Correlation between Au Lithogeochemical Anomalies and Fault-density using Geostatistical and Fractal Modeling in Sharafabad-Hizehjan Area, NW Iran

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Abstract The aim this study is to examine the correlation between Au lithogeochemical anomalies and density of faults utilizing geostatistical analysis, Concentration-Number (C-N) and Concentration-Area (C-A) fractal models in Hizehjan-SharafAbad area, NW Iran. This area is located in the Alborz-Azerbaijan structural zone and Arasbaran metallogenic belt having an Au epithermal type mineralization. In this study, Au variograms, anisotropic ellipse of Au distribution and rose diagram of fault trends were constructed whose analyses showed good correlation between major axis of ellipse with main trend of faults. Consequently, the C-N and C-A log-log plots were constructed for Au and fault-density distributions which revealed very good correspondence/correlation. The results obtained by fractal models indicate a strong correlation between main Au anomalies, anisotropic ellipse major axis and fault-density distributions.

Keywords Geostatistical Modeling, Au Epithermal Type, Fractal Modeling, Concentration-Number (C-N), Concentration-Area (C-A), Hizehjan-SharafAbad

1. Introduction

A geochemical anomaly occurs by various natural processes related to different geological and mineralization events [1-4]. It may reveal important changes either in geological characteristics and/or mineralization processes.

Several methods are used for geochemical data interpretation and modeling such as classical statistics [5-7], geostatistical and fractal/multifractal modeling [8-13]. Fractal theory has been established by Mandelbrot [16] as an important non-Euclidean branch in mathematical sciences. Several models have been proposed and developed based on fractal geometry for application in the geosciences since the 1980s [17-26]. The purpose this study is to examine the correlation between Au geochemical anomalies and faults using geostatistical, Concentration-Number (C-N) and Concentration-Area (C-A) fractal modeling in the Hizehjan-SharafAbad, NW Iran.

2. Geological Setting

This area, situated in East Azbeyjan province, was selected for study of epithermal Au mineralizations occurring in Alborz-Azerbaijan structural zone and Arasbaran (Ahar) metallogenic belt (Fig. 1). There are three types of lithological units in this area as follows:

- 1- Upper Eocene pyroclastic rocks especially tuffs and lava.
- 2- Mio-Pliocene pyroclastic rocks and acidic domes and dykes specifically andesitic and dacitic rocks.
- 3- Quaternary alluvial units.

The main alteration zones include advanced and medium argillic, propylitic and silicification in this area. Furthermore, andesitic and dacitic dykes cut the older rocks.

Figure 1. Geological map of the studied area and its position in the Alborz-Azerbaijan zone

Figure 2. Faults' map and rose diagram of the studied area

3. Tectonic Setting

The main structure in the Arasbaran metallogeny region been achieved as a result of the Alpine orogeny especially Late Cretaceous Laramid phase. The major trend of its fault systems is NNE-SSW. There are two main faults including Hizehjan and SharafAbad faults in this area, as depicted in Fig. 2.

4. Methodology

4.1. Concentration-Area (C-A) fractal model

Cheng et al.[8] proposed an elemental concentration-area (C-A) fractal model, which was used to describe the

geochemical background and anomalies. This model will also serve to illustrate the relationship between the obtained results with the geological, geochemical and mineralogical information. Its most powerful features are easy implementation and the ability to compute quantitative anomalous thresholds [12],[20]. This model was expressed as follows:

$$A(\rho \leq v) \propto \rho^{-a_1} ; A(\rho \geq v) \propto \rho^{-a_2} \quad (1)$$

where $A(\rho)$ denotes the area with concentration values greater than the contour value ρ ; v represents the threshold; and a_1 and a_2 are characteristic exponents. Using fractal theory, Cheng et al.[8] derived similar power-law relationships and equations in extended form Cheng et al.[8]

4.2. Concentration-Number (C-N) Fractal Model

The Number-Size (N-S) fractal model, which was proposed by Mandelbrot [16], can be utilized to defined the distribution of geochemical populations without pre-processing of data. Based on that model, the (C-N) fractal model was proposed by Hasanpour and Afzal [27] for analyzing the raw data of geological models. This model displays relations between geological attributes (e.g., ore elements in this paper) and their cumulative frequency of samples. The model is expressed by the following formula [16],[25],[28-29]:

$$N(\geq \rho) \propto F\rho^{-D} \quad (2)$$

where ρ indicates element concentration, $N(\geq \rho)$ shows cumulative number of samples with concentration values greater than or equal to ρ , F is a constant and D is the scaling exponent or fractal dimension of the distribution of element concentrations. According to Mandelbrot (1983) and Deng et al.[28], log-log plots of $N(\geq \rho)$ versus ρ reveal straight line segments with different slopes, $-D$ values, corresponding to different intervals. This method is based on the fact that the number of samples reduce with increasing concentrations.

5. Discussion and Results

Geostatistical modeling including variography and generation of anisotropic ellipsoid was carried out based on 181 lithogeochemical samples by RockWorks software

package. Main directions in the anisotropic ellipsoid are N176 and N86 for highest and lowest ranges respectively (Fig. 3). Comparison between anisotropic ellipse of variograms and rose diagram of fault trends denotes that there is a good correlation between extension of Au mineralization and main faults in this area, as depicted in Fig. 3.

Moreover, the C-N log-log plot was created for Au which shows five Au geochemical populations. First threshold is 0.012 ppm and extremely anomalies commenced from 1.6 ppm which located in the four samples in the eastern and western parts of the area (Fig. 4). Furthermore, distribution of density of faults was generated by ArcGIS and RockWorks softwares, as depicted in Fig. 5. It was built up based on intersection of faults, length of faults and density of faults in different cells due to Au mineralization type. The density of faults was classified by the (C-A) fractal modeling which was indicated five populations in this area as illustrated in Fig. 6. High and extremely high parts of fault density distribution have threshold values of 12.6 and 25.1, respectively.

Comparison between high density values and Au extremely anomalies reveals that there is a good correlation between Au mineralization and fault density distribution, as is obvious in the western and eastern parts of this area. As a result, the main Au mineralizations and anomalies occurred along the intersections of faults.

Figure 3. Variograms of Au and anisotropic ellipsoid within rose diagram

Figure 4. C-N log-log plots and Au distribution in this area

Figure 5. Faults' density distribution map

Figure 6. C-A log-log plot and distribution map for fault density in the studied area

6. Conclusions

Geostatistical and fractal modeling show that a direct relationship between Au mineralization and faults. The main Au anomalies with Au higher than 0.5 ppm occurred in the faults' intersections. The main directions for faults and Au mineralization is similar based on rose diagram, anisotropic ellipsoid and variography which reveal that the main direction for faults is high values of length in the anisotropic ellipsoid. Moreover, results obtained by the geostatistical and fractal modeling show that there is main Au prospects in the eastern and western parts of the area.

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