International Journal of Science and Engineering Applications
Volume 6 Issue 10, 2017, ISSN-2319-7560 (Online)

Geochemical Studies for Gold in Alut Anomaly District

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Abstract: The target in this research is detecting Gold anomalies in Alut district. This area is located in western Iran. The area mostly consists of metamorphic rocks extended along geological structures. Geochemical anomaly detection for gold begins with sampling in the study area. The samples are obtained from drainages of the area thus the samples are surface soil specimens. These samples are analyzed by ICP-MS. Then statistical and non-statistical methods are applied to define anomalies in the area. Finally anomaly maps are generated.

Keywords: Geochemistry, Gold, Boxplot, C-A fractal, Alut.

1. INTRODUCTION

Gold prospection and exploration date back to centuries ago since the human was familiar with this valuable metal. This process has been systematized in the recent decades. Nowadays mining prospection and exploration includes different fields of study. One of the most important fields is geochemistry. Geochemical behavior of elements in a study area is a critical answer key to exploration uncertainties. Geochemistry as an important field in mining exploration is developed by several experts. Most of the endeavor in this field is trying to locate mineral deposits, which is technically defined as anomaly delineation and separation from background. Delineation of geochemical anomalies from background is one of the major targets in exploration geochemistry. In order to achieve this goal, different descriptive and quantities methods have been employed [1].

Statistical approaches are one of the most popular and useful methods in geochemical exploration. Among different statistical approaches, the Exploratory Data Analysis (EDA) methods are highly helpful in understanding single-element distribution and defining outlier data .The EDA methods are firstly expressed by Tukey [2] and then developed by other experts for geochemical studies[3-8]. The boxplot is one of the EDA methods. The Boxplot function is most informative if the true number of outliers is below 10% [10]. The other statistical approach for anomaly detection is X+tS introduced by Solovov [9].

The other geochemical approach for anomaly separation from back ground is fractal modeling firstly introduced by Mandelbort [10] and then developed by other researchers. One of the most off use fractal modeling types is Concentration-Area (C-A) fractal modeling developed by Cheng et al. [11] and Li et al. [12].

In this study, anomaly delineation and geochemical behavior of gold has been studied in Alut district, Iran. The geochemical surface sampling covers the whole study area. The data obtained from these samples are then processed by different geochemical methods as introduced above. Finally the results of these methods are compared and discussed.

2. GEOLOGY SETTINGS

The geology of Iran is in accordance to continental fragments initially rifted from Gondwana land. The geological studies of Iran has begun since decades ago containing [13-25]. Iran has one of the most complex economic geology settings in the world including several metallic and non-metallic deposits. Among different mineral resources in Iran, gold mineralization is considerable and valuable to be studied and explored.

Alut area in Kurdistan, Iran is noticeable as a promising gold mineralization district. The area is located between 45°30'00" E to 46°00'00" E longitudes and 35°30'00" N to 36°0000" N latitudes. The geology of the area is mostly in consistence to metamorphism. Figure 1 depicts the geological map of the study area.

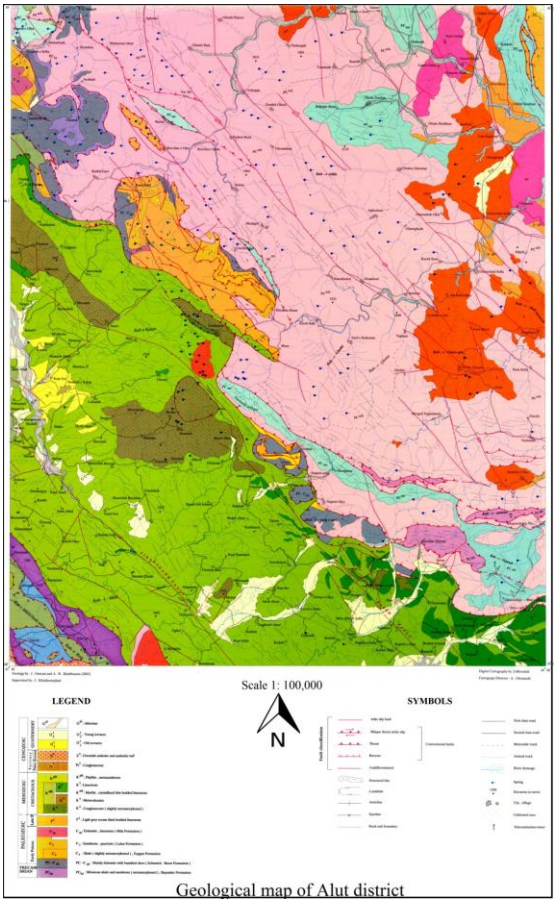

Figure 1. Geological map of the study area (modified after the geological survey of Iran)

The area is generally consisted of metamorphic rocks such as Gneiss, Mica schist and amphibolites. The similarities of rocks with low degree of metamorphism to Kahar formation rocks, inspirits that the metamorphic rocks are derived from Kahar formation and then under tectonic activities, metamorphism degree has increased in some parts. In the north-west of the area, carbonate unites including Shale and Mica-bearing sandstone and in the north-east of the area small outcrop of acidic volcanic rock unites mainly consisted of Rhyolite and meta-Rhyolite observed. The oldest rock unites in the area is Permian carbonates. There is no rock unite in accordance to Triassic and Jurassic age. The youngest rock unite is related to cretaceous age which have suffered low degree of metamorphism. The most noticeable magmatic activities in the area are the granite intrusive series in the north-east of the area with Jurassic age [26].

3. METHODOLOGY

3.1 The Exploratory Data Analysis (EDA) method (The Boxplot)

The Boxplot as one of the most popular and beneficial type of the EDA methods divides the data-set into four quartiles (Fig.2). The box consists of 2nd and 3rd quartiles which approximately contain fifty percents of the samples. The other segments are: lower and upper fences with the distance of 1.5 times of the box length from each side of the box, lower and upper hinges which are the 2nd and 4th quartiles (or the equal median of the first and second half of the dataset around the main median) and lower and upper whiskers extended to the two most extreme data values which are still inside the fences. The threshold value is the upper fence which denotes that samples with higher values than the upper fence can be defined as anomalies in dataset [1].

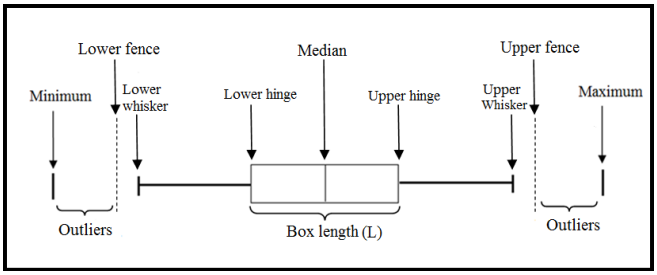

Figure 2. Schematic definition of the boxplot [1].

3.2 The statistical method X+tS method

This statistical method is based on the different levels of confidence which is represented by “t” in the general form of this method “X+tS”. X is the average of the variable and S is the standard deviation. Different confidence levels will cause different anomaly thresholds.

3.3 Concentration-Area (C-A) fractal modeling

In spite of statistical methods, fractal modeling methods are structural approaches meaning that the location of the samples has direct effect on the results. The C-A fractal modeling was firstly expressed by Cheng et al [11] as following:

Let A(p) denote the area with concentration values greater than the contour value p. This implies that A(p) is a decreasing function of p. If v represents the threshold, the following empirical model generally provides a good fit to the data for different elements in the study area:

$$A(p \leq v) \propto p^{-\alpha_1}; \quad A(p > v) \propto p^{-\alpha_2}$$

Where $\propto$ denotes proportionality.

4. DISCUSSION

In this research 836 soil samples were obtained from the area (Fig.3) and then analyzed by ICP-MS method. The data process began with data normalization. Then normalized data are used for the statistical and non-statistical studies for gold.

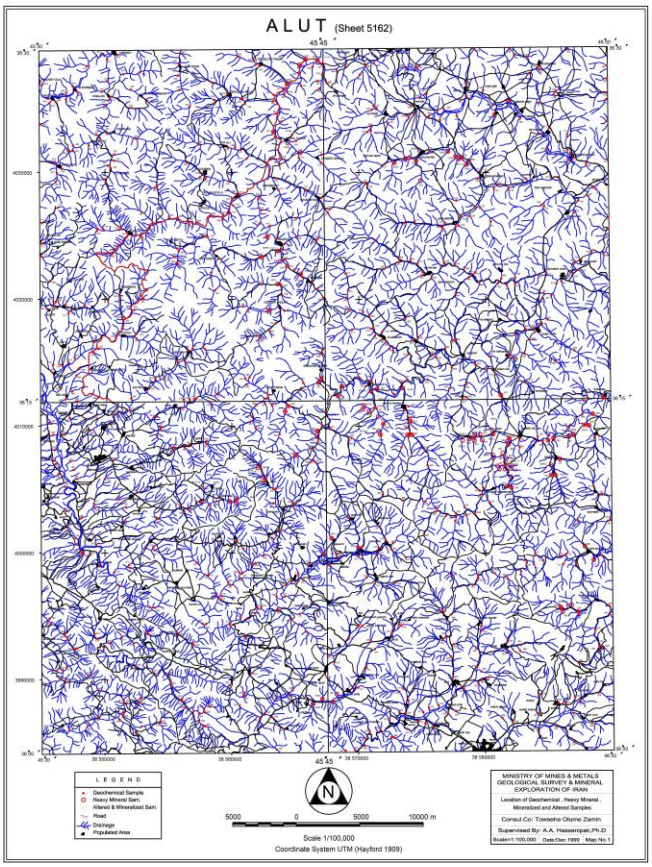

Figure 3. Sampling map.

4.1 The Boxplot

According to the boxplot, the data-set is classified as table 1.

Table 1. Summery statistics of the boxplot for gold.

	Au(ppb)
N	836
Min	0.43
Lower whisker	0.49
Lower hinge	1.40
Median	1.80
Upper hinge	2.66
Upper whisker	3.70
Threshold	4.56
Max	8.30

The threshold for Gold based on this method is 4.56 ppb. This threshold is applied to the map (Fig.4) in which samples are plotted according to their X-Y coordination and Z value (grade of gold). The software used for map generation is Surfer 11.0.642.

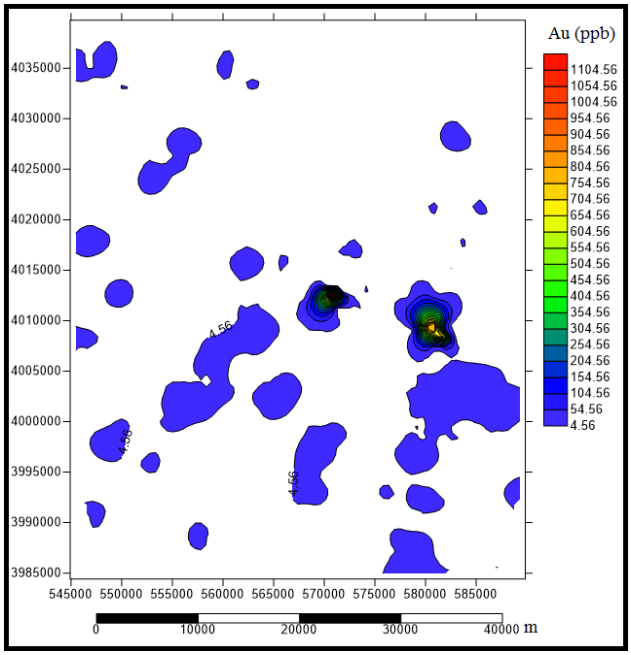

Figure 4. Geochemical anomalies for gold detected by the boxplot method

4.2 The X+tS method

Based on this method, different confidence levels could be applied for anomaly detection. In this study, commonly used confidence level (t=2) is applied. Based on different values of "t", different anomaly maps are generated (Fig.5). The software used for map generation is Surfer 11.0.642.

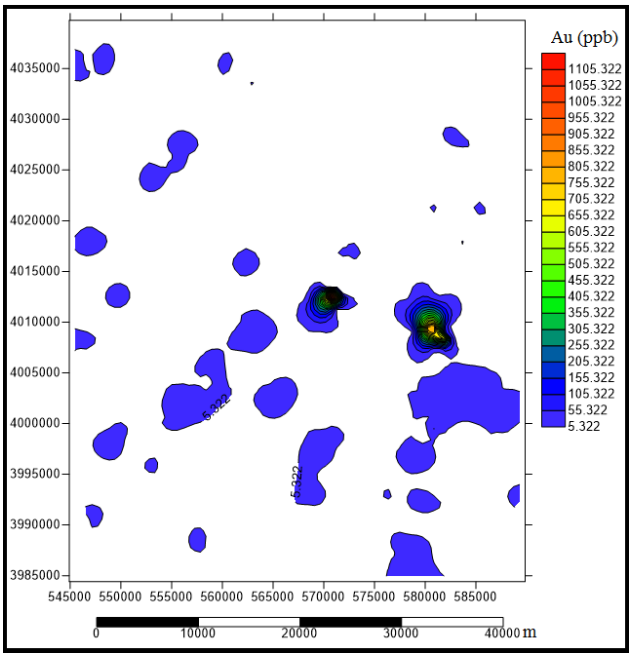

Figure 5. Geochemical anomalies for gold detected by X+2S method.

4.3 The C-A fractal modeling

According to this method, the area enclosed by contours with different values must be calculated firstly. Based on the calculated area for each contour, the C-A log-log plot is drawn (Fig.6).

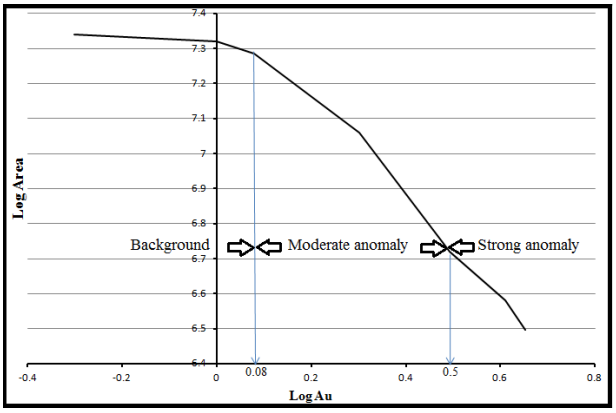

Figure 6. C-A log-log plot.

According to the C-A fractal modeling, the threshold for gold is defined as 3.16 ppb. The anomaly map for C-A fractal modeling is shown in figure 7. The software used for map generation is Surfer 11.0.642.

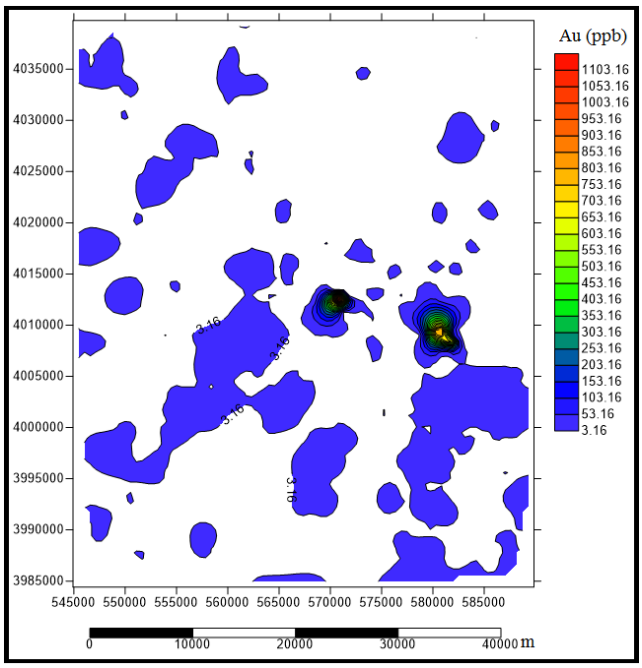

Figure 7. Geochemical anomalies for gold detected by C-A fractal method

5. CONCLUSION

In this study, the aim was detection of gold geochemical anomalies. To begin the studies, 836 samples were obtained from the area (surface soil) and then analyzed. The geochemical data-set was created after data normalization. In order to detect Gold anomalies, different statistical and non-statistical methods were applied and the result was anomaly maps. Based on these anomaly maps, most of gold potential is located in the middle of the area where all the applied methods detected anomaly there.

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