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Mineralogical Study of Huashan Granite-type Uranium Ore Deposit in Northeast of Guangxi

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Abstract: Huashan granite-type uranium ore deposit is originated within the Huashan granite pluton in northeast of Guangxi, the mineral (mineralization) occurrences already found include Changchong, Baishijiao and Caomiping. Previous studies are relatively weak, especially in mineralogical characteristics, in this paper, a detailed study of minerals has been carried out through EPMA and EDS, the results show that the uranium mineral compositions of the three mineral (mineralization) occurrences are significantly different, but all of them are of secondary uranium minerals, among them, the main component of Changchong mineral (mineralization) occurrence is (meta-) autunite, of Baijiaoshi mineral (mineralization) occurrence is kasolite, and of Caomiping mineral (mineralization) occurrence is torbernite and zeunerite, which reflect the difference of their minerals sources.

Preface

As the resources of energy and mineral and defense strategy, uranium ore deposit plays a pivotal role in the development of the national economy, nuclear power industry and defense industry. The granite-type uranium ore deposit is the most important type of uranium deposits and has great significance to alleviate the supply shortage of uranium resources in China. Nanling is the famous area of granite in China, and also the most important metallogenic zone of granite-type uranium, the well-known uranium productive plutons include Guidong pluton, Zhuguangshan pluton, Dadongshan pluton of Guangdong, Taoshan pluton of Jiangxi and Miaoershan pluton of Guangxi, forming a series of uranium deposits from large to super-large scale. The predecessors made a more detailed research on petrology, mineralogy, geochemistry and geochronology, etc. [1-5]. However, as the first found place of uranium ore , the Huashan granite pluton in northeast of Guangxi has not been given enough attention. Prospecting work has gotten a breakthrough until recently, and the research is just on the initial stage. So in this paper, we started from the mineralogy, to make an analysis of EDS and EPMA for the three uranium mineral (mineralization) occurrences , expecting an understanding of its mineralogical compositions and characteristics.

1 Geological background

Huashan granite pluton is located on the border of Gongcheng County and Zhongshan County of Guangxi, showing batholith-like outcrop with an area of about 650 km^2, it is nearly circular in the plane. Feng et al.(2002)have divided Huashan granite pluton into following five units from old to new respectively: Niumiao intrusion(J_2N), Yangmeishan intrusion (J_2Y), Lisong unit (J_2L),

Wanggao unit (J_2W) and Huamei unit (J_3H)[6]. In the temporal and spatial distribution of each unit, the Niumiao intrusion and Yangmeishan intrusion which emplaced in the early stage are located on the outer ring of the rock, while the Wanggao unit and Huamei unit which emplaced in the late stage are located in the inner ring and central part of the rock, forming a typical "positive ring" overlaying granite pluton, of which the outside is old and the inside is new.

In the tectonic setting, the Huashan granite pluton is located in the final junction of Yangtze plate and Cathaysia plate, on the convergence of Hezhou-Chenzhou-Chaling deep faults along the NE direction and Yishan-Quannan deep faults along the SN direction, emplacing in the contact zone of the Dupangling anticlinorium along the SN direction and Hexian County-Zhongshan syncline along the EW direction. The exposed strata in contact zone is mainly of Cambrian metamorphic sandstone, Ordovician sandshale and Devonian quartz sandstone and limestone[7].

2 The geological characteristics of deposits

As shown by the latest research results, the main occurrences of uranium mineral (mineralization) deposits of the study area are in biotite granite and porphyritic biotite monzogranite of Wanggao unit (J_2W). There are three principle mineral (mineralization) occurrences such as Changchong, Baijiaoshi and Caopingmi, and are obviously subject to the control of the fault zone (Fig.1). Changchong uranium mineral (mineralization) occurrence is located in the north of the study area, so far 13 ore bodies have been found, controled by F_{301} along the EW direction and the secondary faults in hanging wall, the occurrence of ore body is basically consistent with that of the tectonic zone. The ore bodies are mostly in veined and lenticular shape with smaller scale, the uranium grade varies a lot, the highest uranium grade reaches 0.731% and the general uranium grade varies from 0.05% to 0.1%, the major part is of low-grade ore. The ore body is thin with the maximum horizontal thickness of 3.07m. The Baishijiao uranium mineral (mineralization) occurrence is located in the northeast of the study area, and the uranium mineralization is mainly subject to the control of the nearly faults along the EW and NW directions. the type of the industrial mineralization with horizontal thickness of 6.65m, grade of 0.172% and horizontal thickness of 11.6m, grade of 0.168%, is of potassic feldspathization (alkali metasomatism type). Caopingmi uranium mineral (mineralization) occurrence is located in the southwest of the study area and the uranium mineralization is mainly subject to the control of the nearly fault along the EW direction. The uranium grade is low and mineralization type is of potassic feldspathization (alkali metasomatism type).

The ore is mainly in filling-metasomatic texture, including the inter granular filling -metasomatic texture, fractures filling-metasomatic texture and metasomatic relic texture, being followed by the crystal texture. The ore are mainly in fine veined, disseminated, drusitic and nodular structures.

The main categories of wall-rock alteration are potassic feldspathization, sericitization, silicification, hematitization and kaolinization followed by chloritization and carbonatization, fluoritization. The alterations are characterized by a certain of zoning. In general, it is developed from the mineralization center to the outside horizontally: silicification→potassic feldspathization→sericitization→ hematitization → kaolinization. The deep alteration vertically is characterized by a wide range of potassic feldspathization, sericitization and silicification, while the shallow alteration is mainly in potassic alteration and accompanied by silicification, chloritization and carbonatization, the Uranium mineralization is closely related to potassic feldspathization, silicification and hematitization.

3 Analysis methods

In order to identify more precisely the compositions and occurrence of uranium minerals of Huashan granite-type uranium ore deposits, this paper has carried out a detailed analysis of EPMA and EDS for the typical ore samples of the three uranium mineral (mineralization) occurrences. The desired probe films for the EPMA and EDS analysis has been produced by Chengxin Geological Services Co., Ltd in Langfang. And the analysis and testing work have been carried out in Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration (Guilin University of Technology). The instrument model number is JXA-8230, and the main parameters are: accelerate voltage: 20Kv, Probe current: 30nA, Probe Dia: 1.0um. The testing data of the three uranium mineral (mineralization) occurrences is shown in Table 1, 2, 3.

Table 1 EDS (deoxy) analysis results of (meta-) autunite of Changchong uranium mineral (mineralization) occurrences

Order	Components content (wt%)								Atoms (in 5 oxygens)					
no.	SiO_2	P_2O_5	CaO	FeO	NaO	Al_2O_3	UO_2	Total	Si	P	Ca	Fe	Na	U
1	0.10	18.67	6.48	0.62	0.00	0.00	70.03	95.90	0.02	2.37	1.05	0.08	0.00	2.35
2	0.28	19.74	6.42	0.44	0.00	0.00	69.03	95.91	0.04	2.47	1.02	0.05	0.00	2.27
3	0.10	20.55	6.25	0.12	0.00	0.00	68.90	95.92	0.02	2.56	0.98	0.01	0.00	2.25
4	2.83	14.83	6.09	0.62	0.84	1.08	66.86	93.15	0.41	1.84	0.96	0.08	0.24	2.18
5	0.62	16.20	7.13	0.65	0.30	0.81	68.37	94.08	0.09	2.06	1.15	0.08	0.09	2.29
6	0.18	19.45	6.34	0.13	0.09	0.00	69.73	95.92	0.03	2.45	1.01	0.02	0.03	2.31
7	0.15	18.86	6.41	0.31	0.12	0.02	69.81	95.68	0.02	2.39	1.03	0.04	0.03	2.32
8	4.92	19.42	4.60	0.50	0.81	1.34	64.74	96.33	0.66	2.22	0.66	0.06	0.21	1.94
9	1.39	19.16	5.73	0.22	0.41	0.57	68.46	95.94	0.20	2.36	0.89	0.03	0.12	2.22
10	0.94	19.92	6.05	0.60	0.21	0.15	68.10	95.97	0.14	2.45	0.94	0.07	0.06	2.20
11	1.66	19.40	5.89	1.33	0.34	0.68	66.74	96.04	0.24	2.35	0.90	0.16	0.09	2.13
12	1.67	19.96	5.44	0.29	0.93	0.42	67.31	96.02	0.24	2.41	0.83	0.03	0.26	2.14
13	0.38	18.57	6.21	2.85	0.00	0.18	66.98	95.17	0.06	2.31	0.98	0.35	0.00	2.20
14	3.15	19.79	5.60	0.59	0.00	1.63	64.91	95.67	0.43	2.31	0.83	0.07	0.00	1.99
15	4.13	18.80	5.47	5.47	0.00	1.94	65.75	101.56	0.57	2.21	0.81	0.00	0.00	2.03
16	0.00	19.34	5.86	0.00	0.00	0.00	70.63	95.83	0.00	2.47	0.95	0.00	0.00	2.37
Average	1.41	18.92	6.00	0.92	0.25	0.55	67.90	95.94	0.20	2.33	0.94	0.07	0.07	2.20

Table 2 EDS (deoxy) analysis results of kasolite of Baishijiao mineral (mineralization) occurrences

Order	Components content (wt%)						Atoms (in 10 oxygons)		
no.	SiO_2	FeO	Al_2O_3	PbO	UO_2	Total	Si	Pb	U
1	11.57	0.00	0.08	37.52	47.96	97.13	1.18	1.03	1.09
2	11.10	0.19	0.00	37.05	47.25	95.59	1.11	1.00	1.05
3	11.87	0.00	0.00	37.26	48.02	97.15	1.21	1.02	1.09
4	11.20	0.00	2.19	37.26	48.66	99.31	1.16	1.04	1.12
5	14.59	1.34	0.00	34.48	43.67	94.08	1.30	0.83	0.87
6	14.00	0.80	1.16	35.86	44.89	96.71	1.31	0.90	0.93
7	12.69	0.38	0.16	36.41	47.36	97.00	1.25	0.97	1.04

8	12.79	0.17	0.45	36.87	46.38	96.66	1.25	0.97	1.01
9	11.24	1.03	1.12	38.48	42.60	94.47	1.05	0.97	0.88
10	15.53	1.97	1.82	34.87	43.25	97.44	1.38	0.83	0.85
11	11.19	0.74	0.05	39.23	46.05	97.26	1.15	1.08	1.05
12	12.71	0.00	0.32	36.34	47.54	96.91	1.25	0.96	1.04
13	14.17	0.00	0.88	34.96	46.64	96.65	1.32	0.88	0.97
14	13.16	0.00	0.24	36.67	46.78	96.85	1.28	0.96	1.01
15	13.49	0.00	0.44	35.91	46.97	96.81	1.30	0.93	1.00
16	13.66	0.05	0.39	36.22	46.18	96.50	1.30	0.92	0.97
Average	12.81	0.42	0.58	36.59	46.26	96.66	1.24	0.96	1.00

Table 3 EDS (deoxy) analysis results of uranium minerals of Caomiping mineral (mineralization) occurrences

Order	Components content (wt%)							Atoms (in 5 oxygens)					
no.	SiO_2	P_2O_5	FeO	CuO	As_2O_5	UO_2	Total	Si	P	Fe	Cu	As	U
1	0.49	6.82	0.94	4.28	15.16	68.18	95.88	0.11	1.27	0.17	1.07	1.75	3.34
2	0.85	11.53	0.65	7.18	8.25	68.68	97.14	0.18	2.03	0.11	1.13	0.90	3.18
3	0.23	10.20	0.48	6.19	12.85	68.62	98.57	0.05	1.85	0.09	1.00	1.44	3.27
4	0.25	10.30	0.26	6.88	12.30	67.70	97.69	0.05	1.84	0.05	1.10	1.36	3.18
5	1.32	8.86	0.72	6.57	14.21	66.38	98.06	0.28	1.58	0.13	1.04	1.56	3.10
6	0.53	10.56	0.36	7.20	12.88	66.33	97.86	0.11	1.86	0.06	1.13	1.40	3.07
7	0.57	15.00	0.97	7.30	5.50	67.42	96.77	0.11	2.52	0.16	1.09	0.57	2.98
8	0.19	8.36	1.49	7.39	10.96	68.82	97.21	0.04	1.54	0.27	1.22	1.25	3.33
9	0.35	9.90	2.39	6.06	14.11	65.30	98.11	0.07	1.75	0.42	0.95	1.54	3.03
10	0.43	10.81	2.40	5.34	11.84	67.16	97.98	0.09	1.91	0.42	0.84	1.29	3.12
11	0.26	10.92	5.12	6.37	10.66	64.30	97.63	0.05	1.89	0.87	0.98	1.14	2.92
12	0.00	10.31	1.26	6.84	9.63	69.20	97.24	0.00	1.86	0.23	1.10	1.08	3.29
13	0.00	9.44	0.00	6.71	14.14	67.68	97.97	0.00	1.71	0.00	1.09	1.58	3.22
14	0.17	10.48	1.83	6.38	11.78	67.32	97.95	0.04	1.84	0.32	1.00	1.28	3.10
15	1.06	9.99	1.21	5.94	10.24	69.05	97.50	0.23	1.78	0.21	0.95	1.13	3.24
16	0.00	12.32	1.89	5.97	10.78	66.62	97.57	0.00	2.14	0.33	0.93	1.16	3.04
17	0.00	13.62	1.74	6.77	7.84	67.22	97.18	0.00	2.34	0.30	1.04	0.83	3.03
18	0.00	11.25	1.32	6.58	11.67	66.84	97.66	0.00	1.98	0.23	1.03	1.27	3.09
Average	0.37	10.59	1.39	6.44	11.38	67.38	97.55	0.08	1.87	0.24	1.04	1.25	3.14

4 Testing results

The testing results of EPMA and EDS show that the ore minerals of the three uranium mineral (mineralization) occurrences of Huashan granite ore deposit are different, among which the compositions of Changchong is (meta-) autunite, of Baishijiao is kasolite, and of Caomiping are torbernite and zeunerite.

The EPMA and EDS analysis results of autunite of Changchong uranium mineral (mineralization) occurrences are shown in Table 1. In autunite, the average content of CaO is 6.00%, UO_2 is 67.90% and P_2O_5 is 18.92%. The crystal chemical formula is $Ca_{0.94}(UO_2)_{2.20}(PO_4)_{2.33}\cdot 8H_2O$, which is similar to the standard chemical formula $Ca(UO_2)_2(PO_4)_2\cdot 8H_2O$ of (meta-) autunite.

Therefore it is called (meta-) autunite (Met), and its EDS map is shown in Fig. 1a. It has three main modes of occurrence: ① filling the fractures of feldspar or quartz (especially feldspar) in leaf shape (more euhedral) (Fig.1a); ② filling the fractures or broken bands in fine veins, coexisting with chalcedony veins, or grown in the quartz crystal cave; ③ symbiotically distributed in the quartz grains with hematite.

The EPMA and EDS analysis results of kasolite of Baishijiao uranium mineral (mineralization) occurrences are shown in Table 2. Among them, the average content of PbO is 36.59%, UO_2 is 46.26%, SiO_2 is 12.81% in the chemical composition of kasolite. According to the EPMA and EDS analysis results, its crystal chemical formula is identified as $Pb_{0.96}(UO_2SiO_4)_{1.12}\cdot H_2O$, which is similar to the standard chemical formula $Pb(UO_2)SiO_3(OH)_2$ of kasolite. So its name has been determined as kasolite and the corresponding EDS map is shown in Fig.2b. The kasolite is yellow and brown, mostly filling and metasomatism along the inter particles or fractures of quartz or feldspar(mainly quartz), showing the metasomatic relic texture, and some of them are in euhedral - subhedral granular, columnar and fine needle (Fig. 1b).

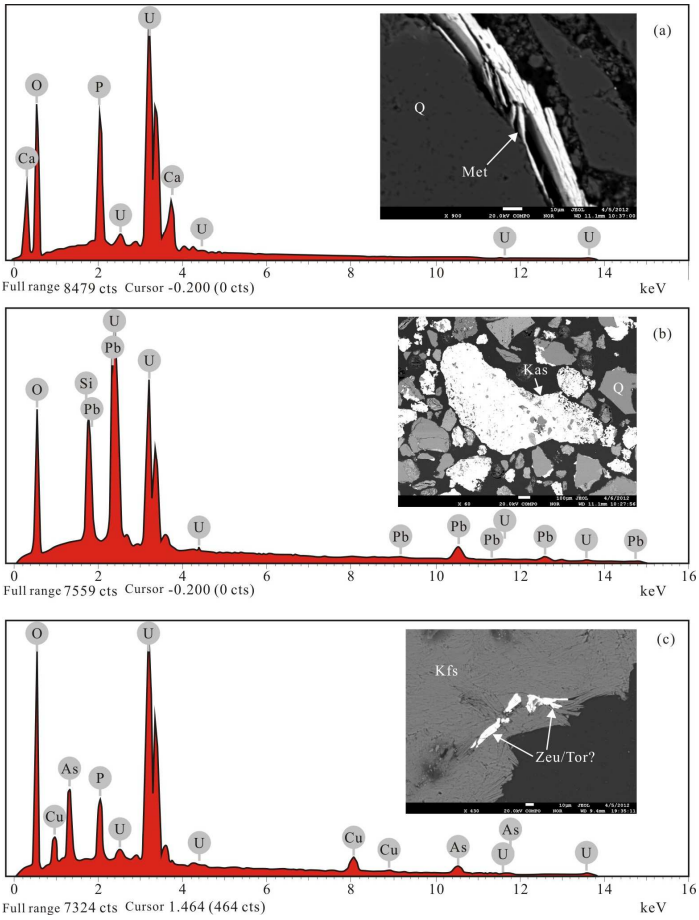

Fig.1 Uranium mineral EDS of mineral (mineralization) occurrences of Huashan granite-type uranium deposits

(a) EDS map of (meta-) autunite; (b) EDS map of kasolite; (c) EDS map of torbernite and zeunerite

The EPMA and EDS analysis results of torbernite and zeunerite of Caomiping uranium mineral (mineralization) occurrences are shown in Table3. In chemical components of this uranium mineral, the average content of CuO is 6.44%, UO_2 is 67.38%, As_2O_5 is 11.38% and P_2O_5 is 10.59%. According to EPMA and EDS analysis results, its crystal chemical formula is identified as

$Cu_{1.04}(UO_2)_{3.14}(PO_4)_{1.87}(AsO_4)_{1.25}\cdot 8H_2O$, which is possibly the combinations of torbernite and zeunerite. Its EDS map is shown in Fig. 1c. Both of them have the similar shape characteristics: in emerald green color, shaped in plates and sheets, the aggregates are shaped in scales, druses and stars. Its mode of occurrence is mainly in filling and metasomatism along the inter particles and fractures of feldspar or quartz (mainly feldspar) , and often accompanied by varying degrees of hematitization (Fig. 1c).

5 Conclusions

1. EPMA and EDS results indicate that the main minerals of Huashan granite-type uranium ore deposit are all secondary uranium minerals, among which Changchong is (meta-) autunite, Baishijiao is kasolite, Caomiping is torbernite and zeunerite.

2.Chemical compositions of the three uranium minerals (mineralization) occurrences are obvious different, implying the different mineral sources, or due to the post secondary alteration process.

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