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Improvement of Power Spectrum-area Fractal Model using linear discriminant analysis in frequency domain of geochemical data

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Abstract

The methods and techniques for separation of geochemical anomaly, background and noise have been the issue of research for many years. Several people have applied the Power Spectrum-area (S-A) Fractal model to identify geochemical anomalies, background and noises. The purpose of S-A method is to divide the power spectrum (PS) values into components characterized by similar scaling properties. The high frequencies in surface geochemical distribution map are related to surface mineral deposits and geochemical noises. Very low frequencies are related to background values and very deep mineral deposits.

S-A fractal method can be used to identify the deep and blind mineral deposits. Very low frequencies in surface geochemical data that have direct relationship to high PSs can be separated using S-A fractal method. In this study, investigations have been conducted on Dalli Cu-Au porphyry deposit that is located in the central province of Iran. Three ranges and two cutoff values for PS have been identified for Cu using S-A Model. This paper introduces the combined approach of S-A fractal method and linear discriminant analysis (LDA) in frequency domain of geochemical data to improve these threshold values. The LDA is a supervised classification method, which investigates a relationship between features space and a dependent categorical class using a set of training data and be able to verify the results of cluster analysis. In this study, LDA method has been performed on the results of the S-A method then the confusion matrix has been formed and correct classification rate indexes (CCR) have been calculated in different threshold values. Then the results were compared together and the optimum threshold value between low and moderate PS values were determined. The results of S-A fractal method have been properly improved using the proposed combined method of S-A fractal and LDA.

Keywords: Power Spectrum-area Fractal, linear discriminant analysis (LDA), anomaly threshold value, frequency domain of geochemical data, 2Dimensional Fourier Transformation

Introduction

Distinguishing the blind and dispersed mineralization zones is an important issue in geochemical exploration [1]. The enrichment and depletion of elements cause the geochemical haloes of mineral deposits [2-4]. The interpretation of geochemical data in frequency domain (FD) can present new exploratory information that may not be concluded in initial data [5-7]. S-A fractal method has been applied for separation of geochemical societies in FD of geochemical data [8-18]. Zuo and Wang reviewed the fractal/multifractal models of geochemical data in spatial domain and FD [19]. Shahi et al. demonstrated that there is a relationship between the frequencies of geochemical distribution map and the depth of mineral deposit [5-7].

This paper introduces the combined approach of S-A fractal method and LDA in FD of geochemical data for optimizing the separation of PS classes.

Some researchers have utilized from FD for interpretation of geochemical data [8, 10, 15, 16, 20]. Spatial data can be transferred to the frequency domain using the 2dimensional Fourier transformation [13, 21].

The equation for conducting the Fourier transformation (FT) is [22]:

$$F(K_x, K_y) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x, y)\cos(K_x x + K_y y)dxdy$$

$$-i\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x, y)\sin(K_x x + K_y y)dxdy$$

where f(x,y) is the signal in spatial domain, Kx and Ky are “wave numbers” with respect to the x and y axes, respectively.

Therefore a function [f(x,y)] (a geochemical map) in the spatial domain can be converted into F(Kx , Ky). It consists of real and imaginary parts of R(Kx , Ky) and I(Kx , Ky). The PS is defined as bellow [23, 24]:

$$E(K_x, K_y) = R^2(K_x, K_y) + I^2(K_x, K_y)$$

Study Area:

Dalli Cu–Au porphyry deposit is located in the Central Province of Iran [25], and formed in the igneous diorite, quartz diorite porphyry and