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Exploring the effects of cell size in geochemical mapping

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ABSTRACT

One ore-forming element (Cu) and one rock-forming element (SiO_2) from stream sediment dataset in Tibet (China) are selected to explore the effects of cell size in geochemical mapping using fractal and multifractal models. Five raster maps for Cu and SiO_2 are obtained by the IDW method with the cell sizes of 300 m, 500 m, 700 m, 900 m, and 1100 m. The results show that (1) whereas raster maps interpolated at different cell sizes have average and standard deviation values similar to those of the original data, their maximum values are lower and their minimum values are higher, indicating that the cell size slightly affects the concentration frequency distribution of geochemical patterns, and that the IDW method smoothens the original data to some extent; (2) the mean absolute error increases as the cell size increases, indicating that the cell size affects the accuracy of prediction; (3) the spatial patterns obtained with different cell sizes have different textures as indicated by different values of multifractal parameters, implying that the cell size affects the spatial texture of geochemical patterns; and (4) different Cu thresholds obtained by C-A fractal model indicates that the cell size slightly affects the delineation of geochemical anomalies.

1. Introduction

Geochemical mapping plays an important role both in mineral exploration and environmental studies (Grunsky et al., 2009). Geochemical point data collected from stream sediments, lake sediments, soils and rocks are significant for finding undiscovered mineral deposits and monitoring environmental changes. Interpolating a point dataset to raster maps is a routine work in geochemical mapping using interpolation techniques such as inverse distance weighted (IDW), kriging, and spline.

IDW is one of the most popular moving average interpolation techniques based on the assumption that the values of neighboring observations contribute more to interpolated values than the values of distant observations. The advantage of the IDW is that it is intuitive and its implementation is straightforward. There are three important parameters in the IDW method. The "power" controls the significance of known points on the interpolated values, based on their distance from the output point. For a higher value of power, the nearest points are emphasized and the resulting surface will have more detail. A lower value of power renders more influence to points that are farther away, resulting in a smoother surface. A power of 2 is most commonly used with the IDW. The second parameter is the search radius, which limits the number of input points that can be used for calculating each interpolated cell, and the generally defaulted number of points is 12 (ESRI, 2004; Philip and Watson, 1982; Watson and Philip, 1985). The output cell size is another important parameter in all interpolation methods. Finer cell size represents higher spatial resolution, and coarse cell size represents lower spatial resolution. The default cell size is to take the width or the height (whichever is shorter) of the extent of the feature dataset and divide by 250 (ESRI, 2004). The selection of cell size is usually based on the density of sampling or mapping scale, or the structure of point pattern (Hengl, 2006, see the Section 4). The interpolation with different cell sizes may result in different concentration frequency distributions and different textures of geochemical patterns. In practice, it is difficult to determine the suitable cell size in geochemical mapping, and the effects of cell size on the structure of in the geochemical mapping and the determination of the thresholds are seldom addressed. In this paper, the effects of cell size in geochemical mapping are explored using multifractal and fractal models.

2. Multifractal model

Mandelbrot (1982) proposed the term fractal to describe a pattern consisting of parts (e.g., fractions) that have geometries (e.g., shape or form), except scale or size, that are more or less similar to the whole pattern. Multifractals are spatially intertwined fractals with a continuous spectrum of fractal dimensions (Cheng and Agterberg, 1996). In the past two decades, several fractal and multifractal models supported by Geographic Information System (GIS) techniques are developed to identify geochemical anomalies and to determine geochemical baselines. Examples include Concentration-Area model (C-A: Cheng et al., 1994), Spectrum-Area model (S-A: Cheng et al., 2000), Concentration-Distance model (C-D: Li et al., 2003), singularity index (Cheng, 2007),

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and Concentration-Volume model (C-V: Afzal et al., 2011). These models have been illustrated to be powerful tools to identify geochemical anomalies (e.g., Afzal et al., 2010; Carranza, 2008, 2009, 2010; Cheng et al., 2010; Deng et al., 2009, 2010, 2011; Q. Wang et al., 2011; X. Wang et al., 2011; Zuo, 2011a, 2011b; Zuo and Cheng, 2008; Zuo and Xia, 2009; Zuo et al., 2009) and to determine geochemical baselines (e.g., Cicchella et al., 2005; Lima et al., 2003, 2008).

The basic concepts involved in a multifractal model include a partition function $\chi_q(\varepsilon)$, mass exponent $\tau(q)$, singularity exponent $a(q)$ and multifractal spectrum $f(a)$. Let $\mu_i(\varepsilon)$ be the total amount of a

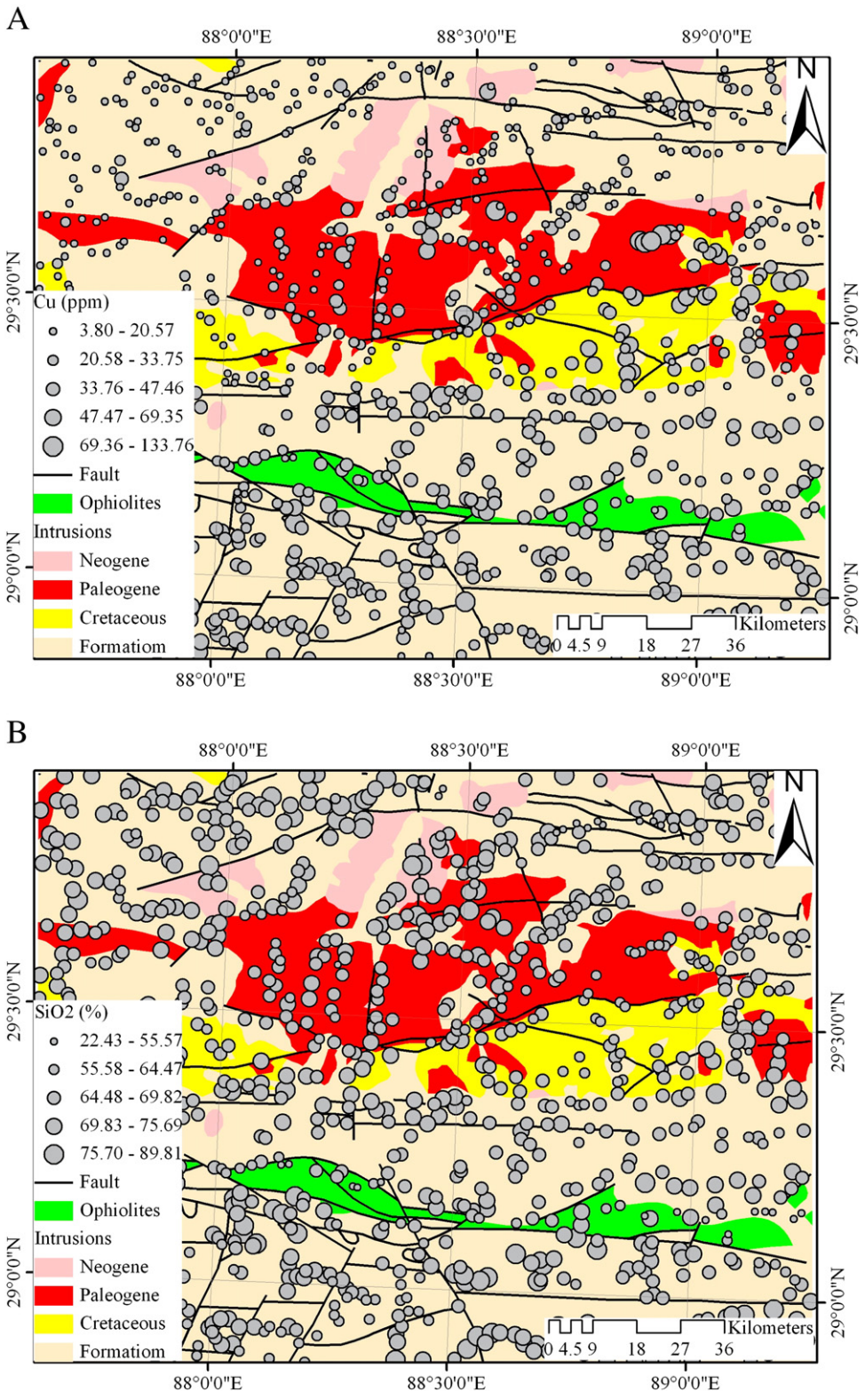

Fig. 1. Simplified geological map (after Chinese Geological Survey (CGS), 2001) and location map of stream sediment point samples for Cu (A) and SiO_2 (B).