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Delineation of geochemical anomalies based on stream sediment data utilizing fractal modeling and staged factor analysis

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ABSTRACT

Recognition of significant geochemical signatures and separation of geochemical anomalies from background are critical issues in interpretation of stream sediment data to define exploration targets. In this paper, we used staged factor analysis in conjunction with the concentration-number (C–N) fractal model to generate exploration targets for prospecting Cr and Fe mineralization in Balvard area, SE Iran. The results show coexistence of derived multi-element geochemical signatures of the deposit-type sought and ultramafic-mafic rocks in the NE and northern parts of the study area indicating significant chromite and iron ore prospects. In this regard, application of staged factor analysis and fractal modeling resulted in recognition of significant multi-element signatures that have a high spatial association with host lithological units of the deposit-type sought, and therefore, the generated targets are reliable for further prospecting of the deposit in the study area.

1. Introduction

Separation of geochemical anomalies from background is fundamentally important in geochemical exploration especially in prospecting. Analyses of stream sediment data can reveal various geochemical populations, some of which can be considered as surficial geochemical signature of the deposit-type sought. Conventional methods consist of statistical methods such as histogram, median, summation of mean and standard deviation and box-plots have been utilized for the purpose of geochemical delineations (Hawkes and Webb, 1979; Davis, 2002; Yasrebi et al., 2013; Mokhtari et al., 2014, 2015). Furthermore, analysis of spatial distribution of geochemical data is crucial for delineation of geochemical populations however; it is not taken into consideration for statistical methods (Bai et al., 2010).

Factor analysis, as one of the multivariate analysis methods, has been widely used for interpretation of geochemical data especially for stream sediment data (Borovec, 1996; Helvoort et al., 2005; Reimann et al., 2002; Grunsky et al., 2009; Sun et al., 2009; Yousefi et al., 2012, 2014). The principal purpose of factor analysis is to describe the variations in multivariate dataset by as few factors as possible (Johnson and Wichern, 2002; Krumbein and Graybill, 1965; Tripathi, 1979). Factor analysis is an appropriate method to recognize the variability inherent in a geochemical dataset. Geochemical dataset including lithogeochemical, stream sediments, and in situ soil have a multifractal nature which can show the differences in geological settings such as lithological units, alterations, mineralization, and geochemical processes. Factor analysis, by combining several correlated variables into a single variable (i.e., factor), can reduce the dimensionality of datasets into uncorrelated principal components based on covariance or correlation matrix of variables (Cheng et al., 1994). Consequently, the factors indicate the geological and mineralization processes via correlation among elemental concentration in this scenario (Johnson and Wichern, 2002; Krumbein and Graybill, 1965; Tripathi, 1979; Zuo, 2011a). Complexities of geological processes (McCuaig et al., 2010; Ford and Blenkinsop, 2008) affect the dispersion patterns

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of geochemical elements, and so, the results of factor analysis (Yousefi et al., 2012; Parsa et al., 2016). Consequently, as Yousefi et al. (2014) mentioned, the results of factor analysis carry geochemical noises because of its mathematical basis. To modulate the effect of noisy element and for improved identification of significant anomalous geochemical signature of the deposit-type sought, Yousefi et al. (2012, 2014) proposed staged factor analysis. By using staged factor analysis, non-indicator elements are identified and removed from the analysis until a clean multi-element signature, with decreasing destructive effect of noisy elements, is obtained (Yousefi et al., 2012, 2014). Hence, in the results of staged factor analysis reliable factor scores (FSs) are obtained, and samples with high FSs values of the factors can be used as indicator factors based on geochemical criteria to prospect a deposit-type sought.

After recognizing significant geochemical signatures, separation

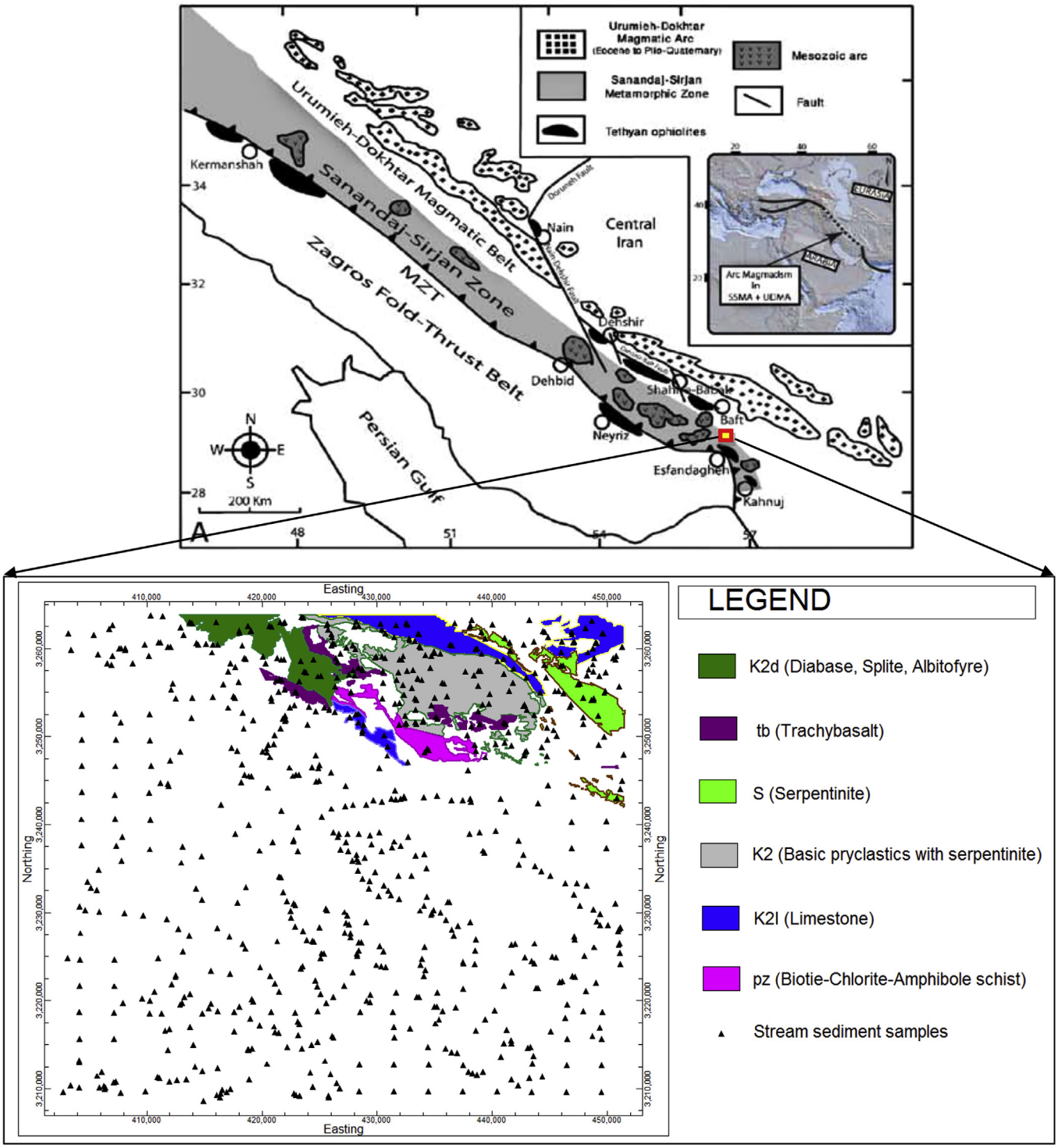

Fig. 1. Simplified Geological map of Balvard 1:100,000 sheet within sample locations the Nain-Baft ophiolites in the structural-metamorphic Sanandaj–Sirjan zone (Shafaii Moghadam et al., 2009; Sepahi et al., 2009).