Evaluation of the Lineaments and Faults in the Alborz Province by Remote Sensing

*Farrokhnia A., Sorbi A.; Department of Geology, Karaj Branch, Islamic Azad University, Karaj, Iran

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Abstract

The studied region in this research (Alborz province) is structurally located in Alborz poly_orogenic system of northern Iran. The purpose of this research is combining the remote sensing and geology sciences to show fault lineaments by analyzing satellite data in a vast region and also comparison between lineaments layer and recognized faults in geology maps. Firstly, two scenes of Landsat ETM+ satellite images with 164-35 and 165-35 numbers were **mosaicked** and also according to coordinates of research area (46° 30´ to 48° east longitude and 34° to 35° north latitude degree) have been crop. Then with remote sensing methods such as combination of bands, filtering, NDVI index to reconstruction the vegetation, principal components analysis (PCA) and band relativity in gray scale and color images have been analyzed the satellite images. Finally, by using the above mentioned methods, the map of fault lineaments and map of lineaments density for Alborz province have been prepared and compared with recognized faults.

Keywords: Lineation, Fault, Remote Sensing, Satellite images, Alborz province.

*Corresponding author Farrokhnia@kiau.ac.ir

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Introduction

Processing Satellite data is a way to recognize lineaments. An important advantage of this way is to study a vast area simultaneously and a same attention. In this method, the lineaments with fault properties will appear in the shape of valleys that are simply recognizable or will be specify via the effects due to fault. So the lineaments that were not detected before, can be specific .The studied area is structurally located in Alborz poly_orogenic system and the active faults Mosha-Fasham, North of Tehran, Taleghan and etc. are identified in this area. In this research the lineaments of Alborz province are studied by the means of Landsat ETM+ Satellite image processing.

Discussion

In identifying fault lineaments from linear complication we should consider these terms [2], [3]:

1. Disconnection, displacement and extension of units and also geomorphology units such as: river, delta, alluvial fan and etc.
2. The obvious lineaments that does not show the displacement but the effect of these lineaments is specific in Satellite images even in Quaternary-age alluvials.
3. The existence of echelon structures and the wrought phacoidal stone units showing the existence of a fault even hidden under alluvials.
4. The stand of springs in a same bearing and the existence of linear valleys.
5. The stand of two different rocks near each other.

To sensiblize fault lineaments on satellite image, we used some standard methods of Remote Sensing:

Using RGB images (False Color Composition): According to the fact that to make a RGB image we need three bands, using six bands 1, 2, 3, 4, 5, 7 of the Landsat image, we made different false color composition and recognized the lineaments on them. By using RGB method 222 lineaments were recognized (Figure1).

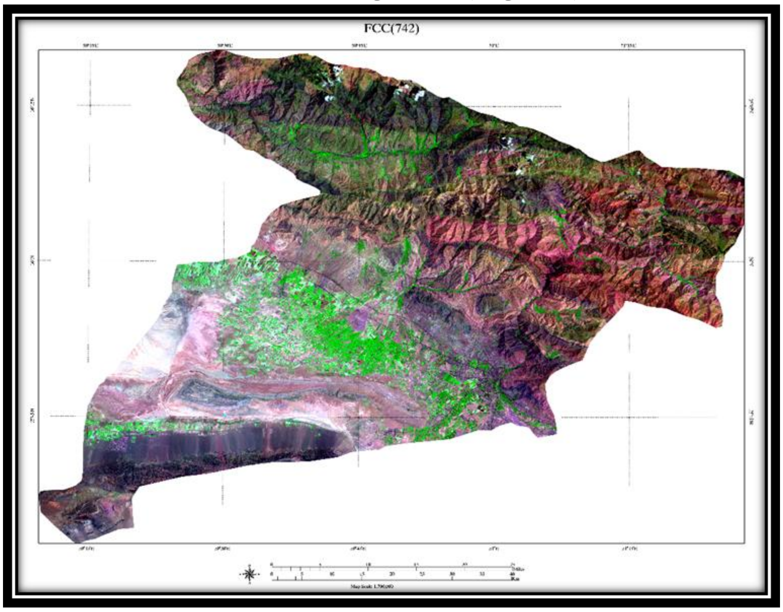

Figure1. False Color Composite image (RGB 7,4,2)

Filtering method: As the edge detector filters are so important in structural geology, especially for recognizing fault lineaments [2], in this research we used Laplacian, Sobel, and Prewitt, Sharpening, Robert high pass filters and also eight edge detector kernels [4]. By applying high pass filters 62 lineaments were found and 66 lineament were found by applying edge detector kernels (Figure2 and Figure3).

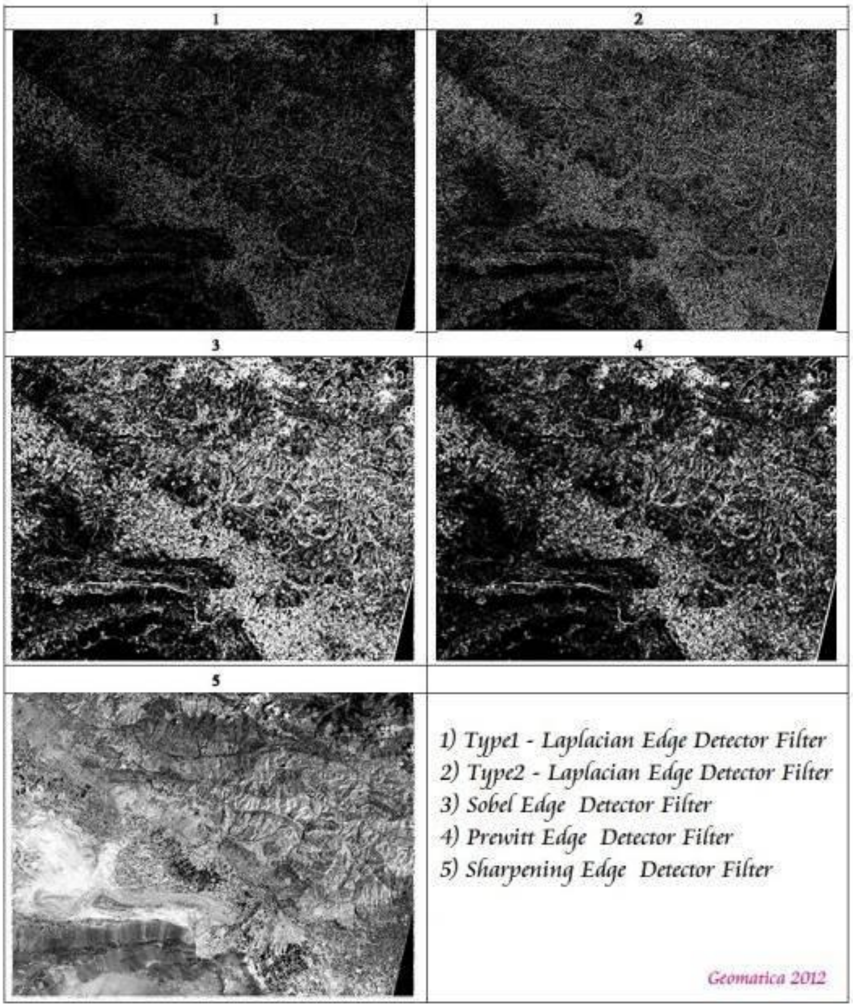

Figure2. Filtering Method (High Pass)

Principal Components Analysis (PCA): PCA is a technique that let us produce images with zero or near to zero correlation [2]. One of the high usage methods to increase the image contrast and shades modification is PCA [5]. By using this method in ENVI 5 software, 68 fault lineaments were recognized (Figure4).

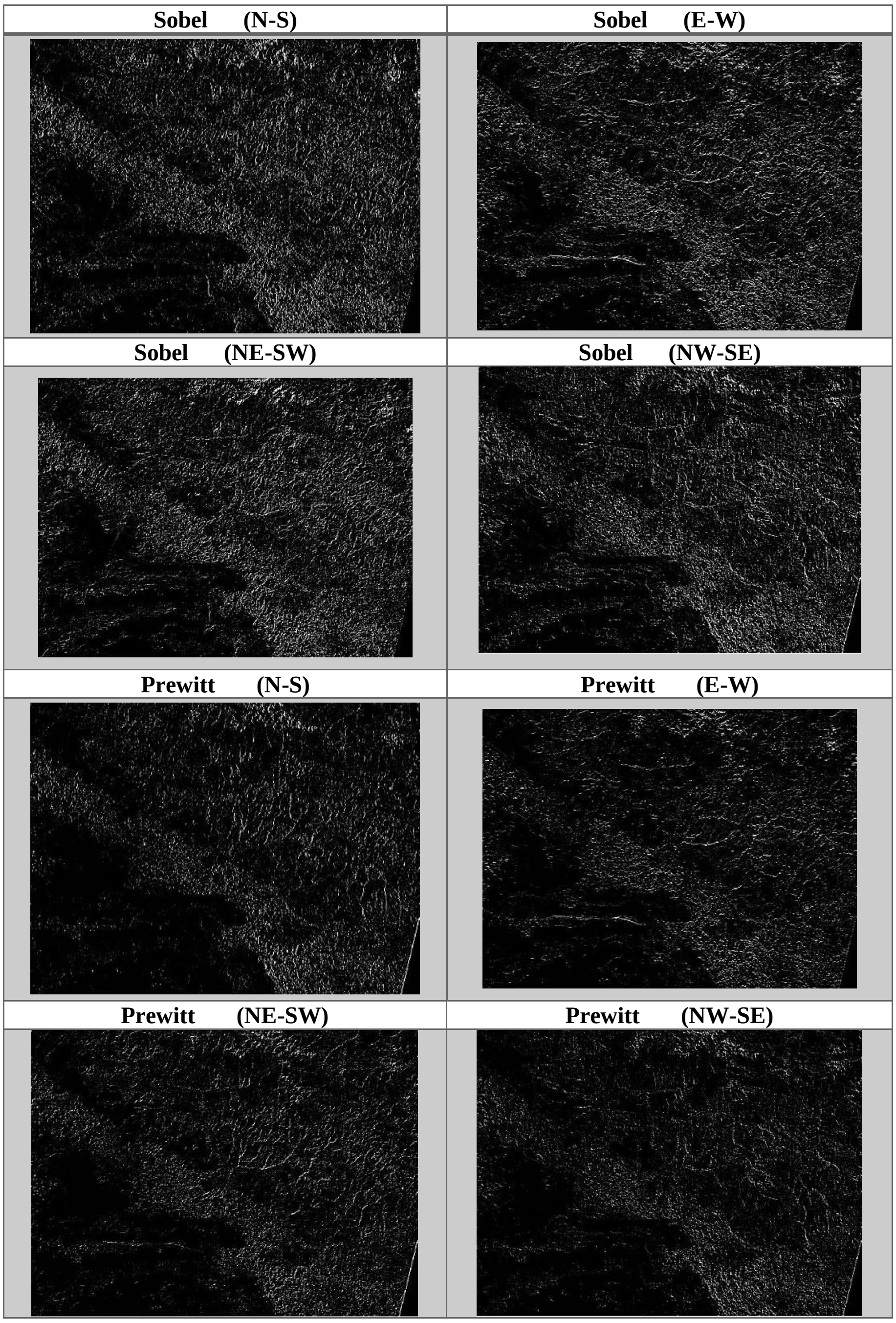

Figure3. Filtering Method (Custom)

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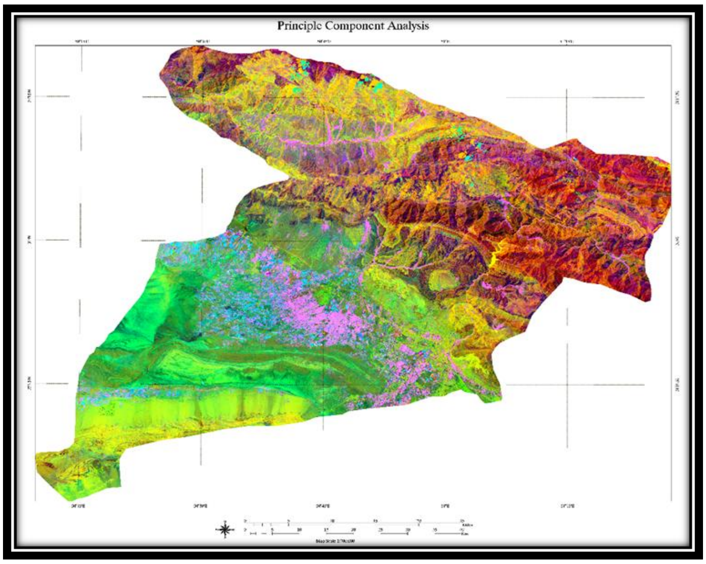

Figure4. Principal Components Analysis (PCA)

4. Band Ratio: Hydrothermal minerals in seventh band of Landsat image has the least reflex, and the most reflex in fifth band. Also Ferric minerals shows the most reflex in first band and the least reflex in third band. So 5/7 Band Ratio is effective to recognize hydrothermal minerals and 3/1 Band Ratio is effective for recognizing Ferric minerals [6]. Relative Vegetation Index (RVI) is calculated as follows [7]:

$$RVI = NIR / R$$

(NIR) and (R) are pixel value in near infra-red and red bands respectively. In this research we recognized complications related to fault lineaments like hydrothermal minerals aggregation and linear vegetative coverage. If 5/7, 4/3 and 3/1 Band Ratios be appropriate to red, green and blue channels respectively, the minerals appear red, plants appear yellow and the context will appear blue [8]. By using Band Ratio method, 34 lineaments were recognized (Figure5).

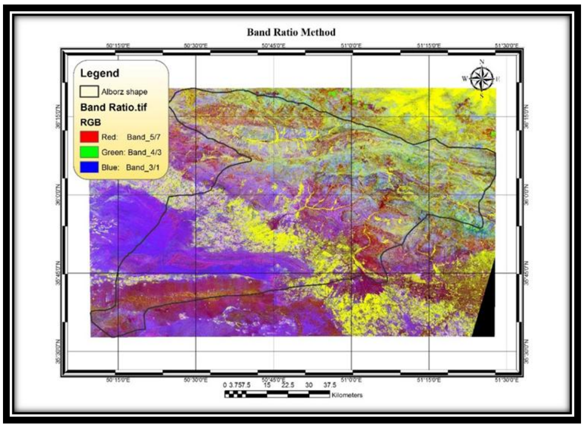

Figure5. The lineaments layer was put on the Band Ratio image (RGB (5/7, 4/3, 3/1))

5. Normal Differential Vegetative Index (NDVI): This Vegetative Index is defined as follows at NIR and R bands [7]:

$$NDVI = (NIR - R) / (NIR + R)$$

NDVI has the same behavioral and operation as RVI (Figure6).

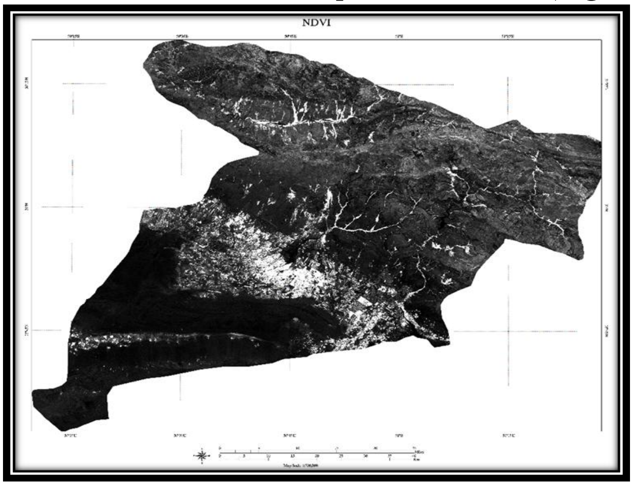

Figure6. Normal Differential Vegetative Index (NDVI)

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Sensiblize fault lineaments

In this work, 815 lineaments were totally recognized using satellite image processing (Figure7). Also density of lineaments map, was prepared in Arc GIS 10 software. In these map each unit spotted 1 km^2 as the colors have shown relative density of lineaments (Figure9 and Figure10). To prepare the final maps, the fault lineaments layer was put on the aeromagnetic lineations (Figure11). Finally, to have a comparison, the location of epicenter of instrumental earthquakes [9] of the area were put on fault lineaments (Figure12) and the lineaments layer was put on the digitized faults layer of the studied area [10] (Figure8).

By comparing the results obtained from the studies in the Alborz province and the adjacent province, Qazvin, these consequences are noticed:

1. The dominant trend of lineaments density in Alborz province is in E-W direction but in Qazvin province, two dominant trends in E-W and N-S directions are detected (Figure13)
2. Accommodation between the lineaments with the length greater than 10 km and magnetics faults are poor in Alborz province but the better match between the lineaments with the length greater than 10 km and magnetics faults are seen in Qazvin province.
3. The density of epicenters in Alborz province is less than Qazvin province.

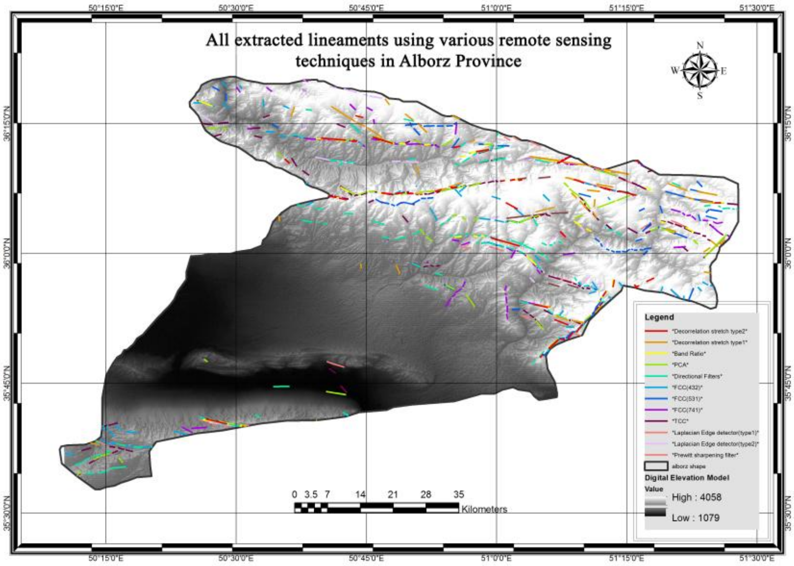

Figure7. Recognized lineaments map

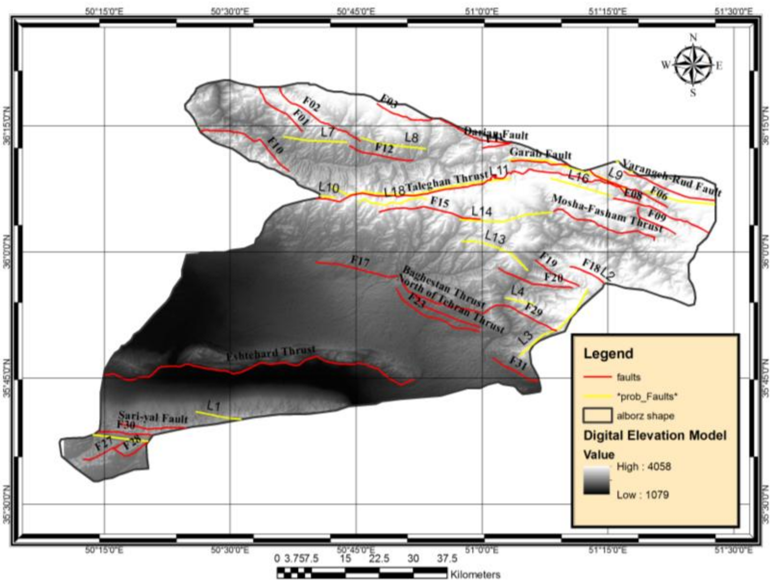

Figure8. The lineaments >10 km and the main faults

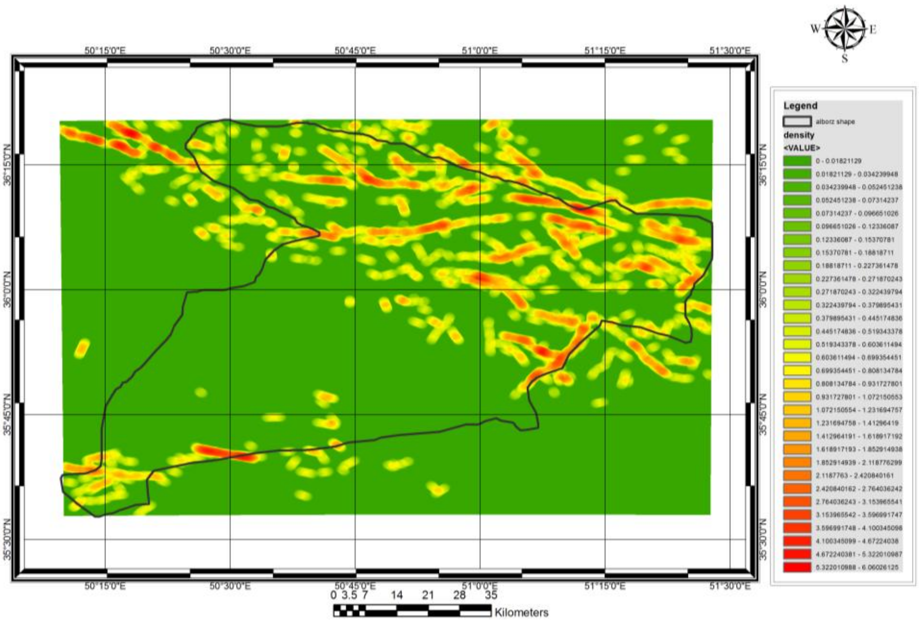

Figure9. Density of lineaments map

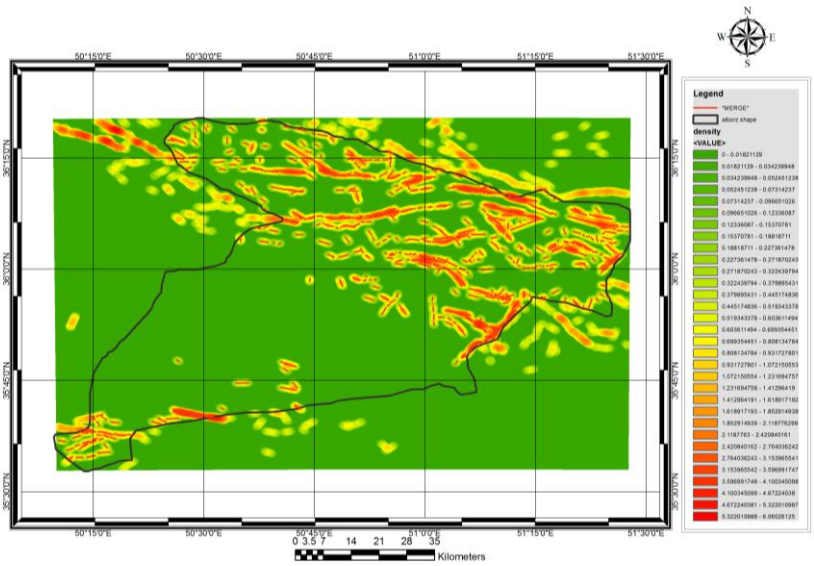

Figure10. The lineaments layer on the lineaments density map

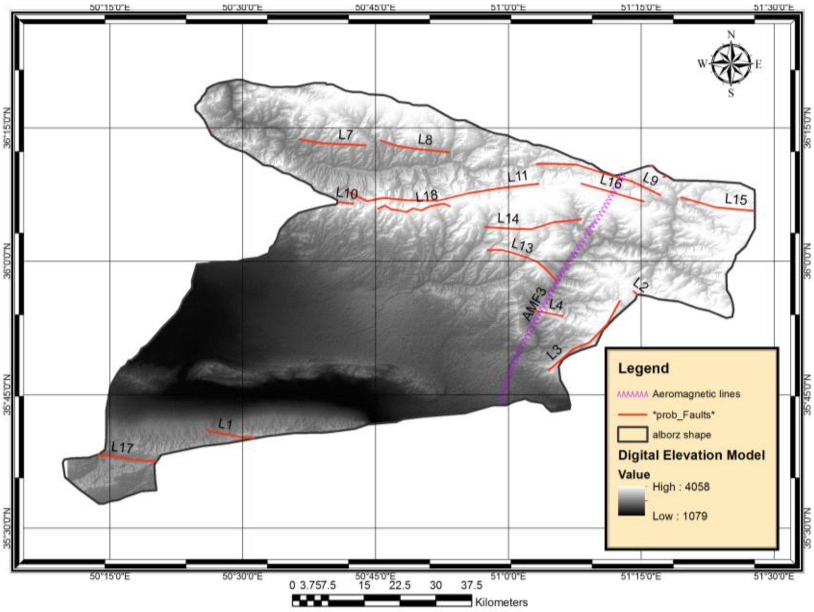

Figure11. The lineaments>10 km and Magnetics faults

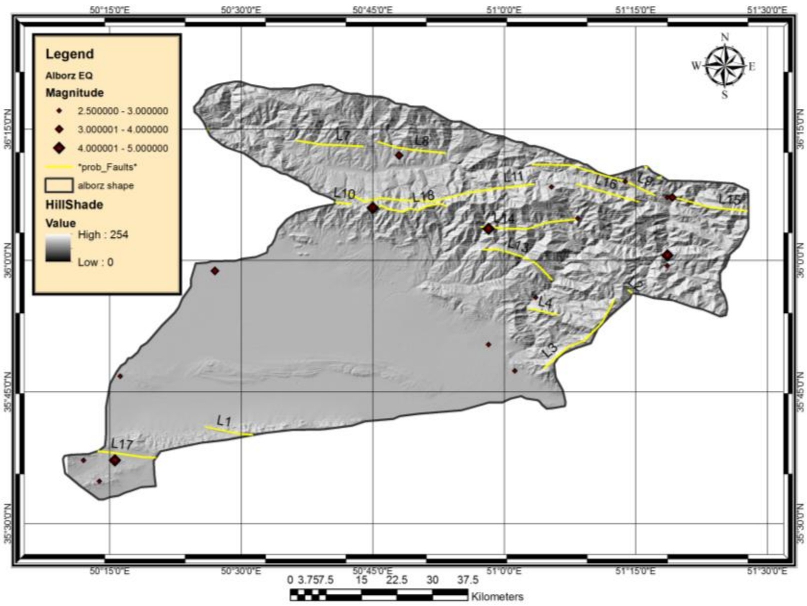

Figure12. The location of epicenters of instrumental earthquakes and fault lineaments >10 km

	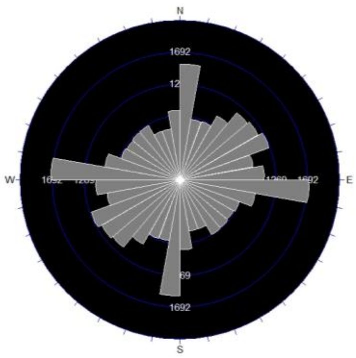
Alborz province	Qazvin province

Figure12. Rose Diagrams in Alborz and Qazvin provinces

Conclusion

1. Satellite data processing is the best method to sensiblize fault lineaments in vast and without field revision qualifications area. Specially to recognize lineaments that don't have fault equivalents on geological maps.
2. Satellite image that are the result of 5/7 and 3/1 Band Ratios that Hydrothermal and Ferric minerals are recognized from other phenomenon are one of the best methods to recognize the fault effect.
3. In lineament density map, red parts show maximum density of fault lineaments.
4. By comparing lineament density map and the area earthquake dispersion, a clear direct relation between the location of lineament maximum density and occurrence of earthquakes will be found.
5. In this research, these faults does not have any peer in aeromagnetic map, so they are surface faults.

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F01, F02, F03, F06, F08, F09, F10, F11, F12, F15, F17, F18, F19, F20, F23, F27, F28, F29, F30, F31, Darian Fault, Garab Fault, Varangeh-Rud Fault, Taleghan Thrust, Mosha-Fasham Thrust, Baghestan Thrust, North of Tehran Thrust, Eshtehard Thrust, Sari-yal Fault.

6. In this research, these faults does not have any peer in lineaments map, so they are dip slip fault.

F01, F02, F03, F09,F10, some segments of F11, F15, F17,some segments of F18, F19, F20, F23, F27, F28, F31, Darian Fault, Mosha-Fasham thrust, Baghestan thrust, Eshtehard thrust.

7. This magnetic lineament (AMF3) does not have any peer in geologic map, so this is a blind faults.

8. In these research, these lineaments are perfectly identic below mentioned faults.

Lineaments	Main Faults
L17	F30
L14	F15
L10, L11, L16, L18	Taleghan Fault
L09	Garab Fault
L15	Varangeh_Rud Fault
L08	F12

9. Only the lineament L03 is parallel with the aeromagnetic lineament AMF3 with the horizontal distance of 6 to 11 kilometers.

10. In these research, these lineaments are not identic none of the outcropped faults on geology maps and aeromagnetic maps.

L01, L13, L03, L14, L07

11. The lineament L14 is exactly on the strike, and continue to Mosha-Fasham fault and connected it to the Fault F15. Thus it is possible that F15 is the western part of the Mosha-Fasham fault.

12. According to the results that mentioned above and great extent of regions, no logical relationship detected in the Alborz province and

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Qazvin province in structural concepts and geological remote sensing meanings.

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