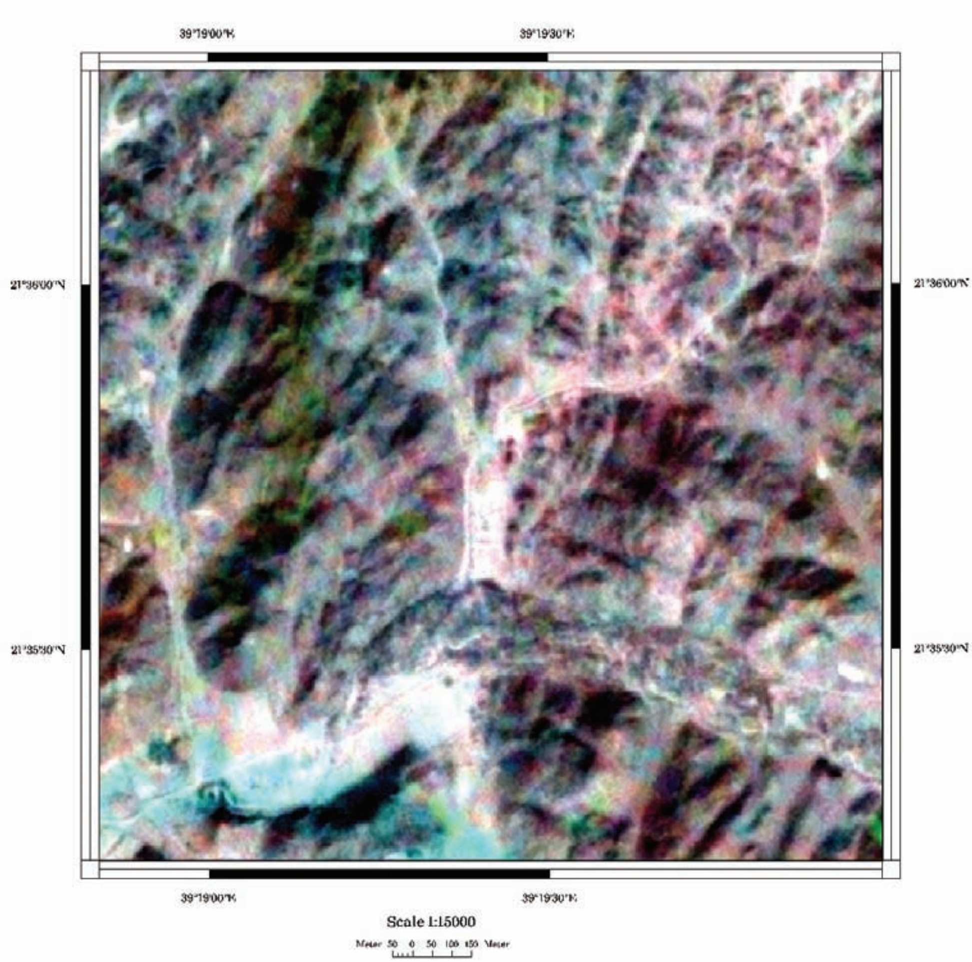

Fig. 12. Fused color composite image created by the fusion between Landsat ETM multispectral bands (30-m resolution) and Indian panchromatic band (5-m resolution). This image is created for the area squared in Fig. (11).

2- Lineaments Extraction from HSR Data

The structural lineaments for the study area were, automatically extracted from the digital satellite imagery of high spatial resolution, IRS Panchromatic-5 m (Fig. 11). The extraction of lineaments was carried out using the PCI algorithms and under the user defined parameters, as discussed earlier. These extracted lineaments were edited by visual interpretation to determine the main structural lineament trends affecting the investigated area (Fig. 13). The total number of these extracted structural lineaments, 3235 from the HSR imagery (IRS) was the highest number than those 484 extracted from the LSR imagery (TM) or from the MSR imagery (Spot Pan.).

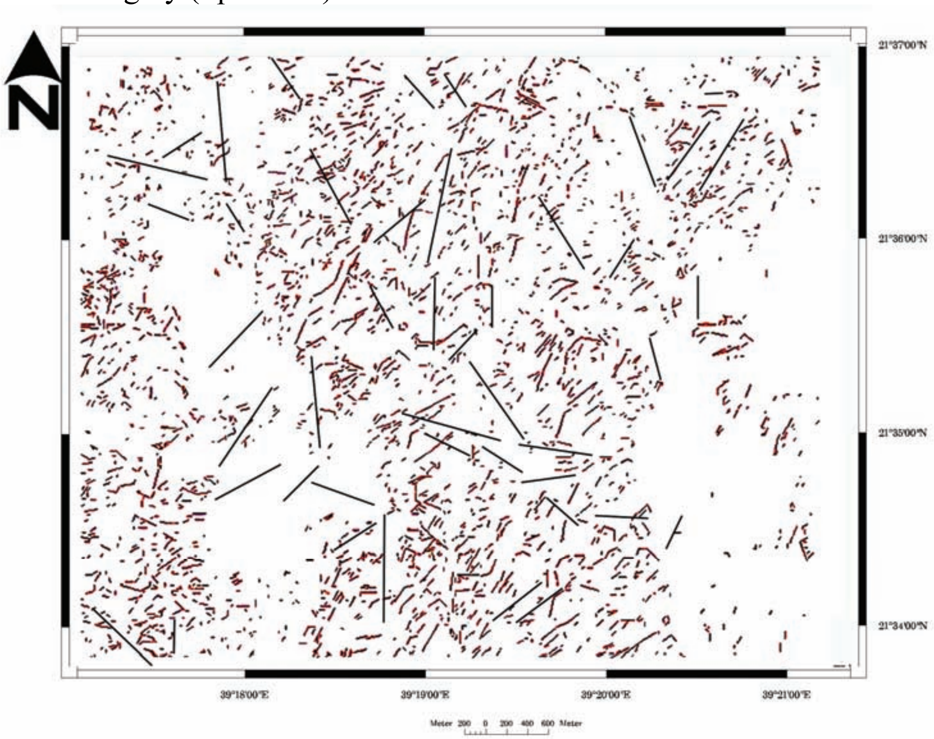

Fig. 13. Structural lineaments for the study area, automatically extracted from the Indian IRS imagery of high spatial resolution, HSR, (IRS Pan-5 m).

The extracted structural lineaments from HSR imagery (Fig. 13) were analyzed for constructing the lengths density contouring map, and azimuth trends of lengths as shown in Fig. 14. This Figure shows that the main structural trends affecting the investigated area are in the NE-SW and WNW-ESE. These structural lineaments are highly concentrated and have higher density in the west central parts of the mapped area restricted mainly to the ganitic and dioritic rocks.

3- Detailed Geological Map

Figure (15) shows a geological map of the study area in scale 1 : 100,000 (Spencer *et al*., 1988). This was the largest scale geological map for the study area constructed by previous workers. This map shows that the study area consists of the following rock units: metamorphic rocks, diorite, gabbro, tonalite to quartz diorite, granodiorite to quartz diorite, granite (alkalic to calcalkalic) and sand and gravel (Fig. 15).

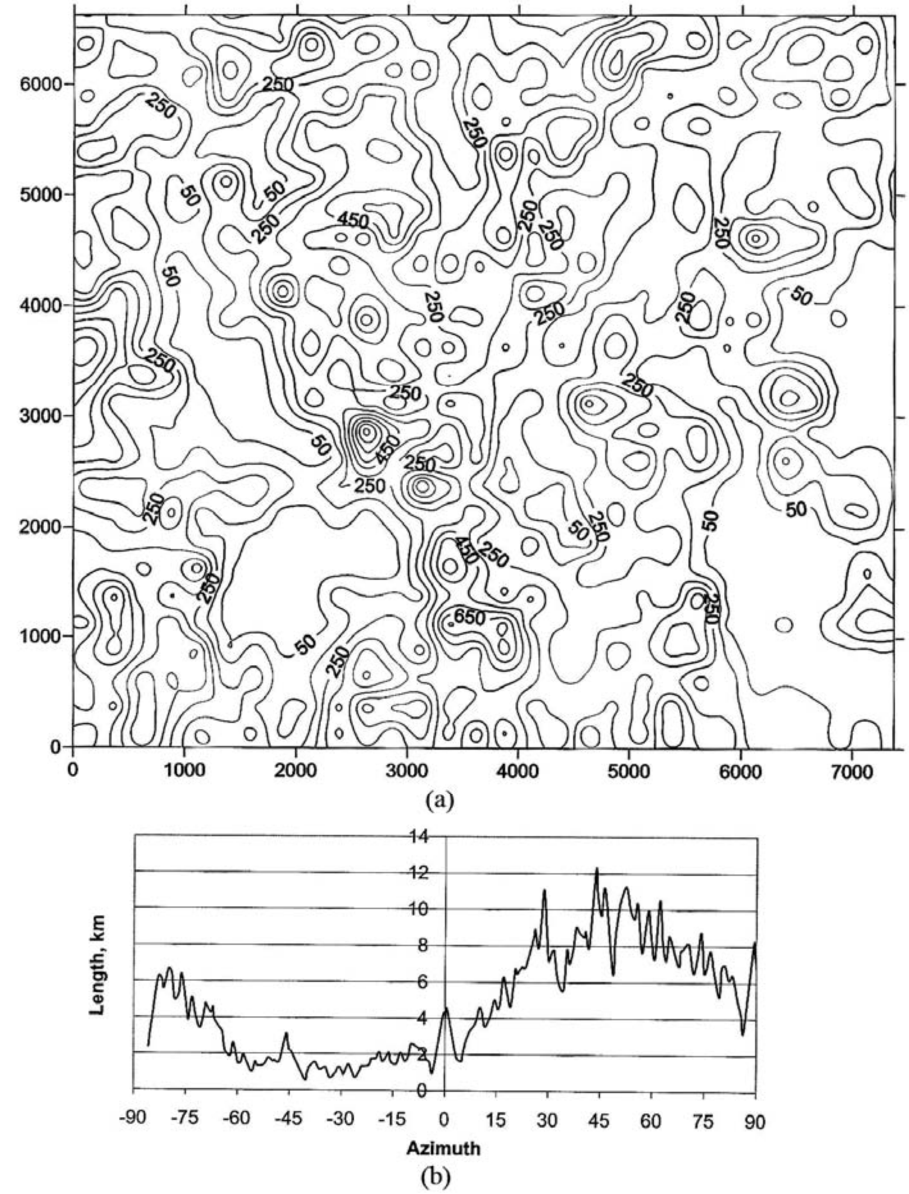

Fig. 14. (a) Lengths density contouring map, and (b) Azimuth trends of lengths, of the extracted lineaments for high resolution satellite imagery IRS 5 m.

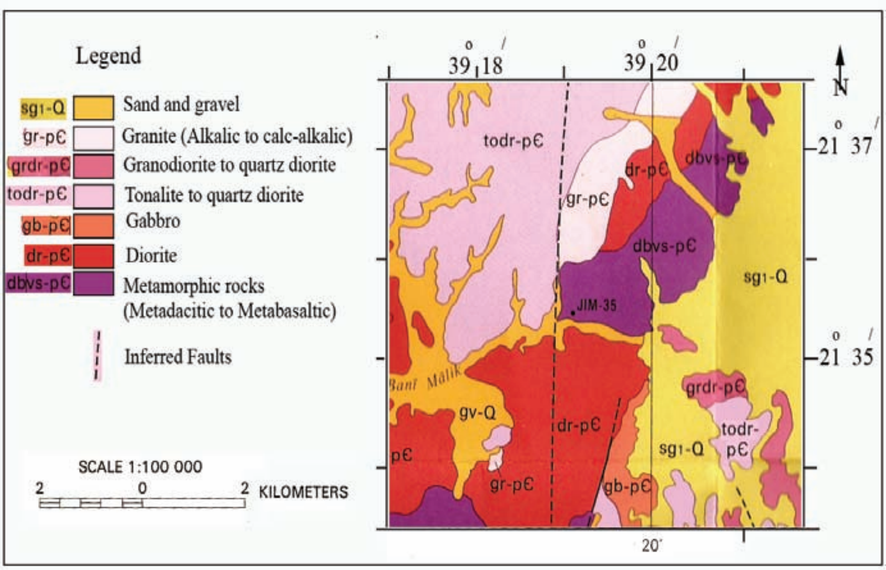

Fig. 15. Geological map of the investigated area Scale 1 : 100,000 (Modified after Spencer *et al.*, 1988).

The satellite imagery of high spatial resolutions (HSR) is characterized by a spatial resolution greater than 10 m (higher than both LSR and MSR). The HSR type is exampled in this investigation by the Indian Remote Sensing Satellite IRS panchromatic data of 5 m resolution. The image processing techniques applied to this data gave a detailed colored satellite imagery of high resolution. The geological interpretation of the fused colored composite image of high resolution (5 m) gave a detailed geological map of the investigated area in scale 1 : 5,000 (Fig. 16). The detailed geological map gave more geological information than the previous studies.

The detailed geological map interpreted from the HSR imagery (Fig. 16) shows some important differences than the previous geological map (Fig. 15). This map shows that the alkalic to calcalkalic granitic rocks in the northern part of the mapped area is mainly divided into two phases: Granite phase-1 displayed in pinkish color signature and coarse texture on the fused color image, and granite phase-2 displayed in brownish color signature and medium texture on the fused color image.

The outcrops of the metamorphic rocks occupied a larger area in the detailed geological map (Fig. 16) than the previous geological map.

The metamorphic rocks are displayed in dark brown color signature and fine texture on the fused color image and extended from the central to the western parts along Wadi Bani Malik area. The field verifications distinguished these metamorphic rocks into two types mainly acidic and basic (Fig. 17). Some other accurate contacts and outcrops for the rock units of tonalities, gabbros, and granodiorites are shown on the east southern parts of the new detailed geological map (Fig. 16).

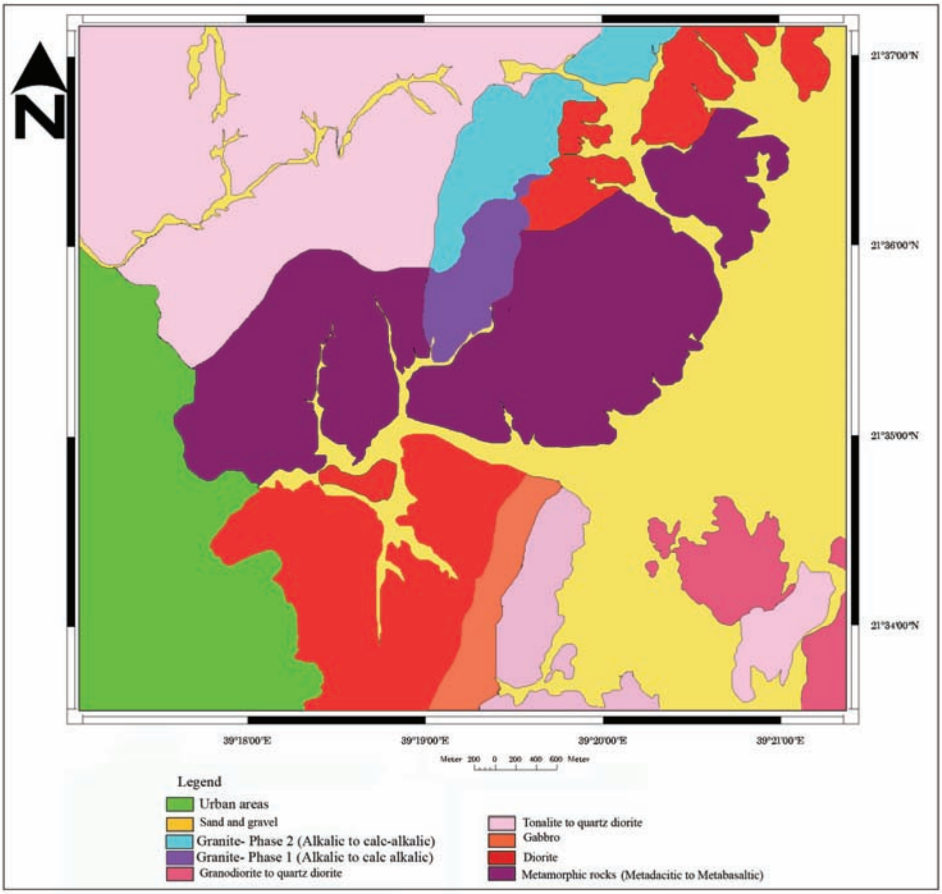

Fig. 16. Geological map of the investigated area interpreted from the HSR satellite imagery (original scale 1 : 5,000).

Fig. 17. Field photographs showing the metamorphic rocks (a) Acidic, (b) Basic, of Gabal Bani Malik.

Conclusions

The processed satellite imageries produced from the three data sets were used in the geological mapping and gave the following results:

1- Satellite imagery data of low spatial resolution (LSR), including imageries of spatial resolution of 25 m or lower. They are used for the regional studies, and producing geological maps of scale 1 : 100,000 or smaller. These data are used to construct false color composite images in

RGB, color ratio images, and color composite images of principal component analysis. Also the unsupervised classification is carried out for these data.

2- Satellite imagery of moderate spatial resolution (MSR) including satellite imageries which have a spatial resolution ranging between 25 m to 10 m. They are used for the semi-regional studies, and producing geological maps of scale ranging between 1 : 100,000 to 1 : 20,000. The main processing technique applied for these data is the fusion technique, between the SPOT panchromatic image (MSR) and another multispectral color image of the lower resolution, such as ETM+ image(LSR) to get a color MSR image. Another important technique applied for the MSR data is the automatic lineament extraction from the digital panchromatic SPOT data.

3- Satellite imagery of high spatial resolution (HSR) are characterized by a spatial resolution greater than 10 m. They were used for the detailed studies, and producing geological maps of scale 1 : 20,000 or larger. The main processing technique applied for these data are the fusion and the lineaments extraction.

4- The processed HSR imageries are used for the geological and structural interpretation, and producing a detailed geological and structural maps of the investigated area in scale 1 : 5,000. These maps are larger in scale, and containing more information than the previous geological mapping.

5- It is recommended to use the LSR imageries for the regional studies, and producing regional geological maps. It is also recommended to use the LSR imageries with either MSR or HSR imageries, for applying the image processing techniques, to produce semi-regional geological mapping or detailed geological mapping, respectively.

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تقييم استخدام مرئيات الأقمار الصناعية متعددة الدقة في التخريط الجيولوجي، حالة دراسة لمنطقة جبل بني مالك، شرق مدينة جدة، المملكة العربية السعودية

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المستخلص. تعتبر الأنواع المختلفة لصور الأقمار الصناعية أحد مصادر البيانات المفيدة والهامة جدًا في عمليات التمييز الصخري والتخريط الجيولوجي. كما أن تقنيات الاستشعار عن بعد المتقدمة والحديثة تجهزنا دائما بكميات ضخمة من مرئيات الأقمار الصناعية ذات دقة مختلفة. ويهدف هذا العمل لتقييم استخدام مرئيات الأقمار الصناعية المختلفة الدقة في عمليات التخريط الجيولوجي. ولقد تم اختيار منطقة جبل بني مالك بشرق مدينة جدة لتطبيق استخدام هذه التقنية في هذا العمل. وهذه المنطقة متكونة من صخور الدرع العربي النارية والمتحولة، والمتأثرة بكسور فى اتجاهات مختلفة.

وفي هذا العمل تم استخدام أنواع مختلفة لمرئيات الأقمار الصناعية الرقمية لمنطقة الدراسة، التي تشمل: لاندسات MSS ٨٠ م لاندسات TM ٣٠م ولاندسات TM ٢٥م و لاندسات +ETM ٣٠م و١٥م وسبوت ١٠م والقمر الصناعي الهندي للاستشعار عن بعد IRS ٥م. وهذه البيانات تم تصنيفها إلى ثلاث مجموعات على أساس الدقة المكانية:

١- بيانات مرئيات أقمار صناعية ذات دقة مكانية منخفضة (LSR): التي لها دقة مكانية ٢٥م أو أصغر،

٢ - بيانات مرئيات أقمار صناعية ذات دقة مكانية متوسطة (MSR): التي لها دقة مكانية تتراوح بين ١٠ إلى ٢٥م.

٣ - بيانات مرئيات أقمار صناعية ذات دقة مكانية عالية (HSR): التي تتميز بدقة مكانية أكبر من ١٠م. ولقد تم تطبيق معالجات المرئيات الفضائية التي تناسب كل نوع من الأنواع السابقة.

ومرئيات الأقمار الصناعية المنتجة من الثلاثة مجموعات ذوات الدقة المختلفة استعملت في التخريط الجيولوجي لمنطقة الدراسة. ولقد اتضح أن بيانات الأقمار الصناعية ذات الدقة المنخفضة (LSR) يمكن استعمالها للدراسات الإقليمية والخرائط الجيولوجية المنتجة من مقياس ١: ١٠٠,٠٠٠ أو أصغر. بيانات الأقمار الصناعية ذات الدقة المتوسطة (MSR) يمكن استعمالها للدراسات نصف الإقليمية والخرائط الجيولوجية المنتجة من مقياس يَتراوح بين ١: ١٠٠,٠٠٠ إلى ١: ٢٠,٠٠٠. أما بيانات الأقمار الصناعية ذات الدقة المكانية العالية (HSR) فتستعمل للدراسات المفصلة والخرائط الجيولوجية المنتجة من مقياس ١: ٢٠,٠٠٠ أَو أكبر. ولقد تم استخدام المرئيات الفضائية المنتجة من الأقمار الصناعية ذات الدقة المكانية العالية في التفسير الجيولوجي والتركيبي وانتاج خرائط جيولوجية وتركيبية لمنطقة الدراسة. هذه الخرائط أكبر في المقياس وتحتوي على المزيد من المعلومات أكثر من الدراسات السابقة.