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Evaluation of effective factors in window optimization of fry analysis to identify mineralization pattern: Case study of Bavanat region, Iran

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Abstract

The known ore deposits and mineralization trends are important key exploration criteria in mineral exploration within a specific region. Fry analysis has conventionally been considered as a suitable method to determine the mineralization trends related to linear structures. Based upon literature sources, to date, no investigation has been carried out that includes the Sensitivity Analysis of Feature's Number (SAFN), Sensitivity Analysis of Window Size (SAWS), and Sensitivity Analysis of Spatial Distribution (SASD) of Fry analysis related to mineral locations. In this work, SAFN, SAWS, and SASD are performed by moving several different sub-windows among the main window in order to identify the main trends of mineralization by Fry analysis in the Bavanat region of Iran, which is qualified by its regional and local faults pattern. Based upon our investigation, the effectiveness of the window size and the number of features on Fry analysis are 15-30%. The determined main trends of sub-windows increase, whereas its distribution function of Fry outputs is more similar to the distribution function of Fry outputs of the main window. Moreover, the directions of rose diagrams could be changed due to the edge effects of marginal features around the selected window. However, by selecting an appropriate window, this problem can be solved. Additionally, by an appropriate window selection, the most suitable regional situation is an area that contains the largest number of deposits with a similar metallogenetic origin. Based upon our investigation, the distribution function of the Fry outputs is the main factor that directly controls the identified mineralization pattern of the selected windows.

Keywords: *Mineral Exploration by Fry Analysis, Sensitivity Analysis, Mineralization Trend, Window Size, Features Number.*

1. Introduction

Mineral prospectivity mapping and the evaluation of undiscovered mineral deposits are two major aims of prospecting regions of the earth for the discovery of new mineral resources [1]. There are different approaches available for mineral potential classification when the regional and local geology are known and when systematic and comprehensive exploratory data analysis is still missing [2]. It has been proven that certain types of mineral deposits are spatially associated with certain curvy or linear geological controlling features [3]. For a more successful exploration, investigation of the spatial distribution of known mineralization is generally accepted as an effective method [4]. Analysis of the spatial relationship between known occurrences of mineral deposits with certain types of geological features is an empirical guide in weighing the relative importance of the geological features in separate evidence layers that control the location of the mineral deposits for the prediction of new prospective areas [5, 6].

Both on a regional and district scale, known mineral deposits and occurrences are always plotted as point features [7]. Investigation of the spatial distribution of various types of mineralization can be carried out by different methods. The spatial distribution pattern of a set of points can be investigated by point pattern analysis [8, 9]. There are several methods available for such point pattern studies. The X2 statistics plot (Morisita analysis) [10] is a simple one of such diagnostic methods. Morisita has utilized this method to find point relations [10]. In 1983, Mandelbrot stated that the mineralization distribution patterns may be fractal within the Earth [11, 12], a hypothesis that was subsequently accepted. Different methods to characterize fractal geometry are the box-counting, density, number in-circle, and fixed-mass ones. The box-counting method is more sensitive to the number of features and changes significantly with scale [13]. A more sophisticated option is the Fry analysis plot [6], which was technically improved by Crespi in 1986 [14]. It is the scatter plot of vector differences xi-xj between all point pairs (Figure 1). Fry analysis is a visual method used to determine a certain geometric trend for a group of point data. This method was originally designed to quantify the limited strain, and it is based upon the 2D analyses of the nearest neighbor distance from a reference center point. When a deposit is small, Fry analysis provides interpretive results [15], which is common in green field areas. Fry analysis is used to study the mineralization distribution of an area and its relationship with linear structures [6]. In other words, application of the Fry analysis method is applied to study linear and also oriented features. On a regional scale, this method is capable of analysing the distribution patterns of mineralization at the deposit scale including the mineralization trend, trend of high-grade zones, and grade distribution [4]. Furthermore, it can be used to study the anisotropy in the point feature distribution. From a mathematical viewpoint, a plot of Fry analysis is a point pattern of X as well as a plot from xi to xj vectors to connect all the specified pair points of the x vector space.

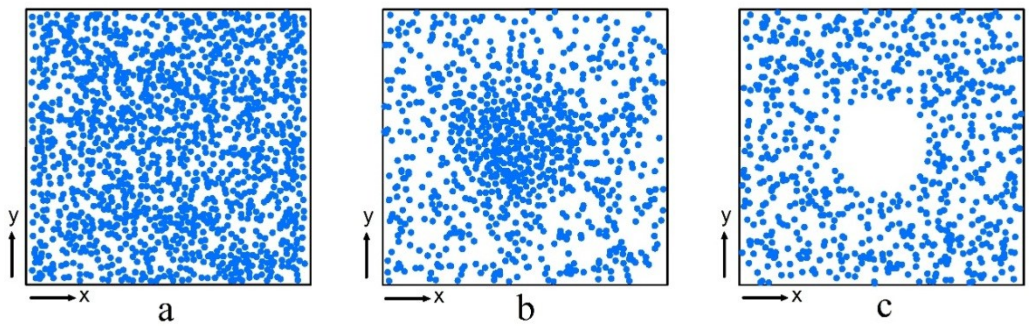

Figure 1. Plot of Fry analysis: (a) independent; (b) clustered; (c) regular or normal.

In 2003, Moghaddam analyzed the spatial distribution of geothermal resources on a regional scale [16]. In 2015, Wang & Zhang used the point pattern statistics, fractal analysis, and Fry analysis in support of a GIS to explore the spatial distribution characteristics of Fe deposits and the spatial relationships between the mineralization and geological features in the Fujian Province in China [17]. In the same year, Mehrabi et al. applied point pattern and Fry analysis to known occurrences and to the distribution of epithermal mineral deposits within the Troud-Chah Shirin belt in Iran [18]. In 2015, Gorum & Carranza examined the hypothesis that the spatial pattern of earth-quake-triggered landslides is influenced by the style of faulting based on the distance distribution analysis and Fry analysis. By combining these methods, they obtained a higher prediction accuracy of landslides compared to that obtained by using unclassified faults [19].

The distribution of known ore deposits, fossils or sedimentary lithotypes is usually random and non-clustered but igneous rocks most commonly show a clustered (clumps of crystals) distribution [20, 21]. In 1979, Fry estimated the minimum number of crystals that were necessary to make a reliable Fry plot around 300 crystals. He used 382 centers in undeformed porphyritic andesitic lava for an unstrained rock [6]. In 1986, Crespi described the dependence between the degree of non-clustering of particles and the required minimum number of them to take into consideration [14]. He stated that for a very strong non-clustered distribution, 100 particles would be sufficient but this number increases for a more random distribution [22]. These authors used the application of statistics on point distribution with the help of a Morishita diagram and cumulative histograms of angles between point tests in un-deformed and deformed porphyritic granite to reveal that the K-feldspar phenocrysts of such granites can be used as strain indicators with the Fry method. In 1983, Lacassin & Van den Driessche obtained a good adaption between the macroscopic deformation axes and the ellipse axes inferred from the Fry plots using 100-400 centers of blue quartz [23]. In 2002, Treagus & Treagus used just 28 to 85 particles in tillites and conglomerates for acceptable results [15]. This necessary number of particles used seems to decrease in younger studies. In 1999 [4], Vearncombe & Vearncombe emphasized that Fry analysis can produce meaningful results with a modest 14 or more samples, although the larger size datasets can typically provide more reliable results. These authors emphasized that this method provides acceptable results even when we do not have large numbers of mineral deposit points [4]. Despite this large number of published studies by Fry analysis, application of the selection of an optimized study window, which can produce improved results, has rarely been considered. Our review of published literature on this issue raised the question of what is the minimum number of point features required in this method to achieve acceptable results in the exploration for mineral deposits? Other questions are: What are the effective criteria for selection of the studied area in Fry analysis? How strong is the effect of the selected window on the Fry results? Are there any special factors or distribution properties effective to achieve reliable results in the analysis? In an attempt to answer these crucial questions, we carried out this comparative study. Conventionally, Fry analysis is considered as a usual method to determine the main distribution directions (trends) of ore deposits that are related to linear controlling structures. In this work, SAFN, SAWS, and SASD were applied and the data obtained was analyzed to achieve reliable results in mineral deposit point features. This paper discusses the crucial assumptions necessary to apply the Fry method by increasing the reliability of the Fry method in prospecting areas; the main contribution of this paper is to address and solve the following problems:

- How to select a suitable population of mines or mine indicators? (by choosing a suitable window)?
- How to choose the suitable number of centers?
- How to select the studied area regarding the spatial distribution of Fry outputs?
- How to avoid the effect of edge phenomenon in Fry plots.

2. Geological setting of Bavanat region, Iran

The Bavanat (Jiyan) Cu-Zn-Ag Besshi type volcanic-hosted massive sulfide (VHMS) deposit is located in the southern part of the Sanandaj-Sirjan Zone (SSZ) [24]. The 150-250 km wide SSZ in Iran extends over a distance of 1500 km along strike, passing from the towns Sirjan and Esfandagheh in the SE to Urumieh and Sanandaj in the NW of Iran (Figure 2). SSZ is characterized by metamorphosed and deformed rocks that are spatially associated with highly deformed and non-deformed plutons as well as widespread Mesozoic volcanic rocks. Berberian has stated that SSZ represents a Mesozoic magmatic-arc and a Tertiary fore-arc [25]. Eftekharnejad has divided SSZ into two sub-parts [9]:

- Southern Sanandaj-Sirjan Zone (SSSZ): mainly consisting of Paleozoic and Early-to-Middle Mesozoic volcanic and intrusive rocks;
- Northern Sanandaj-Sirjan Zone (NSSZ): mainly containing Middle-to-Late Mesozoic volcanic and intrusive rocks.

Within the Bavanat area, a Mesozoic submarine volcanic district in SSZ is associated with the VHMS mineralization but also includes dominantly the Triassic and Jurassic volcanic rocks within SSSZ [26] (Figure 2).

For the first stage of our investigation of the studied area, we selected just the Bavanat region VHMS deposits (see small window in Figure 8). The Fry plot of points was prepared according to the VHMS deposits and mineral indicators of the Bavanat region. The results of this stage of the Fry analysis were nearly identical to the real distribution patterns of the deposits but the trends were not exactly the same as the major trends of the faults that play the most important role for the mineralization. In a second stage of our research work in the studied area, we selected all the VHMS deposits as well as all the mineral indicators that were located within SSSZ.

After creating the Fry plot, we emphasized that all the major extracted trends were exactly coinciding with the major trends of faults that played a major role controlling the distribution of the mineralization. This work demonstrated that the appropriate window must be adjusted to a wider size that has the same mineralization type of mines and mineral indicators. The mine and mineral indicator data, which was used for the second test, is shown in Table 1. Specifications and results of the research tests of SSSZ are presented in Figures 3-6 and Table 2.

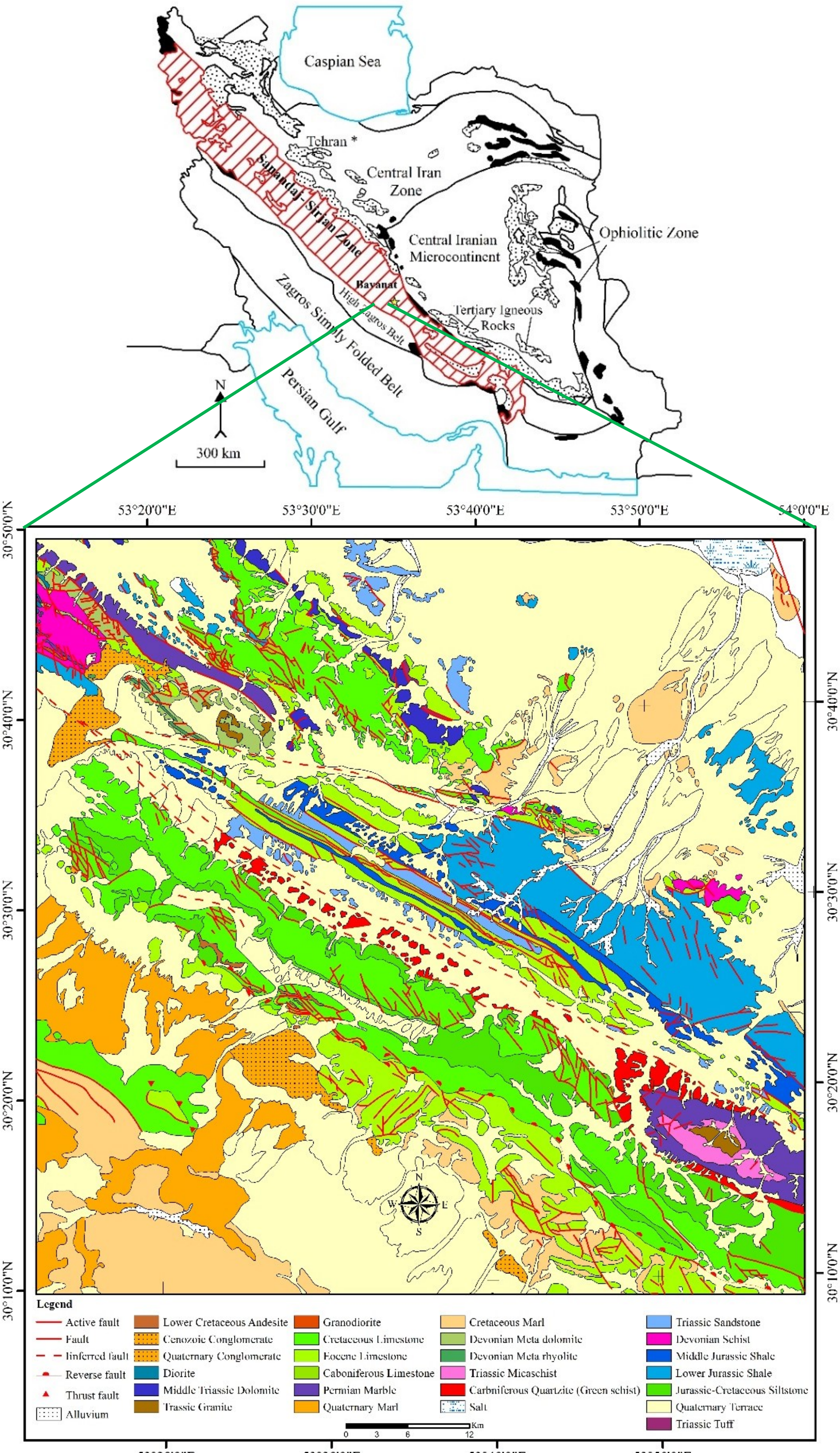

Figure 2. Geological map, 1: 250,000 scale, of Bavanat region and its situation within larger structural map of Iran, extracted from geological map of Eqlid [27].

A Fry plot of SSSZ is shown in Figure 3. The probability density of the Fry analysis of the output dataset is shown in Figure 4. Figure 5 shows the rose diagram of the main mineralization trends, which have been indicated in the dataset specification table. The rose diagram results indicate that the spatial distribution of the VHMS deposits and mineral indicators have a linear trend with a strike of 300 to 310 degrees azimuth in this region. Figure 6 shows the normalized probability density curve of the Fry outputs and its most similar distribution function curve.

There are many software packages specialized in creating rose diagrams but in our study, the ESRI extension Polar Plots were used for the visualization of Fry points [28].

Table 1. Southern Sanandaj–Sirjan VHMS deposits and mineral indicators.

No.	Mineralization type	Name of deposit or mine	Commodity
1	VHMS	Jiyan Mine	Cu-Zn-Ag
2	VHMS	Jafarieh (Chir)	Cu
3	VHMS	Mazayjan (Koureh-mesi)	Cu
4	VHMS	South of Monj1	Cu
5	VHMS	South of Monj2	Cu
6	VHMS	Jashnyan	Cu
7	VHMS	Chah-gaz Mine	Pb-Zn-Cu

Table 2. Specifications of VHMS of Southern Sanandaj-Sirjan. (Expon. = Exponential distribution; Weibull = Weibull distribution; ExtValue = Extreme Value distribution; LogLogistic = Log-Logistic distribution; Normal = Normal distribution; InvGauss = Inverse Gaussian distribution).

VHMS Sanandaj-Sirjan	Number of Original Points	Number of Fry Plot Points	Chi Square Test Score	Best Fitted Distribution Functions	Uniformity (Critical value = 123)	Main trends, Trends	Number of Trends
N	6	36	127.333	**Weibull, LogLogistic**	Not Uniform	**N58W, N62W, N67W**, N17E, N67E, N70E, N87E	7
N-NW	5	25	135	**LogLogistic, Weibull**	Not Uniform	**N58W, N62W, N67W**, N87E	4
NW	2	4	98	Expon., ExtValue	Uniform	**N62W**	1
S	3	9	97	**Weibull**, Normal	Uniform	N67E, N70E, N87E	3
S-SE	3	9	163.667	ExtValue, InvGauss	Not Uniform	**N58W, N62W**, N87E	3
Total	7	49	207.286	**LogLogistic, Weibull**	Not Uniform	**N58W, N62W, N67W**, N17E, N67E, N70E, N87E	7

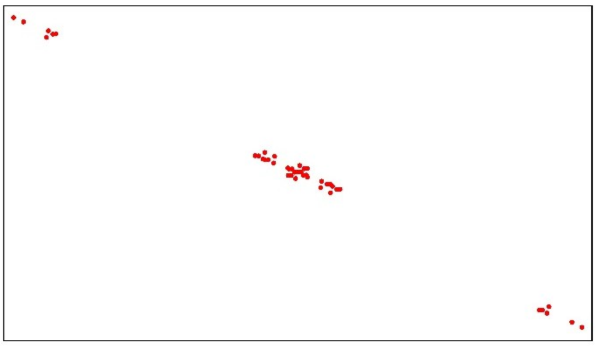

Figure 3. Fry plot of Bavanat region.

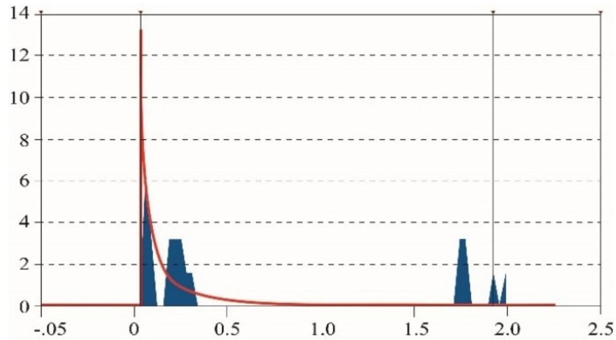

Figure 4. Best fitted curve of Fry data from Bavanat region.

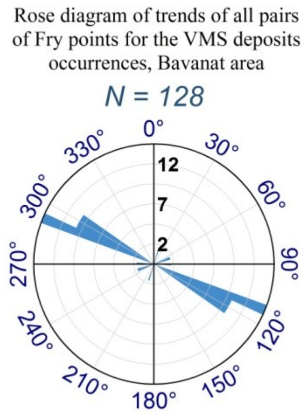

Figure 5. Rose diagram of Fry data.

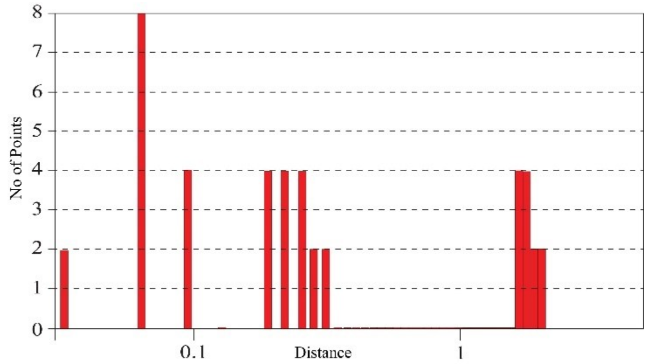

Figure 6. Probability density graph of Fry data.

3. Methodology

A general approach of the study is as follows (see also the chart in Figure 7):

- Gathering data of deposits/mines and mineral indicators.
- Producing sub-windows from the main window with different sizes and feature numbers moving among the main window (Figure 8). It is clear that with this sub-window motion, the specifications of points such as the number of points, mean, standard deviation, uniformity, distribution function, distribution function of Fry analysis outputs and linear trends will change accordingly.
- Carrying out the Fry analysis and preparation of Fry plot.
- Plotting a Fry analysis rose diagram.
- Determination of the major and minor mineralization trends.
- Calculation of the mean, standard deviation, Chi square analysis, and uniformity.
- Fitting the best distribution curve to each dataset [29].
- Comparison of characteristics of the produced sub-windows with the main window.

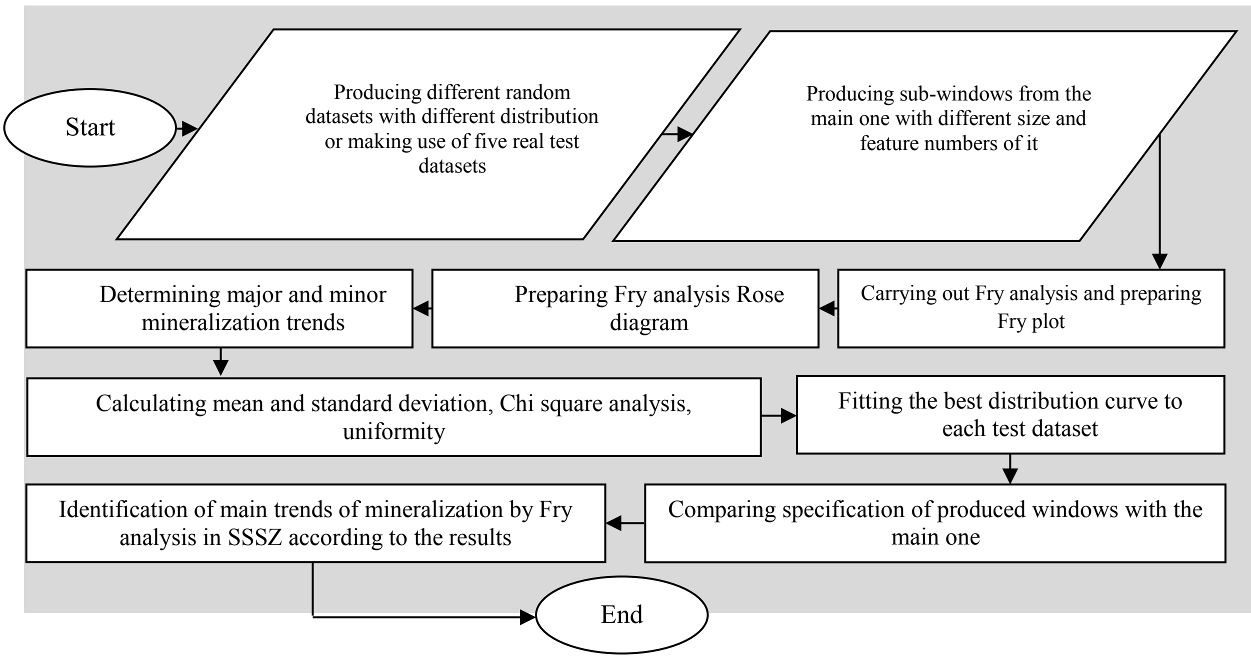

Figure 7. Work flowchart.

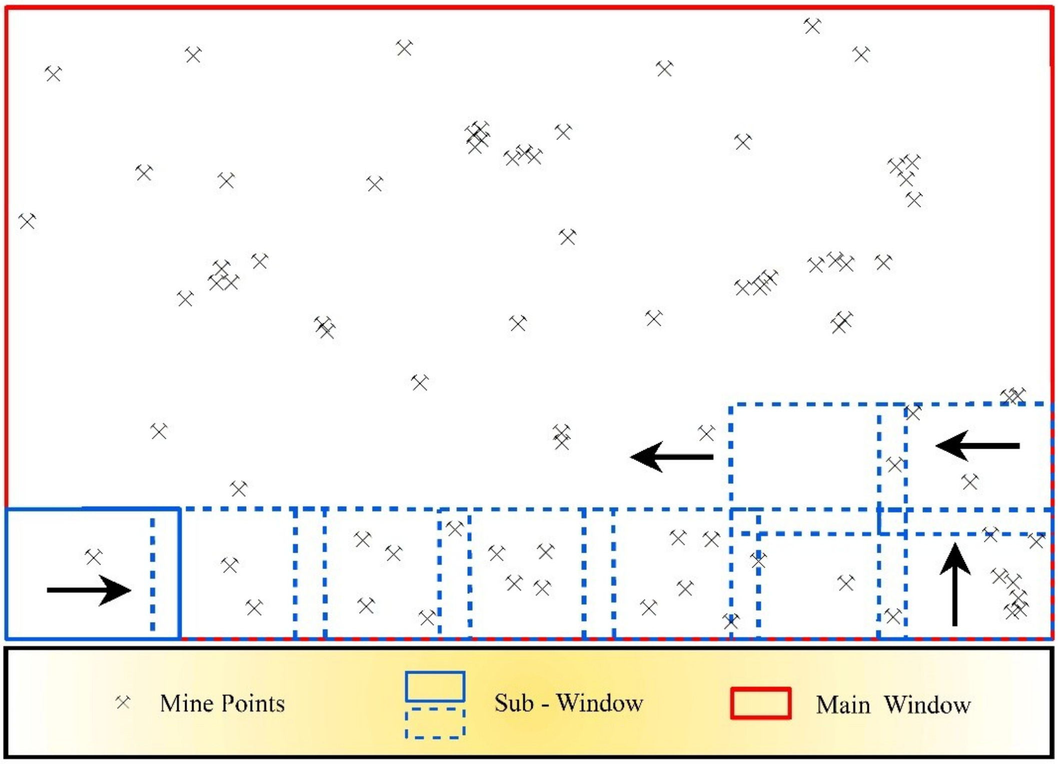

Figure 8. Schematic representation of sub-windows moving within main window.

3.1. Fry analysis

Let us assume that a trend of points was plotted on a paper sheet. A sheet of paper was selected as the point trace sheet, and a red dot was drawn in the middle. Subsequently, a point trace sheet was moved on the point trend sheet in such a way that the red dot can be fitted on one of the points. All the data points were copied on the point trace sheet afterwards. This was done for all the points, and this was the method of preparing a Fry plot (Figure 9).

In fact, this was carried out by drawing a line connection between the feature centers. One of these methods is that of Ramsay. In this method, the separation of features is performed using the nearest neighbor method. This statistical method is one of the most appropriate ones to study the spatial distribution relationship of different mine indicators, and is mainly used in structural geology and geostatistics, in which, there is n^2-n spatial relationship for n points [4].

The algorithm of a Fry analysis is as follows:

- Plot the points on a sheet of paper
- Specify a red dot in the middle of a sheet of paper as point trace sheet
- Move the sheet of paper to match the red dot with one of the points
- Copy all points on the point trace sheet
- Repeat the procedure for all the other data points

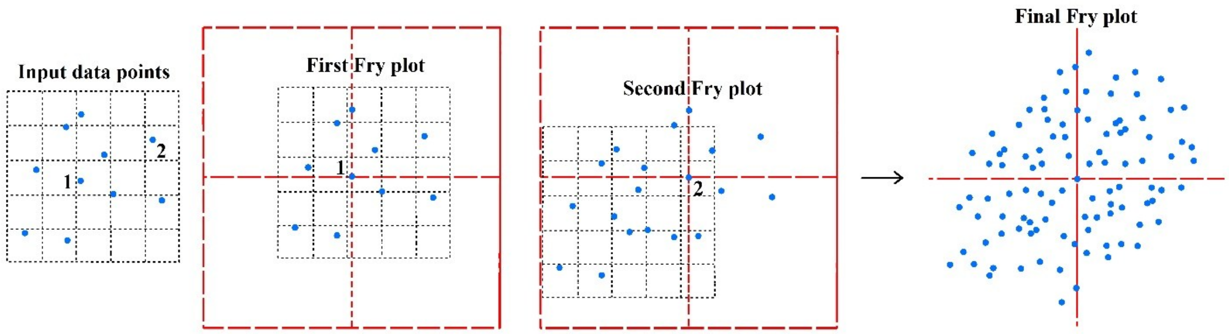

Figure 9. Schematic representation of Fry analysis plot.

4. Results of sensitivity analysis and discussion

A probability density graph of the Fry analysis output, the rose diagram of the main mineralization trends (Figure 10.a–10.e), a normalized probability density curve of the Fry outputs, and its most similar distribution function curve for all sub-windows were provided in this work. Based on these results, SAFN, SAWS, and SASD were carried out to find the major trends of the mineralization. In Figures 10.a,b, it can be seen that the main trends detected in the N and N-NW sub-windows are exactly the same as those of the main window. The factors that are the same in these two windows are the best fitted distribution functions (for the Fry outputs data) and uniformity (Table 2). A comparison between the NW window and the main window results show that with difference of the best fitted distribution function, the major trends of mineralization decrease to just one main trend (Figure 10.c). The results obtained indicate that uniformity or non-uniformity of distribution has no relation to the window selection. This means that in the time of selection of each window, regardless of its distribution (i.e. uniform or non-uniform), the other factors will affect the accuracy of the Fry analysis results. In Figure 10.d,e, we can emphasize that by changing the best fitted distribution functions, the number of main mineralization trends that were detected decreases (Table 2). The number of points has a direct effect on the analysis results; while in the windows with even two points, the main mineralization trend was quite correctly recognized (Figure 10.c). Additionally, in the tests with five points, all the main mineralization trends were detected (Figure 10.b).

Scatter plots of the number of original data points (mine indicators) versus the number of detected mineralization trends are given in Figure 11. As it can be seen in this figure, with increase in the window size, and therefore, the point numbers, the number of known mineralization trends will also increase. From a certain point to the next, the mineralization trends remain almost identical. This is due to the fact that the sub-window Fry plot distribution is very similar to the Fry plot distribution of the main window. This fact also happens in some datasets with two or three original point sub-windows. This means that despite an increase in the number of points in sub-windows, the number of mineralization trends generally increases. The most attractive observation is that the main mineralization trends are more important than the minor ones in mineral exploration, which will be detected with the same small number of points.

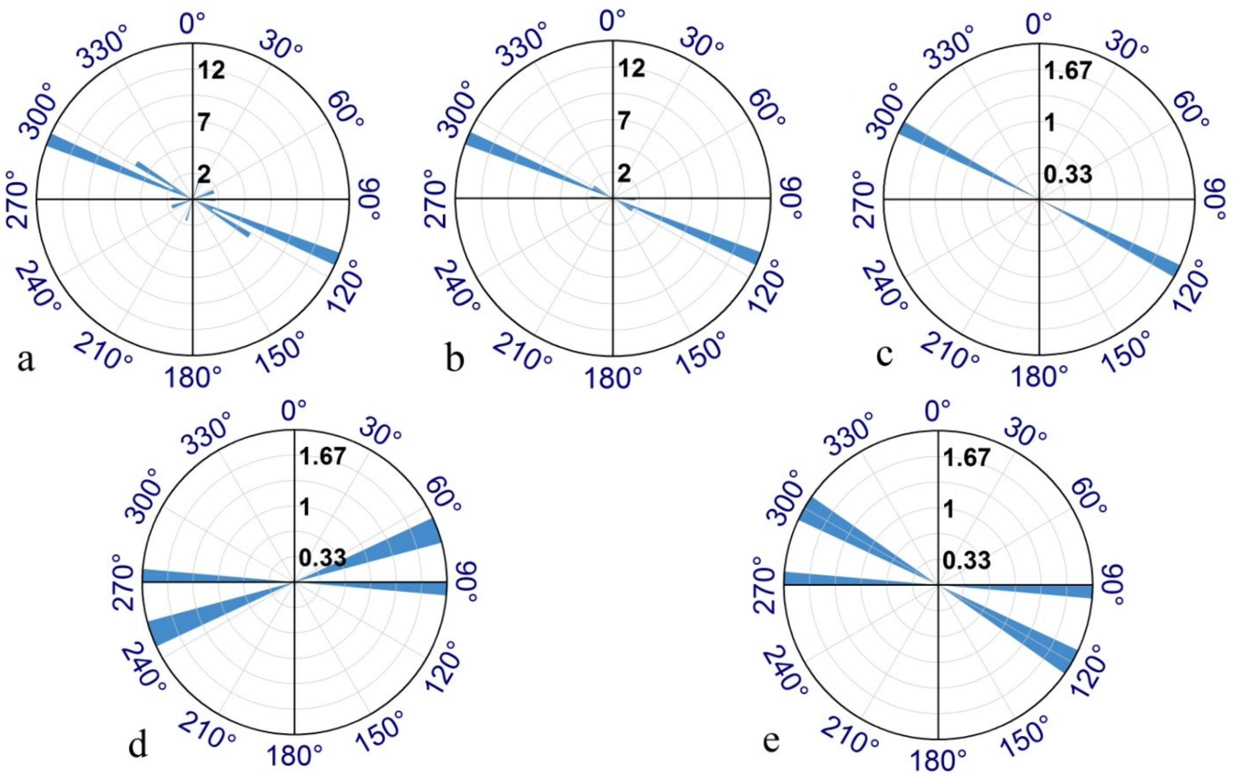

Figure 10. Rose diagrams of Fry analysis output data for selected sub-windows.

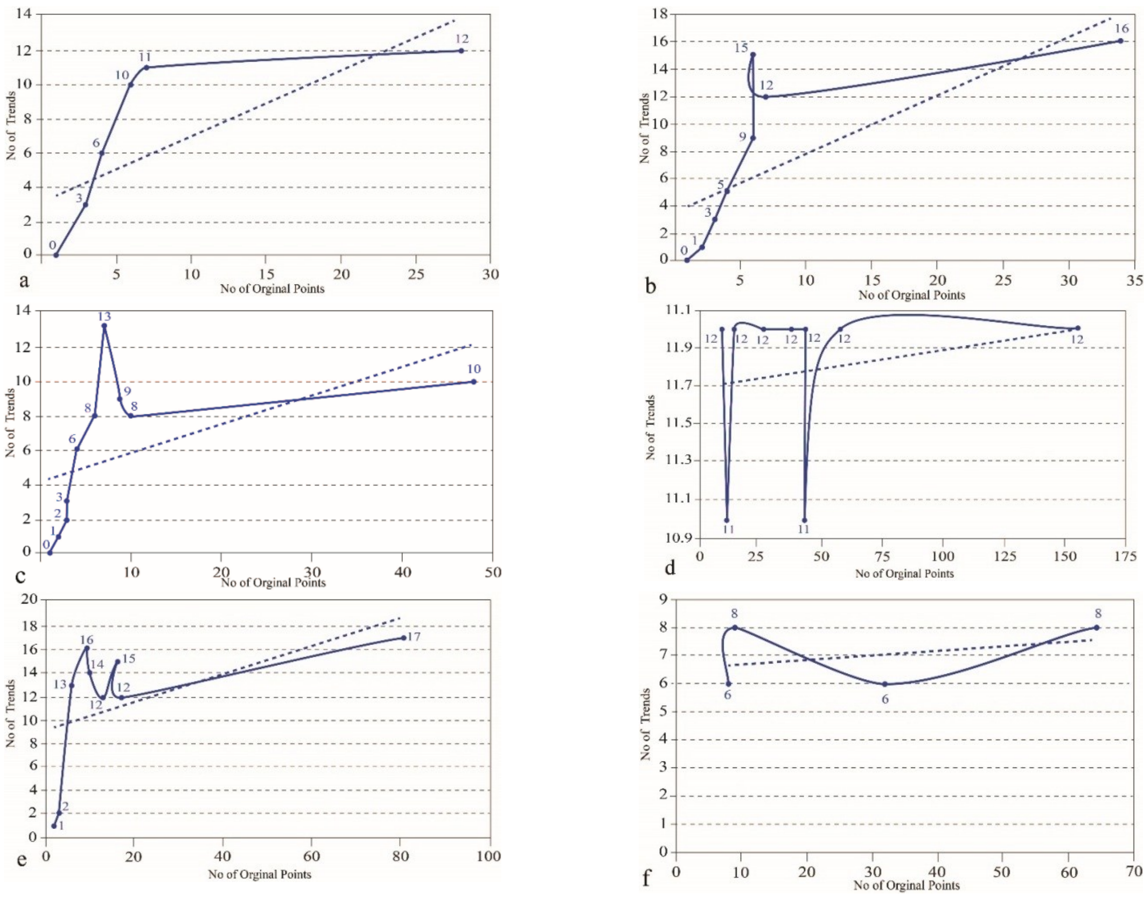

Figure 11. Scatter plots of numbers of original data points (mine indicators) versus numbers of detected trends.

At this stage, the simultaneous changes showed that the read number in the horizontal graph after the first sharp appearance distinguishing between the two graphs is a critical point. We highlighted them in yellow (Figures 12.a-f). These points can determine the optimum original data point numbers, which have the most similar distribution to the main window. In this window data, the majority of the main mineralization trends were detected when the selected sub-window was wider. These two graphs do not have this optimal point. They were almost parallel, and the first selected sub-window had a similar Fry distribution to the main window (Figures 12.d,f).

There are seven mines and mineral indicators with VHMS-type mineralization in this part of SSZ. The Rose diagram results (Figure 5) indicate that linear controls with the azimuth of 300-310 degrees play the most important role in the localization of the mineralization of the VHMS deposits in this area. Additionally, in the regional scale, huge faults such as the Sureyan, Jiyan, Dehbid, Jovakan Fault, and a few other faults that control mineralization all trend along an azimuth of 300 degrees (Figure 13). Figures 14-17 show the satellite images of the studied area with interpreted faults on a local scale and certain mines and mineral occurrences. Figure 14 shows the spatial association between the Jafarieh (Chir) copper occurrence and fault intersecting a ring structure. The azimuth of the major local fault in this region is 295 degrees. The outcrops supported the Fry analysis results. In Figure 15, the spatial association between the location of the Jiyan Cu-Zn-Ag Mine location and the specific azimuth of a fault is clearly visible. The fault has an azimuth of 310 degrees. Figures 16 and 17 show the spatial association between the “south of Monj2” and “south of Monj1” copper occurrence and two faults with an azimuth of 300 degrees that cross several faults. The faults trending at 300 degrees have the best spatial association with the ore deposits and mineral indicators of the studied area with a maximum distance of 250 m to these faults. This indicates the importance of the mentioned mineralization trends in the studied area. In addition, this confirms the results of the Fry plot shown in Figure 5 and its main mineralization trends. Based upon these results, we can conclude that this is a metallogenetically significant fault trend and thus must have a high value in exploration evidence maps for the preparation of mineralization predicting models. Additionally, as shown in Figure 14, there is a significant spatial relationship between mineral occurrences and ring structures (red circle) in satellite imagery. These results demonstrate the additional importance of ring structures in the exploration of this mineralization type in this region.

In the Fry plots, the density of points is gradually stretched near the edges of the plot. This edge effect results from limited sampling windows (Figure 18). Usually it is not important for the application in raw geology and crystallography since one does normally focus on the behavior of the criteria near the center of the window, and the edge effects can thus be ignored. However, in exploration projects, where the identification of mineralization trends is of great importance, the edge effects can change the direction of the Rose diagrams. For this reason, the selected Fry window should be a little bit wider than the real studied area to avoid such edge effects. Those features that are placed wrongly in the studied area, due to this enlargement of the window, should not be included in the Fry analysis. Considering that the studied area was selected based on similar metallogenesis processes, other features with different formation mechanisms may be included in the area that affects the results. We should avoid them in the Fry analysis as well. Additionally, in exploration projects, the windows should be selected in a way to cover the largest area with the same type of mineralization and mineral controlling factors, which will help to reduce the edge effects, and major and minor mineralization trends will also not be removed. It looks even better than to select a larger studied area than usual and remove the not desired deposits that exist now in the studied area for enlargement reason.

Finally, the distribution function of the Fry analysis outputs is the most important factor that directly affects the results of the Fry analysis. When comparing the results of each sub-window with the main window, it can be concluded that a higher similarity between the fitted curves and the sub-windows with the main window will produce similar major and minor trends detected in the Fry analysis results.

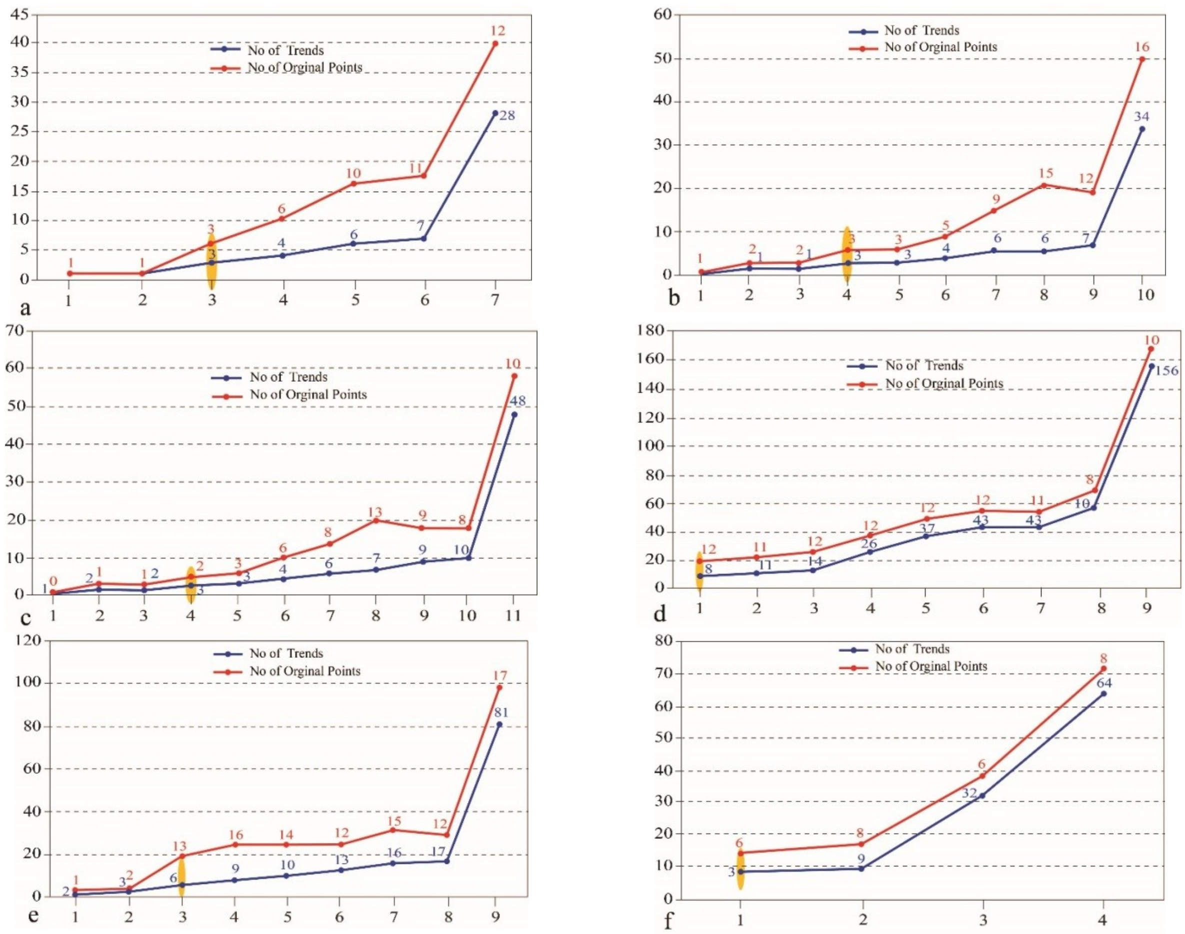

Figure 12. Comparison between simultaneous changes in number of original data points (mine indicators) and number of detected mineralization trends.

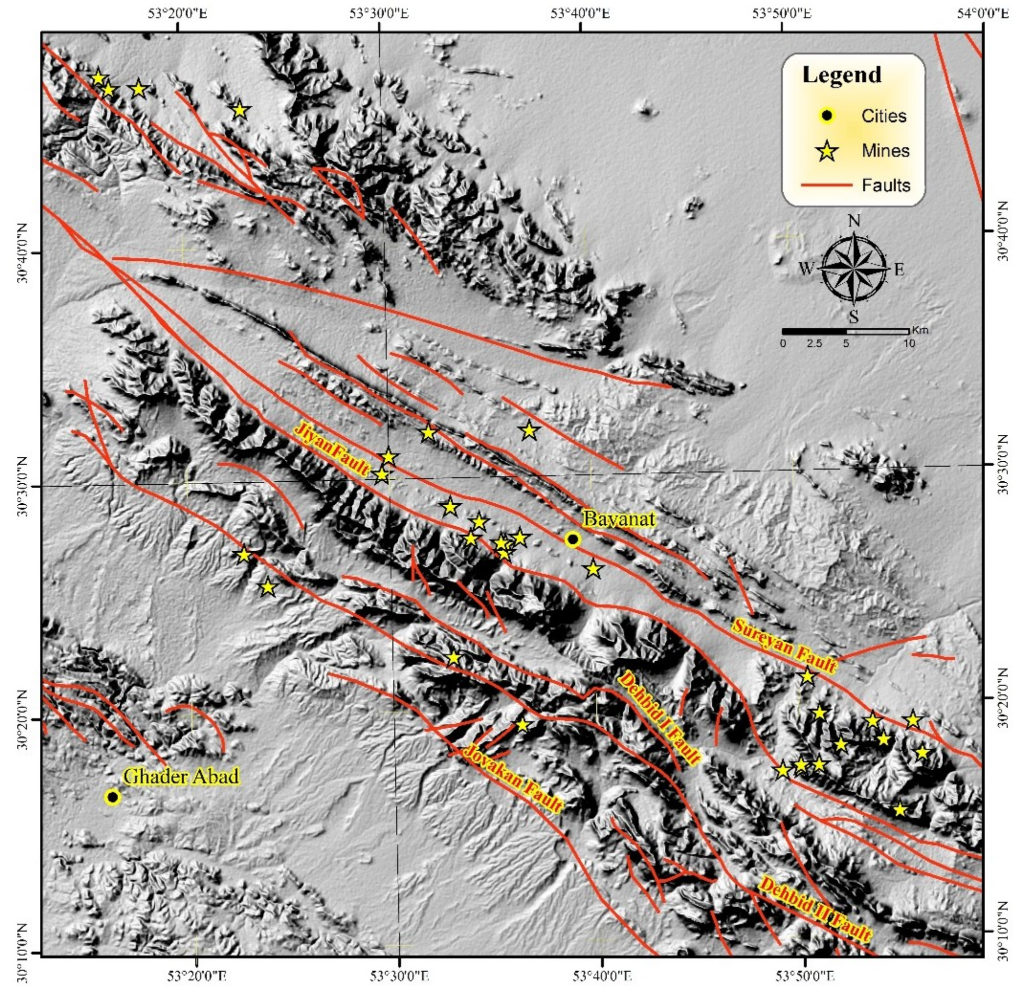

Figure 13. Spatial association between major faults and mineralization on a regional scale in Bavanat region.

Figure 14. Spatial association between a mineral indicator location and certain azimuths of several faults superimposed over a ring structure.

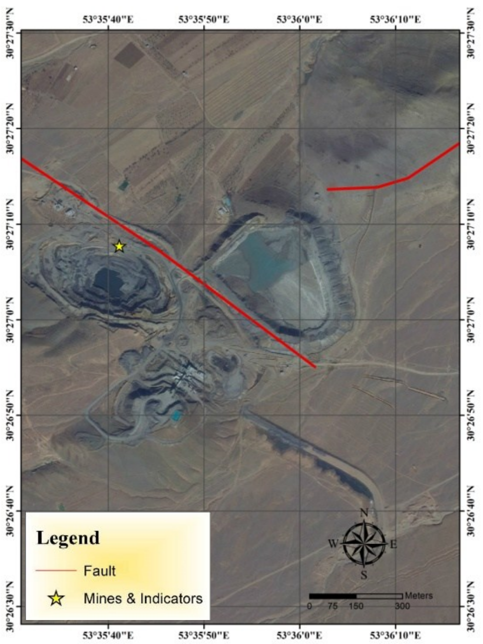

Figure 15. Spatial association between location of Jiyan Mine and two faults with different strikes.

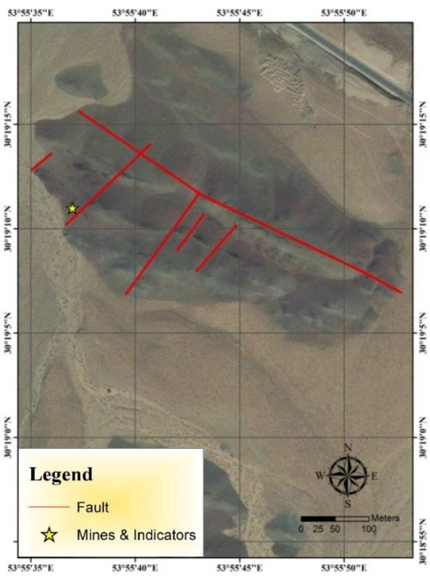

Figure 16. Spatial association between a mineral indicator location and several intersecting faults with different strike directions.

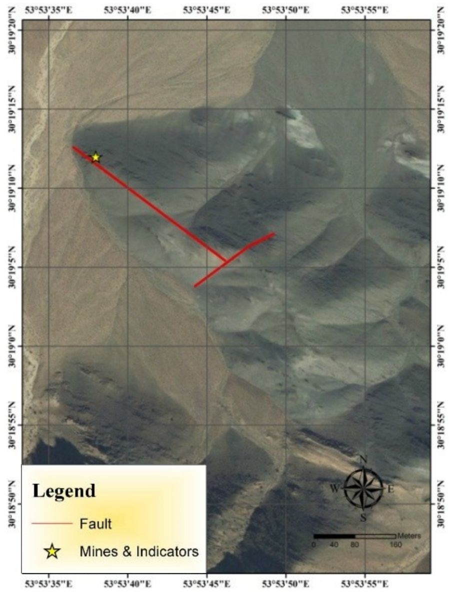

Figure 17. Spatial association between a mineral indicator location and two intersecting faults.

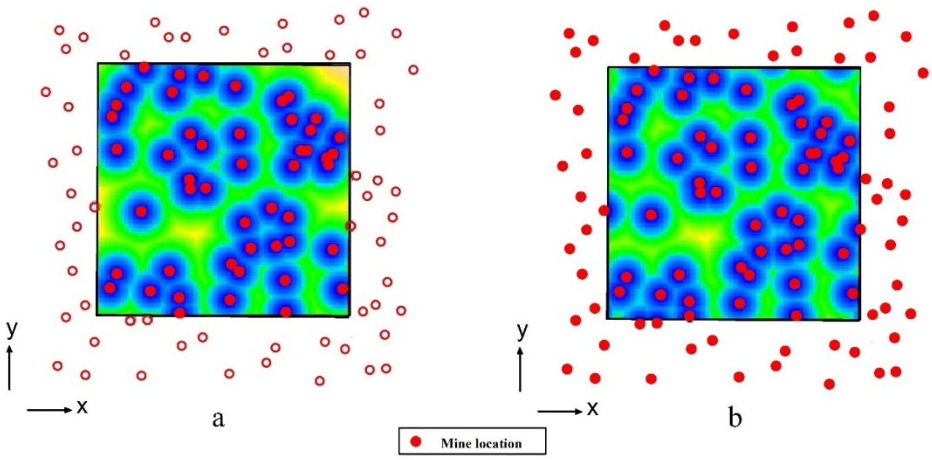

Figure 18. Edge effect presentation: (a) Observed nearest neighbor plot; (b) True nearest neighbor plot.

5. Conclusions

The main results of our work can be summarized as follow:

- In non-random distributed data (completely isotropic data), the Fry analysis in sub-windows was nearly to the same as the main window.
- The uniformity or non-uniformity of distribution had no effect on the inclusivity and exclusivity of the selected window.
- The window size directly affected the results around 20-30%.
- The number of features is a function of the window size, and consequently, it has a direct effect on the analysis results. It can affect the Fry plot results up to 15-20%.
- The type of mineralization has an effect on the major trends of mineralization but existence of a similarity in the mineralization type is not a reason for obtaining the same determined mineralization trends in different regions. In other words, the data with the same distribution that are indicative of different mineralization types may still show the same orientation trends.
- Any type of mineralization can produce a specific spatial trend of mineralization but there is no pattern or special relationship of this trend between the windows and sub-windows.
- Regarding the regional Fry outputs distribution function, the studied area

should be selected a little larger than the original studied area to avoid the edge effects but those features that are placed wrongly in the studied area due to the window enlargement must be excluded manually and should not be included in the subsequent Fry analysis. In fact, the optimum window is a window that includes all mineral deposits and mineral indicators that share a common metallogenesis within the same structural zone.

- Contrary to the previous belief that in order to prevent the interference deposits or mines with different mineralization type, in which the smallest window was elected, in exploratory research works, this research work proved that we must choose a window with a little bit larger than the mineralization type in the studied area. Such a window will help to avoid edge effects but, at the same time, will not eliminate the major and minor mineralization trends. Even it is better to select a window slightly larger than usual and eliminate irrelevant deposits in the mineralization type, which may be set in marginal.
- The distribution function of the Fry output data is the strongest factor with the largest effect on the results of the sub-window mineralization trends. Comparing the results of each sub-window with the results from the main window, it was concluded that the similarity between the fitted curves of these two will produce similar major and minor trends in the Fry analysis. In other words, the similarity of the same distribution function in the main window and sub-window is the reason for both similar mineralization trends obtained. Even when the selected sub-window is very small and the number of mines is low, both obtained similar mineralization trends.
- The understanding of the metallogenesis of the mineralization, geology, and type of mineralization can help to obtain acceptable results in exploration. For example, if a Fry analysis plot shows any trend, the experts still need to interpret the results in comparison with the results from published literature and from field observations. In such a comparison, the major trends of faults play an important role in the control of mineralization of this type in the region. In case there is still a major difference between the plot analysis and published literature results, the experts will have to change the window of observation (based on the factors explained above) because otherwise the selected window is not suitable to identify the most important trends correctly.

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بررسی عوامل مؤثر در بهینه‌سازی پنجره در تجزیه و تحلیل فرای جهت شناسایی الگوی کانه‌زایی: مطالعه موردی منطقه بوانات، ایران

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چکیده:

ذخایر معدنی شناخته شده و روندهای کانه زایی در یک منطقه مشخص، معیار کلیدی بسیار مهمی در اکتشاف مواد معدنی در آن منطقه هستند. آنالیز فرای به عنوان یک روش مناسب مرسوم برای بارزسازی روندهای کانه زایی مرتبط با ساختارهای خطی شناخته شده است. بر اساس مطالعات انجام شده، تاکنون تحقیقی در راستای آنالیز حساسیت تعداد داده‌ها، آنالیز حساسیت اندازه پنجره و همچنین آنالیز حساسیت توزیع فضایی داده‌های آنالیز فرای انجام نگرفته است. در این پژوهش، آنالیز حساسیت تعداد داده‌ها، آنالیز حساسیت اندازه پنجره و آنالیز حساسیت توزیع فضایی داده‌های آنالیز فرای به وسیله جابجایی تعداد زیادی زیرپنجره در داخل پنجره اصلی برای شناسایی روندهای اصلی کانه‌زایی در منطقه بوانات ایران انجام شد و نتایج به وسیله الگوی محلی و ناحیه‌ای گسل‌های منطقه اعتبارسنجی شد. بر اساس نتایج به دست آمده، میزان تأثیر اندازه پنجره و تعداد داده‌ها در نتایج به دست آمده از آنالیز فرای حداکثر ۳۰-۱۵٪ است. روندهای اصلی مشخص شده در زیرپنجره‌ها زمانی که تابع توزیع خروجی آنالیز فرای در پنجره اصلی و زیرپنجره شباهت بیشتری به هم داشته باشند، به طرز قابل ملاحظه‌ای افزایش می‌یابد. همچنین، امتدادهای مشخص شده توسط رزدیاگرام می‌تواند تحت تأثیر اثر حاشیه‌ای بر روی داده‌ها در حاشیه پنجره، به غلط تغییر کند که این مشکل با انتخاب پنجره مناسب قابل حل است. به علاوه، پنجره مناسب پنجره‌ای است که بیشترین تعداد ذخیره مشابه از نظر متالوژنی در آن موجود باشد. بر اساس این تحقیق، تابع توزیع داده‌های خروجی آنالیز فرای، عامل اصلی کنترل کننده الگوی کانه زایی مشخص شده در یک پنجره انتخابی است.

کلمات کلیدی: اکتشاف مواد معدنی با استفاده آنالیز فرای، آنالیز حساسیت، روند کانه‌زایی، اندازه پنجره، تعداد داده‌ها.