Research Advances

In-situ Chemical Age of the Sandstone-hosted Uranium Deposit in Ningdong Area on the Western Margin of the Ordos Basin, North China

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Objective

The Ordos Basin located in the western part of the North China Craton bears various energy resources such as oil, gas, coal and uranium. It is one of the richest uranium-bearing basins in China. Since the discovery of the large-scale Dongsheng, Hangjinqi and Daying uranium deposits in the north of the Ordos Basin, a new breakthrough of uranium exploration has been achieved in the Ningdong area (eastern Ningxia) on the western margin of the Ordos Basin (WMOB) in the past two years (Wang Feifei et al., 2017).

The sandstone-type uranium deposits in the WMOB lack precise dating data. A previous study has dated the Huianbu uranium deposit, which is further south than Ningdong, based on the U-Pb whole rock isochronal method (Jing Guoqiang et al., 2015). However, that data is considered mixed and controversial to represent the uranium mineralization age there. In view of this, we examined drill hole YCZK2-1 of the newly found uranium in the Ningdong area (Fig.1). With the electron probe microanalyses (EPMA), this study initially performed in-situ chemical dating of uranium mineral in the WMOB to understand its ore-forming mechanism better.

Methods

ND-1 and ND-2 were sampled from uranium ore sandstone of the drill hole YCZK2-1 at depths of 417 m and 418 m, respectively. The Zhiluo Formation of the Middle Jurassic (J_2z) consists of two sections, and uranium ores occur in sandstone of the lower section (J_2z_1). Concentrations of elements (U, Th, Pb, etc.) were sequentially determined in the selected appropriate areas of uranium mineral with the EPMA. Then the single point ages could be obtained by solving the age equation with an iterative program (more details in A. Cross et al., 2011). The weighted mean age and error were calculated using Ludwig's Isoplot 4.16.

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Results

Results of the EPMA show that brannerite is the only kind of uranium mineral occurring in the two samples (Appendix 1, Fig. 1). Analysis of sample ND-1 at 9 spots along a certain direction yielded ages ranging from 3.9 Ma to 10.7 Ma. The weighted mean age is 6.3±2.7 Ma (Fig. 1c). An interesting pattern was found between the location of the spots and the age distribution: the age decreases from the center spot to the edge spot, with the oldest age point (10.7 Ma) in the center and the two youngest age points (3.9 Ma and 4.2 Ma) on the edge. This suggests a multiple-staged and inside-out regulation of the brannerite mineralization. Sample ND-2 was measured at 2 spots. One yielded 6.6 Ma (Fig. 1d) while the measured data at the other spot was discarded due to the mistake of its location. This age data is consistent with the weighted mean age of sample ND-1. Therefore, 6.5 Ma is considered as the main uranium mineralization age of the drill hole YCZK2-1in this paper.

The uplift of the Tibetan Plateau in the middle and late Miocene enhanced its extrusion to the southwest corner of the Ordos Basin. In the same period at about 8−5 Ma, east-west tectonic inversion occurred in the Ordos Basin with an uplift of the west and a depression of the east. This inversion made the target formation (J_2z) of part of the anticlinal apex in the WMOB exposed to the surface. The uranium-bearing oxygenated water could then get into the target formation and form interlayer oxidation zone. As the underground environment changed, uranyl ions entering the target formation were reduced and precipitated, and eventually formed uranium deposits in Ningdong and adjacent areas.

Conclusion

This study initially yielded in-situ ages of the uranium

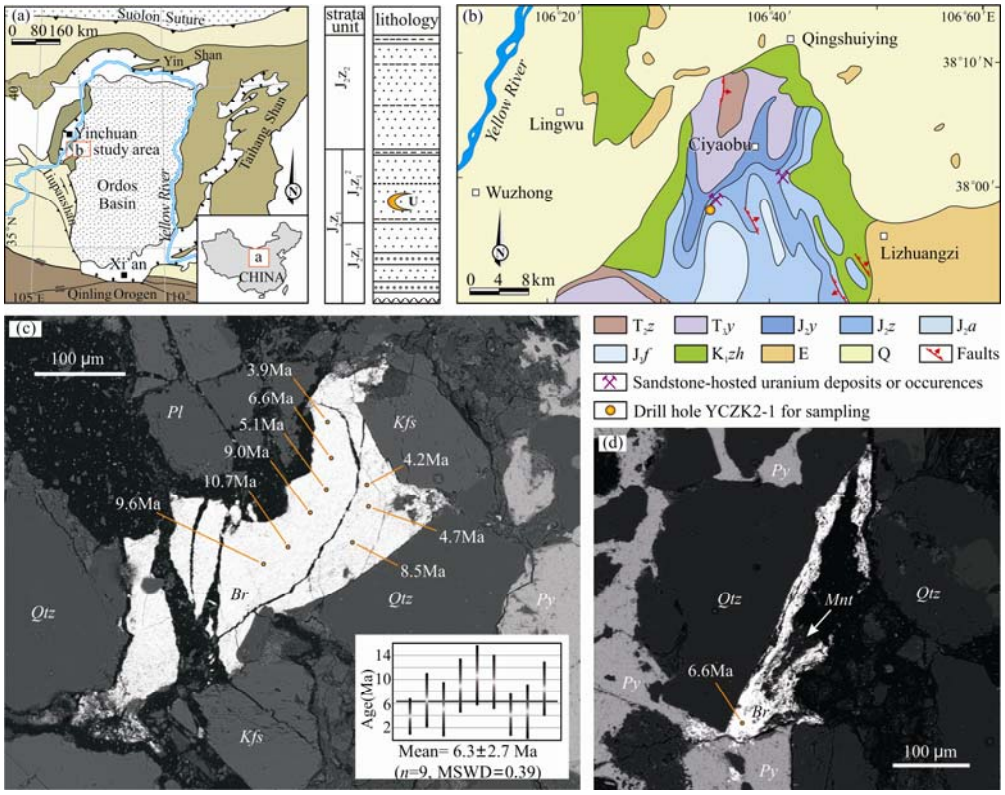

Fig. 1. (a), Tectonic map of the Ordos Basin with its adjacent area and stratigraphic column of the Zhiluo Formation (J_2z); (b), simplified geological map of Ningdong (study area) in the WMOB, showing the sample location; (c), back Scatter Electron (BSE) image showing EPMA spot locations, age distribution and their weighted mean age of sample ND-1 (n = 9, 2σ error bars shown); (d), BSE image showing EPMA spot location and age of sample ND-2.
Br − Brannerite; Kfs − K-feldspar; Mnt − Montmorillonite; Pl − Plagioclase; Py − Pyrite; Qtz − Quartz.

mineral (brannerite) in the WMOB with EPMA chemical dating. One of the main mineralization age of the uranium deposit in Ningdong is 6.5 Ma, with a multiple-staged mineralization age ranging from 10.7 Ma to 3.9 Ma. The regional tectonic setting of mineralization includes the outward extension of the Qinghai-Tibet Plateau uplift and the east-west tectonic inversion of the Ordos Basin in the middle-late Miocene.

Acknowledgments

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Appendix 1 EPMA analyses (wt%) and calculated chemical ages of uranium mineral grains from drill hole YCZK2-1

Spot No.	Na_2O	Al_2O_3	SiO_2	P_2O_5	MgO	Y_2O_3	CaO	TiO_2	FeO	Nd_2O_3	PbO	ThO_2	UO_2	MnO	Ce_2O_3	Total	Age (Ma)
ND-1-1	0.099	0.670	3.460	0.542	0.332	0	1.191	35.691	1.122	0.033	0.028	0.030	53.242	0.106	0.322	96.868	3.9
ND-1-2	0.071	0.929	3.777	0.419	0.404	0	1.077	37.391	1.114	0	0.042	0.021	47.472	0.057	0.266	93.040	6.6
ND-1-3	0.081	0.743	4.080	0.562	0.240	0	1.063	32.669	1.134	0	0.035	0.011	51.126	0.034	0.369	92.147	5.1
ND-1-4	0.118	0.821	3.622	0.422	0.347	0	1.071	34.073	1.165	0.143	0.063	0.002	52.289	0	0.359	94.495	9.0
ND-1-5	0.061	0.494	2.996	0.456	0.226	0	1.088	34.358	0.944	0.153	0.076	0.054	53.433	0.029	0.389	94.757	10.7
ND-1-6	0.108	0.913	4.380	0.260	0.255	0	0.997	36.240	1.146	0.121	0.063	0.002	49.050	0.054	0.261	93.850	9.6
ND-1-7	0.114	0.510	3.580	0.504	0.372	0	1.153	28.183	0.949	0.076	0.032	0	56.737	0.074	0.474	92.758	4.2
ND-1-8	0.091	0.379	2.830	0.516	0.156	0	1.034	35.904	1.492	0	0.031	0.093	49.772	0.072	0.249	92.619	4.7
ND-1-9	0.032	0.320	2.644	0.568	0.161	0	0.953	39.018	1.439	0.187	0.055	0.004	48.388	0.053	0.431	94.253	8.5
ND-2-1	0.048	0.376	2.632	0.520	0.083	0	1.115	33.615	1.438	0	0.046	0.042	52.859	0.045	0.346	93.165	6.6

*Analyses were performed under a 1~2 μm beam at the lab of Xi'an Center of Geological Survey, China Geological Survey.