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Vertical Zoning Characteristics of Trace Element in Zoige 510-1 Uranium Deposit，Sichuan Province，China

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The Zoige uranium ore field is located in the junction region of the Zoige County in northwest of Aba State of Sichuan Province, Diebu County and Luqu County of Gansu Province. This ore field, distributing nearly EW, is almost 50km in length, 6km in width, ～300km^2 in area, and 2900～4060 meters in altitude. As one of the extremely valuable and promising uranium resource base in China, more than 10 uranium deposits and 20 ore spots have been discovered in the Zoige uranium ore field. The study of 510-1 Uranium Deposit in Zoige region has the guiding significance for the prospecting work in Zoige area, due to it its large scale, high grade and representative significance.

The recent research (Chen, 2008; Zhang et al.,2011) shows that the vertical zoning of gangue minerals (quartz and calcite) in 510-1 uranium ore deposit have an distinct characteristic of "acid upper veins and alkaline lower veins" , which is similar with the granite-type uranium deposits in South China. Quartz veins are developed on the top of ore deposit (level No.1 and upper), and both of quartz veins and calcite veins are developed (or formed) in the mid (level No.2 to No.4). While on the bottom of ore deposit (level No.5 to No.7 and below), only calcite veins are developed, No quartz vein has been found there. The research results indicates that there exists an "acid and alkaline isolation" geochemical interface nearby No.5 level of 510-1 uranium deposit. In this paper, the distribution characteristics of trace element in ore were studied in details to reveal the essential vertical zoning characteristics of this deposit from a microscopic view.

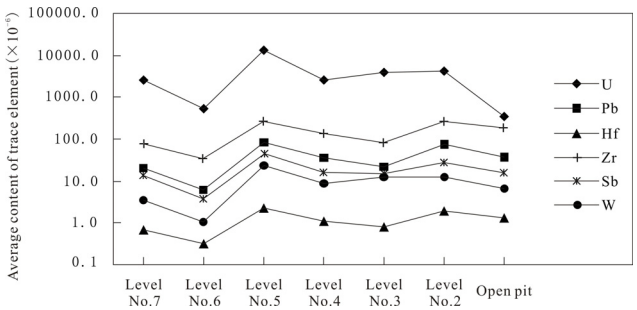

Fig.1 Comparision of average content of trace element in ores from different sections of 510-1 uranium deposit

1 Geological background

The ore-bearing rock in Zoige 510-1 uranium deposit

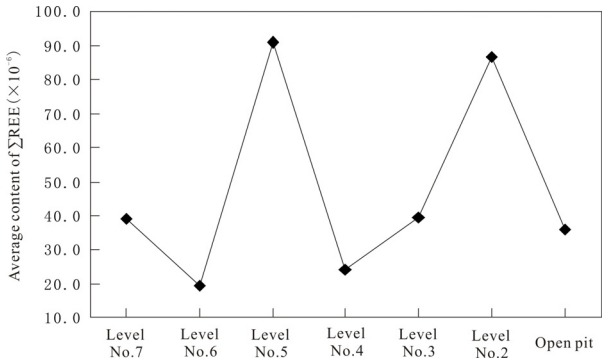

Fig.2 Comparision of average content of ∑REE in ores from different sections of 510-1 uranium deposit

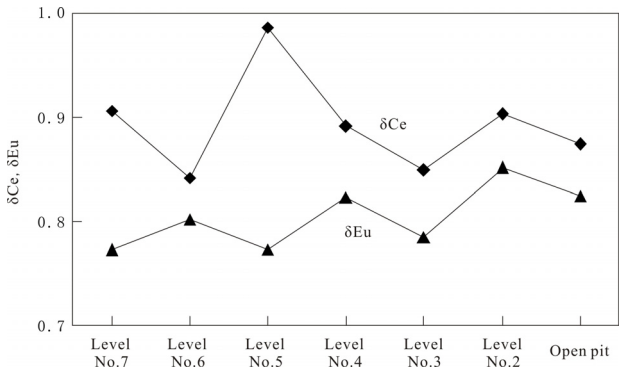

Fig.3 Comparision of δCe and δEu in ores from different sections of 510-1 uranium deposit

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Table 1 correlation coefficient of trace elements in ores of 510-1 uranium ore depositt

	U	Pb	Zr	Hf	Sb	W
U	1.00					
Pb	0.75	1.00				
Zr	0.71	0.94	1.00			
Hf	0.77	0.95	0.99	1.00		
Sb	0.91	0.89	0.83	0.86	1.00	
W	0.92	0.79	0.77	0.82	0.89	1.00

are composed of the Lower Silurian sediment series of Yangchangou formation, known as "carbonaceous-siliceous-argillitic rock", which mainly consists with silicalite, limestone and slate(Chen et al.,2007). The ore bodies mainly occur in the crushed siliceous limestone in the form of vein. The metal minerals mainly exist as uraninite, colloidal, particulate, quasi-massive, veined pyrite and contain a small amount of sulfide including nickel, zinc, molybdenum, vanadium and copper. The non-metallic minerals are mainly consisted with calcite and with some quartz, few barite and dolomite. The ore mineral assemblages are characterized by consociation with uraninite-pyrite-calcite-quartz, which indicates that typical hydrothermal minerals, such as pyrite, calcite and quartz, are closely associated with the mineralization procedure of uranium .

2 Sampling and analytical methods

The rock samples from different levels (the openpit and levels No.2～7) in 510-1 uranium ore deposit were collected and sent to the analytical laboratory of Beijing Research Institute of Uranium Geology for analysis. The samples were crushed, ground into 200 mesh and analyzed according to a standard analytical method (DZ/T00223—2001). For the determination of trace elements, an HR-ICP-MS(Finnigan Element Ⅰ) was used，with an

Table 2 Average contents of trace element in ores from different sections of 510-1 uranium deposit ($\times10^{-6}$)

Location	Open pit	Level No.2	Level No.3	Level No.4	Level No.5	Level No.6	Level No.7
Number(a)	3	6	6	8	4	3	9
U	355.00	4270.50	3985.33	2623.84	13414.75	545.33	2612.56
Pb	38.60	77.58	22.75	37.91	85.63	6.59	20.97
Zr	191.67	268.48	85.45	138.63	268.30	35.63	78.66
Hf	1.40	2.06	0.85	1.17	2.43	0.34	0.72
Sb	15.66	27.93	15.42	16.36	44.83	3.80	13.78
W	6.70	12.58	12.46	8.79	23.54	1.10	3.59

Table 3 Average content of REE and parameter in ores from different sections of 510-1 uranium deposit ($\times10^{-6}$)

Location	Open pit	Level No.2	Level No.3	Level No.4	Level No.5	Level No.6	Level No.7
Number(a)	3	6	6	8	4	3	9
La	5.02	4.81	5.15	4.60	9.94	2.30	5.38
Ce	9.44	13.26	9.65	8.15	22.92	4.35	10.80
Pr	1.30	2.47	1.36	0.99	2.72	0.71	1.53
Nd	6.61	13.49	7.22	4.22	13.16	3.61	7.28
Sm	2.14	4.57	2.10	0.90	3.63	1.04	1.92
Eu	0.63	1.64	0.63	0.26	1.17	0.33	0.56
Gd	2.64	7.72	2.87	1.10	5.61	1.52	2.46
Tb	0.49	1.86	0.54	0.20	1.31	0.29	0.49
Dy	3.19	13.95	3.69	1.39	10.27	2.00	3.27
Ho	0.62	3.08	0.83	0.30	2.30	0.42	0.67
Er	1.81	9.36	2.64	1.00	7.91	1.36	2.15
Tm	0.27	1.36	0.37	0.15	1.18	0.19	0.32
Yb	1.73	8.18	2.28	0.93	7.61	1.22	2.07
Lu	0.25	1.10	0.35	0.15	1.16	0.20	0.34
ΣREE	36.14	86.84	39.69	24.35	90.88	19.54	39.23
δCe	0.874	0.903	0.849	0.891	0.986	0.842	0.906
δEu	0.825	0.852	0.786	0.824	0.774	0.803	0.773

analytical precision less than 10%.

3 Results and Discussion

3.1 Results and Discussion on trace elements

The trace elements, which significantly correlated with U, are listed in Table 1. It is obvious from Table 1 that U has significantly positive correlation with Pb, Zr, Hf, Sb and W. Especially for Sb and W, the correlation coefficients are higher than 0.9, showing a close genetic relationship of the mineralization of U and the enrichment procedure of the two elements.

The average contents of trace elements significantly correlating with U, are listed in Table 2, and their variation trends in the investigated area are depicted in Fig. 1. These trace elements are highly enriched in level No.5 (Fig. 1, Table 2), which is consistent with the "acid upper veins and alkaline lower veins" rule of gangue minerals in field observation. There is an important geochemical interface nearby the No.5 level of the 510-1 uranium deposit as well as a high concentration position of multi-metal for outburst of mineralization.

3.2 Results and Discussion on REE

The average contents and characteristic parameters of the rare earth elements in different levels of 510-1 uranium deposit are listed in Table 3, and their variation trends are shown in Fig. 2. These rare earth elements are highly enriched in level No.5 (Fig. 2, Table 3), which is consistent with the that of the trace elements.

3.3 Vertical zoning characteristics of *δ*Ce and *δ*Eu in ores

Both Ce and Eu are significant variant valence elements, which present in different valence state relied on the redox condition of the surrounding environment (Zhao, 1997). Under a relatively reductive condition, Ce^{3+} is stable in solution for a long time.While Eu^{3+} will be reduced into Eu^{2+} and precipitated resulting in the loss of Eu in the fluid, which contributed to the negative anomaly of Eu in hydrothermal minerals. . Conversely, under the relatively oxidized condition, Eu^{3+} can be stored in the solution for a long time, while Ce^{3+} will be oxidized into Ce^{4+} and precipitated, leading to thenegative anomaly of Ce in hydrothermal minerals. Therefore, δCe and δEu can be used as indicators of the redox condition of environment surrounded.

4 Conclusions

Based on the distribution characteristics of trace elements in ores from 510-1 uranium ore deposit, it can be concluded:

(1) The enrichment zone of trace elements and REE in level No.5 illustrate that there is an important geochemical interface nearby the No.5 level of the 510-1 uranium deposit as well as a high concentration position of multi-metal for outburst of mineralization.

(2) The 510-1 uranium deposit formed from deep to shallow is corresponding to the environment changed from the relative reduction to relative oxidation condition . The significant changes of δCe and δEu nearby the No.5 level of the 510-1 uranium deposit indicates a geochemical interface of oxidative-reductive condition existing nearby the No.5 level.

Key word: Uranium deposit; Vertical zoning; Trace element; Zoige

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