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Detection of deep and blind mineral deposits using new proposed frequency coefficients method in frequency domain of geochemical data

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ABSTRACT

The surface geochemical data in spatial domain can be transferred to frequency domain using two-dimensional Fourier transformation. The analysis of surface geochemical data in frequency domain has been led to the exploratory information which may be not achievable in the spatial domain of geochemical data. In this research, the frequency domain of surface geochemical data has been analyzed for recognizing the complex geochemical patterns related to ore deposits. In order to predict the variations of mineralization in the depth and identifying the blind mineral deposits, the developed Frequency Coefficients Method (FCM) has been proposed and applied in hidden Zafarghand Cu–Mo porphyry deposit. This proposed approach has desirably demonstrated the relationship between different frequencies in the surface geochemical distribution map and various depths of deposits. The results, obtained from applying the proposed technique to a real scenario, reveal significant improvements, compared to the results obtained from the spatial domain of geochemical data. The introduced method as a pattern recognition technique makes possible, without exploration drilling, the determination of mineralization trends in depth and the distinction between blind mineralization and dispersed ore mineralization zones.

1. Introduction

Identification of blind ore deposits is an important issue in geochemical exploration. In general, two main approaches have been applied to detect the presence of mineral deposits near or beneath the ground surface. One approach is based on the ore deposit type and the other employs the primary geochemical haloes of the ore deposit (Carranza and Carranza and Sadeghi, 2012). A mineral deposit model provides descriptive and genetic descriptions of the essential geological, geochemical and geophysical features of a type of mineral deposit (Cox and Singer, 1986; Roberts et al., 1988). Primary haloes of mineral deposits are characterized by element/metal enrichment/depletion (e.g., Goldberg et al., 2003; Govett, 1983; Safronov, 1936) and/or mineral alterations (e.g., Bierlein et al., 1998; Hannington et al., 2003; Lovering, 1949).

Grigorian (1985, 1992) presented a zonality model in spatial domain to identify blind mineralization zones from dispersed mineralization zones. Vertical zonality of elements about certain mineral deposits has been used as guides in mineral exploration (Beus and Grigorian, 1977; Distler et al., 2004; Gundobin, 1984; Ziaii et al., 2011). The zonality method assumes a linear relationship between vertical zonality coefficients and depth of mineralization responses (Ziaii et al., 2009). In addition to the zonality method, several other methods have been proposed, and then, applied to detect hidden ore bodies in spatial domain of geochemical data based on the horizons of erosional surface (Levinson, 1980; Grigorian, 1992; Ziaii et al., 2007, 2011). Ziaii et al. (2012) separated dispersed mineralization from blind mineralization using neuro-fuzzy modeling based on genetic algorithm.

Depletion and enrichment of particular elements and their certain ratios in primary haloes of certain mineral deposits have also been used for vectoring toward ore zones (e.g., Goodell and Petersen, 1974; Jones, 1992; Pirajno and Smithies, 1992).

The geochemical interpretations have usually been carried out in spatial domain. In addition to spatial domain of geochemical data, the frequency domain of geochemical data has been used to decompose the complex geochemical patterns. The analysis of geochemical data in frequency domain can provide new exploratory information that may not be exposed in spatial domain (Shahi et al., 2014, 2015). The frequency domain of geochemical data has been used to separate the background from anomalous factors. Power spectrum-area (S–A) fractal method has been applied for separation of geochemical patterns on the basis of distinct self-similarity in frequency domain of geochemical data (Afzal et al., 2012, 2013; Cao and Cheng, 2012; Cheng and Zhao, 2011; Zuo, 2011a, 2011b; Hassani et al., 2009; Cheng et al., 2000; Cheng, 1999; Zuo et al., 2012, 2013). The S–A fractal model can decompose the complex geochemical patterns into anomaly and background (Cheng, 1999). Zuo and Wang (2015) reviewed the fractal/multifractal models

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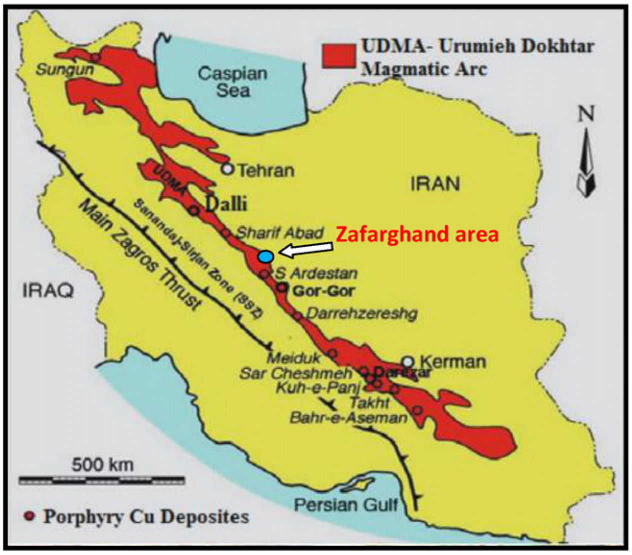

Fig. 1. Location of Zafarghand and other property Cu properties at UDMA.

of geochemical data in spatial and frequency domains (e.g. S–A) and discussed about their benefits and limitations, their applications and the relationships between these models. Wang and Zuo (2015a) compared the trend surface analysis and S–A multifractal approach in decomposing mixed geochemical patterns into background and anomalous components. In S–A fractal method, a log–log plot of variations of power spectrum values and their areas enclosed is obtained. Subsequently, the number of straight lines is fitted to the data using the least squares method. Therefore the power spectrum values are classified using these straight lines. The low power spectrum values are generally related to anomaly areas and the high power spectrum values in the right-hand line represent the low-frequency background component which maybe is related to favorable rock types. The anomaly map and background map are obtained by using inverse Fourier transformation to convert these ranges of power spectrum back to the spatial domain (Cao and Cheng, 2012; Cheng and Zhao, 2011; Zuo, 2011a, 2011b; Hassani et al., 2009; Cheng et al., 2000; Cheng, 1999; Zuo et al., 2012, 2013). Wang and Zuo (2015b) presented a Matlab-based program for processing geochemical data by means of fractal/multifractal method in spatial and frequency domains.

Shahi et al. (2014) demonstrated the relationship between high and low frequencies of mineralization elements in frequency domain of surface geochemical data and depths of mineral deposit. The geochemical haloes of mineral deposits at different depths affect different frequency distribution of elements (FDEs) in the surface. The very low frequencies are related to background values and deep mineral deposits, while the high frequencies are related to surface mineral deposits and geochemical noises (Shahi et al., 2014). In this research, to identify deep and blind mineral deposits, a new developed approach based on frequency domain of surface geochemical data, named frequency coefficients method (FCM), has been proposed. The zonality method can be used

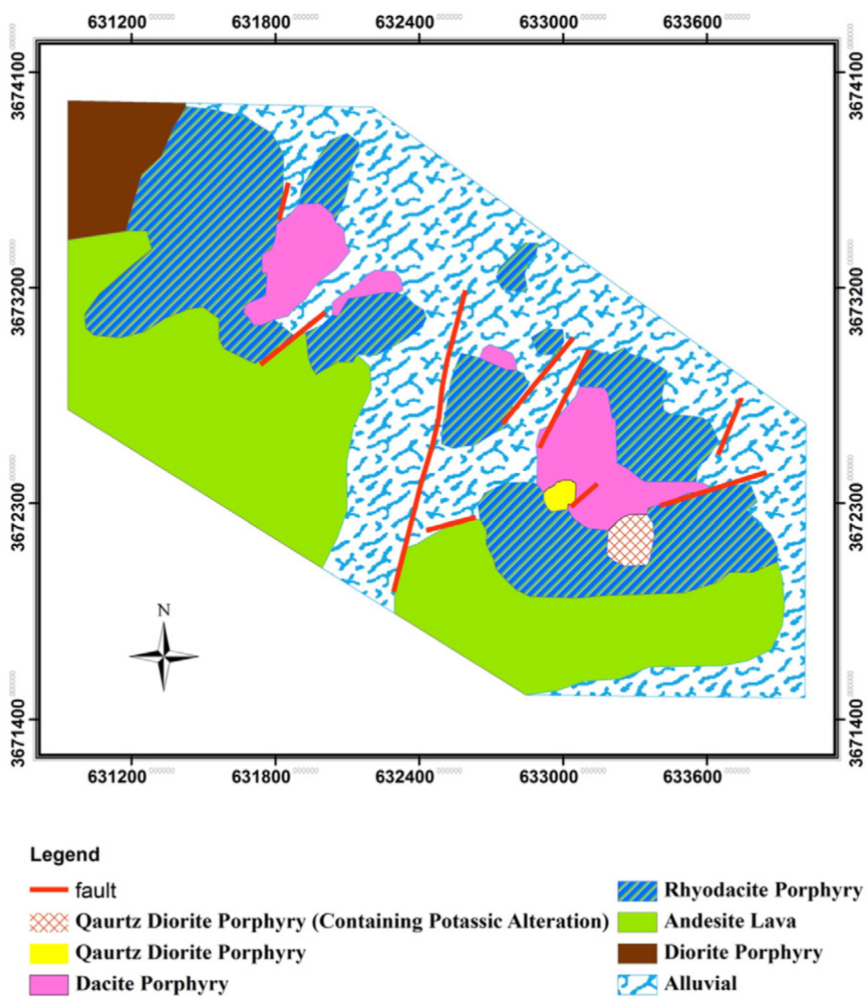

Fig. 2. Geological map of Zafarghand area (scale 1:5000).