Separating geochemical anomalies by applying fractal concentration-area method, Case study: Kerver porphyry system, SE Iran

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Abstract

Nowadays, one of modern technique for separating anomalies from background is fractal methods and Concentration-area (C-A) fractal method is very useful and high level confidence for separating of geochemical populations. In this study, background and anomalies were separated for Cu and Mo in Kerver porphyry system situated in Kerman province, SE Iran. First, 393 lithogeochemical samples were collected from the area and these were chemical analysis. Also, elemental thresholds were calculated by general statistical methods. Next, the area was gridded and elemental grades evaluated by IDS method. In this stage, RockWorks v. 2006 was used for this process. Then, Concentration-area logarithmic diagrams were drawn for these elements and geochemical populations were separated. In Kerver area, several anomalies at the local scale were identified for Cu (282 ppm) and Mo (21 ppm) by C-A method. But high intensity anomalies thresholds for Cu and Mo are 891 ppm and 63 ppm, relatively. Finally, elemental distribution maps were drawn in the area and their results were comprised by classical statistics and coefficient correlations. The comparison shows that fractal concentration-area model is better than classical statistics. Also, results from usage of fractal concentration-area method shows there are a high potential for a Cu-Mo porphyry system, especially for Cu.

Keywords: *Geochemical anomaly, Concentration-area Fractal method, Kerver porphyry system, Iran*

INTRODUCTION

Separation of background and anomalies is a fundamental issue in exploration geochemistry. For the past years, the traditional statistical methods assumed that the concentration of chemical elements in the crust follows a normal or log-normal distribution (Li et al., 2003). It is well known that geochemical data are characterized by their spatial positions, which means that the elemental concentration varies spatially. However, the traditional methods emphasize only the frequency distribution of the element concentration, but ignore spatial variability, especially the information about the spatial correlation. Also, data needs to changes in traditional methods such as rejection of outliers data and normalize data. In addition to geological and geochemical environments were not affected for separation of geochemical populations (Rafiee, 2005).

Fractal models are solving these problems. This word was coined by Benoit Mandelbrot (1983) from the latin word fractus, meaning broken, which he applied to objects that were too irregular to be described by ordinary Euclidiean geometry (Davis, 2002). Fractal theory has been applied to mineral resources prediction since the 1980s. Turcotte (1986) proposed a fractal relation between average grade and cumulative ore reserves. Meng and Zhao (1991) concluded that fractal structures exist in geological data. Cheng et all start to using fractal geometry for determination of different geochemical populations specially anomalies. Based on this, Cheng et all is innovation concentration-area model in 1994 (Cheng et al., 1994; Wei & Pengda, 2002). In this paper Cu and Mo geochemical populations are separated by C-A model and anomalies are determined in Kerver area, SE Iran.

Fractal concentration–area model

This method 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 (Goncalves et al., 2001). Cheng et al. (1994) proposed an element concentration–area (C–A) model, which was used to define the geochemical background and anomalies

$$A(\rho\leq\upsilon)\propto \rho^{-a1}\ ;\ A(\rho\geq\upsilon)\propto \rho^{-a2} \qquad (1)$$

Where $A(\rho)$ denotes the area with concentration values greater than the contour value ρ; υ represents the threshold; and a_1 and a_2 are characteristic exponents. By box-counting, one superimposes a grid with cells on a study region. The area $A(\rho)$ for a given q is equal to the number of cells (multiplied by cell area) with concentration values greater than q. Average concentration values are used for those boxes containing more than one sample (Cheng et al., 1994).

Geological setting

The Kerver area is situated in Kerman province, SE Iran. This area is located in main Iranian volcanic belt (Urumieh-Dokhtar) one of the subdivition of Zagros orogenies and product of subduction and closer of new tethys ocean (Alavi, 1994). This belt extended from NW to SE Iran. This volcanic belt is hosting all of the Iranian large porphyry copper deposits same Sarcheshmeh, Sungun, Meiduk and Darehzar (Fig. 1). The main lithological units are granodiorite, andesite porphyry, Dacite porphyry, quartz monzonite and diorite. Its alteration assemblages are quartz-sericite (phyllic), potassic, argillic, propylitic, irone oxide, quartz-magnetite vein/stockwork and silica alterations. Main types of mineralization are chalcocite, bornite, covelite, chalcopyrite, malachite and pyrite (paragenesis). Iron oxide is magnetite, limonite, jarosite and goethite. The visible copper (malachite) and iron oxide mineralization (mostly jarosite and goethite) occur in the intense zone of quartz stockworks and quartz-sericite alteration.

Geochemical anomaly separation by C-A model

This model was applied for Cu-Mo porphyry system exploration in Kerver. 393 lithogeochemical samples were collected from outcrops and lithological units. These samples analysed by ICP-MS for Cu, Mo and 41 other elements. Statistic results show that Cu and Mo means are 221 and 6.4 ppm, relatively. Their distributions are not normal. Variation between maximum and minimum for Cu and Mo are high. If median is equaled to threshold it is 185.4 ppm for Cu and 5.6 ppm for Mo.

First stage is evaluation Cu and Mo distribution in this area. For this operation RockWorks™ v. 2006 was used. The area was grided to 20×20 m^2 cells. Grade evaluation method is IDS (Inverse Distance Squared). Next stage is sorting grades and their areas. Cumulative areas for any grades and higher were calculated. Log-log plots were drawn for Cu and Mo (Fig. 2).

Area-concentration [A(ρ)] with element concentrations greater than ρ show a power-law relation. The breaks between straight-line segments on this plot and the corresponding values of ρ, have been used as cut-offs to separate geochemical values into different components, representing different causal factors, such as lithological difference and geochemical processes (e.g. mineralizing events, surficial geochemical element concentrations, surficial weathering) (Lima et al., 2003). Basis this charts Cu and Mo thresholds calculated and equal to 281 ppm and 21 ppm, relatively. There are three geochemical populations for Cu and Mo. Also, this charts shows that there are minimum 2 stages of mineralization and dispersion existence events for Cu and Mo, relatively. First event for Cu occurred in grades below 281 ppm. Second event is existence between grades 281 ppm and 891 ppm. Final event that it included major Cu mineralization occurred in grades higher than 891 ppm. Proved anomalies for Cu and Mo are 891 ppm and 63 ppm because after these cutoffs the fitted straight-lines are near to vertical. Breaks between straight-line segments and corresponding values of Cu and Mo have been used as cutoffs to reclassify cell values in the IDS interpolated maps.

Basis these results Cu and Mo grade distribution maps were drawn (Fig. 3). Most of Cu anomalies are located in southern, eastern, central and NE parts especially High intensive Cu anomalies and few parts of these are occurred in NE and eastern parts (Fig. 4). Mo anomalies were situated in central and southern parts of the area and they are small (Fig. 3). Based on these maps, potential of Cu and Mo are located in central and southern parts. Also, several intensive Cu anomalies are seen in NE part of the area (Fig. 4). By Cu and Mo anomalies situation comparing, it is determined that Cu and Mo anomalies in central and southern parts of the area are together.

Conclusions

Study on Kerver area shows the potential use of the fractal C-A model for geochemical anomaly separation as a useful tool for geochemical and mineral exploration. The advantages of the method reside essentially in its simplicity, and easy computational implementation, as well as in the possibility to compute a numerical value (the anomalous threshold) which is most useful for cross information with numerical data from other sources, especially lithogeochemistry. The C-A model has proven useful in the definition of the Cu and Mo anomalous thresholds in Kahang area. Cu and Mo thresholds were computed 281 ppm and 21 ppm and proved anomaly cutoffs for Cu was computed 891 ppm that it shows proper potential for Cu in this area. There is a proper Cu-Mo porphyry system.

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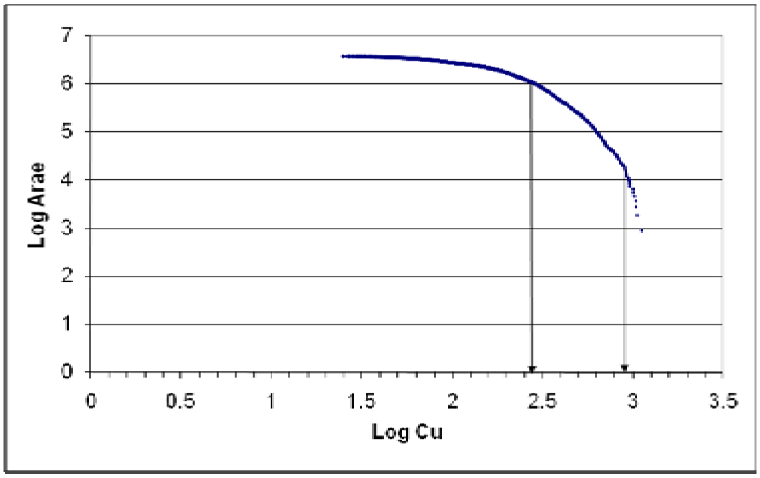
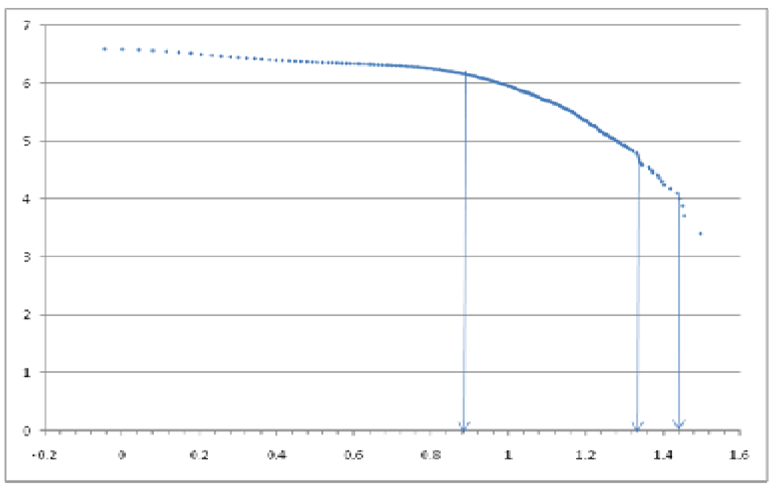
Fig. 1. Urumieh-Dokhtar volcanic belt

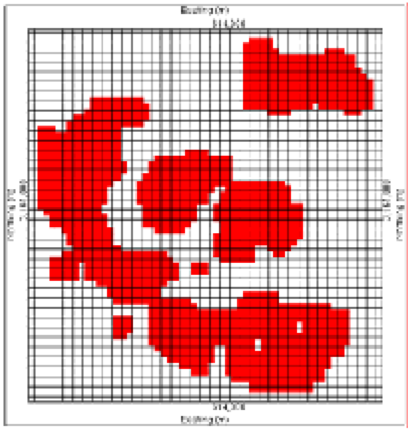


(a)

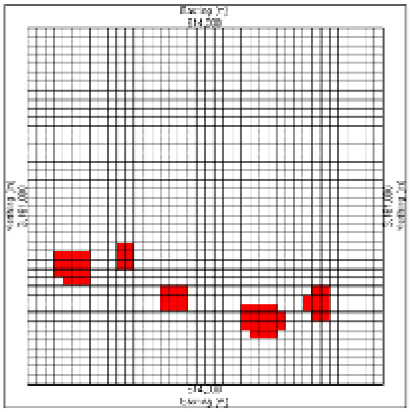


(b)

Fig. 2. Fractal concentration-area plots for Cu (a) and Mo (b). The vertical axis represents cumulative cell areas A(ρ), with element concentration values greater than ρ, and the horizontal axis the values itself (ρ).



(a)



(b)

Fig. 3. Cu (a) and Mo (b) anomalies distribution maps basis C-A model

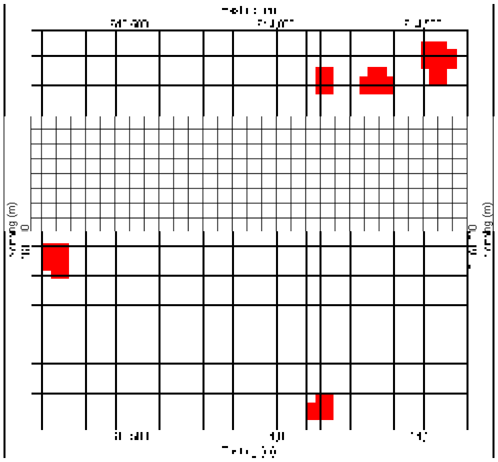


Fig. 4. Cu proved anomalies distribution maps basis C-A model