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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Application of fractal models to delineate mineralized zones in the Pulang porphyry copper deposit, Yunnan, Southwest China" *by* Xiaochen Wang et al.

Xiaochen Wang et al.

qlxia@cug.edu.cn

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1. We check the Cu data distribution of Pulang deposit. And the distribution of Cu data is log-normal. So we make a logarithmic transformation for the original data (Fig. 1). We revise the statistical results.The experimental semi–variogram of Cu data of Pulang deposit indicates a range and nugget effect of 320.0 m and 0.25, seperately(Fig. 2).

2. The 3D model of the distribution of Cu in the Pulang porphyry copper deposit was generated with ordinary kriging using the Datamine software. Fundamentally, the accuracy of the interpolation results mainly depends on whether the interpolation model could well fit the spatial distribution characteristics of the deposit. The original drill-

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hole data of ore element concentrations were interpolated by using the ordinary kriging method to calculate the V($\leq \upsilon$) and V($\geq \upsilon$) enclosed by a concentration contour in a 3D model in this study. The method estimates values in un-sampled locations based on moving average of the variable of interest satisfying different dispersion forms of data. It is a spatial estimation method that provides a minimum error-variance estimate of any unsampled value. The correct variogram in kriging interpolation can guarantee the accuracy of the interpolation results. The accuracy of the spatial interpolation analysis is verified by comparing the difference between the measured values and the predicted values, so as to select the best variogram model. In order to test the variogram model, the cross-validation method was used to determine whether the parameters of the variogram model are correct(Fig. 3). The distribution of the residual is normal and the mean of error between the actual and estimated Cu grade values is equal to 0. It indicates that this model is reasonable, and the variogram parameters are unbiased for estimating the Cu grade.

3. In the many cases, drillcore logging in the field is dealing with the lack of proper diagnosis of geological phenomenon and it can undermine delineation of mineralized zones because it depends on the interpretation of individual loggers, which is subjective and no two loggers usually have the same interpretations. However, conventional geological modeling based on drillcore data is fundamentally important for ore body spatial structure understanding and mathematical applications. Grades of the ore elements are not observed in conventional methods of geological ore modeling while the variations in ore grades in a mineral deposit is an obvious and salient feature. Given the problems as mentioned above, using a series of newly established methods based on mathematical analyses such as fractal modeling seems to be inevitable. This study utilized the concentration–volume (C–V) and power spectrum–volume (S–V) fractal models to delineate and recognize different grade Cu mineralization of Pulang copper deposit. Both the fractal models reveal high grade Cu mineralization is located at the central and southern parts of Pulang deposit. The Cu threshold of high grade mineralization is 1.88% according to C–V method. And Cu threshold of super-

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gene enrichment zones is 1.33% on the basis of S–V method. Models of moderate grade mineralization zones contain 1.38–1.88% Cu according to the C–V method. And the hypogene zones contain 0.23–1.33% Cu according to the S–V model. The C–V method shows barren host rocks include <0.25% and weak grade mineralization include 0.25–1.38% Cu. And the S–V model reveals that barren host rock and leached zone contain <0.23% Cu. Carranza (2011) has illustrated an analysis for calculation of spatial correlations between two binary especially mathematical and geological models. An intersection operation between the mineralization zones obtained from fractal models and different alteration zones in the geological model was performed to derive the amount of voxels corresponding to each of the classes of overlap zones. Using the obtained numbers of voxels, Type I error (T1E), Type II error (T2E), and overall accuracy (OA) of the fractal model were estimated with respect to different alteration zones due to geological data. And the values of OA of fractal models of mineralized zones were compared with each other. The comparison between highly mineralized zones on the basis of the fractal models and potassic zones resulted from 3D geological model illustrates that the S–V fractal model is better than the C–V model because the fact that the number of overlapped voxels (A) in the S–V model is higher than those in the C–V model. The overall accuracy values of C–V and S–V fractal models with respect to the potassic alteration zones of the geological model are 0.50 and 0.52, which illustrate that the S–V model gives better results to recognize high grade mineralization in Pulang deposit. On the other hand, correlation (from OA results) between highly mineralized zones obtained from S–V modeling and the potassic alteration zones is higher than the C–V model because of a strong proportional relationship between extension and positions of voxels in the S–V model and potassic alteration zones in the 3D geological model. Comparison between phyllic alteration zones resulted from the 3D geological model and moderate grade mineralization obtained from fractal methods indicates that OA values of C–V and S–V fractal methods in regard to phyllic alteration zones of the geological model are 0.59 and 0.56, respectively. The OA values of moderate and weak grade mineralization zones obtained from C–V model is higher than the results obtained by S–V model. On the other hand, moderately mineralized zones defined by C–V modeling have overlap with the phyllic alteration zones in the 3D geological model. However, the outcomes of the C–V model are more accurate than those of the S–V model with respect to the phyllic alteration zones in the 3D geological model. According to the correlation between results driven by fractal modeling and geological logging from drill holes in the Pulang porphyry copper deposit, high grade mineralization zones generated by fractal models, especially the S–V model, have a better correlation with potassic alteration zones resulted from the 3D geological model than the C–V model. And moderately mineralized zones correlate with phyllic alteration zones in the central and southern parts of the Pulang deposit. There is a better relationship between moderately and weakly mineralized zones derived by the C–V model and the phyllic alteration zones according to the 3D geological model than the S–V model.

4. Several samples were collected from different drill holes in different grade mineralization zones of Pulang deposit to validate the results of fractal models. They were analyzed by microscopic identification and XRF (X-ray Fluorescence Spectrometer), as depicted in Figure 4. PL-B82 sample was collected from the drill hole situated in the high grade mineralization zones. There are high chalcopyrite content and some molybdenite (Fig.14a). PL-B62 sample was collected from the drill hole situated in the moderate grade mineralization zones. There are low chalcopyrite content and some pyrrhotite content in polished section (Fig.14b). PL-B74 sample was collected from the drill hole located at the weakly mineralized zones with lower chalcopyrite content and some pyrrhotite (Fig.14c and Fig.14d). Results obtained from mineralogy, microscopic identification and drillcore scanning via XRF of these samples indicates that Cu values are 1.80%,1.32% and 0.41% in PL-B82, PL-B62 and PL-B74, respectively.

5. I have revised my manuscript. Many of the articles listed in References have been added and cited in the text. And a new revision of this manuscript has been uploaded.

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Please also note the supplement to this comment:
https://www.nonlin-processes-geophys-discuss.net/npg-2019-8/npg-2019-8-AC1-supplement.pdf

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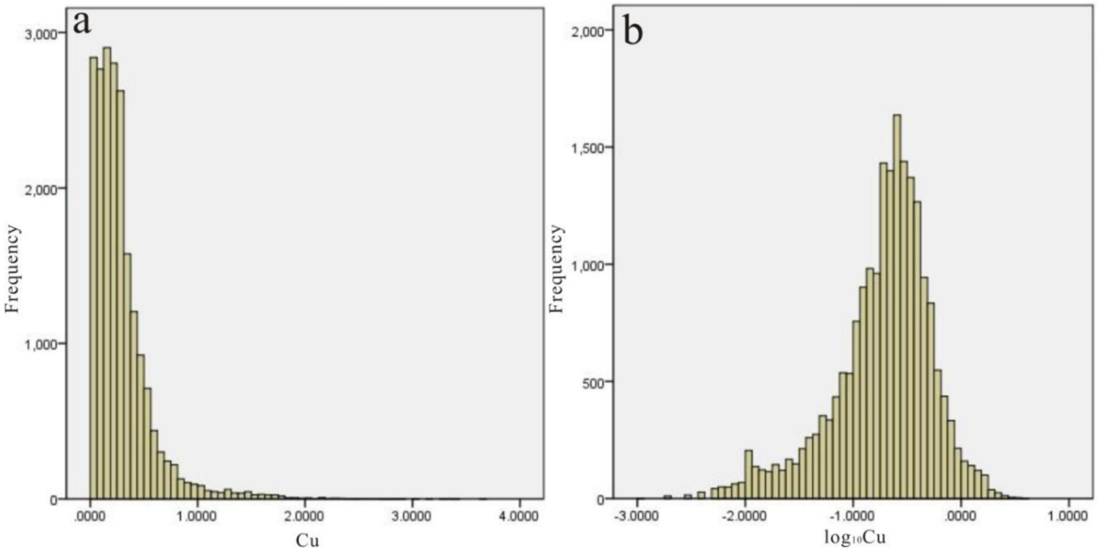

The histogram of the Cu raw (a) and logarithmic transformation (b) data.

Fig. 1. The histogram of the Cu raw (a) and logarithmic transformation (b) data.

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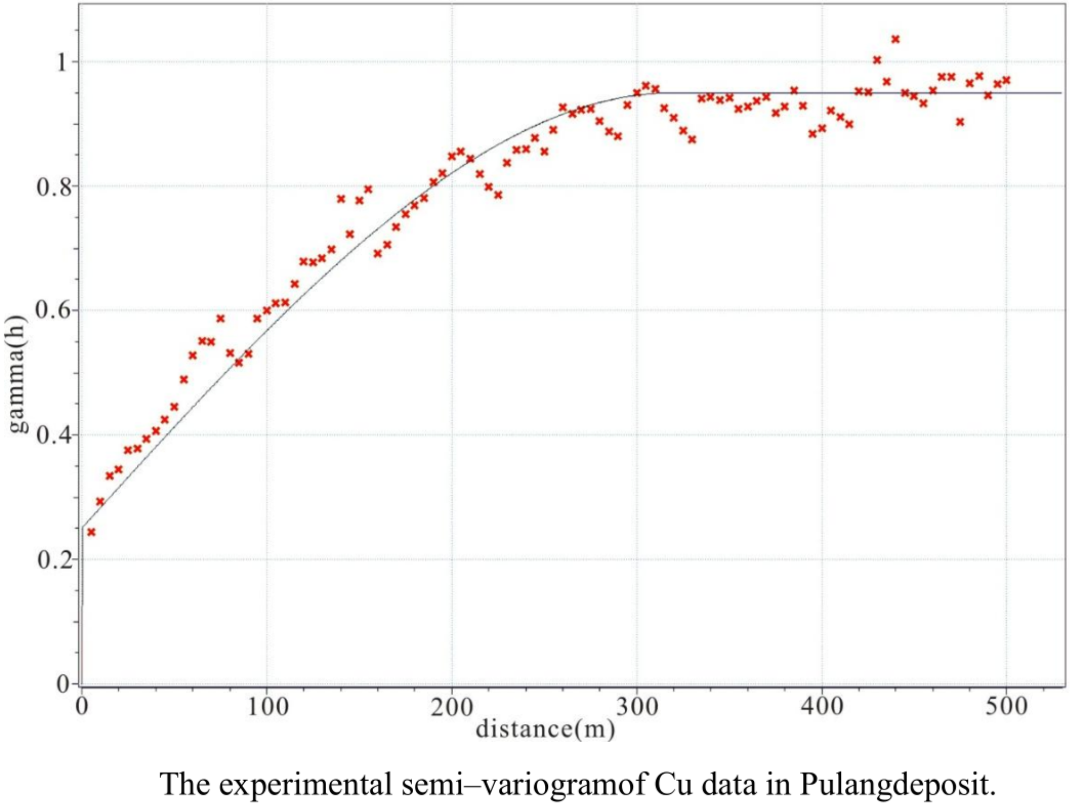

Fig. 2. The experimental semi–variogram of Cu data in Pulang deposit.

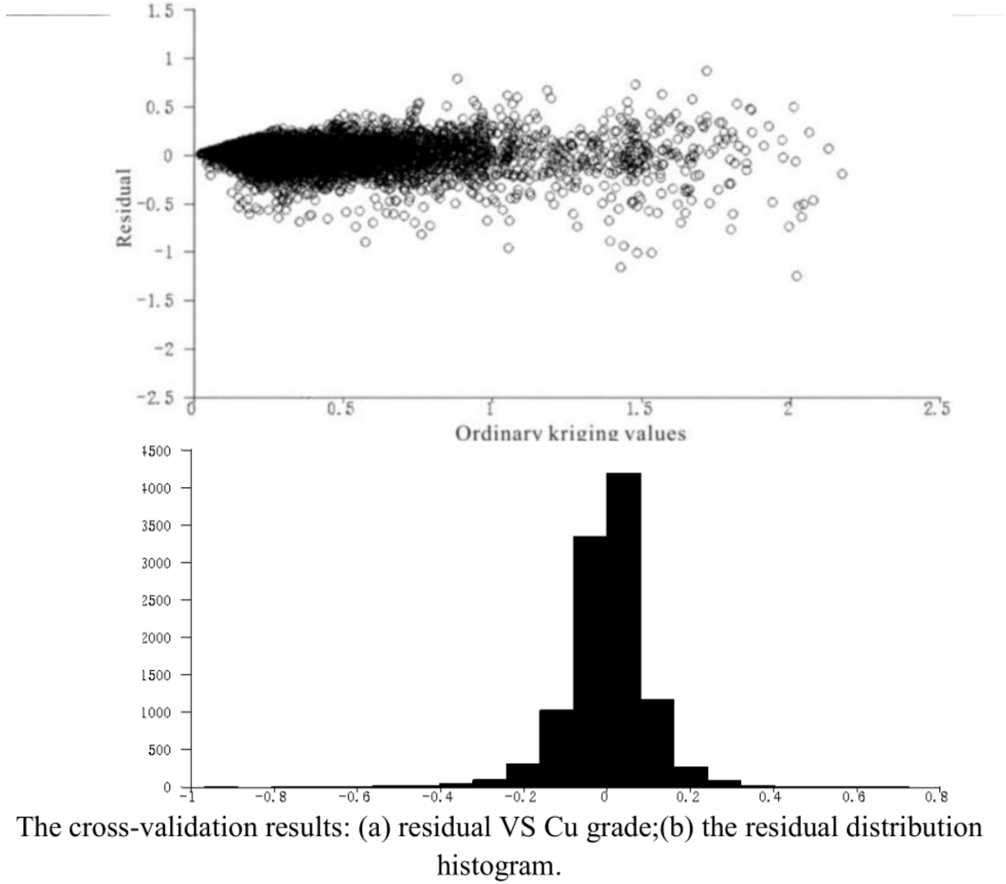

Fig. 3. The cross-validation results: (a) residual VS Cu grade;(b) the residual distribution histogram.

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Sample no.	Mineralized zones obtained by fractal models	Cu(%)
PL-B74	Weakly mineralized zones	0.41
PL-B62	Moderately mineralized zones	1.32
PL-B82	Highly mineralized zones	1.80

Fig. 4. Results of XRF analysis of samples collected from different mineralized zones in the Pulang porphyry copper deposit.

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