Information Extraction and Interpretation Analysis of Mineral Potential Targets Based on ETM+ Data and GIS technology: *A Case Study of Copper and Gold Mineralization in Burma*

DU Wenhui, WANG Gongwen[1],CHEN Yongqing, GUO Nana, HAO Yinglong, ZHAO Pengfei
State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences (Beijing), Beijing, 100083, PRC

E-mail: gwwang@cugb.edu.cn

Abstract. Mineralization-alteration and structure information extraction plays important roles in mineral resource prospecting and assessment using remote sensing data and the Geographical Information System (GIS) technology.Choosing copper and gold mines in Burma as example, the authors adopt band ratio, threshold segmentation and principal component analysis (PCA) to extract the hydroxyl alteration information using ETM+ remote sensing images. Digital elevation model (DEM) (30m spatial resolution) and ETM+ data was used to extract linear and circular faults that are associated with copper and gold mineralization. Combining geological data and the above information,the weights of evidence method and the C-A fractal model was used to integrate and identify the ore-forming favourable zones in this area. Research results show that the high grade potential targets are located with the known copper and gold deposits, and the integrated information can be used to the next exploration for the mineral resource decision-making.

1. Introduction

Since the 80's, the rapid development of the GIS technique has provided a platform for the comprehensive utilization of the multi-source ore-forming information in the exploration of mineral resources. The combination of multi-source information and the GIS technique is the inevitable trend and the main means of predicting mineral resources. Metallogenetic prognosis and evaluation of mineral resources using the GlS technique, is to obtain effective evaluation of mineral resources through integrating various geological spatial data with a variety of spatial analysis methods, understanding the relationships between geological objects and mastering the coupling relationship between various geological phenomena and metallogenic regularity[1-2].Mineralized alteration information extraction and the structure information extraction plays a significant role in metallogenetic prognosis using the multi-source ore-forming information.

    In the paper, Choosing copper and gold mines in Burma as an example ,the authors utilized the ratio method, threshold segmentation and principal component analysis (PCA) to the extraction of copper and gold mineralized alteration information by the ETM+ remote sensing images in Burma.

---

[1] WANG Gongwen, man, associate professor, master tutor, E-mail: gwwang@cugb.edu.cn.

Based on the GIS platform, associated with the linear and circular structures, using the weights of evidence method and the C-A fractal model for integration, the potential targets of the study area were delineated.

2. Geological background of the study area

Burma is a part of the giant metallogenic unit of the Indochina Peninsula metallogenic domain with rich mineral resources and a sound metallogenic geological environment,where copper, gold, lead and zinc deposits have been found, particularly the copper and gold deposits that form among the orogenic belt and the magmatic arc environment in Mesozoic and semi-late Cenozoic era.

The territory in Burma is relatively complete, ranging from the Proterozoic to the Cesozoic.The Mesozoic basin to the East is divided into 3 major stages of deposition. The dolomite and limestone deposition in the Carboniferous-Permian Period; the limestone marl, siltstone and shale in the Triassic-Jurassic Period; shale, the siltstone and sandstone deposition in the late Jurassic to the Cretaceous Period. Four main sedimentary sequences distribute in the western and the middle basin in the Tertiary Period, the upper Cretaceous series, the middle Eocene series, the upper Eocene series, the Oligocene series and the Miocene-Pliocene series. The state boundary of Shan separates the western India-Burma geosynclines in the Tertiary Period from the eastern Indo-Shan platform [3] (figure 1).
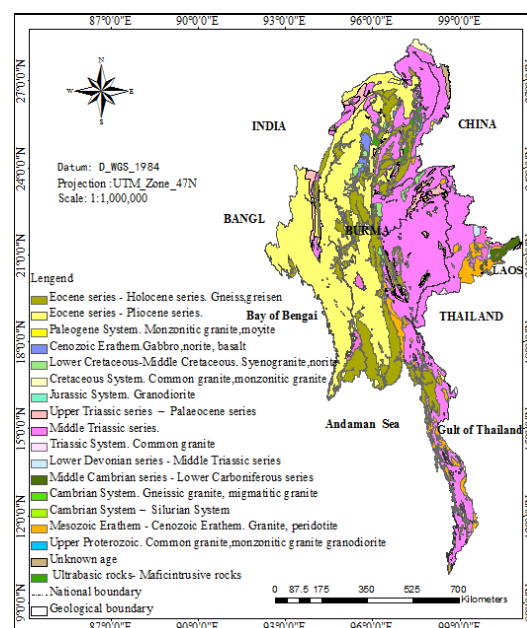

Figure 1. Geological map of Burma at 1:1,000,000 scale

3. Data processing and analysis of the results

3.1. Remote sensing data source and pretreatment

In the study, 44 scenes of ETM+ images cover all the study area and are relatively clear. Cloud cover is less than 10% and vegetation cover is less than 45%, which meet the needs of the study. In order to extract effective spectral and favorable prospecting information, pretreatment of the image is indispensable. After the pretreatment of radiometric correction, geometric correction, mosaic, resize et al, ETM+ data was used to extract alteration information and geological structure information relating to copper and gold mineralization.

3.2. Extraction of remote sensing geological structures

Linear and circular structures are not isolated, but in fact have a close relationship with the mineral resource generation [4]. The mountain shadow map can be obtained from DEM data. After filtering, stretching and enhancement of ETM+ data, combined with the mountain shadow map, geological map, linear and circular faults were interpreted. (figure 2).
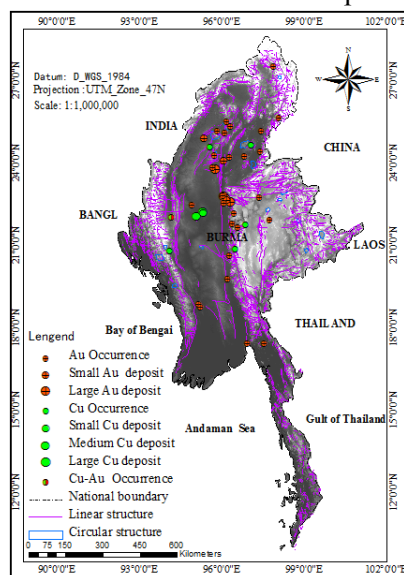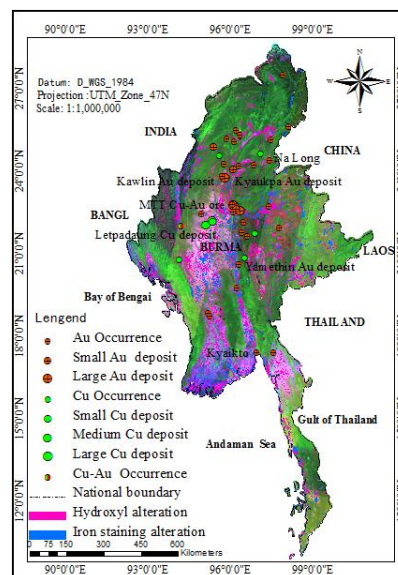

Figure 2. Linear and circular structure map of Burma

Figure 3. Distribution map of alteration anomalies of Burma(ETM$^+$742)

3.3. Extraction of remote sensing alteration anomaly information

3.3.1. Removal of the interference information. Authors used the ratio method to eliminate water (TM7/TM1), saline (TM4/TM3), vegetation (TM5/TM4) and utilized the method of high-end or low-end cutting to remove the interference information of cloud, shadow, snow.Mask processing of interference information is significant in the removal of false alteration information.

3.3.2. Enhancement processing of the images. Based on the analysis of ETM+ spectral information, with "De-interfered Anomalous Principal Component Thresholding Technique" the hydroxyl alteration anomalies and the iron staining anomalies were respectively obtained by (TM1, TM4, TM5, TM7) and (TM1, TM3, TM4, TM5) bands.

TM1, TM4, TM5, TM7, these four bands were analyzed by the principal component analysis (PCA), the critical principal of identifying the hydroxyl alteration anomaly component is: the signs of TM5 coefficient is contrast with the coefficient signs of TM7 and TM4,TM1 and TM5 coefficients are of the same sign.

TM1, TM3, TM4, TM5, the four bands were analyzed by principal component analysis. The critical principal of identifying the iron staining component is: the TM3 coefficient sign is contrast with coefficient signs of TM1 and TM4, TM3 and TM5 coefficients are of the same sign.

"Mean value + N × standard deviation" was used to classify the alteration anomalies. For Hydroxyl alteration anomalies, N is usually 2-3; for the iron staining alteration anomalies, N is usually 1.5-2.5[5]. With the threshold segmentation of the iron staining alteration anomaly and hydroxyl alteration anomaly component, alteration anomaly information is divided into three grades.

3.3.3. Analysis of Results. The distribution map of the hydroxyl alteration anomalies and the iron staining anomalies of Burma show, block aggregation alteration anomalies are distributed in the central region, which conforms to the distribution of many typical copper gold deposits. Some stripped alteration anomalies are found in the South and in other areas, small pieces of alteration anomalies

have been distributed sporadically, which may be related to regional alteration information of the local area (figure 3).

4. Integration of multi-information

4.1. Evidence weight method
Evidence weight method was proposed by the Canadian Mathematical geologist Agterbergn [6-7].This is a mathematical model originally based on two-value images and is used to delineate favorable metallogenic regions with mineral posterior probability. It uses a statistical analysis model that is based on the Bias condition probability and can be used to delineate mineral prospecting areas.

Suppose that the study area is divided into T pixel units, including D mines, the probability of a pixel unit being randomly selected that represents ore is:

$$P_{prior}=P(D) =D/T \tag{1}$$

Each kind of geoscience information is seen as an evidence factor of metallogenic prognosis, the contributing value of prediction is determined by its weight value, which is defined as:

$$W^+ = \ln\left\{\frac{P(B/D)}{P(B/\overline{D})}\right\} \tag{2}$$

$$W^- = \ln\left\{\frac{P(\overline{B}/D)}{P(\overline{B}/\overline{D})}\right\} \tag{3}$$

$W+$ and $W-$ is respectively the evidence weight factor of existent area and non-existent area. For the region with deletion of the original data, the weight value is 0;

B represents the total number of grid cells where a certain factor is existent, $\overline{B}$ is the total number of grid cells where the certain factor is nonexistent.

C represents the extent of which the evidence layers related to the deposits (mines) evidence layers. C is defined as:

$$C = W^+ - W^- \tag{4}$$

For *N* evidence factors, if conditions are independent of the distribution of mines. The possibility of the random grid cell *k* which represents ore within the study area is:

$$P_{posterior} = \exp\left\{\ln\left[\frac{P(D)}{1-P(D)}\right]+\sum_{j-1}^{n}W_j^k\right\} \tag{5}$$

In the formula (5): W_j^k is the weight value of the j_{th} factor, the posterior probability represents the ore-forming favorability of the grid cell. The higher the value is, the more advantageous it is for ore-forming.

4.2. Fractal theory
Fractal theory is a science about the study on the complexity of the nature space structure, in which, extraction of the parametric deterministic of regularity from the complicated but seemingly unordered pattern can be obtained.

In 1994, Cheng Qiuming established the petrogeochemistry "density-area(C-A)"fractal model [8-9]:

$$A(C > V) \propto T^{-\beta} \tag{6}$$

In the formula (6): *A (C>V)* represents that the element (density *C*) is greater than a certain threshold of *V* area; β is a index; ∝ represents a proportion.

With these methods to delineate the prospecting target areas, the spatial characteristics, geometric feature, numerical characteristics and frequency distribution feature of ore-forming favorability can be all taken account of . Thus the delineation of potential targets can be made more scientifically [10].

4.3. Application to the study area

Based on the MORPAS (mineral ore resources perspective and assessment system) software system，with "evidence weight method"，through the comprehensive analysis of multi-source ore-forming information, the favorable strata, circular structures (5km buffer), linear structures (5km buffer), hydroxyl anomalies and the iron staining anomalies are ultimately determined as the evidence layers in the study. In view of the 1:1 000 000 scale of original layer, the grid unit was divided at the 10km × 10km scale. Thus the posterior probability of grid unit partitioned was calculated. With C-A fractal method, based on the ore-forming geological conditions and mineral distribution characteristics in Burma, eleven potential targets were delineated (figure 4).
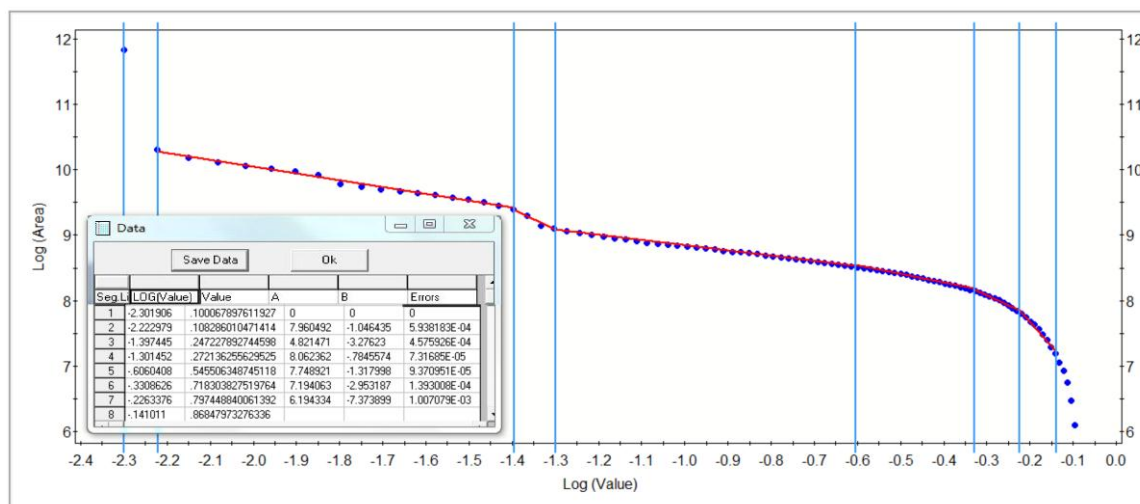

Figure 4．Threshold segmentation of calculation of C-A fractal method

Potential targets of the study area are further divided into three grades. Each grade contains different prospecting target areas. Three potential targets with relatively high metallogenic favorability, which conform to the distribution of a great deal of known typical copper and gold deposits, belong to grade I; the other four potential targets with medium metallogenic favorability that are located with a small amount of copper and gold deposits, belong to grade II; the last four potential targets located with few copper and gold deposits and with relatively low metallogenic favorability belong to grade III (figure 5).
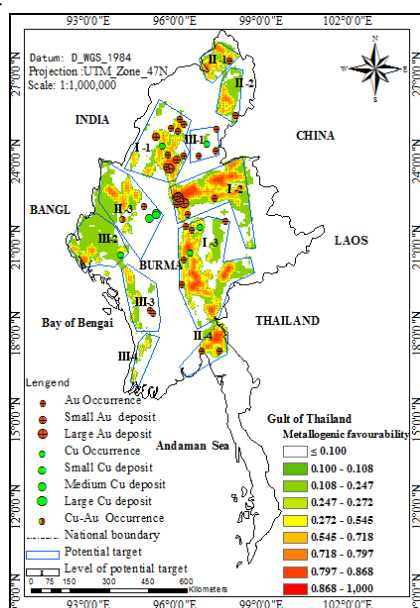

Figure 5. Map of copper and gold mineral potential targets of Burma

5. Conclusion

- Eleven prospecting targets of copper and gold mineralization in Burma have been delineated. Research results show potential targets of grade I conform to the distribution of the known copper and gold deposits. The integrated information can be used to the next exploration for the mineral resource decision-making, which lays a basis and provides useful information within the study area.
- Based on the GIS platform, through the weight of evidence method and C-A fractal model by means of the MORPAS software system, the objectivity and accuracy of prediction results has been greatly improved.
- Because of the absence of regional data in the study area, the appropriate supply of the related Geophysical and Geochemical information in the key metallogenic targets would be profitable to the accurate delineation of ore prospecting targets.

References
[1] Xiao Keyan, Zhang Xiaohua, Wang Silong, et al.2001 *A GIS Evaluation System for Mineral and Resources* (Beijing: Geological Publishing House) pp 1-105.
[2] Liu Shixiang, Xue Linfu, Qie Ruiqing et al. 2006 Application of weights of evidence method in the northwest of Heilongjiang gold metallogenic prediction based on GIS. *Proc. Innovation and development of 2006 University GIS Forum*, Beijing, pp 298-304
[3] He Yongjun.1995 The geological background and basin in Burma *J.Marine Geology Frontiers*, **10** 20-21.
[4] Wei Guanjun, Gao Jianguo, Yang Shiyu et al. 2010 A study on the linear and circular structure interpretation and prospecting in the Lancang area using remote sensing image *J. Mine Surveying*,**6** 8-10
[5] Zhang Yujun, Zeng Zhaoming,Chen Wei.2003 The methods for extraction of alteration anomalies form the ETM+(TM) data and their application: method selection and technological flow chart *J. Remote sensing for land & resources,* **2** 44-49.
[6] Agterberg, F.P. and Bonham-Carter, G.F., 1990Deriving weights of evidence from geosciences contour maps for the prediction of discrete events-*Proc. 22nd APCOM Symp.*vol 2, Berlin. pp 381-395.
[7] Agterberg, F.P., Bonham-Carter, G.F, and Wright D.F., 1990 Statistical pattern integration for mineral exploration: in computer app Hcations in resource estimation-*Predictions and Assessment tor Metalsand Petroleum,* Eds. G. Gaal and D.F. Merriam, Pergamon, Oxford, pp1-21.
[8] Cheng Qiuming, Agterberg F, Ballantyne S.1994 The separation of geochemical anomalies from background by fractal methods *J. Journal of Geochemical Exploration,* **51** 109-130.
[9] Cheng Qiuming, Li Q. 2002 A fractal concentration-area method for assigning a colour palette for image representation *J. Computers & geosciences,* **28** 567-575.
[10] Xiao Qiaoyan, Wang Gongwen, Zhang Shouting et al.2011 Research on molybdenum polymetallic metallogenic prognosis in Duguan-Yunyang district, southwest Henan province *J .Geoscience,* **25** 94-100.