Application of Multi-fractal Filtering in Geochemical Data Decomposing — A case study from the south region of “Sanjiang ore-forming belt”, South-western China

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ABSTRACT

The south region of “Sanjiang” ore-forming belt, South-western China, is located at the joined belt between the Indian plate and Yangtze plate, and is an important region of eastern Tethyan tectonic ore-forming domain. Multi-periods of tectonic-magmatic activities and ore-forming processes write complicated geochemical records. It is a difficult subject to decompose geochemical data from stream sediment into background and anomaly. In case study, Multi-fractal filtering (S-A) is used to separate Cu anomaly from background based on Cu data from stream sediment survey. Conclusions are as follows: (a) The multi-fractal filtering (S-A) can effectively decompose the Cu concentration data from stream sediment survey into regional backgrounds, local backgrounds and anomalies; (b) The regional background of Cu mineralization originates from the volcanic geological processes, and the local background of that does from the tectonic intrusive processes controlled by the fractures of both NW and NE trends. The majority of Cu anomalies are associated with the hydrothermal mineralization caused by magmatic activities in the study area; (c) Not all element concentration data from stream sediment survey can be effectively decomposed into background and anomaly by the multi-fractal filtering method (S-A). For example Pb and Ag anomalies can’ t be effectively separated from their background in this study, which is a subject to be explored further.

INTRODUCTION

Regional geochemical data such as that from stream sediments can be usually expressed as

$$T(x, y)=B_0(x, y)+B_1(x, y)+A(x, y) \qquad (1)$$

Where T(x, y) represents the bulk concentration measured at location (x, y) in an area, the component B_0(x, y) reflects regional scale rock-forming processes: i.e. depositional and volcanic processes. B_1(x, y) reflects regional tectonic-intrusive process. A(x, y) reflects the anomaly associated with ore-forming process. There are a number of methods of decomposing T into B_0, B_1, and A. In this case, the fractal filter method is applied to separate Cu geochemical anomalies from background in the south region of “Sanjiang ore-forming belt ”, South-western China. The dataset of Cu, utilizing stream sediment samples mapped at scale 1:200000, analyzed by ICP-AES, is provided by the Center for Geomatics of Yunnan province.

The south region of “Sanjiang” ore-forming belt, South-western China, is located at the joined belt between the Indian plate and Yangtze plate; and is an important region of eastern Tethyan tectonic ore-forming domain. There are numerous base metal deposits and precious metal deposits, including a few world-class deposits such as the Pulang porphyry Cu deposit, the Jinding Pb-Zn deposit and the Laowangzhai Au deposit within the region (Fig.1). The complexity of geological background and the diversity of ore-forming processes caused by the multi-cyclic tectonic-magmatic activities makes it difficult to extract geochemical anomalies related to mineralization from their multi-population of geochemical background using conventional methods such as Geostatistics(Chen, 2006). For solving this problem the Multi-Fractal Filtering (S-A methods) are introduced in this study.

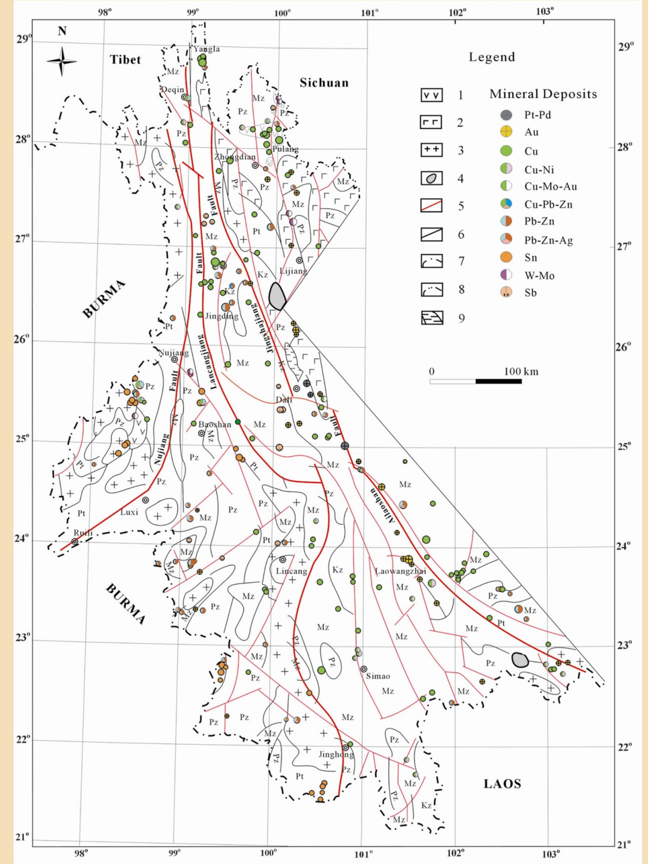

Fig.1. Geological map and the distribution of the known mineral deposits in south area of “the Sanjing” region, the southwestern China. Kz-Cenozoic clastic rock and some volcanic rock; Mz-Mesozoic clastic rock, limestone and some volcanic rock; Pz-Palaeozoic limestone, dolomite, clastic rock and some volcanic rock; Pt-Proterozoic metamorphic rock; 1-Tertiary andesite; 2-Permian basalt; 3-Granitic rock; 4-Basic rock; 5-Fault; 6-Geological boundary; 7-International boundary; 8-Province boundary; 9-Lake.

OUTLINE OF FRACTAL FILTERING METHOD (S-A)

In addition to the spatial feature of element concentration anomaly, the frequency feature of the element concentration anomaly caused by different geological processes may be useful for anomaly identification (Chork and Mazzucchelli ,1989). For example, the geochemical pattern in spatial domain caused by rock-forming process commonly represents low frequency feature in frequency domain. The geochemical pattern related to ore-forming process commonly represents high frequency feature, and the geochemical pattern associated with tectonic-intrusive process commonly represent intermediate frequency feature. Fourier transformation can convert element concentration in spatial domain into its spectrum energy density in frequency domain where the geochemical patterns with different frequencies can be identified. The geochemical patterns with certain ranges of frequencies in frequency domain can be converted back to corresponding patterns reflecting regional background, local background and anomalies in spatial domain by inverse Fourier transformation (Cheng, Xu, and Grunsky, 2000).

The S-A method developed by Cheng, Xu, and Grunsky (2000) constructs fractal filters on the basis of distinct power-laws determined by fitting different relations.

$$A(>S)\propto S^{-\beta} \qquad (2)$$

Where S represents spectrum energy density, A represents the area that its spectrum energy density is greater than S_0 (threshold). Different value of β can be obtained on log $A(>S_0)$—log(S), which depends on filter types. Generally, all straight-line segments can be fitted to the relation (2) on log $A(>S_0)$—log(S). Different straight-line segment represents different fractal relation, yielding a cross point of two adjacent straight-line segments which can be used as a threshold in constructing different types of filters to separate background and anomaly. These background and anomaly obtained in frequency domain on the above mentioned filters can be transformed back into the corresponding components in the spatial domain by means of the Inverse Fourier Transformation. The method can be implemented by GeoDAS software (Cheng, 2002) and MORPAS3.0 software (Chen, 2006).

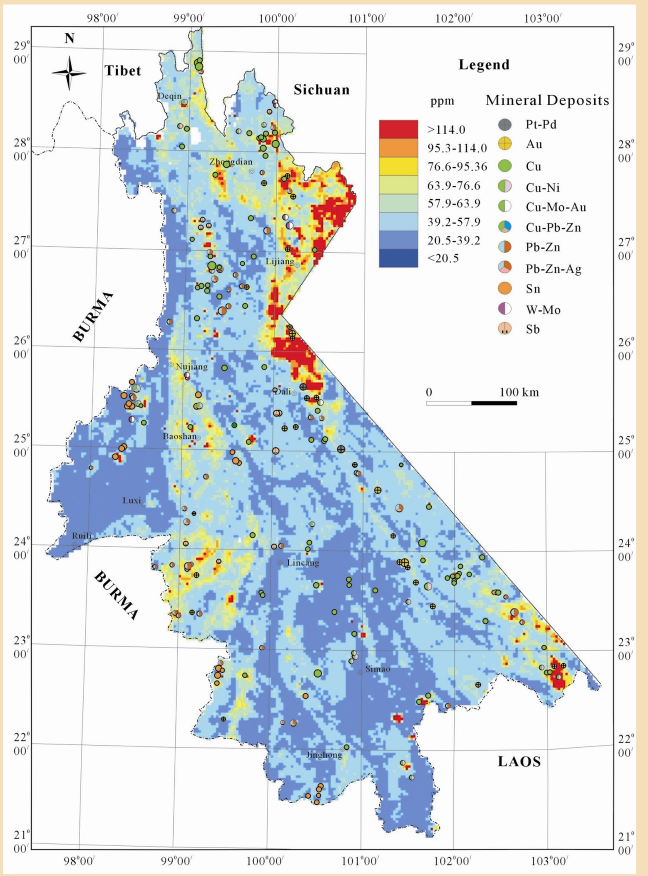

Fig.2. Cu original concentration map

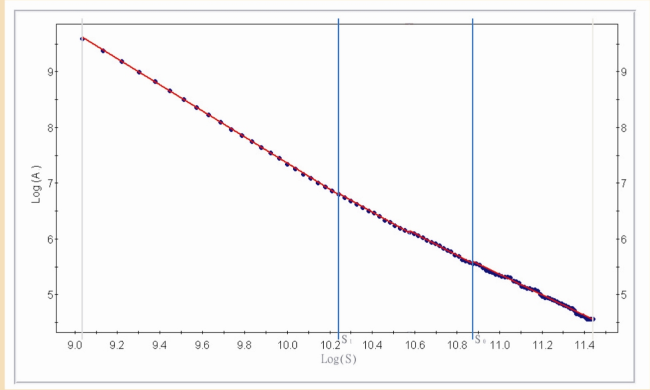

Fig.3. Ln-ln plot showing the relationships between power spectrum value S and “area” A(>S) on Cu spectrum energy density. Three straight line segments were fitted using LS. Two breaks obtained are LnS_0=10.87 and LnS_1=10.23, respectively.

GEOCHEMISTRY DATA DECOMPOSITION

Cu original concentration map is illustrated in Fig.2, which shows that almost all high Cu concentrations are distributed in basalt areas. The average Cu concentration in basalt is up to 196 ppm, which is 2.5 times of that of the world basalt. However, the average Cu concentration in sediment rocks in the study area is extremely low, only 25 ppm (Chen, 2003, 2005). Therefore the S-A method is introduced to decompose background and anomaly of Cu.

The log A (>S)—log (S) is illustrated in Fig. 3. Two thresholds, 10.87 (S_0) and 10.23 (S_1), are obtained respectively, based on which three types of filters can be constructed as follow: the first filter is defined as G_{B0} (ω) =1 if S (ω) >S_0, otherwise, G_{B0} (ω) = 0; the second one as G_{B1} (ω)=1 if S_1<S (ω) <S_0, otherwise, G_{B1} (ω) = 0; the third one as G_A (ω) = 1 if S (ω) <S_1 , otherwise, G_A (ω) = 0. They can correspond to the regional background filter, the local background filter and the anomaly filter, respectively.

Maps showing regional background, local background and anomalies of Cu, obtained using the S-A method, are illustrated in Fig.4, 5, and 6, respectively. Fig.4, combined with Fig.1, shows that the high regional backgrounds of Cu well coincide with the volcanic rock series, which may imply that regional volcanic processes construct the favorable geological background for Cu mineralization. In the study area, the spatial distribution of high backgroundof Cu is controlled by both the Nujiang fault of SN trend (the western part of the study area) and the Ailaoshan-Jinshajiang fault of NW trend (the eastern part of the study area). As is shown in Fig.5, most of the high local backgrounds of Cu are spatially associated with intrusive complexes. The majority of those intrusive complexes with obvious magnetic anomalies are concealed and located at the crossing area controlled by faults of both NW and NE trends (Chen and Xia et al, 2007). Most of the Cu anomalies are associated with the known Cu deposits (Fig.6), which may imply that the Cu anomalies can be defined as the target areas for searching for new Cu deposits.

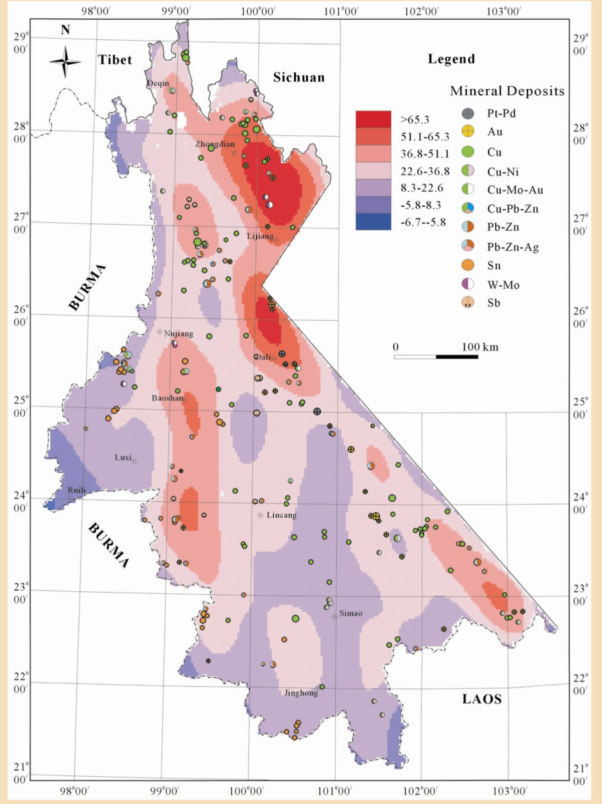

Fig.4. Regional background component of Cu decomposed from the Cu power spectrum density using IFT with regional background filter as defined in Fig.3

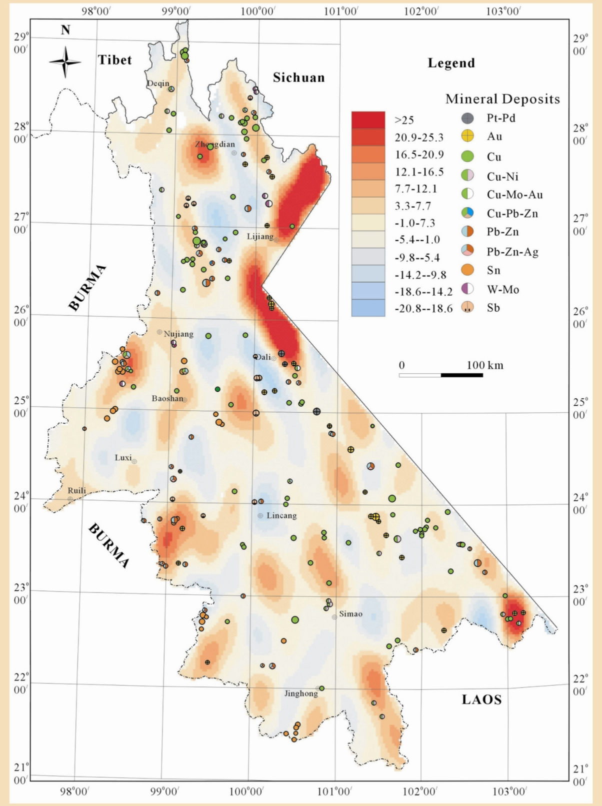

Fig.5. Local background component of Cu decomposed from the Cu power spectrum density using IFT with local background filter as defined in Fig.3

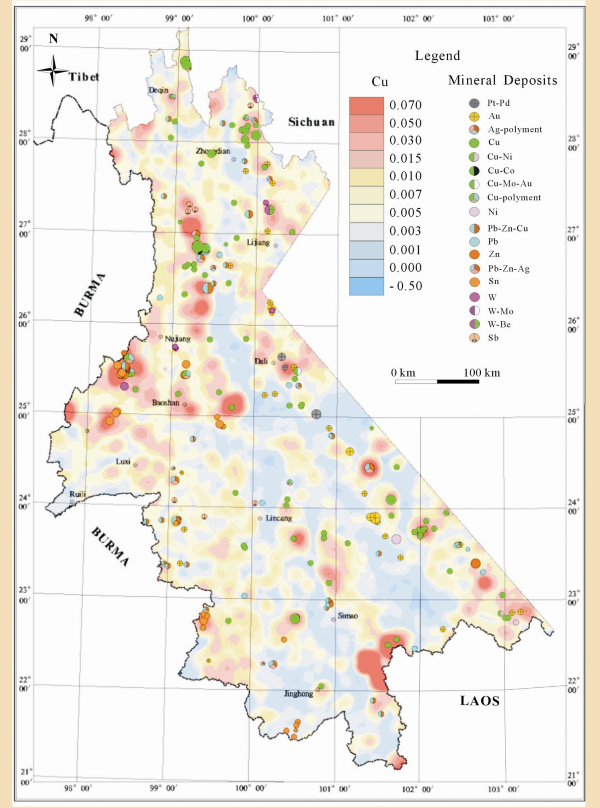

Fig.6. Anomaly component of Cu decomposed from the Cu power spectrum density using IFT with anomaly filter as defined in Fig.3

CONCLUSIONS

The above mentioned research results show the followings: (a) the multi-fractal filtering (S-A) can effectively decompose the Cu concentration data from stream sediment survey in complicated geological setting into regional backgrounds, local backgrounds and anomalies;(b) The favorable regional background of Cu mineralization originates from the volcanic geological processes, the favorable local background of Cu mineralization does from the tectonic intrusive processes controlled by the fractures of both NW and NE trends. The majority of Cu anomalies are associated with the hydrothermal Cu mineralization caused by magmatic activities in the study area; (c) Not all element concentration data from stream sediment survey can be effectively decomposed into background and anomaly by the multi-fractal filtering method (S-A). For example Pb and Ag anomalies can’ t be effectively separated from their background in this study, which is a subject to be explored further.

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