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Analysis of Aeromagnetic and Landsat7 satellite Data for identifying Suitable Zones for Regional Groundwater Exploration, East of Kermanshah Province

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Abstract

Appeal to new water sources is increasing day by day, and now its request is not limited to special geographical place. Decreasing of detected and general water sources causes that we appeal to identify new strategic groundwater sources in igneous, metamorphic and even sedimentary rocks for present and future usages. The aim of this article is to identify suitable zones for regional groundwater exploration. To achieve this goal, we use the processed remote sensing and aeromagnetic data and compare them with other information such as the geological map of the study area. Suitable zones for groundwater exploration are located around faults, fractures, joints, lithological contacts and weathered zones. Existence of waters in these zones also reduces its magnetic response and this helps us identifying suitable zones. The study area is east of Kermanshah province where expected zones are located. In the study, the remote sensing data selected from Landsat7 satellite and its ETM + sensor. After importing data in the related software, false color composite (FCC) 7-4-1 (RGB) image prepared from the study area. Then, this color image is placed under the operation of Linear Stretching (contrast improving). The Aeromagnetic data are also filtered with filters such as Reduction To the Pole (RTP), first Vertical derivative, Upward & Downward continuation, High & Low pass filters and Tilt Derivative. The color shaded relief maps of applied filters for the study area were also prepared. Suitable zones for having water potential condition usually have linear form, that stretched along certain strikes and the interpretation was done in the study area by lineaments detection in processed aeromagnetic and remote sensing data. Remote sensing data correlates with shallower depth structures that helps us in detecting drainage networks, shallow canals and groundwater feeding, while the aeromagnetic data correlates with deeper structures, and this data has a significant role in detecting reservoirs and groundwater accumulation. The best zones / areas are those ones Landsat aeromagnetic methods are recommended. The detected lineaments are simultaneously compared with the geology and topography maps of the study area in a geographic information system (GIS) to identify suitable zones for groundwater exploration. The best zone in this researchis recognized in a section of Sahne fault that is located in Northwest Sahne city, where both Landsat and aeromagnetic data are shown as a proper zone. The strike of this zone is NW-SE that is directed along the general trend in the study area. Ground magnetic survey was performed in this zone with high resolution, and the results of the interpretation of these data showed that the strike of zone is parallel with other detected lineaments

with slight offset, and these results confirmed the methods used for identifying suitable zones for groundwater exploration in this area.

Introduction

With the sharp increase in the world's population and its increasing need for newer water sources for various purposes, exploring new water sources become important in addition to the conventional water sources (river and alluvial). The underground water sources in the rock units can meet this need. For this purpose, we decided to use remote sensing and aero magnetic data and process those to identify suitable zones for the regional exploration of groundwater.

There have been studies on the simultaneous use of remote sensing and aeromagnetic data in earth sciences, some of which can be mentioned. Using aeromagnetic and Landsat TM data, suitable structures were identified for exploration of minerals and underground water in the southcentral zone of Zimbabwe (Ranganai,1996). In 2004, Neawsuparp researched about "Usage of aerial geophysics and remote sensing data in structural and tectonic geology in north eastern Thailand" (Neawsuparp, 2004). In 2008, aeromagnetic and Landsat TM data were used to identify regionally suitable areas for groundwater exploration in the southcentral zone of Zimbabwe. Then, by using the interpretation of the geological structures, they found suitable results that are in harmony with existing wells in the interpreted favorable points. In this study, using geographic information system (GIS), the processed data has been compared with other information simultaneously and the necessary results have been extracted (Ranganai and Ebinger ,2008) . In 2010,, using remote sensing, aeromagnetic and gravity data, surface and subsurface structures were identified in southern Egypt in the Kalabshah region(Khamies and El-Tarras ,2010). In 2018, using aeromagnetic and Landsat data hidden faults were identified in Qom province (Aryamanesh et al, 2018). Studies have also been conducted to identify geological structures using remote sensing or aeromagnetic data separately, some of which can be mentioned. Remote sensing data has been used in hydrology (MEIJERINK ,1997) . In 2006, the identification of tectonic lines and complications in a region in Eritrea was done using Landsat TM data (Solomon and Ghebreab,2006). Partial fault identification was done in Finland using aeromagnetic data (Airo and Vannerström, 2010). In this study, the work of Ranganai and Ebinger in 2007 has been used.

In the studied area, igneous and metamorphic rock units are of prime importance due to their appropriate magnetic response. These units have crystalline formation, which have no primary porosity and permeability, and as a result, this type of formation does not have a suitable condition for the accumulation of underground water. In order to exist suitable condition for the accumulation of underground water, the foundation of the crystalline rock must have secondary porosity and permeability, which is caused by faults joints, the penetration of dykes and contacts. As a result, the faults, joints and in general, fractures, dyke margins, weathered zones or an intersection of them together is known as a suitable zones for underground water exploration. These geological structures cause the destruction or creation of magnetite as a magnetic mineral. This effects leads to the fact that these changes can be identified by the aeromagnetic data interpretation (Ranganai et al., 2008)

In addition to investigating igneous and metamorphic units, sedimentary units have been investigated despite their low magnetic response, which constitutes a significant part of the studied area.

The mechanism of remote sensing data is related to the shallow depth of the earth, which is related to the drainage networks, surface channels and underground water supply, while the mechanism of aeromagnetic data is related to deeper depths. Aeromagnetic data used in this study with a flight line distance of 7.5 km which is related to reservoirs and underground water accumulation. By comparing the identified lineaments with other information, including the geological map of the region, it is possible to relate the lineaments to geological features, which are both compatible. It suggests the best zone or region for underground water exploration. The suitable detected zones mentioned above are usually linear in a certain direction. In general, the study conducted is based on the identification of these lines in the remote sensing image and aeromagnetic interpreted data and relating the results with the geological and topography information of the area and getting the desired results from it.

Data and research method

In this study remote sensing and aeromagnetic data have been used, which are described below:

Data used in this study were selected from ETM+ sensor of Landsat 7 satellite which was collected in 2005. This data has been downloaded from the website of the University of Maryland, USA. In this study, bands 1, 4 and 7 of the ETM + sensor have been used, which perform better than other bands in displaying geological features and structures, soil moisture, and vegetation.

The aeromagnetic data used in this study was prepared from the Geological Survey and Mineral Exploration of Iran. These data were collected between 1974 and 1977 (1353-1356) by the Geological Survey and Mineral Exploration of Iran. The distance between the flight lines in collecting this data was 7.5 km and the distance between the control lines was 40 km. The flight height of the plane in this collection was between 500 and 600 meters. This data was from the Geological Survey and Mineral Exploration of Iran was in the form of grid data. To be better detected lineaments and features geologically, the filters were applied to the magnetic grid data. In this study, filters of reduction to pole, first vertical derivative, downward continuation, automatic gain control, high pass, low pass and tilt derivative have been used. The purpose of using these filters in the study is to use their characteristics to improve the magnetic data in order to better detect the lineaments related to geological features.

In this study, the basis method used in this research is based on using the proper processing of data to detect lineaments and finally compare them with other information in the form of a geographic information system. So, based on this, hopefully the identification of suitable zones for underground water exploration is provided at the end.

Location and geology of the area

The studied area is located in the 1:250,000 geological map of Kermanshah (Figure 1), where the lower corner position is on the left side and 46 degrees and 30 minutes east and 34 degrees north and the upper corner position on the right side is 48 degrees east and 36 degrees north. This area is located in the east of this province.

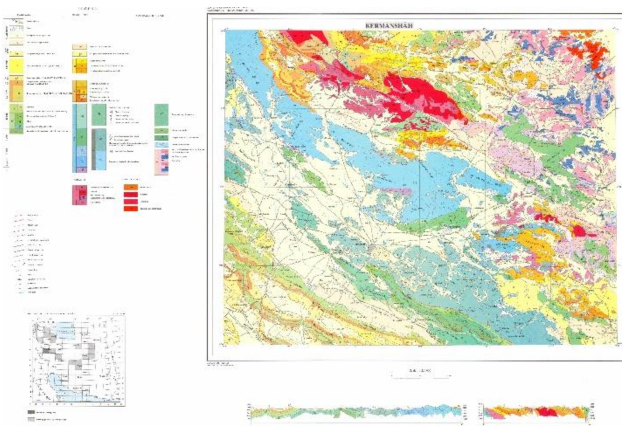


Figure 1: Geological map 1:250000 of Kermanshah (related to the studied area)

From the point of view of geomorphology, it is included two features, northeast and southwest, which do not have the same morphology. The northern highlands have a harsh appearance and morphology. It is mostly the result of performance thrust faults which are abundantly present in the area. While, in other areas, the shape and form of the region is due to the tectonic efforts of folding, so its morphology is in the form of anticlines and synclines parallel to the northwest trend. Geology data shows that most of it is the sedimentary - structural basin of Zagros. Therefore, its northeast corner has geological characteristics of Sanandaj-Sirjan zone. Therefore, it divided this area into two separate sub -zones, and their border with young and seismic faults of Morwarid and Sahne are determined. These two areas are:

Sanandaj- Sirjan zone: its northeastern corner is a small part of the Sanandaj- Sirjan metamorphosed area which is one of the young and seismic faults of Zagros (Morwarid-Sahne fault) which separated from other parts. In this area, the rock outcrops include Mesozoic-Cenozoic variants (Songhor limestone volcanic complex), Alvand granite intrusive masses (Late Cretaceous) and Eocene-Oligocene intrusive masses, such as the Kamiyaran intrusive mass.

Zagros zone: most part of it is located in the south of the Morwarid-Sahne fault, which includes two sub zones: high Zagros and folded Zagros.

The part related to the high Zagros is located in its northeastern part. Its rocks include Upper Triassic-Deep Cretaceous sediments, among which sedimentary rows of radiolarite, disturbed carbonates, and ophiolitic rocks (Kermanshah radiolarites, Bisoton limestones, Sahne-Harsin ophiolites) have the most frequent. The structural pattern of this part is the result of the action of thrust faults, which is associated with significant displacement of rock outcrops and thickening of the crust.

All the heights located in the southwestern part of the region can be considered related to the Zagros area. This part of the Zagros, which is also called the Outer Zagros, is a part of the Arabian shield marginal depression, which was continuously settling during the Mesozoic period, but in the Cenozoic period, it turned into a sedimentary basin with orogeny. This extent is noticeable because the Cretaceous rocks of the anticline and the formations of the Tertiary period have created large sediments. (Agha Nabati, 2013).

Data processing

Before detecting the lineaments and desired zones, the data should be prepared with the necessary processing for this task. In the following, the methods for processing remote sensing and aeromagnetic are data mentioned.

Remote sensing data processing

Two methods are used to detect the lineaments related to geological features and structures from remote sensing data. In the first method, the used bands (gray color image) are subjected to image contrast improvement and in the second method, a false color composition is formed from different bands. In this study, the second method is used.

The false color composition 7-4-1(R-G-B) was chosen because of the low correlation between the bands and the good matching of the image of this combination with the geological map. After creating this false color composition, for better identification of lines and linear structures, the color composition will improve the linear stretch by 2%. Figure 2 shows the false color combination map prepared from the study area.

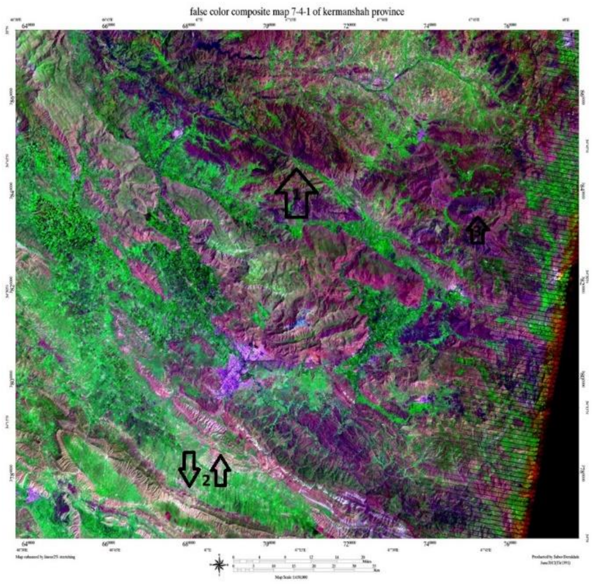


Figure 2: Final processing of remote sensing data - false color composition 7-4-1 (RGB) of the study area.

Aeromagnetic data processing

For the processing of aeromagnetic data, as mentioned before, it is performed by applying appropriate filters. Geosoft software and its algorithm have been used in this study.

In order to process the Aeromagnetic data, first, the reduction to pole filter was applied to the grid data. Applying this filter causes the movement of anomalies to their producing sources, the independence of the anomalies in the direction of the magnetic field and finally the easy interpretation of the magnetic data. Because the reduction to the pole filter causes the anomalies to move to their original sources, the other filters are separately and independently of each other can be used to the data of the new grid that is the result of applying the reduction to the pole filter is used.

According to Geosoft's algorithms for applying reduction to the pole filter, data is needed to apply it. These data include the angle of deviation and magnetic inclination of the area at the time of data collection, the angle of the flight lines with the north in the clockwise direction. Using the information from the international geomagnetic reference field (IGRF), the magnetic deviation angle is 3.16 degrees and the magnetic inclination angle is 51.25 degrees for the studied area. The angle of the flight lines with the north is 45 degrees clockwise.

Applying filters such as the first vertical derivative, the first vertical derivative + Automatic gain control, high pass, downward continuation, and tilt derivative make the edges of the anomalies more prominent and as a result better detection of linear features and lineaments in the data. Meanwhile, tilt derivative filter has the best resolution for identifying(high-frequency) linear anomalies, which plays a greater role in detecting lineaments. In order to better detect the lineaments, a map of the color shaded relief of the area caused by the application of the mentioned different filters has been prepared separately for the studied area. In the map of the color shaded relief of the area, the magnetic data is considered as a surface similar to the features of the earth, and it is irradiated from a source of artificial light, such as the sun, from a specific direction and height. The color relief map of the earth has a good correlation with the elevation and lowness and the features of the earth's surface and improves the anomalies with short wavelength and low intensity and mostly linear (Bordie, 2002) and (Ranganai and Ebinger, 2008). In Figure 3, the map of the color shaded relief of the earth due to the application of the reduction to the pole is displayed.

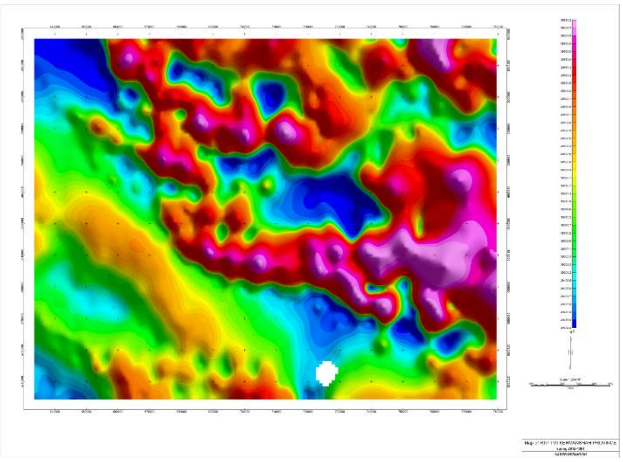


Figure 3: Map of color shaded relief due to the application of reduction to pole in the study area.

Identification of lineaments

After processing the desired data, it is time to detect the lineaments and linear features in the remote sensing images and the processed data of aeromagnetic. This identification is based on the characteristics associated with each of these processed data.

To detect the lineaments in the aeromagnetic data that are related to the geological features, the following modes are used:

1-Severe drop in magnetic response: Lineaments identified in this case are usually observed around features such as faults, joints and fractures and some lithological unit contacts, which help to identify this feature. It is effective. Around these features, after a drop, the magnetic response increases.

2-Strong increase in magnetic response: the detected lineaments in this case are related to geological features such as the contact of lithological units, the edge of dykes and some faults and fractures, and in identifying these features it has a significant role.

3- The presence of shadow in the image: this state is highlighted in the color shaded relief map which is prepared from magnetically processed data and the lines identified in it caused by geological features such as lithology units, faults and fractures.

Figure 4 shows the lineaments identified in the map of the earth's color shaded relief caused by the application of the reduction to the pole filter on the aeromagnetic data. These lines are purple and the blue lines are the border of the province.

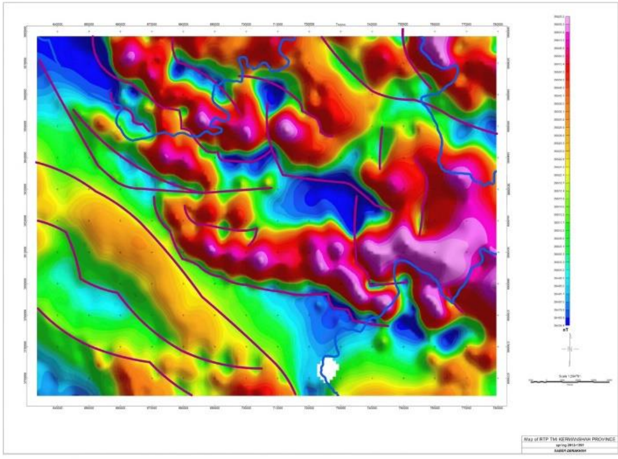


Figure 4: Lineaments identified in the map of color shaded relief resulting from the reduction to the pole filter, which are marked in purple color. The border of the province is marked by blue color.

The following features are also used to detect lineaments in remote sensing images

1-Vegetation: Vegetation usually exists along faults, joints and fractures, and by identifying vegetation; its features and trends can be identified. In Figure 2, the Sahne fault is identified using the vegetation trend. (Black Arrows, No.1)

2-Color change: In Figure 2, different lithological units are displayed in different colors, and this color change is a factor for detecting lineaments related to geological features, such as lithological units, the edge of dykes, There are other faults and fractures. In Figure 2, the symmetry of the sedimentary units and faults in the southwest of Kermanshah city has been identified using color change. (Black Arrows, No.2)

3- The presence of shadow in the image: The presence of shadow in the image, especially in gray remote sensing images, plays a significant role in identifying geological features and lineaments. Also, in color images, the presence of shadow in the image causes the identification of lines related to geological features such as faults, joints, fractures, and contact of lithology units with an extension of local and small scale. It is necessary to explain that it is appropriate to use more features in satellite images with higher spatial resolution. In Figure 2, the geometry of limestone units in the northeast of Kermanshah city is identified using the presence of shadows in the image. (Black Arrows, No.3)

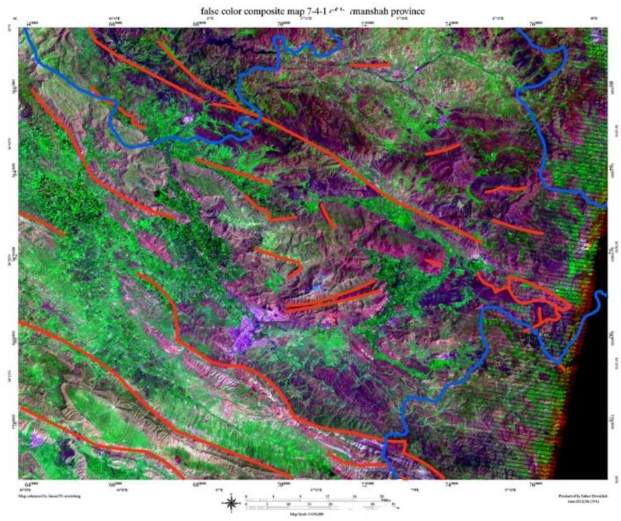


Figure 5: Lineaments identified in the 7-4-1 false color composition map of the region (Landsat 7 satellite) marked with red-blue color indicate the border of the province

In Figure 5, the lineaments identified in the false color composition map of the area are displayed, which are in red. After detecting the lineaments in the processed magnetic and remote sensing data, a map of the lineaments identified in the area was presented, which is shown in Figure 6. It is possible that some of the detected magnetic lineaments can be seen simultaneously in the other color shaded relief maps of different filters, and because of the overlap in the display of the lineaments in one zone, some of these lineaments are shown in Figure 7 has been discarded.

Comparison of detected lineaments with other information

The detected lineaments have been compared simultaneously using geographic information system methods with other information such as the lineaments of other data, geological map and topography map of the area. This simultaneous comparison is effective in identifying and interpreting the appropriate zones better and faster.

This comparison was made by forming a geographic information system for the study area, which consists of the following layers:

1- Geological map of the area (Figure 1)

2-Topographic map of the area

3-The map of color shaded relief due to the application of reduction to the pole filter (Figure 3)

4-The map of color shaded relief due to the application of reduction to the pole filter + the first vertical derivative

5-The map of color shaded relief due to the application of reduction to the pole filter + automatic gain control + first vertical derivative.

6-The map of color shaded relief due to the application of reduction to the pole filter + downward continuation of 1000 meters

7-The map of color shaded relief due to the application of reduction to the pole filter + downward continuation of 1500 meters

8-The map of color shaded relief due to the application of reduction to the pole filter + high pass filter of 500000 meters

9-The map of color shaded relief due to the application of reduction to the pole filters + tilt derivative

10- 7-4-1 false color composition map (RGB) of the Landsat satellite region, which has improved the linear stretch by 2%. (Figure 2)

11- The border of Kermanshah province

12- Remote sensing lineaments (Landsat) (in red)

13- Identified lineaments from reduction to the pole filter to the pole (in purple color)

14- Identified lineaments from reduction to the pole filter + first vertical derivative (in brown color)

15- Identified lineaments from reduction to the pole filter + tilt derivative (in yellow)

16- Identified lineaments from reduction to the pole filter + automatic gain control + first vertical derivative (in black).

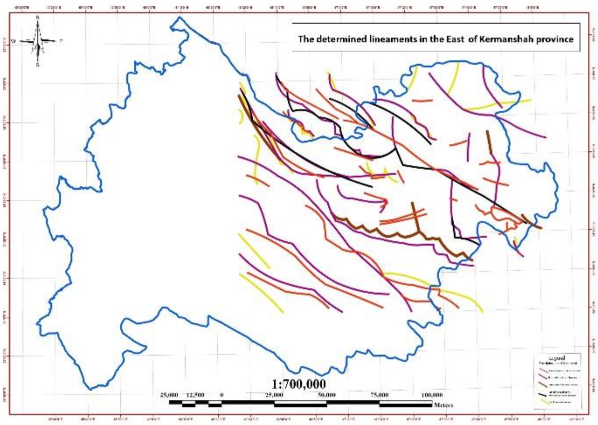


Figure 6: The map of all the identified lineaments in the study area (east of Kermanshah province) - the blue color is the border of Kermanshah province and the other colors are mentioned in the legend.

Results and its Interpretation

After comparing the detected lineaments with other information, results are obtained. Some of the results are shown in Table 1, which includes suitable zones for regional groundwater exploration. Table 1 contains information such as geological map The identified zone, its locations, the type of lineament identified in it and the interpretation made in relation to the identified zone type.

In this study, prioritization has been done in determining the best zone for underground water exploration according to the lineaments identified in aeromagnetic data and remote sensing images, which is as follows:

1-Simultaneous identification of remote sensing lineaments (Landsat) and aeromagnetic in a zone (presence of feeding and accumulation factors of underground water)

2-Identification of aeromagnetic lineaments in a zone (presence of underground water accumulation factor)

3-detecting the lineament of remote sensing (Landsat) in a zone (presence of groundwater feeding factor)

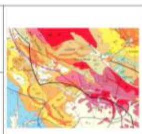
These prioritizations have been stated because underground water sources are considered as a sustainable source for us. In addition to the existence of suitable water storage (accumulation), has also been added to its storage by surface water (feeding). The nature of these data that was mentioned in the introduction, and the simultaneous identification of aerial magnetic and remote sensing lineaments in a zone can introduce that zone as the best priority for underground water exploration. With the completion of information in the phase of exploration and exploration of underground water in a zone, next priorities can also be suitable for underground water exploration, and even its priority can be improved. According to the prioritization of the identified zones for underground water exploration mentioned above, the zones identified in Table 1 refer to all the priorities.

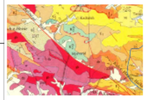
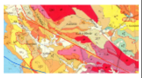
Table 1: The final interpretation and identification of suitable zones for underground water exploration in the study area.

Interpretation and further explanations	Lineaments				The location of the beginning and end	Geological map of the identified zone	row
Identifying the fault zone (Sahne fault), the zone in the metamorphism unit, the strong drop in magnetism, the good identification of its trend	Tilt der	1st vertical der	RTP	ETM+	X:47°28'30 "E		1
	Detected	Detected	Detected	Detected	Y: 34° 36'29 "N		
	1st vertical der + AGC		High pass	Downward continuation	X:47° 41' 31"E		
	Detected		Detected	Detected	Y: 34° 30'53 "N		
Identification of the fault zone, the zone between the alluvial and sedimentary unit and low magnetism, the well-defined trend of the fault zone in the data	Tilt der	1st vertical der	RTP	ETM+	X:46° 32'11 "E		2
	Detected	Detected	Detected	Detected	Y: 34° 51' 48"N		
	1st vertical der + AGC		High pass	Downward continuation	X:46° 50' 47"E		
	Detected		Detected	Detected	Y:34° 35' 53"N		

(X: Longitude, Y: Latitude, ETM+: Landsat 7 sensor, RTP: reduction to pole, 1ST Vertical der: Vertical first derivative, Tilt der: Tilt derivative, 1st Vertical der+AGC: first vertical derivative + automatic gain control).

Continuation of Table 1

Identification of lithology units, sedimentary units and lower magnetism, relative identification of the trend and boundary of the lithology	Tilt der	1st vertical der	RTP	ETM+	X:46°30' 6"E		3
	Detected	Detected	Detected	Detected	Y:34°11 '11 "N		
	1st vertical der + AGC		High pass	Downward continuation	X:46°56 '26 "E		
	Detected		Detected	Detected	Y:34°1' 18" N		
Identification of lithology units, correlation between sedimentary and alluvial units, low magnetism, good identification of boundary and trend of correlation	Tilt der	1st vertical der	RTP	ETM+	X:46°30 '12 "E		4
	Detected	Detected	Detected	Detected	Y:34°28'48.5"N		
	1st vertical der + AGC		High pass	Downward continuation	X:47°11 '59 "E		
	Detected		Detected	Detected	Y:34° 2' 30" N		
Identification of fault zone, zone between igneous and calcareous units, magnetic drop, zone extension outside the province	Tilt der	1st vertical der	RTP	ETM+	X:46°40 '17 "E		5
	Detected	Detected	Detected	Not detected	Y:34°59 '33 "N		
	1st vertical der + AGC		High pass	Downward continuation	X:46°51 '25 "E		
	Detected		Detected	Detected	Y:34°51 '16 "N		
Identification of fault zone, zone between igneous and calcareous units, magnetic drop, identification of zone trend	Tilt der	1st vertical der	RTP	ETM+	X:47°6 '00 "E		6
	Detected	Detected	Detected	Not detected	Y:34°40 '8.7"N		
	1st vertical der + AGC		High pass	Downward continuation	X:47°16 '48 "E		
	Detected		Detected	Detected	Y:34°40 '44 "N		

Identification of the fault zone, extension of the Sahne fault outside the province, no change of magnetism in it, good identification of its trend and boundary in satellite .images	Tilt der	1st vertical der	RTP	ETM+	X:46°51 '50 "E		7
	Not detected	Not detected	Not detected	Detected	Y:34°57 '51 "N		
	1st vertical der + AGC		High pass	Downward continuation	X:47°02 '01 "E		
	Not detected		Not detected	Not detected	Y:34°50 '54 "N		
Identifying the fault zone, the zone between calcareous and igneous units, not changing the magnetism in it, well identifying its trend and boundary in satellite images.	Tilt der	1st vertical der	RTP	ETM+	X:46°45 '10 "E		8
	Not detected	Not detected	Not detected	Detected	Y:34°56 '12 "N		
	1st vertical der + AGC		High pass	Downward continuation	X:46°58 '54 "E		
	Not detected		Not detected	Not detected	Y:34°50 '1.5 "N		

Ground magnetic survey

After identifying the suitable zones for underground water exploration in the region in Table 1, to compare the obtained information and complete the investigations in this study, magnetic field survey was carried out in one of the identified zones. Then the data obtained from this field survey was compared with other data.

Ground magnetic survey performed in the identified fault zone, which is located in the first row of Table 1, which is a part of the Sahne fault. The reason for choosing this zone for collecting these data is the simultaneous observation of lineaments on the remote sensing and aeromagnetic maps and the presence of metamorphic units around the fault that have a high magnetic response. This survey was carried out in two profiles in an area on the Sahne fault in the northwest of this city, at the border of the rural road between the villages of Kargsan and Azizabad (Figure 9). In this study, a new generation Proton Precession Magnetometer (Overhauser Magnetometer) manufactured by GEM-System of Canada was used. The length of the first profile is about 750 meters and the second one is about 680 meters. These two profiles are almost parallel to each other and the distance between these two profiles is about 90 meters, which is less than this value at the end of the profiles. The distance between the sampling points in these profiles is approximately 10 meters.

After the end of the magnetic survey and the removal of spurious data, in order to place the anomaly on the source of their production, and to be able to identify the exact location of the geological features, the reduction to the pole filter was used. In applying this filter, the geomagnetic inclination angle is 52.6 degrees, the geomagnetic deviation angle is 4.3 degrees, and the profile angle is 40 degrees clockwise in relation to the north. After applying the reduction to the pole filter to the data, the first and second vertical derivative filters, upward and downward continuation, high-pass and low-pass filters were applied to this processed data separately. These filters have been used for better and more accurate identification of the fault zone. After that, the graph of the applied filters according to the latitude and longitude of each profile was drawn in the software so that the location of the fault zone can be recognized. In Figures 7 and 8, for each individual profile, there is a graph of the filters according to longitude or latitude.

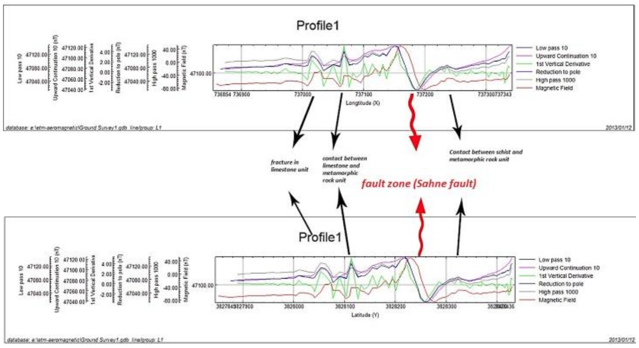


Figure 7: The diagram of the filters applied to the data collected in the first profile - the upper diagram in terms of x or longitude and the lower diagram in terms of y or latitude

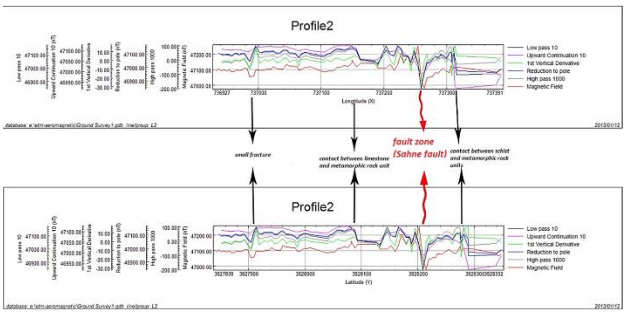


Figure 8: The diagram of the filters applied to the data collected in the second profile - the upper diagram in terms of x or longitude and the lower diagram in terms of y or latitude

The interpretation made in Figures 7 and 8 is based on the shape of the diagrams and the geological map. The detected fault zone is also shown by a red arrow. After that, by determining the position of the two ends of the fault zone identified in the profiles and displaying it in the geographical information system of the study area, it was realized that the trend identified for this fault zone is parallel to the previously identified lines with a short distance. May it be a confirmation of the previous identifications? This matter is shown in Figure 9. The locations of the detected fault zone (Sahne fault) in two profiles based on the interpretation are as follows:

The first profile (point E in Figure 9)

X: 47 ° 35 ' 7.5 "E

Y: 34 ° 34 ' 7.4 "N

The second profile (point F in Figure 9)

X: 47 ° 35 ' 10.2 "E

Y: 34 ° 34 ' 5.7 "N

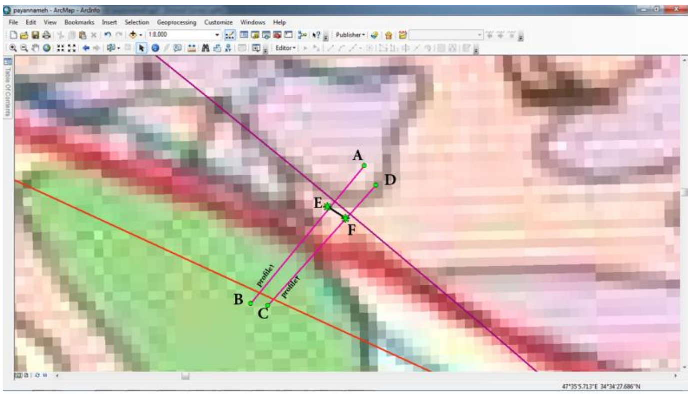


Figure 9: The trend of the fault zone (Sahne fault) identified from the ground magnetic survey and is parallel with the identified lineaments - display under ArcMap software - A, B, C and D: the beginning and end points of two profiles, E and F are the beginning and end points of the identified fault zone and the purple and red colored lines show the lineaments identified in the remote sensing and magnetic data map due to the reduction to the pole, respectively.

General conclusion and suggestions

The results of this study are shown in detail in Table 1, but below are some of the general results obtained from this study:

1-Identification of suitable zones for underground water exploration

2-Among the most important zones that were identified according to the objectives of this study and mentioned in Table 1, can be represented as follows:

2-1 A part of the Sahne fault (in the first row of Table 1). This part is located between metamorphic and calcareous units. In this section, a magnetic ground survey has been carried out.

2-2 The fault zone identified in the southeast of the area, which is located in limestone units. This zone has a regional extension. In the third and fourth rows of Table 1, these zones are listed.

2-3 Fault zones identified in the northwest of the region, which are located between igneous and limestone units. These zones are listed in rows 5 and 6 of Table 1. The identification of these zones has been done well by processed magnetic data.

3-The general trend and extension of geological formations and units in the region is northwest-southeast. This process was well confirmed and demonstrated by magnetic data.

4-The trend and boundary of geological features can be identified in sedimentary units, especially limestone, despite their low magnetic response.

5- Presenting a broader and more complete view of the structural geology of the region (east of Kermanshah province) which can be used for future research.

In the end, there are suggestions and plans to continue and improve this study, which are as follows:

1-Use of aeromagnetic and remote sensing data with higher resolution

2- Dividing the area into several smaller areas and conducting more complete investigations in those areas

3- Carrying out additional exploration such as resistivity and, electromagnetics methods. and exploratory drilling in the proposed zones.

4-Using information available in the region such as wells and aqueducts and their water level, excavations and geophysical operations carried out in the region, etc. and comparing them with the available information.

5-On-the-ground visit and full geological survey of second priority zones whose have been interpreted as the hidden features and if possible, more detailed surveys should be used

6-Carrying out these studies in the west of Kermanshah province.

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