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ARTICLE

INTRODUCING THE PROMISING MINERAL AREAS OF THE NORTHWEST OF QAZVIN PROVINCE BASED ON GEOCHEMICAL STUDIES

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ABSTRACT

The study area is located in the northeast of Qazvin Sheet 1: 100,000 and the south of Javaherdeh Sheet 1: 100.00 in the Hir area. The aim of this study was to conduct geochemical studies on Hir Region using heavy mineral and stream sediments. In regional and even semi-detailed geochemical explorations, regarding the relatively vast area under exploration, secondary geochemical halos were investigated. The present study aimed at finding anomalies and possible mineralization in Baijan and the surrounding areas. For this purpose, all data of the region were investigated. Then, using these maps and satellite imagery of the digital elevation model (DEM), the stream network map, heavy minerals, and stream sediment sampling points were prepared. After sampling and sending the samples to the laboratory, analysis was done on raw data. Then, the final map of geochemical exploration and anomalous areas were plotted.

KEY WORDS
Mineral potential, heavy mineral, stream sediments, Qazvin Province, geochemical exploration

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INTRODUCTION

The Hir sheet of 1: 25.000 in the northwest of Qazvin province is located between geographical lengths of 50 degrees and 30 minutes as well as latitudes of 36 degrees and 45 minutes and 36 degrees and 30 minutes in the area of Hir village [Fig. 1]. Hir is a village in the western Alamut, Rudbar of Qazvin province in Iran with a coal mine[1]. Due to the geographical position of Qazvin province on the southern slopes of Alborz Mountains and abundant mineral traces of this province, geological and explorative activities have a long history in this province [2].

LITERTURE

Conducted regional explorations are limited to the northwest corner of Qazvin province. Unlike regional explorations, thematic explorations are significant, particularly in the field of alunite, kaolin, copper, lead and zinc. Regional explorations in the province of Qazvin are of geochemical type performed by geographical maps with a scale of 1: 100,000. The northern section units (Alborz) and the southern part of the province (Central Iran) are not appreciably different and rock sequences with late Precambrian platform deposits (Soltanieh Formation) are seen everywhere which continue more or less with several large and small sedimentary units to the Middle Triassic[3]. Upper Triassic-Middle Jurassic rows of a unit are limited to two orogeny events of early Cimmerian (Upper Triassic) and Middle Cimmerian (Middle Jurassic) which are mainly composed of shale and sandstone (Shemshak Formation) and are the coal-bearing sediments of Iran which have been accumulated on early Cimmerian forelands. All over Qazvin Province, Upper Cretaceous-Middle Jurassic rocks are [composed of] carbonate marl rows with small outcrops in the north and south of the province (Avaj). Cenozoic rocks begin with Eocene clastic igneous collections (Karaj formations) where granitic intrusions related to the Pyrenean orogeny are sometimes injected into them [Fig. 2]. Most parts of Cenozoic rocks of Qazvin province are the rows simultaneous with Cenozoic orogeny which have mainly been accumulated in the basins between mountains and have limited outcrops at the foot of heights [4][5].

Geological study of the area

The study area is a part of the complex tectonic system on the southern part of Central Alborz. Geological structures include fractures and folds that mainly have a northwest - southeast trend and follow the main trend of Alborz folding. These fractures are mainly of compressional faults. In addition to these fractures, other fractures were also observed in the area which follow the northeast - southwest trend.

Fig. 1: Road maps of the area under study

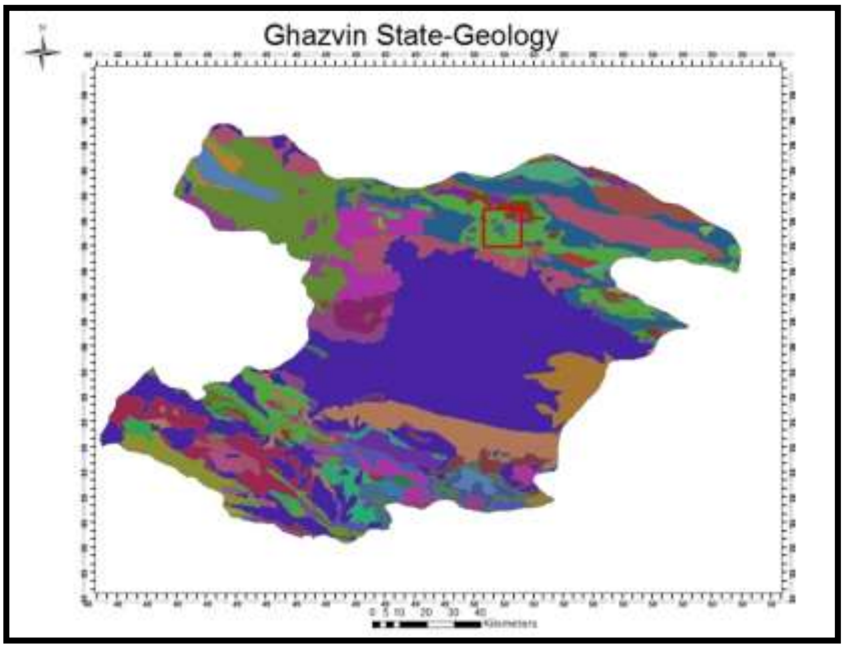

Fig. 2: Geological map of Qazvin Province

MATERIALS AND METHODS

Digital elevation model (DEM): In order to provide a sampling network of stream sediments, stream network and catchment area were provided. There are different ways to map the stream network of a region including the provision of river maps, review of topographic maps and aerial photos. One of the best and most important tools to study and design the sampling network of stream sediments is to use DEM satellite imagery in order to map the stream network and catchment of an area [6]. After defining the direction of flows in pixels of digital elevation images using Flow Accumulation tool, flow accumulation (i.e. the direction toward which each pixel flows) is identified [Fig. 3]. Having acquired the flow direction in the study area with use of various hydrology tools in GIS software, the drainage basin and stream network maps of the intended area are obtained[7].

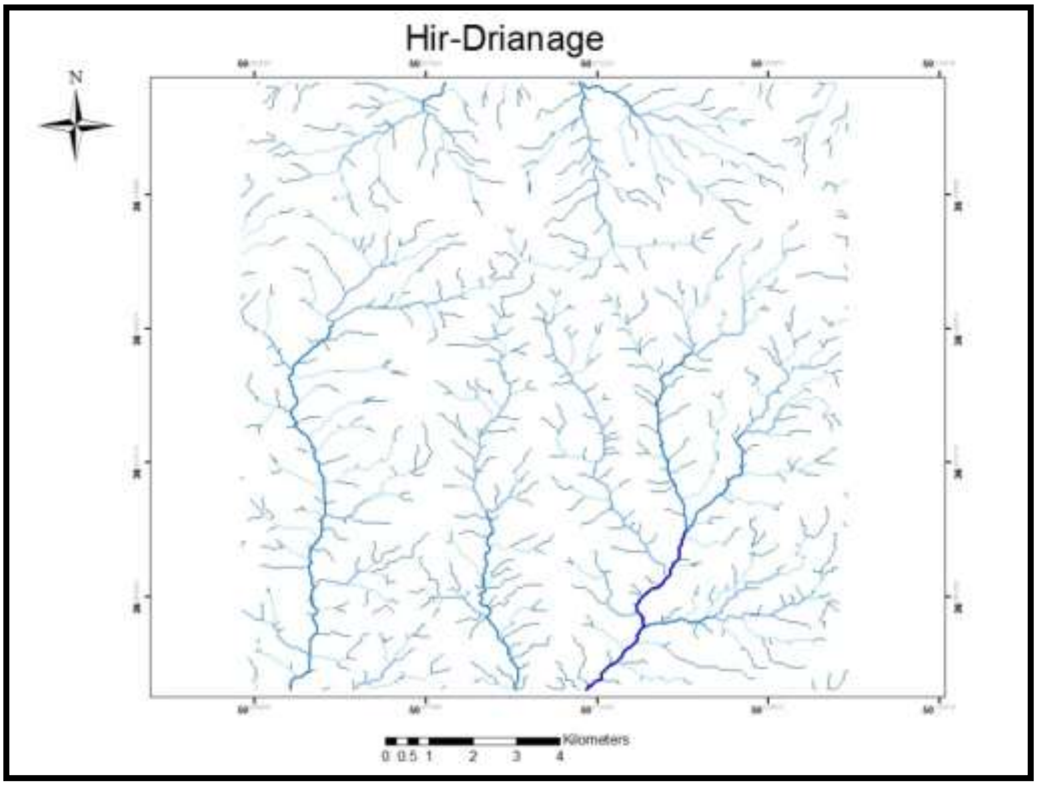

Fig. 3: Drainage using DEM

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Heavy mineral sampling

Heavy mineral sampling density is mainly a function of the area which should be assessed using this method. The greater is the basin area under study, the more is the number of samples needed for precise evaluation. Respective lithology could also be effective in heavy mineral sampling density. In this division, it is assumed that one or two samples are enough for each basin with an area of one or a few kilometers. Heavy mineral sample weight changes depending on the intended target. Usually, some amounts of heavy mineral samples of the river sediment are taken to obtain about 4 liters of -20 to +80 mesh after sieving and they are sieved in place. Samples are balled out in place and the sample size is measured before and after ball out. Then, pan washing is carried out on the samples. The remaining part was divided with standard intensities into three parts of strong and weak magnetic components as well as the non-magnetic part and the volume of each was measured. The non-magnetic part is then sent to be exposed to bromoform for separating the heavy and non-heavy parts [8]. Following the above steps, each component is studied and its percentage in the component is determined. Finally, using this percentage and the initial sample size in each stage, the amount of each of the heavy minerals is determined in ppm. It is obvious that the resulting numbers do not represent ppm in their stream environment because the samples are already sieved and their coarse components are removed. Of course, we can say that the values in their environment should certainly be less than the obtained values [Fig. 4]. It should be noted that the areas selected for heavy mineral sampling are introduced through the geochemical sample number in the same area. Each geochemical sample contained about 300 grams of stream sediments with a size of less than 80 mesh which were poured into a clean sack after sieving and numbered. After geochemical sampling, heavy mineral samples were also taken independently of the alluvia developed along the lithofacies. In heavy mineral sampling, it was attempted to design the sampling site on the separation border of heights with the low areas so as to achieve the highest concentration of heavy minerals due to sudden lowering of water velocity [9].

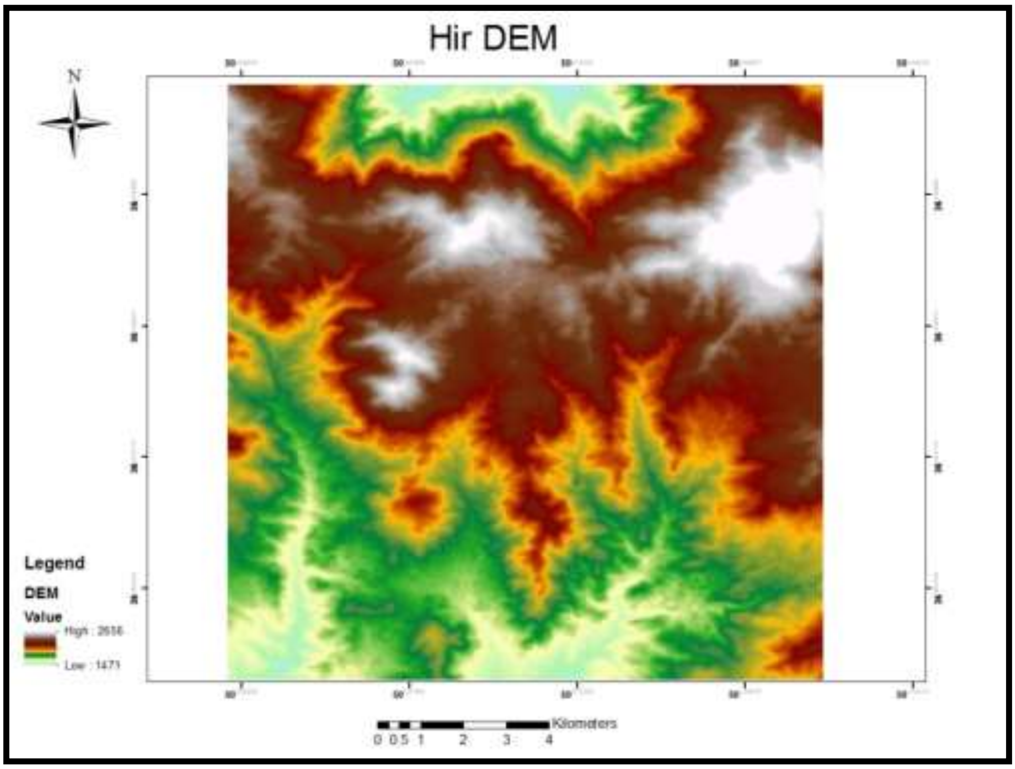

Fig. 4: Satellite imagery, digital elevation model of the study area DEM

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Analysis of geochemical samples

When sampling stream sediments mainly containing detrital components, sieving sediments and selecting components of suitable size is essential. This size is usually considered as 100 mesh based on experience in geochemical work carried out or being done in the country [10]. After transferring the samples to the laboratory, sample preparation steps such as drying, removing organic materials, powdering, and other tasks were done. After preserving half of the samples as control, the rest were sent for analysis of the elements to the Alborz Zarkavan Co. laboratory. After preparation, all samples were analyzed for [presence of] 44 elements. Measurement of all elements except gold was done using ICP-MS machine and FIRE ASSAY method was used for analysis of the gold element [11].

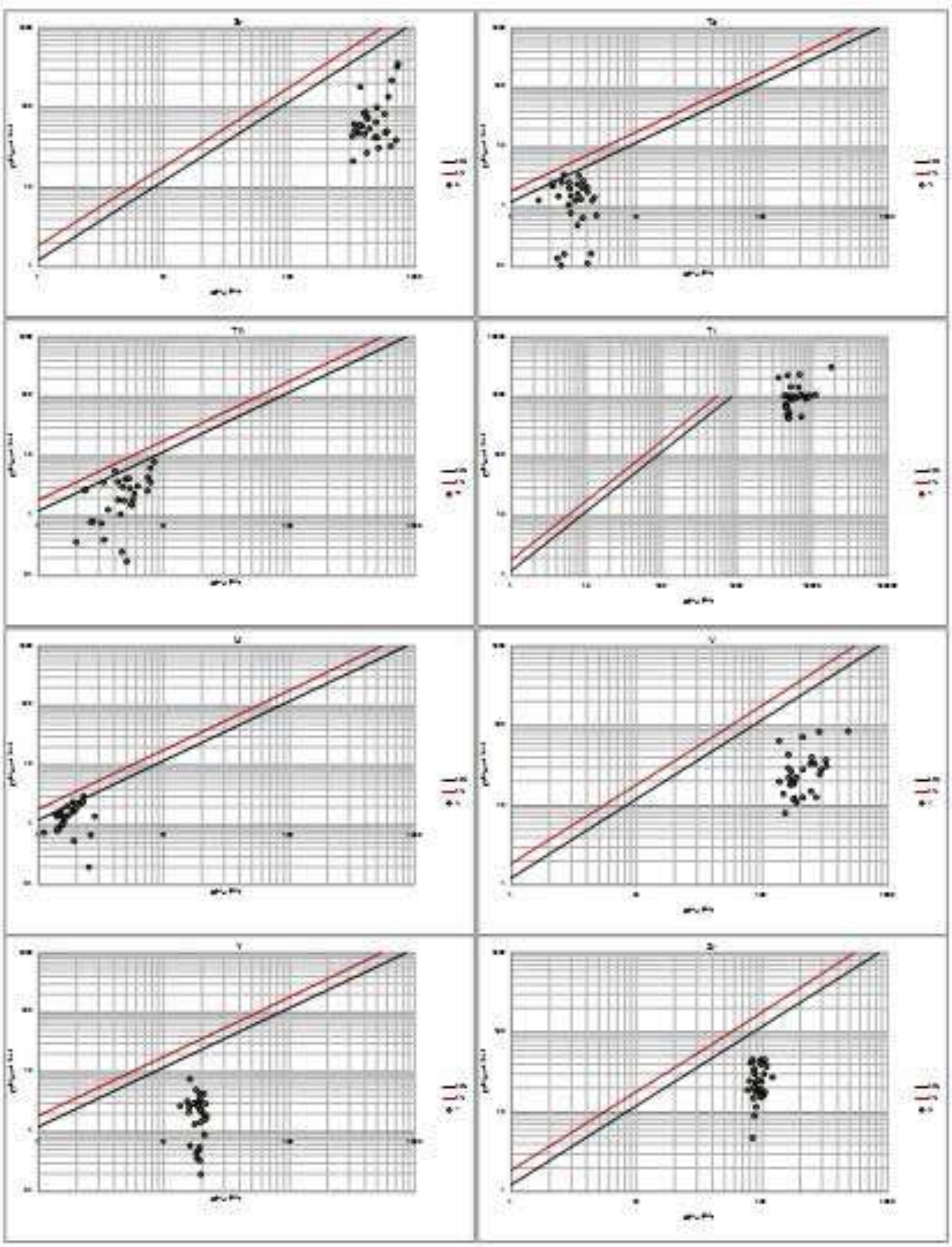

Fig. 5: Some elements of the graphical approach logarithmic graph Thompson – Havars

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Estimates of the censored data

Before analysis of geochemical data, censored data and errors have to be removed [Fig. 5]. Censored data are the ones among which some data can be found with quantities smaller than the device sensitivity limit due to the high sensitivity limit of measurement devices. Presence of such numbers among a series of data can disrupt statistical data [12].

Most important causes of such disorders include:

1. Statistical methods need a complete set of non-censored data;
2. In cases where relative measurements are carried out, such as separation of the anomaly from the field, the presence of censored data results in imprecise evaluations;

If censored data are estimated and replaced, the field value and anomaly intensity will be calculated more accurately.

There are different methods for estimating censored values which are used for data censored from top and bottom. In this project, a simple alternative method is used. Meanwhile, there is no data censored from top among the existing data. In this simple method, values less than the sensitivity limit at the lower bound are replacing by 3.4 of it. Generally, if the number of censored data vs. the whole data is negligible (around 15-10 percent), we can usually use this method [13].

Elements Ag, B, Cd, Hg, and Te have been removed from the process flows with 100% of censored data. In the case of Au element with 31% of censored data, process stages will be done with care. Regarding all elements of censored data, 3.4 of their sensitivity limit is used as the alternative value.
In cases where the data are mutually linked together, investigating their relationship with a bivariate statistical method yields appropriate answers. In this study, bivariate statistical methods of correlation coefficient and cluster analysis were used[14].

As stated in the analysis error section, the error values measured for a number of elements, particularly gold, has been more than 10%. Anomalies observed in interpretation of the data tree structure are most likely associated with the errors applied in the analysis of samples. According to the data tree structure, geochemical variables are divided into two groups.

According to the dendrogram, two main categories can be distinguished. The first category begins with Fe and ends with Au; it contains three sub-groups which collectively encompass all ore-forming elements.

The second category begins with As and ends with S; it has two sub-groups which collectively contain pathfinder elements of mineralization in the area.

Elements of Fe, V, Sc, and Cu are in the first subgroup of the first category indicating copper mineralization in the area along with enrichment of the iron group elements. This is observed frequently in the study area. In the second sub-group that is immediately below the first subgroup, there are Cr, Co, Ni, and other elements of the iron group which show the association of iron mineralization in the region with the main mineralization. Main mineralizers of the region, i.e. the elements Pb, Zn, Mn, and Au, are in the third subgroup which are in direct contact with the first and second sub-groups indicating their accompany with each other[15].

All mineralization pathfinder elements such as As, Sb, Tl, Bi, Be, W, Sn, Mo, Ba, and S are in the second category, some of which are related to the intrusive mineralizer mass in the region and are the associated elements of mineralization. With slight variations, such relations are visible in all statistical analyses for understanding the interrelationship between various elements. In this category, low and high temperature elements are respectively placed in the first subgroup (As, Sb, Tl) and the second subgroup (Bi, W, Sn, and Mo) and show a proper separation.

Factor analysis

One of the most complex and important issues in geochemical explorations is the simultaneous study of elements. One of the reliable methods in this field is factor analysis. This method has two huge advantages:

1. Reduction in data dimensions
2. Showing the relationship between various elements

With regard to the large number of elements and samples, the role of factor analysis is revealed more than ever which makes comprehension of data variability much easier[16].
Factor analysis is based on PCA method. This method is a technique for finding a linear combination of the primary variables forming new coordinate axes. These linear combinations are known as principal components and have the following properties:

1. A large part of variability can be justified by a limited number of new variables;
2. New variables, as a product of the linear combination of primary variables, are not correlated [Fig. 6].

It is important to note two points before using PCA method:

- If the primary variables are not correlated (with a small correlation coefficient), there is no reason to use this method because it does not offer satisfactory results;
- Factor analysis is used only when there is a sufficient number of primary variables.

Factor analysis is performed in four steps:

1. Calculation of the correlation coefficients;
2. Extracting factors (i.e. determining the number and calculation method of factors)
3. Rotations and specific conversions of factors for better interpretation of the relationship between data;
4. Calculating the score of each factor for all samples.

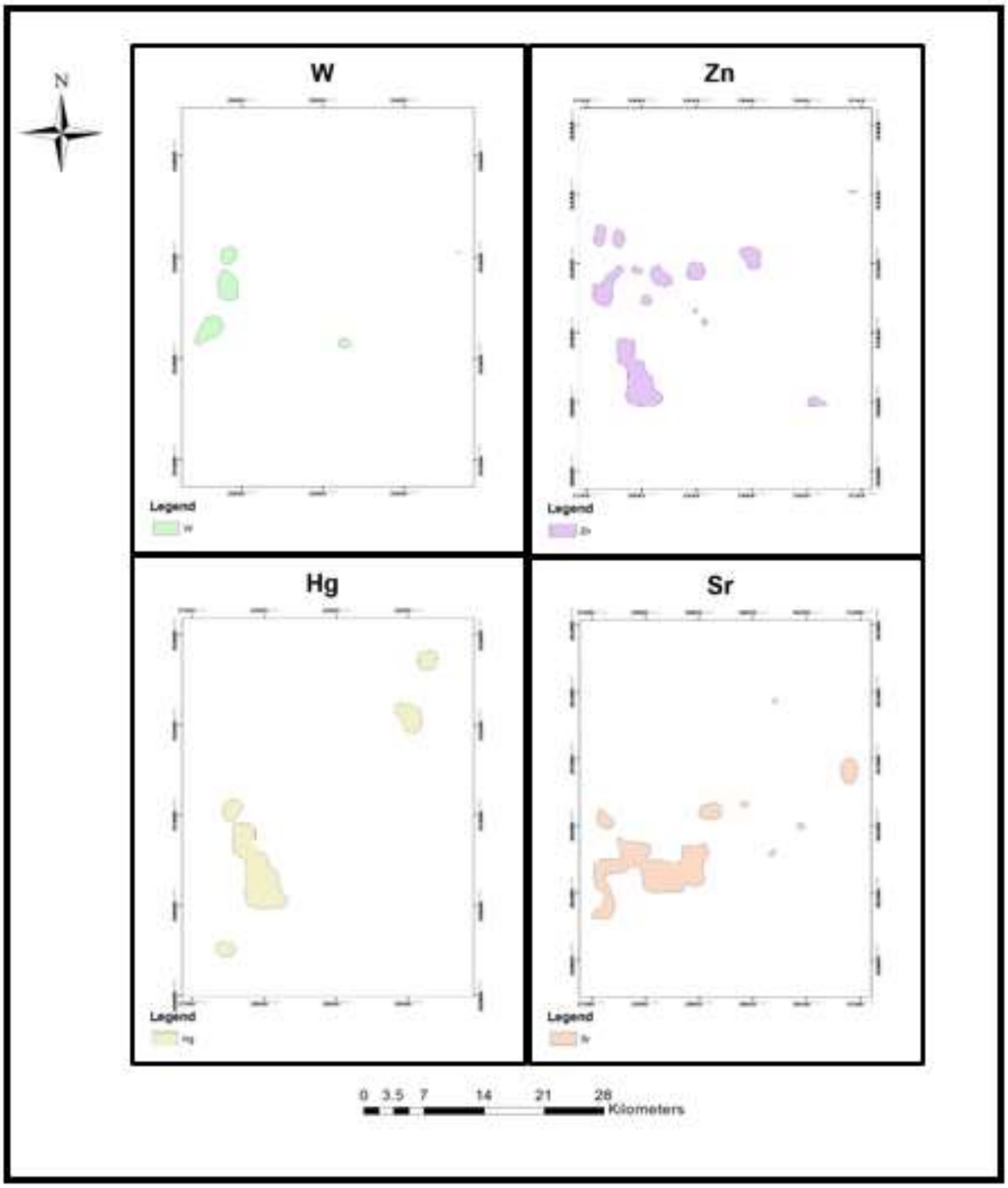

Fig. 6: Anomaly map elements univariate statistical method

Drawings estimated maps

Final geochemistry map of Hir region was obtained using ArcMap software. In this map, areas of possible and suitable anomalies can be introduced as the areas having suitable potential. Here, we explore the promising areas [Fig. 7]. The final map of geochemical studies was obtained with regard to various samplings and statistical studies on geochemical data of the study area. After the investigation, four areas having anomaly and potential were introduced. Then, the areas introduced as having the potential are assessed [17].

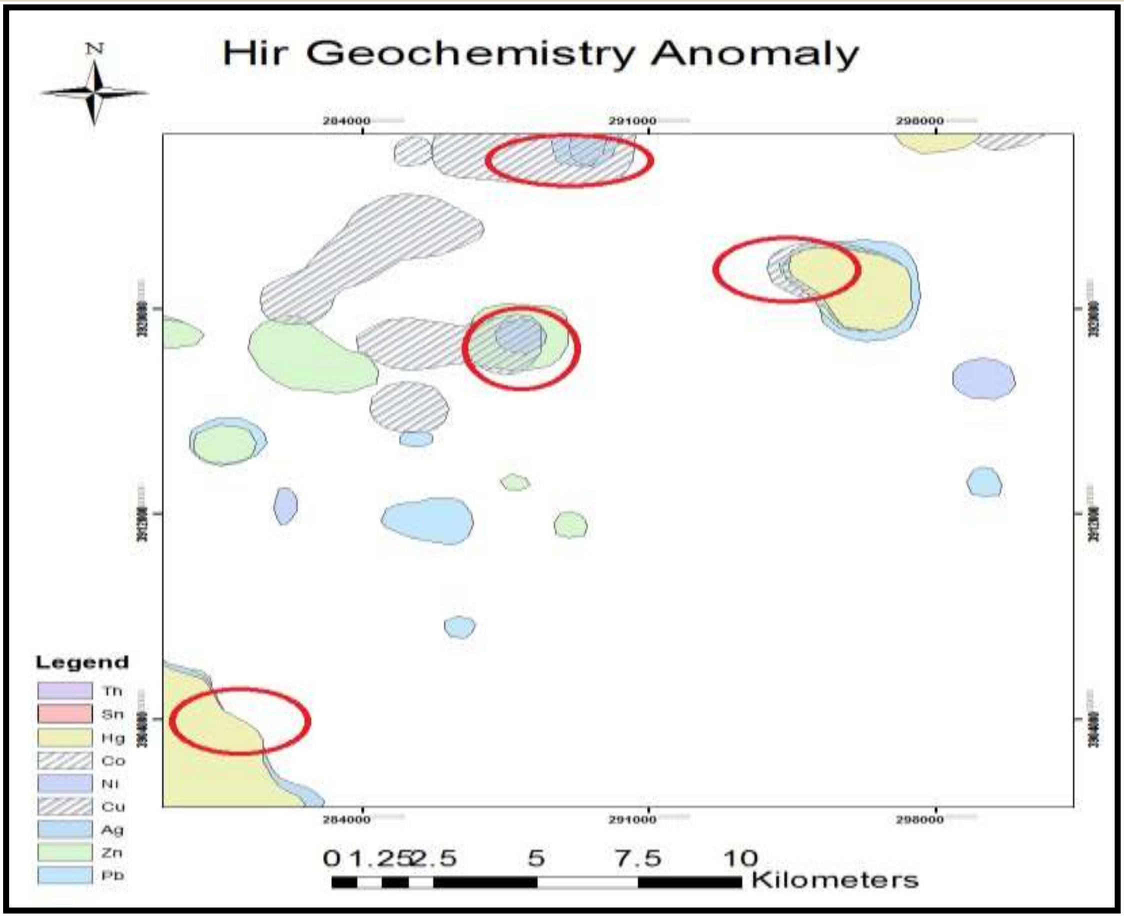

Fig. 7: Zone anomaly

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CONCLUSION

The results of geochemical explorations in the Hir sheet of 1: 25.000 resulted in identification of 4 areas having anomaly among which only one promising area was identified. This area is in the southwest of the study area and most of its anomalies are due to the elements zinc, copper, barium, cadmium, bismuth, iron, and manganese which can be used as pathfinder elements in exploring the resources.

For years, BLEG sampling has been used in mining countries of the world, especially in Australia and it can be very effective and useful in exploration of gold over large areas with low sample concentration. We can have a full confidence in the results of BLEG sampling in case of careful sampling and analysis of samples. Accordingly, planning to continue exploration activities of the following stages can be done without concern and high risks. Compliance of more than 90% of BLEG sample outputs with the results of geochemical samples within Hir region is a firm reason for high accuracy of the results of samplings carried out in this region.

3. The big advantage of BLEG vs. the traditional method is the possibility of identifying small amounts of gold at very long distances from the mineralization center due to which BLEG has become a very important and useful method in regional exploration projects.

4. Stream sediment samples were analyzed for 44 elements. Using ICP-MS device, the measurement method yielded reliable answers for all elements except gold; and FIRE ASSAY method was used for analysis of gold element.

5. After the review, elements of Ag, B, Cd, Hg, and Te were removed from the process flow with 100% of censored data. The processing will be done with care in the case of element Au with 31% of censored data. In the case of all elements with censored data, 3.4 of their sensitivity limit is used as the alternative value.

6. To determine accuracy of the laboratory, a total of 30 duplicate samples were selected and one of the best ways to determine the accuracy of measurements is using the graphical method of Thompson - Howarth in this project.

7. One, two, and multivariate statistical methods were used in this study, and it was observed that overlap

among these methods increases the accuracy of assessments.

8. In examining the correlation coefficient, it was observed that the element Be has a good correlation with Pb, Sb, Sn, Ti, and W and the maximum correlation of Be in this group was 0.649 with the element W. According to the surveys conducted in the study area, major mineralization in the area is of hydrothermal vein-type and these elements are always present in such mineralization as trace elements and byproducts.

CONFLICT OF INTEREST

There is no conflict of interest

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FINANCIAL DISCLOSURE

None

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