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Research Advances

Early Mineralization Age of the Hengjian Uranium Deposit: Constraints from Zircon SIMS U-Pb Dating

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Objective

The Hengjian uranium deposit is a typical hydrothermal deposit in the Xiangshan uranium ore field. The uranium mineralization ages of the Xiangshan deposits are poorly constrained, and only a few mineralization ages using the pitchblende U–Pb method have been published. These ages are commonly discordant and dispersed for abundant inclusions and an open U–Pb system. Zircon grains after strong hydrothermal alteration are usually characterized by high common Pb contents, and their U–Pb isochron ages recorded the hydrothermal alteration event without interference of common Pb components. The Hengjian gray/grayish-green granite porphyry experienced strong alteration by hydrothermal fluids during the pervasive uranium mineralization in the Xiangshan uranium ore field. Uranium mineralization in the Hengjian deposit may had different stages, and strong hydromicatization alteration occurred at a relatively early stage. Their altered zircon U–Pb isochron ages possibly represent relatively early mineralization age of the Xiangshan uranium deposits. Altered zircon grains from the Hengjian granite porphyry were analyzed using the secondary ion mass spectrometry (SIMS) U-Pb method in this study, and U–Pb isochron ages were measured to constrain the relatively early mineralization age of the Hengjian uranium deposit.

Methods

Zircon grains from granite porphyry in the Hengjian uranium deposit were separated from crushed samples using conventional magnetic and density techniques. The grains were mounted in epoxy resin along with TEMORA and Qinghu zircon standards. The mounts were polished to expose the centers of the grains. Prior to U–Pb isotopic analysis, zircon grains were examined with transmitted and reflected light and cathodoluminescence CL images to reveal their internal textures. U–Pb isotopic analysis of zircon crystals were performed at the analytical laboratory of the Beijing Research Institute of Uranium Geology. Measurements of U, Th and Pb were conducted using the CAMECA IMS 1280 ion microprobe. The uncertainties of individual analyses were reported at a 1 sigma level. The ^{206}Pb–^{238}U and ^{207}Pb–^{235}U isochron ages were used because of high common Pb content.

Results

Zircon grains are mainly euhedral with short or long prismatic crystals (Fig. 1a), and display oscillatory zoning with variable luminescence and clear rim-core textures in CL images. The analyzed samples have U and Th contents that vary from 102 to 8,925 ppm and 54 to 4,261 ppm, respectively (Appendix 1). Most analyzed points have high common Pb contents (f_{206}=0.48%–8.78%) and Th/U ratios (0.2–1.1), displaying characteristics of altered zircon. SIMS in-situ O isotopic ratios of altered zircon are lower than normal zircon (unpublished data), and normal zircons experienced strong alteration to vary O isotopic ratios. The concordia ages of analyzed samples after common Pb correction are not reliable in representing the uranium mineralization ages because of the high content of common Pb in altered zircons. In order to avoid the imprecise common Pb correction, the analyses yielded a 121.5±7.8 Ma ^{206}Pb–^{238}U isochron age (Fig. 1b, MSWD=0.85); and a 119.4±9.6 Ma ^{207}Pb–^{235}U isochron age (Fig. 1c, MSWD=1.08) (Fig. 1b, c). The isochron ages of altered zircon from the Hengjian granite porphyry are similar to the uranium mineralization age of 120–126Ma according to pitchblende U–Pb dating (Li et al., 2006; Li et al., 2014), and possibly represent the relatively early uranium mineralization age of the Hengjian uranium deposit.

Discussions and Conclusions

The altered zircons from highly altered Hengjian granite porphyry has the obvious characteristics of dark CL, high common Pb, and different ages in contrast to primary igneous zircon. Previous studies show that hydromicatization alteration occurs at relatively early uranium mineralization stages and the ages of high common Pb zircon may represent relatively early uranium mineralization ages. SIMS O isotopic ratio results show that the normal zircon experienced relatively early uranium-rich hydrothermal alteration, because zircon O isotopic ratio is very hard to change at general hydrothermal alteration status. The altered zircon analyzed in this study yielded ^{206}Pb–^{238}U and ^{207}Pb–^{235}U isochron

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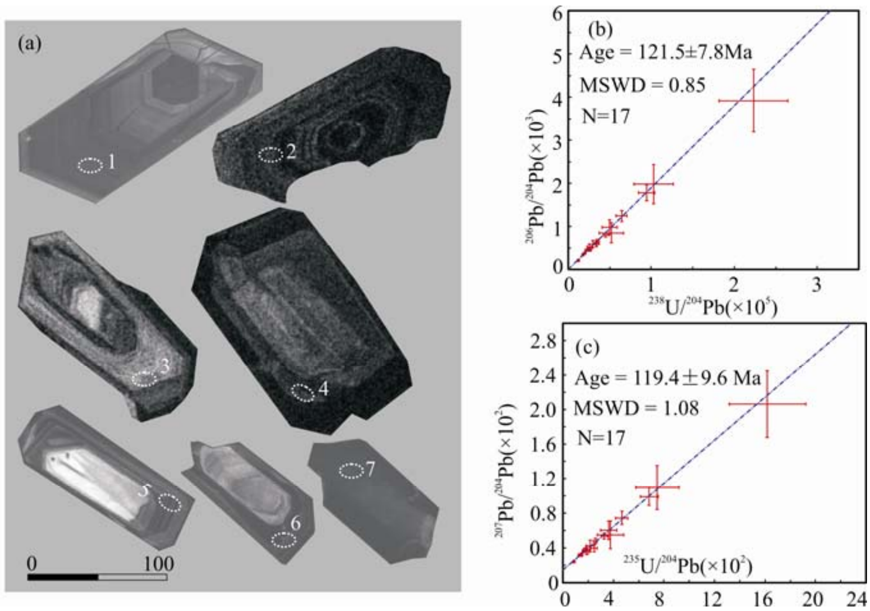

Fig. 1. Cathodoluminescence images (a) and the zircon ^{206}Pb-^{238}U (b) and zircon ^{207}Pb-^{235}U isochron curves (c) for altered Hengjian granite porphyry.

ages of 121.5±7.8 Ma and 119.4±9.6 Ma, respectively. The isochron ages of altered zircon eliminate the interference of uncertain common Pb components, suggesting that the Xiangshan relatively early uranium minerlization occurred at the Early Cretaceous.

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Appendix 1 SIMS zircon U-Pb dating results of Hengjian granite porphyry

Sample	Isotopic ratios								Contents (ppm)		Th/U
	^{238}U/^{204}pb	1σ	^{206}Pb/^{204}Pb	1σ	^{235}U/^{204}pb	1σ	^{207}Pb/^{204}Pb	1σ	U	Th	
X6@1	20186.70	5.77	380.63	5.45	146.41	5.77	32.57	6.45	3527	794	0.23
X6@2	64252.90	10.27	1242.35	10.14	466.01	10.27	74.72	10.27	1847	889	0.48
X6@3	22088.34	5.21	446.79	3.51	160.20	5.21	36.47	3.56	948.5	389.3	0.41
X6@4	29757.41	15.29	583.35	14.77	215.82	15.29	42.30	15.34	603.7	246.3	0.41
X6@5	94304.79	10.53	1784.10	10.43	683.96	10.53	99.34	10.53	7342	3424	0.47
X6@6	35295.28	6.44	661.09	6.20	255.99	6.44	47.96	6.37	8925	4261	0.48
X6@7	223182.07	18.65	3922.79	18.57	1618.67	18.65	206.68	18.64	6695	1660	0.25
X6@8	49970.40	17.93	977.81	17.51	362.42	17.93	60.43	17.67	114.1	54.5	0.48
X6@9	12037.46	6.42	213.09	6.07	87.30	6.42	24.53	6.31	395	135	0.34
X6@10	24756.42	6.76	460.75	5.55	179.55	6.76	38.14	5.58	1718.9	727.0	0.42
X6@11	45197.86	7.18	803.44	6.06	327.81	7.18	54.04	6.12	1802.4	986.9	0.55
X6@12	17694.55	4.30	340.43	4.03	128.33	4.30	31.69	4.20	1280	511	0.40
X6@13	51886.68	28.08	851.87	27.16	376.32	28.08	55.00	29.51	334	295	0.88
X6@14	102911.09	22.94	1982.42	22.87	746.38	22.94	109.74	22.99	1140	505	0.44
X6@15	25815.35	12.58	517.71	12.42	187.23	12.58	37.62	12.63	777	262	0.34
X6@16	26134.30	9.26	469.47	8.86	189.54	9.26	35.80	8.99	210	67	0.32
X6@17	33995.47	10.19	591.63	9.68	246.56	10.19	40.07	9.96	102	111	1.09