Factor Analysis of Geogas and Prospecting Significances in a Mining Areas in Zhuguang Mountain

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Abstract: Ultiple uranium deposits have been found in south of Zhuguang Mountains, and the deep prospecting foreground is huge. In this paper, the relationship between the geogas and hydrothermal deposition is analyzed by factor analysis. The result shows that there is some corresponding relation between the geogas and hydrothermal in time and space and turn out to be different diagenetic age to different element enrichment. The geogas area can reflect the information of the deep concealed uranium deposits. Thus, it can be predicted that Uranium enrichment favourable mentallogenic province exist in early Yanshan type A granite rock mass in the oxide layer through the characteristic.

1 INTRODUCTION

In recent years, important progresses have been made in the study of the mineralization pattern of the granite type rich-uranium ore in the southern part of the Zhuguang Mountains in North Guangdong. It turns out that there are still a large number of blind uranium deposit in the southern mining area, but no breakthrough has been made for the deep uranium deposits (Du, 2011; Liu, 2011; Zhang et al., 2011; Zhu, 2010). Recently, scholars (home and abroad) have confirmed through Transmission Electron Microscope (TEM) that the geogas can carry nanoscale trace elements (Cao, 2009; Cao et al., 2011; Lippmann et al., 2011) from the deep ore body and utilize the gases release from the crust for prospecting the deep concealed deposits by a deep penetrating geochemical method -- geogas method, which is of great strategic significance (Wang and Ye, 2011; Zang et al., 2012; Xie and Wang, 2003). Although many studies have found that the geogas method can reflect the buried information of deep ore bodies, reasonable explanation and analysis on the amount of information and inner link between the information and the orebody rock have not shown before. Based on the uncertainties between the geogas method and the deep concealed deposits, the author conducts the R-type factor analysis on the geogas prospecting data from a uranium deposits rock mass in the southern part of the Zhuguang Mountains in northern Guangdong. The author analyzes the relationship between the factor cluster, uranium metallogenic fluid and find significance in prospecting.

2 GEOLOGICAL ASPECTS OF THE WORK AREA

The Yangtze River mining area is located in Changjiang Town, Renhua County, Guangdong Province, which is at the junction of three provinces -- Guangdong, Jiangxi and Hunan. It’s location is between the southwestern margin of the Caledonian uplift in Fujian and Jiangxi Province and the southeast margin of the junction of Hunan, Guangxi and the North guangdong Hercynian-Indosinian Depression, where lies south part of the Zhuguang Mountains rock mass (Ke et al., 2009).The Yangtze river Mining area is located at the junction of the Rucheng-Huilai cutting fault in the northwest direction, the Jiufeng-Xianyou fault in the east-west direction and the deep fault in the north-east direction of Wuchuan-Shaoguan (north to Tan-Lu fault), where it is a mantle slope transition zone good for uranium mineralization. Rocks exposed in

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the work area mainly are early Yanshanian, followed by Indosinian and late Yanshanian intrusive granites and a few late Yanshanian mafic dikes. According to the intrusion relationship of rock mass, lithofacies and lithology contrast, the intrusive rock in the area is divided into six intrusive stages and eight intrusion activities (Zhang et al., 2010).

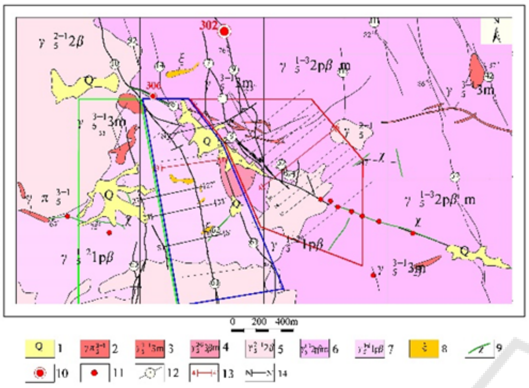

Figure 1: The Yangtze river region oil hole geological map.

1-Quaternary; 2-Granitie porphyry; 3-Yanshanian fine-grained white mica granite; 4-Yanshanian fine-grained two-mica granite; 5-Yanshan grain biotite granite; 6-Indosinian small medium grained porphyritic mica granite; 7-Indosinian Coarse grained porphyritic biotite granite; 8-Syenite; 9-Bright spot pulse; 10-Deposit; 11-Abnormal point; 12-Tectonic-alteration zone; 13- Exploration line

Exploration area (Figure 1) has a total of three measuring lines, the first measuring line is N line, whose direction is perpendicular to north-south direction to the 10 large faults with 10m dot pitch and 500m line length; the second line is the No. 14 measuring line, whose direction is perpendicular to east-west direction with 10m dot pitch and 1000m line length; the third line is the No. 19 measuring line, whose direction is parallel to N line , the direction parallel to the N line with 10m dot pitch and 500m line length.

3 BASIC PRINCIPLE OF MEASUREMENT METHOD

Geogas sampling device is composed of sampler, dryer and gas trap, each part connected by a silicone catheter. During sampling, a 50cm-deep hole was drilled on the surface coating of the earth with drilling steel, and the sampler was then inserted into the borehole and the cone portion of the top of the sampler was blocked against the orifice, and silicone catheters were used to connect the port of each device. Set the pumping rate of 2L / min to make the geogas materials filter the 5% dilutes nitrate acid solution. Subsequently, the field dilute nitric acid solution that successfully collected geogas was brought back to the laboratory for concentration treatment, and 20 ml of the extract solution was concentrated to 5 ml and analyzed using an ELAN DRC-e inductively coupled plasma mass spectrometry (made by Perkin-Elmer Company) (Renata et al., 2013). At present, the analytical method uses different elements with different mass-to-charge ratios and can analyze up to 38 elemental contents.

4 FACTOR ANALYSIS

The ratio of 32 geogas elements (Bi, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Gd, Hf, Ho, La, Lu, Mn, Mo, Nd, Ni, Pb, Rb, Sm, Sr, Tb, Th, Tm, U, W, Y, Yb, Zn, Zr) measured from the three lines in the long-row area is the original data [ratio of the amount of the element in the nitric acid extract to the total amount of the extract in units of (/ g)]. As the measuring time interval is long, it converts the original data of each measuring line into the contrast value and set 10-6 as a unified dimension in order to reduce the measurement error. It uses SPSS 17.0 software to do the KMO and Bartlett test on data (Table 1). When the KMO value is 0.927, the Approx. Chi-square is 16542 and the df (degree of freedom) is 496, the probability P value Sig. (significance probability p value) is 0 (Tian et al., 2013). Thus, it is credible to use this data for factor analysis. The first six common factors (the cumulative contribution rate of the first six common factors = 80.974%) are taken out to represent the geologic characteristics of the oil cave area. All kinds of factors for the geological significance are shown in Table 2.

Table 1: KMO's and Bartlett test.

KMO's and Bartlett test	0.927
KMO Value	16542.972
Bartlett Spherical Degree Test Approximate chi square	496
Df	0.000
Sig.	0.927

Table 2: All kinds of factors for the geological significance.

Factor Number	Component elements	Cumulative rate (%)	Geological significance
1	Y,REE,Co,U,Th, Cs,Mn,	50.611	Uranium mineralization related element, Indosinian granite mineralization enrichment element
2	Th,Zn,Cu,Co,Cr, Cs,Bi,W	60.124	With the enrichment of Th elements, oxygen elements enrichment, a small part of the pro-sulfur enrichment.
3	Zr,Hf,Rb	66.898	Hydrothermal activity, enrichment of oxy-elements
4	Sr,U,Mn,Rb	72.171	With the enrichment of U elements, the second enrichment of oxy-elements
5	Mo,Ni	77.282	Pro-Fe element, the enrichment of amphoteric element
6	Cd,Pb	80.974	During the condensation process, the ultimate enrichment of pro-sulfur element

In Table 2, the 32 elements in the geogas are sorted by factor analysis and the elements with correlations greater than 0.4 were formed into elemental factor group.

In factor group 1, all the radioactive elements U, Th, Co, Cs, Mn and other high-temperature rock-forming elements have a high correlation, known as the main control component in factor group 1. It acts in coordination with the medium-coarse-grained biotite granite (bedrock) formed in the early mineralization (the second Indosinian stage) deposits and the potash feldspathization (surrounding rock) during the alteration process.

In the factor group 2, some Th elements are gradually separated from the U-rich hydrothermal solution and enriched at the early stage, and some elements of high temperature were also enriched Zn, Cu, Co, Cr, Sc, W, which correspond to the formation of ductile granites (bedrock) and albitization, calcitization and hematitization (surrounding rock) during alteration. It is noteworthy that the lower temperature is the larger correlation between ore-forming elements and the factor group 2. This may be related to the interaction of various elements during metallogenic period which leads to the transitional ore-forming temperature.

Enrichment of high-temperature elements Zr, Hf, Rb and others in factor group 3 is highly related to the basic biotite granites (bedrock) formed by the high-temperature hydrothermal activities during the early Yanshanian intrusion period and the mid-temperature muscovitization, purple black fluoritization and pyritization (surrounding rock) during the alteration process.

In the factor group 4, with the decrease in temperature, the ionic radius of uranium is gradually reduced, and it can enter the crystal lattice of the rock-forming minerals well. Along with the re-enrichment of radioactive element U, the middle and low temperature elements such as Sr, Mn and Rb were also enriched. It corresponds to a small amount of sphalerithmization, pyritization and fluorite and quartz mineralization.

In the factor group 5, for a lower contribution ratio, the enrichment of the iron-containing elements (neutral elements) such as the main components Mo and Ni, are correspond to the surrounding rock formed by silicification, sericitization, fluoritization, carbonatation (to form tungsten, nickel ore) in the later stage of the ore-forming with a lowering temperature.

In factor group 6, the final enrichment of the main components chalcophile element Cd and Pb correspond to the low-temperature sphalerite and lead zinc ore formed by the greisenization, hydromicazation, fluoritization and carbonatation of condensate surrounding rock. According to a large amount of geochemical data, the uranium-bearing rock mass in this area belongs to the supersaturated series of aluminium and the lead is the final decay product of uranium, which proves that the occurrence of the main component Pb in factor group 6 corresponds with the final decay products of uranium mineralization.

Compared the results of trace element analysis of intrusive rock mass in two Phases of Yanshan (Table 3), it was found that the U, Th, REE and some of the oxygen-proximal elements such as Zr, Co and Cr are more enriched in the early Yanshanian intrusive rocks. It is basically consistent with the result of factor analysis of geogas. Most of the lithophile elements and chalcophile element such as Cd and Pb are more enriched in the later Yanshanian stage, which correspond to the elemental results of geogas factor analysis.

According to the author's speculation, there are also early-stage and late-stage granite-type uranium deposits from the oil cave uranium deposit in the long-row area. The most proven mineralization age for most uranium-rich metalloges is about 70Ma (Late Yanshanian Period), which belongs to S-type granites, and a small number of uranium deposits are distributed in the age of 50Ma, 90Ma and 110Ma. However, according to the analysis of factor group of geogas, it can be seen that there is still a large amount of U-rich ore-forming belt in the granitic rocks formed during the second stage of Yanshan (about 120 Ma). From the perspective of the alteration of nearby surrounding rock, the composition of altered rock mineral in early Yanshan Period is similar to the composition of granite mineral in the late Yanshan Period, both of which are characterized by locally strong silicification, fluoritization, locally clustered and choritization (Qiu et al.,2013) All of these characteristics clearly reflect that the magmatic stage of late Yanshan Period stage is the product of the interaction between the post-gas fluid and the early Yanshan rock mass. According to the analysis, the oxide contents of the early and late Yanshanian granites in the Zhuguang Mountains area are different, but the correlation between the major elements are obvious. The two reactioned rock masses are likely to be the product of magmatic evolution in the same source area from the perspective of uranium mineralization, its age and granite diagenetic age also have some differences. It is because of the early-late Yanshanian homology in the area that the ore-forming process is in the intense geothermal depression period (Yanshanian period), in which multi-stage and multi-order reciprocal hydrothermal re-melting mineralization occurred, that's why in the analysis of factor group 4, there is a difference between the U-element enrichment and the uranium mineralization age. From the perspective of redox analysis, most of the 70Ma enriched uranium deposits that have been identified are located in the vicinity of the deep-eroded and middle-eroded transitional zone, that is, the vicinity of the pro-sulfur and oxy-element vertical zoning, the transition zone of geochemistry. However, the area exposed to the Earth's surface by uranium-bearing geochemical stratum, which belongs to deep denudation, accounts for only about 20% of the work area, the remaining 80% of the area is covered by the oxygen-rich geochemical environment layer (Huang, 2014). Based on the age-related hydrothermal mineralization features of geogas method, the author predicts that in the oxygen-rich geochemical environment of the oil cave area, as the main body of the Yanshan deep hidden A-type granite, there still exists U-rich high-grade Uranium ore body, and its Th element content should be lower than the late Yanshan ore body content.

5 CONCLUSIONS

The geogas field of the uranium ore district in the southern part of the Zhuguang Mountain has a corresponding relationship with the hydrothermal mineralization of the granite ore body, and corresponds to different enrichment elements for different ore body formation ages. The distribution of enrichment elements from old to new with the age of mineralization is roughly subject to the distribution from oxyphilic to pro-sulphur.

In the analysis of geogas field factor of the mine lot, it is predicted that U highly enriched uranium mineralization exist in the early Yanshan A-type granitic rock mass in the deep concealed stratum under an oxygen rich environment.

The geogas field has a corresponding relationship with hydrothermal mineralization in time, so during the prospecting process in the working area, the period of diagenetic hydrothermal activity corresponding to its U enrichment can be analyzed first, and the rock mass strata in this period can be highly prospected.

Table 3: Trace element contents of intrusive rocks.

Parameter (/10^{-6})	Late Yanshan biotite long granite				Yanshan early biotite monzonitic granite					Early Yanshan altered rock	
	Sample 1	Sample2	Sample 3	Sample 1	Sample2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample2
Cr	3.62	7.49	5.46	8.89	16.3	8.18	8.24	8.77	5.17	13.8	6.02
Co	0.524	0.442	0.457	0.576	2.65	2.61	2.45	2.77	2.6	1.69	2.04
Ni	3.6	1.88	2.05	2.57	3.13	2.62	2.3	2.71	4.16	2.03	1.69
Rb	466	607	440	207	442	420	440	476	440	430	435
Sr	4.81	6.87	4.6	4.25	63.3	46.2	65.7	68	66.9	31	53
Y	23.8	14.5	21.4	9.65	34.7	19.6	38.1	45	43.3	37.2	34
Cd	0.224	0.094	0.104	0.125	0.118	0.15	0.156	0.088	0.162	0.961	0.149
Cs	52.9	25.8	37.4	21.9	46.4	42.5	34.7	36.5	35.1	45.7	26.6
La	2.52	5.82	10.5	2.9	48	34.6	54.5	65.4	46.3	31.7	42.7
Ce	4.5	13.3	37	4.98	94.3	68.4	106	128	91.4	65.1	83.3
Nd	3.27	6.47	18.5	4.43	38.8	28.5	44.8	54.6	38.4	27.6	34.9
Sm	2.11	2.91	7.24	2.08	8.07	6.03	9.59	11.3	8.75	6.39	7.52
Eu	0.024	0.051	0.034	0.019	0.663	0.543	0.63	0.588	0.634	0.483	0.552
Gd	2.14	2.22	4.29	1.45	6.9	4.94	8.09	9.33	7.43	5.83	6.83
Tb	0.602	0.532	0.785	0.301	1.17	0.79	1.35	1.62	1.35	1.16	1.21
Dy	3.5	2.96	3.93	1.46	6.56	4.17	7.33	8.67	7.91	7.03	6.76
Ho	0.485	0.472	0.559	0.23	1.22	0.698	1.24	1.53	1.46	1.27	1.18
Er	1.6	1.44	1.82	0.797	3.45	1.91	3.7	4.39	4.43	3.88	3.31
Tm	0.443	0.303	0.442	0.187	0.546	0.284	0.576	0.703	0.692	0.646	0.538
Yb	4.76	2.36	4.05	1.74	3.46	1.89	3.52	4.52	4.5	4.26	3.22
Lu	0.892	0.407	0.694	0.316	0.529	0.288	0.578	0.705	0.717	0.683	0.497
Hf	12.2	4.78	8.76	3.55	7.76	5.46	7.01	8.19	7.83	13.1	6.23
Th	5.69	11.6	15.5	5.34	42.7	32.6	48.4	65.8	46.8	38.5	39.9
U	10.7	10.8	7.7	5.23	19.6	14.5	12.4	41.9	19.9	23.9	13
Zr	125	43.6	84.5	32	260	187	246	277	241	208	203

Notes: Unit of analysis: Test Center Analysis of 230 Nuclear Industry Research; Analytical method: DZ/T0223-2001; Analysis instrument: Inductively coupled plasma mass spectrometry (ICP-MS)

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