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Reprint of "Identification of weak anomalies: A multifractal perspective"☆

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ABSTRACT

Attention has increasingly been focused on weak geochemical anomalies. In this paper, the singularity mapping technique, a powerful multifractal tool to identify weak anomalies, is presented. The original algorithm for estimation of the singularity index could not directly process the data containing negative values, and the resulting singularity index is influenced by the background value. A modified algorithm for estimation of the singularity index is introduced to overcome these shortcomings, and a Matlab program is coded for estimation of the singularity index, using both the original and modified algorithms. The advantage of the modified algorithm is demonstrated using a case study from Chaobuleng Fe polymetallic district, covered with grassland, in Inner Mongolia of northern China.

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1. Introduction

A number of mineral deposits have been discovered through processing geochemical exploration data to identify geochemical anomalies. These geochemical anomalies – linked to high element concentrations, large size, and marked coincidence of element assemblages – have been preferentially evaluated for over 30 years in China. Attention has increasingly been focused on the weak geochemical anomalies (e.g., Cheng, 2012).

Up to now, there is no explicit definition for the concept of weak anomalies. 'Weak', in general, is a relative term compared with the 'strong' or 'high' value. In the field of applied geochemistry, weak anomalies could represent anomalous areas linked to a low magnitude concentration value compared with the background value. Weak anomalies can occur within areas linked to either a high or low background value. Two types of weak anomalies can be recognised: Type I representing the anomalous areas having a low background value, and Type II the anomalous areas characterised with a high background value. Fig. 1 illustrates simulated simple patterns. The left two patterns denote high (Fig. 1a) and weak (Fig. 1c) (Type II) anomalies occurring within a high background. The right two patterns represent high (Fig. 1b) and weak (Fig. 1d) (Type I) anomalies occurring within a weak background.

A threshold was used to identify the anomalies that effectively signify a specific value separating high and low data values of fundamentally different characters reflecting different causes (Sinclair, 1974, 1976, 1991). The areas with concentration values greater than the threshold are defined as anomalies and areas with smaller concentration values are defined as background. Various methods, ranging from frequency-based to spatial frequency-based models can be applied to determine the threshold (Lepeltier, 1969; Sinclair, 1991; Tennant and White, 1959; Zuo et al., 2013a). The traditional method involving the estimation of the mean and standard deviation of a data set with an arbitrary choice of a threshold at a value corresponding to the mean plus two standard deviations is a widely used frequency-based method, which does not take into account the compositional nature of geochemical data (Aitchison, 1986; Filzmoser and Hron, 2008; Filzmoser et al., 2009, 2010; Reimann et al., 2012; Zuo, 2014a, 2014c; Zuo et al., 2013a). The method also does not adequately take into account the fact that anomalous and background populations have fairly extensive ranges of overlap in some cases. Moreover, as they are at least two statistical populations, the mean and standard deviation derived from the whole data set do not really have a statistical validity and are just numbers (Reimann et al., 2012; Sinclair, 1974). When this method was applied to Fig. 1, only high anomalies (Fig. 1a) occurring within the high background could be identified. In addition, the frequency-based methods do not incorporate the spatial variation of a geochemical field, which is a typical feature of geochemical variables (Zuo et al., 2013a).

The recent advances for identification of weak geochemical anomalies refers to singularity mapping technique proposed by Cheng (2007), and has been demonstrated as a powerful multifractal tool to recognise the weak geochemical anomalies in complex geological settings or in overburden covered areas (e.g., Agterberg, 2012; Arias et al., 2012; Bai et al., 2010; Chen et al., 2013; Cheng, 2007; Cheng and

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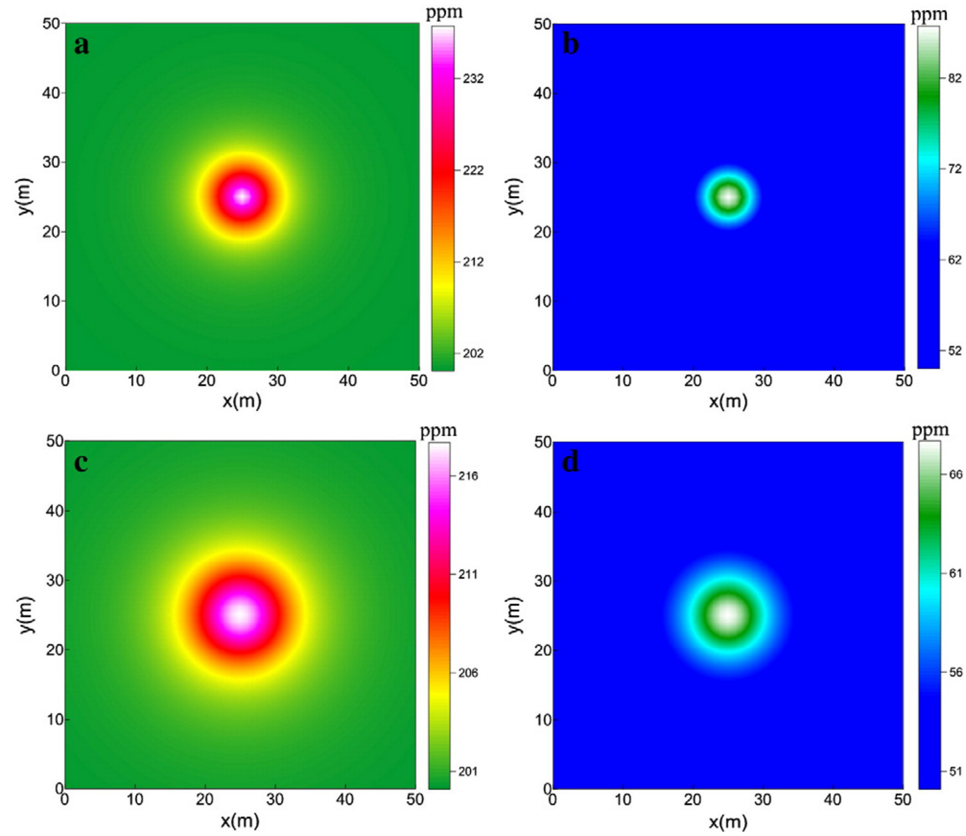

Fig. 1. Illustration for simulated simple patterns. The left two patterns denote high (Fig. 1a) and weak (Fig. 1c) geochemical anomalies occurring within a high background. The right two patterns represent high (Fig. 1b) and weak (Fig. 1d) anomalies occurring within a weak background.

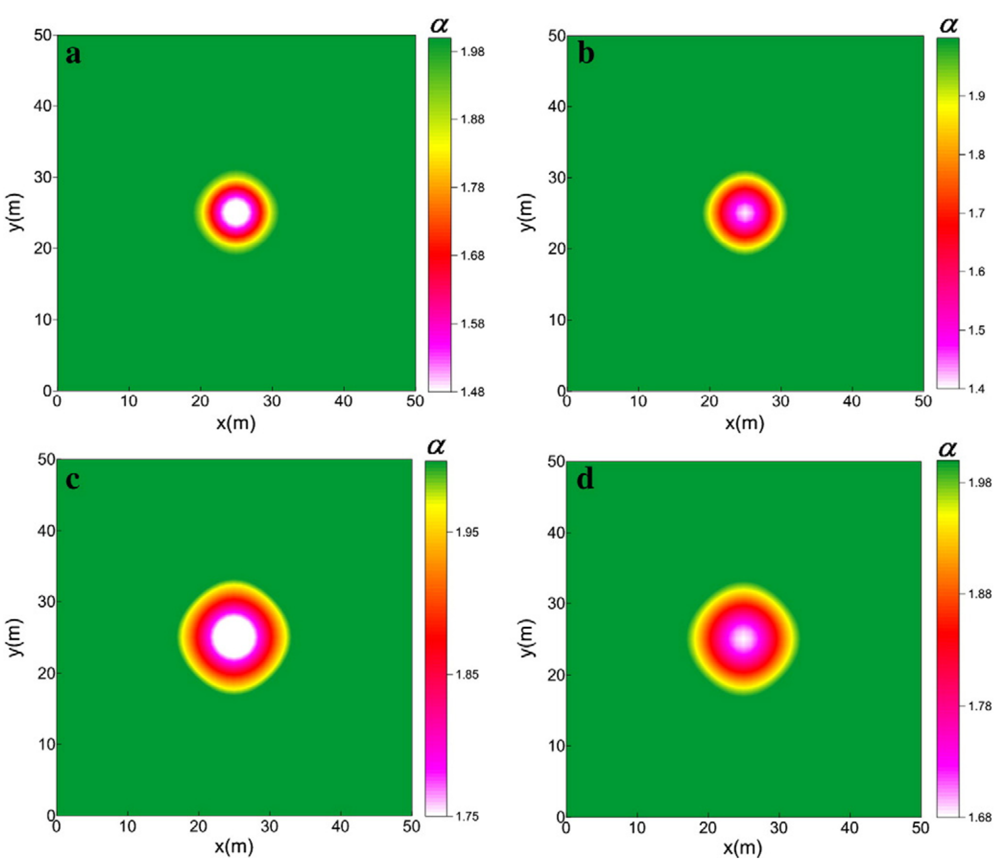

Fig. 2. Maps of singularity index maps of Fig. 1.

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