Modern Physical Chemistry Research (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/mpcr.2024.040104
ISSN 2616-1702 Vol. 4 Num. 1

Delineation and Evaluation of Soil Geochemical Anomaly in Xialonggang Lead Polymetallic Mine, Shannan

Aohua Wang[a], Hua Wu[b,*], Yicun Cun[c], Xincan Li[d]

College of Engineering, Tibet University, Lhasa, Tibet, 850000, China
[a]1872316094@qq.com, [b]xzwhua@qq.com, [c]zxy18235298200@outlook.com, [d]2640922776@qq.com
[*]Corresponding author

Keywords: Xialonggang, Soil Geochemistry, Abnormal Target Area, Lead Polymetallic Ore, Cluster Analysis, Factor Analysis

Abstract: Xialong post is located in the periphery of Zhaxikang large-scale lead-zinc-antimony deposit. The structure is developed in the area, and the prospecting potential is great. Geochemical exploration in the study area is an effective way to find useful minerals in the area. Therefore, 1: 10 000 soil survey was carried out in the area, and geochemical statistics were carried out on 18 elements in the area. Cluster analysis and factor analysis were used to analyze the symbiotic combination of elements. The traditional iteration method was used to determine the lower limit of anomaly of each element. The outer, middle and inner zones were determined by 1, 2 and 4 times of the lower limit of anomaly of each element, and the single element anomaly map was drawn. Combined with the geological background, the target area was delineated, the prospecting range was narrowed, and the prospecting target area was optimized.

1. Introduction

The Xialonggang study area is located in Longzi County, Shannan City. The strata in the area are developed, and multi-stage magmatism and tectonic activities are developed. There is a Zhaxikang ore concentration area near the periphery of the mining area, and the mineral resources in the area are abundant [1-2]. The predecessors have done more geological work, carried out regional geological and mineral surveys at different scales, and accumulated certain geological and mineral data, but the degree of research on geochemical characteristics is low. Therefore, by carrying out 1: 10 000 soil geochemical survey in Xialonggang study area, this paper analyzes the content, distribution, single element anomaly characteristics and comprehensive anomaly characteristics of elements by means of cluster analysis, factor analysis and traditional iteration method[3-5].

2. Geological Overview

2.1. Regional Geological Background

Xialong is located in the Himalayan plate of the first-order structure of the Tethys-Himalayan structure, which belongs to the basement erosion area of the stable continental margin in the southern part of the New Tethys Ocean. The stratigraphic system belongs to the Himalayan stratigraphic area and the Kangma-Longzi stratigraphic division. This stratigraphic division develops a continuous Jurassic-Cretaceous boundary stratum. The structure is located at the southeastern end of the Yangzhuoyong-Nariyong composite syncline and the southwestern side of the Ridang fault. The study area has concealed magmatic activities in the late Himalayan period [2-4].

2.2. Geological Characteristics of the Deposit

The Jurassic strata are mainly exposed in the study area, with an overall trend of NWW and a tendency to the north. It includes Ridang Formation (J1r), Lure Formation (J1-2l), Zhela Formation (J2z ^) and Quaternary. The Lure Formation is divided into four sections from the original three sections, and the first section of the original Zhela Formation is not exposed in the area. Alluvial deposits and glacial tills are newly divided in the Quaternary. The overall structural trace of the mining area is NWW to near east-west, and the NWW to near east-west structures in the area are mainly, followed by NE and NW structures. Faults and folds are well developed, and foliation replacement is also strong. In addition, magmatic rocks are well developed in the mining area, including basic-intermediate-acid intrusive rocks and basic-intermediate-acid volcanic rocks, and the development of neutral sub volcanic rock wall. The Xialonggang Pb-Zn deposit is located in the north-central part of the Zhaxikang ore concentration area, adjacent to the Keyue, Suoyue, and Zedang Pb-Zn polymetallic deposits. The ore bodies in the deposit are controlled by nearly north-south faults. The host rock is mainly Ridang Formation slate, tuff, etc. The Jurassic strata are mainly exposed in the mining area. The strata generally strike nearly east-west and incline to the north. The strata are divided into Ridang Formation, Lure Formation and Zhela Formation from bottom to top [4].

3. Soil Geochemical Survey

3.1. Characteristics of Element Content

The average value, standard deviation, enrichment coefficient (K) and coefficient of variation (Cv) of the element content of the test sample were calculated [6].

Comparing the above criteria with Table 1, it can be seen that the strong enrichment elements and enrichment elements Ag, Cd, Pb, Sb, Zr and Au are obviously enriched in the area, among which Pb and Ag have certain mineralization, which is basically consistent with the ore-forming elements in this area. Sb may be related to the structure in the area, and Cd and Zr may be related to the dyke. Zn is weakly enriched in this area, which is related to the structure of the area. Background and depleted elements: W, Mn, Ga, Sn, Ni and Ti are background in the region; be, Cu and Nb are of low background type in the area. U and Mo are depleted elements in the area, and the mineralization is relatively weak. The strongly differentiated elements are W, Au, Sb, Pb, Ag, Cd and Zn, reflecting the extremely uneven distribution of the above elements in the strata, strong differentiation, easy migration, and may be the main ore-forming elements. Sn is a weakly differentiated element, which is unevenly distributed in the strata and has certain mineralization.

3.2. R-type Cluster Analysis

The R-type cluster analysis mainly studies the similarity between variables, aiming to classify each element and reveal its affinity in the metallogenic process [5].

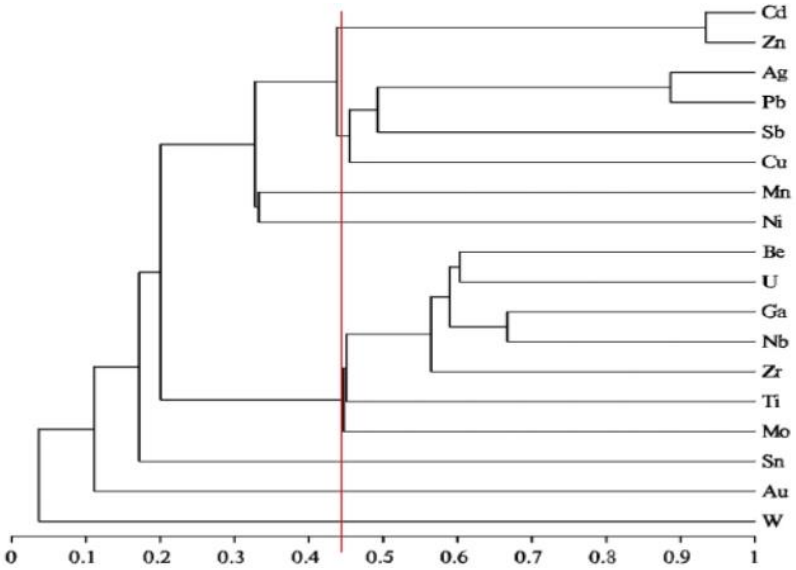

Figure 1: R-type clustering pedigree chart of Xialonggang

It can be seen from the figure 1 that the whole can be divided into three categories and five groups: the first group is Pb, Zn, Ag and Cd, which is related to the middle and low temperature minerals and the later hydrothermal activation. Pb, Zn and Ag may be superimposed and enriched in the later secondary tectonic activities. The second group is Be, U, Ga, Nb and Zr, which are high and medium temperature minerals related to later contact metasomatism. The third group is As, Sb and Hg, which are related to the later contact metasomatism of medium and low temperature minerals. The fourth group is Mo and Ti, which are medium and high temperature minerals related to the later dykes. The fifth group is Au, Sn and W with separate factors, indicating that gold, tin and tungsten elements are dispersed and depleted in the survey area, and may not be enriched and mineralized.

3.3. R-type Factor Analysis

In the process of geological data analysis, factor analysis is applied to classify and combine a large amount of data, and variable factors are used to characterize the change law of geological data, which can summarize and summarize the change law between geological facts more concisely and intuitively [1].

Factor analysis was performed on the data results. When the variance contribution was greater than 75 %, six main factors were selected, including most geological information. The main factors of F01 include Ag, Pb, Zn and Sb.Among them, Ag, Pb and Zn are exploration elements in geochemical exploration, which belong to low-temperature semi-metallic amphoteric elements. They have similar geochemical behaviors and strong migration ability, and can be used as front-edge element combinations. Pb, Zn and Ag in the survey area are the element combination types for finding lead-zinc deposits. F06 and F07 are independent element factors, which are W and Au, respectively. The representative elements are superimposed and transformed after hydrothermal mineralization. The gold element of F07 factor is usually associated with Sb, which is combined into a combination of metallogenic indicator elements of low-temperature hydrothermal gold deposits.

4. Geochemical Anomaly

4.1. Determination of Lower Limit of Anomaly

Table 1: The abnormal lower limit of each element

Element	Max	Min	$\overline{X}$	S	Eliminate three times the standard deviation			Threshold
					$\overline{X}$	S	Ca	
Ag	20.46	0.01	0.17	0.43	0.13	0.06	0.25	0.30
Be	18.23	0.01	3.16	0.89	3.10	0.74	4.60	4.00
Cd	38.28	0.02	0.25	0.51	0.20	0.09	0.37	0.40
Cu	505.98	4.66	26.95	10.99	26.13	6.61	39.36	40.00
Ga	65.09	3.4	22.7772	4.385	22.6874	3.9745	30.64	30.00
Mn	10822.75	128.52	922.89	384.25	890.53	285.31	1461.169	1500.00
Mo	12.93	0.24	0.94	0.29	0.92	0.20	1.33	1.50
Nb	109.37	3.59	21.04	5.49	20.63	4.48	29.58	30.00
Ni	1395.78	7.84	51.38	25.29	48.81	12.54	73.89	75.00
Pb	8667.24	5.15	50.94	150.28	40.75	16.14	73.02	75.00
Sb	913.49	0.16	6.29	19.40	4.45	3.04	10.53	10.00
Sn	226.53	0.01	4.04	2.10	3.96	0.69	5.34	5.00
Ti	72936.88	882.1	5853.40	2332.04	5484.79	1314.54	8113.88	8115.00
U	7.25	0.30	1.53	0.57	1.48	0.49	2.46	2.50
W	2710.98	0.28	2.88	23.32	2.50	0.93	4.3651	4.00
Zn	14571.71	25.32	122.13	177.45	110.20	32.84	175.88	175.00
Zr	3095.00	58.00	288.07	83.99	273.19	49.62	372.43	375.00
Au	913.20	0.13	2.76	12.53	1.72	1.04	3.80	4.00

It can be seen from the table 1 that the traditional iterative method with strong practicability and easy operation is selected to determine the abnormal lower limit of the study area. The anomaly concentration zones were calculated according to 1, 2 and 4 times of the actual value of the lower limit of the anomaly [1].

4.2. Single Element Anomaly Characteristics

Through the analysis of the single element anomaly map, it can be obtained that the anomalies of Pb, Ag, Zn, W, Cd, Sb, Ni, Au and Cu are obvious, all of which have concentration centers, and the inner, middle and outer zoning characteristics are clear. The anomalies of Mn, Ti, Mo, U, Be, Nb, Zr, Ga and Sn are relatively weak, with middle, outer bands or only outer bands. The distribution of Pb, Zn, Ag, Au and Cd is relatively concentrated, mainly distributed in the middle of the mining area. The anomaly scale of Pb, Zn, Ag, Au and Cd is large, the intensity is high, the anomaly distribution is similar, and it has a good fit, indicating that the correlation between Pb, Zn, Ag, Au and Cd is high. The distribution of these elements is also in the fracture zone, small alteration zone near or above. Sb and W anomalies are mainly distributed in the central and northern parts of the study area, and the abnormal area of Sb is larger than that of W. The anomaly distribution of Be, Nb, Ni, Sn and Ti is similar, mainly distributed in the north and south of the mining area, and the anomaly distribution is scattered. The anomalies of Ga, Mn and Mo are weak and the distribution area is small. U and Zr are mainly distributed in the south of the mining area, with a large distribution area and relatively concentrated distribution [7-9].

5. Target Prediction

Through the combination of abnormal conditions and comprehensive analysis of geological conditions, a total of three metallogenic target areas are divided.

(1) It can be seen from the figure 2 that The No.1 target area is located in the middle of the Xialonggang study area. The exposed strata in the target area are mainly the third section of the Lure Formation, and there are many siltstones and sandstones in this section. The largest faults in the target area are distributed in the northeast direction, and strong silicification alteration, pyritization, lead-zinc veins, etc. are developed along the faults. The degree of integration of each element is good, and the concentration center is obvious. The Pb and Ag elements are consistent, and the anomaly is closely related to the NE-trending fault structure. The faults in the area are developed, and the possibility of fault ore control is large. The lead veins are developed in the fault zone. Through the fault action in the area, Pb and Ag are activated, enriched, and abnormal, so its metallogenic conditions are superior [10-13].

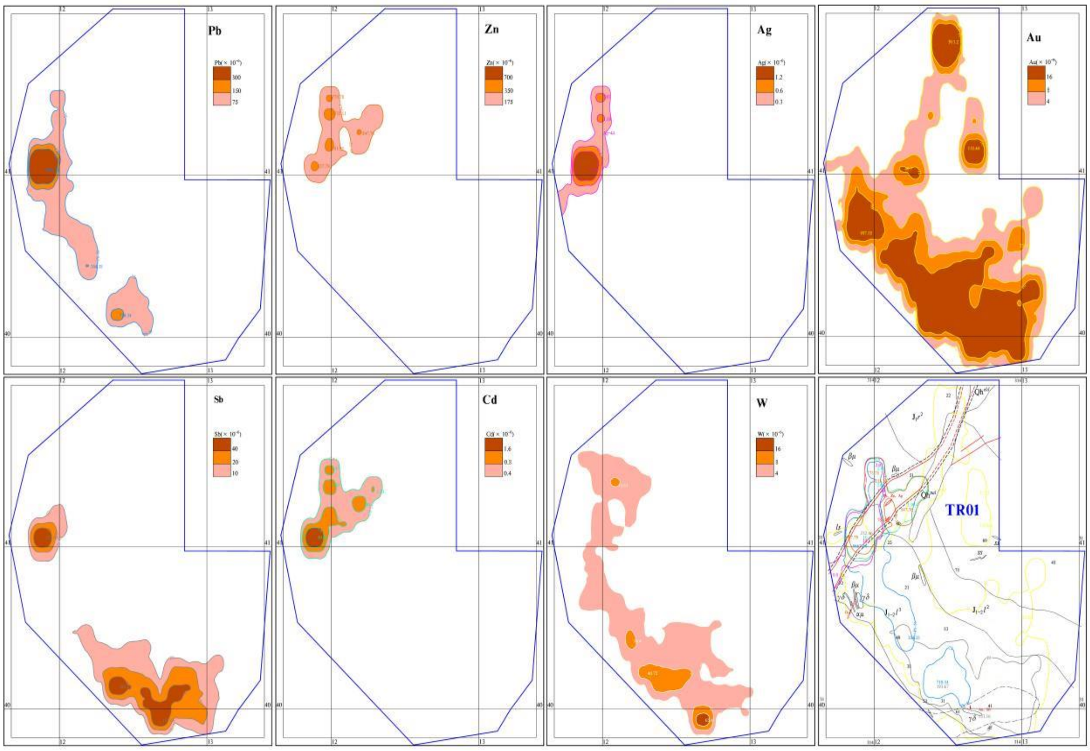

Figure 2: No.1 target area analysis diagram

(2) It can be seen from the figure 3 that the No.2 target area is located near the Segang in the middle of the Xialonggang study area. The main strata exposed in the target area are the fourth member of the Lure Formation and the third member of the Lure Formation. The two strata mainly appear sandstone and siltstone. The largest faults in the area are distributed in the northeast direction, and strong silicification alteration, pyritization and lead-zinc vein are developed along the faults. The comprehensive anomaly is large in scale, the element nesting degree is good, the concentration center is obvious, and the Pb, Zn, Sb and Ag elements in the area are consistent. The anomaly is closely related to the NE-trending fault structure and the contact zone between the stratum and the rock mass. The fault provides a channel for the migration of elements, so it has certain prospecting potential [14-17].

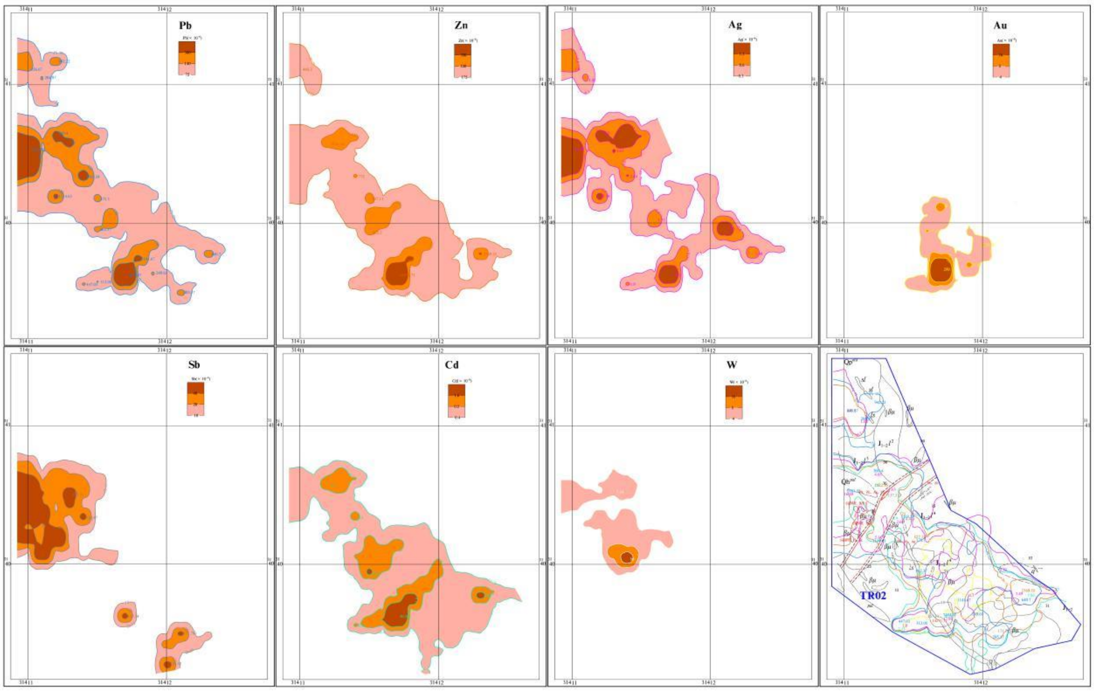

Figure 3: No.2 target area analysis diagram

(3) It can be seen from the figure 4 that the No.3 target area is located in the southern part of the southern part of the Segang in the Xialonggang study area. The main exposed strata in the area are the third and fourth members of the Lure Formation, and the two strata are mainly exposed siltstone and sandstone. The abnormal form is planar. The four single element anomalies of Pb, Zn, Ag and Cd are relatively well matched, and the concentration center is obviously distributed. The inner and middle zones of the anomaly have the characteristics of northeast distribution, which is related to the small-scale northeast fault zone developed on the surface. The lead-zinc ore (mineralization) body is developed in the fault zone, which is an important metallogenic area in the mining area. The distribution of Au anomaly is consistent with the northwest diabase vein developed in this area, which may be caused by the intrusion of diabase. The element combination and concentration zoning in this area are good, and it has good prospecting potential [18-22].

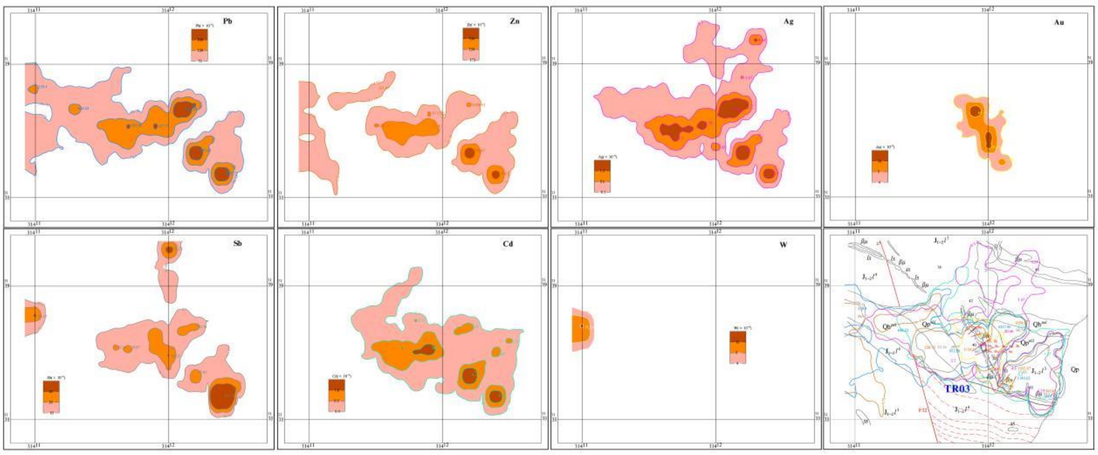

Figure 4: No.3 target area analysis diagram

6. Conclusion

(1) Through the analysis of the basic geological conditions of the Xialonggang study area and the analysis of 1: 10 000 soil geochemical survey data, it can be seen that Pb, Ag and Zn are the main ore-forming elements in the area, and the elements are well nested. The third and fourth members of the Middle-Lower Jurassic Lure Formation are favorable strata for lead-zinc mineralization.

(2) Through SPSS software, comprehensive R-type cluster analysis and R-type factor analysis results, the 18 elements in this area are divided into 5 combinations, namely Pb-Zn-Ag group, Ag-Pb-Sb-Cu-Cd-Zn group, Au-Sn-W group, Ga-Nb-U-Be-Ti-Zr-Mo, Mn-Ni group.

(3) Combined with the geological data, field geological work and soil geochemical characteristics of this area; the mineralization of this area is mainly controlled by the three factors of structure, stratum and rock mass. The ore-bearing source layer provides ore-forming materials for the ore body, and the tectonic activity provides migration channels and metallogenic space for the ore-forming materials.

Acknowledgements

In the process of field work and writing, we have received the guidance and help of Feng Dexin, chief engineer of The Ocean Mineral Exploration Co., Ltd. and Wu Hua teacher, and express our heartfelt thanks.

References

[1] Hao Lin, Wu Xingxing, Li Sen, et al. Study of soil geochemistry and prospecting of gold deposit in Jingouzai, Yangxi County, Guangdong Province. Journal of Hefei University of Technology (Natural Science), 2012, 35(12):1686-1692.

[2] Zhang Chengzhi, Zhong Kanghui, Luo Jian. Geological characteristics and prospecting criteria of lead polymetallic deposit in the Xia Longgang mining area. Prospecting Technology, 2018, (14):81-82.

[3] Hu Sen, Wu Hua, Dai Kegang, et al. Remote sensing prospecting prediction of polymetallic Deposit in Xialonggang mining area. China Mine Engineering, 2023, 52(03):1-6.

[4] Liu Yuqi, Zhang Zhi, Li Guangming, et al. Geological characteristics and source of ore-forming materials of Xialonggang lead-zinc deposit in Zhaxikang ore concentration area, Constraint of in-situ S isotope of sulfide. Mineralogy and Petrology, 2021, 41(1):93-105.

[5] Cai Xianjun. Application and comparison of different geochemical data processing methods used in Halaqiaola area. World Nonferrous Metals, 2016, (17); 65-66.

[6] Pei Shengliang, Yuan Jianjiang, Huang Mingda. Characteristics of soil geochemical anomalies and prospecting directions in the Xinbaerhu area of Inner Mongolia. Contributions to Geology and Mineral Resources Research, 2018, 33(3):449-457.

[7] Ge W C, Wu F Y, Zhou C Y, et al. Mineralization ages and geodynamic implications of porphyry Cu-Mo deposits in the east of Xingmeng-orogenic belt. Chinese Science Bulletin, 2007, 52(20):2407-2417.

[8] Maepa F, Smith R S, Tessema A. Support vector machine and artificial neural network modelling of orogenic gold prospectivity mapping in the Swayze greenstone belt, Ontario, Canada. Ore Geology Reviews, 2021, 130: 103968.

[9] Cai Y D, Ricardo P W, Jen C H, et al. Application of SVM to predict membrane protein types. Journal of theoretical biology, 2004, 226(4):373-376.

[10] Zheng C J, Liu P F, Luo X R, et al. Rock geochemical data mining and weak geochemical anomalies identification—a case study of ashele copper-zinc deposit. Geotecton Metallog, 2022, 46(1):86-101.

[11] Šimíček D, Bábek O, Hron K, et al. Separating provenance and palaeoclimatic signals from particle size and geochemistry of loess-palaeosol sequences using log-ratio transformation: Central European loess belt, Czech Republic. Sedimentary Geology, 2021, 419:105-107.

[12] Zuo R, Xia Q, Zhang D.A comparison study of the C–A and S–A models with singularity analysis to identify geochemical anomalies in covered areas. Applied geochemistry, 2013, 33:165-172.

[13] Liu K, Simon A W, Zhang J J, et al. Zircon U-Pb dating and whole-rock geochemistry of volcanic rocks ineastern Heilongjiang Province, NE China: Implications for the tectonic evolution of the Mudanjiang andPaleo-Pacific oceans from the Jurassic to Cretaceous. Geological Journal, 2020, 55(03):1866-1889.

[14] Xie X J, Yao W S. Outlines of New Global Geochemical Mapping Program. Acta Geologica Sinica-English Edition, 2020, 84(03):441-453.
[15] Mo X, Niu Y, Dong G, et al. Contribution of syncollisional felsic magmatism to continental crust growth: a case study of the Paleogene Linzizong volcanic succession. Chemical Geology, 2008, 250(1-4): 49-67.
[16] Molan Y E, Behnia P. Prospectivity mapping of Pb–Zn SEDEX mineralization using remote-sensing data in the Behabad area, Central Iran. International Journal of Remote Sensing, 2013 34(4): 1164-1179.
[17] Wu W, Chen Y L. Application of isolation forest to extract multivariate anomalies from geochemical exploration data. Global Geology, 2018, 21(1): 36-47.
[18] Seyyed Saeed Ghannadpour, Ardeshir Hezarkhani. Exploration geochemistry data-application for anomaly separation based on discriminant function analysis in the Parkam porphyry system (Iran). Geosciences Journal, 2016, 20(6):837~850.
[19] Cheng Q. Multiplicative Cascade Processes and Information Integration for Predictive Mapping. Nonlinear Processes in Geophysics, 2022, 19(1): 57-68.
[20] Li N, Xiao K, Sun L, et al. Part I: A resource estimation based on mineral system modelling prospectivity approaches and analogical analysis: A case study of the MVT Pb-Zn deposits in Huayuan district, China. Ore Geology Reviews. 2018, S1005192888.
[21] Reimann C, Caritat P D. New soil composition data for Europe and Australia: demonstrating comparability, identifying continental-scale processes and learning lessons for global geochemical mapping. Science of the Total Environment. 2022, 416(none): 239-252.
[22] Williams P M. Statistical levelling of multi-element geochemical data. Applied Computing and Geosciences.2021, 10(9): 100060.