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Research Advances

Cassiterite U-Pb Date of the Yangbin Porphyry Tin Deposit in Zhejiang and its Geological Significance

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Objective

The Yangbin porphyry tin deposit in Taishun County of Zhejiang Province is one of the few porphyry-type tin deposits in South China, which is located in the middle portion of the Mesozoic volcanic active belt on the southeastern coast of China. The Yangbin granite porphyry is closely related to the tin mineralization in this region. Based on petrologic and Sr-Nd-Pb isotopic characteristics, Shen Weizhou et al. (1994) suggested that the parent magma of granite porphyry belongs to S-type and probably formed by partial melting of Mesoproterozoic metasedimentary rocks which were unexposed in this area. Meanwhile, granite porphyry ages were also reported as 101.7± 2.1 Ma by the whole rock Rb -Sr method (Shen Weizhou et al., 1994). Up to now, the mineralization age of the Yangbin porphyry tin deposit is unclear. In recent decades, benefiting from the progress in analytical techniques, LA-(MC)-ICP-MS U-Pb dating on zircon and other U-bearing minerals (e.g., rutile, allanite, titanite, cassiterite) has been developed to obtain robust results (Wang Sen et al., 2017). Cassiterite is the most significant ore mineral in tin deposits. It usually contains high concentration of U in the lattice and is hardly affected by late hydrothermal alteration after crystallizing. As a result, it provides suitable conditions of operating U-Pb isotopic chronology research. Recently, great progress has been made in the mineralization ages of tin deposits by cassiterite U-Pb dating (Zhang et al., 2017). In this contribution, we present in situ LA-ICP-MS U-Pb dating of cassiterite to constrain the timing of tin mineralization in the Yangbin porphyry tin deposit.

Methods

The sample (No. YBC01) was collected from surface outcrops. Cassiterite grains without cracks and fluid inclusions are selected by microscopes for U-Pb dating analysis. Backscattered electron (BSE) and cathodoluminescence (CL) images were taken by a Zeiss Supra 55 field emission scanning electron microscope (SEM) coupled with a cathodoluminescence detector at the State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences (GIG-CAS). According to the BSE and CL images, the clear areas of zonings of cassiterite grains were chosen to operate U-Pb dating trial. In situ cassiterite U-Pb dating analysis was performed at the CAS Key Laboratory of Mineralogy and Metallogeny, GIG-CAS, using an Agilent 7900 ICP-MS equipped with a Resonetics RESOlution S-155 laser ablation system. The system was optimized using NIST SRM610 ablated with 37 μm spot size and 5 μm/s scan speed to ensure maximum signal intensity and low oxidation ratio. Helium gas carrying the ablated sample aerosol was mixed with argon (carrier gas) and nitrogen (additional di-atomic gas) to enhance sensitivity, and finally flowed into the ICP-MS instrument. Raw data reduction was performed off-line using ICPMSDataCal 10.1 software. Common Pb correction was based on the ^{207}Pb method, and the corrected data were used to calculate weighted mean ^{206}Pb/^{238}U ages. Data uncertainties of isotopic ratios for individual spots are reported at 1σ level, and the errors of their weighted mean ^{206}Pb/^{238}U ages are 2σ.

Results

Cassiterite grains from the sample YBC01, with grain sizes of 50–300 μm, are disseminated in the ore. Most euhedral cassiterite grains display color zoning patterns, with dark brown cores and pale yellow/colorless rims observed under a microscope. The CL images show that the cassiterite grains are euhedral-subhedral with long

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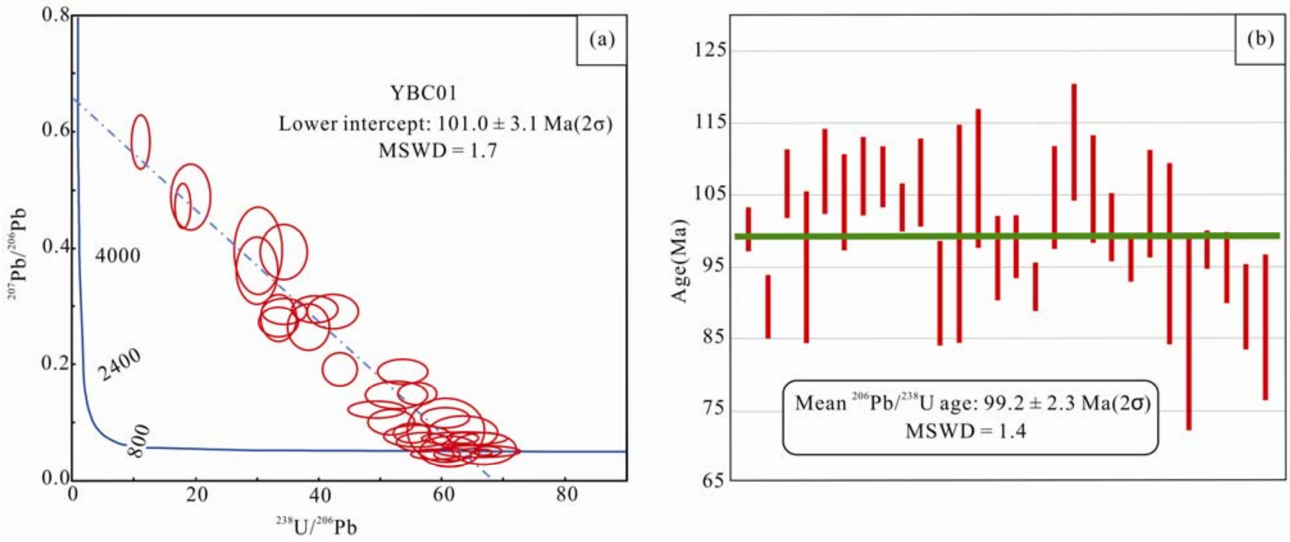

Fig. 1. (a), Tera-Wasserburg U-Pb concordia plot; (b), Weighted mean ^{207}Pb corrected $^{206}Pb/^{238}U$ age diagram for cassiterite from the Yangbin porphyry tin deposit.

columnar shape, while fine-grained cassiterite crystals are mainly euhedral. The cassiterite grains normally show a spongy texture in the core and oscillatory zonings in the rims due to the dissolution by fluids. The CL images generally show weak luminescence probably because of high contents of Nb and Fe. Thirty-four points were analyzed by U-Pb isotopic test via cassiterite grains with clear zonings and eventually achieved a Tera-Wasserburg U-Pb concordia lower interceptage of 101.0±3.1 Ma (MSWD=1.7) (Fig. 1a). After ^{207}Pb-based correction, the analyses yielded a weighted mean $^{206}Pb/^{238}U$ age of 99.2±2.3 Ma (MSWD=1.4) (Appendix 1; Fig. 1b) which agrees well with the Tera-Wasserburg U-Pb concordia lower intercept age.

Conclusion

Based on in-situ LA-ICP-MS analyses of cassiterite sample from the Yangbin porphyry tin deposit, the Tera-Wasserburg U-Pb concordia lower interceptage of 101.0±3.1 Ma and the weighted mean $^{206}Pb/^{238}U$ age of 99.2±2.3 Ma were obtained. These ages agree well with the previously published age of 101.7± 2.1Ma of the granite porphyry, which was obtained by the whole rock Rb-Sr method, therefore reinforcing the genetic relationship between tin mineralization and granitic magmatism. South China is one of the most important tin metallogenic belts in the world. The tin mineralization in South China is mainly distributed in the Late Jurassic (160–150 Ma) in the Nanling area and spread in the Late Cretaceous (95–80 Ma) in southeastern Yunnan and western Guangxi area. Recently, an Early Cretaceous (145–135 Ma) W-Sn mineralization event has been reported in southeast coast of China. The recognition of tin mineralization at 100 Ma in Yangbin is of great significance to the study of tin mineralization in South China. And our study also provides idea for prospecting of non-ferrous metals in southeast coast of China.

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References

Shen Weizhou, Liu Changshi, Chu Xuejun, Wang Dezi, Li Huiming and Yang Jiedong, 1994. Neodymium Strontium and Lead isotopic study of topaz granite porphyry in Yangbin Zhejian province. *Journal of Nanjing University* (Natural Sciences edition), 30(2): 314–321 (in Chinese with English abstract).

Wang Sen, Zhang Da, Wu Ganguo, Cao Ke, Qu Hongjie, Ma Shuai and Yu Tengda, 2017. New geochronologic evidence of diabases and their metallogenic relationship with the makeng-type iron deposits in southwest Fujian, SE China. *Acta Geologica Sinica* (English Edition), 91(6): 2324–2326.

Zhang R.Q., Lehmann B., Seltmann R., Sun W.D., and Li C.Y., 2017. Cassiterite U-Pb geochronology constrains magmatic-hydrothermal evolution in complex evolved granite systems: the classic Erzgebirge tin province (Saxony and Bohemia). *Geology*, 45(12): 1095–1098.

Appendix 1 LA-ICP-MS U-Pb dating results of cassiterite from the Yangbin porphyry tin deposit

Spots	Isotopic rations							Ages (Ma)				^{207}Pb correctedages (Ma)	
	^{238}U(ppm)	^{207}Pb/^{206}Pb	1σ	^{207}Pb/^{235}U	1σ	^{206}Pb/^{238}U	1σ	^{207}Pb/^{235}U	1σ	^{206}Pb/^{238}U	1σ	^{206}Pb/^{238}U	1σ
YBC01-1	13.33	0.080492723	0.008217644	0.155294673	0.012400229	0.016543114	0.000476081	146.6	10.9	105.8	3.0	100.2	3.0
YBC01-2	5.09	0.180268204	0.019874119	0.368479568	0.03572073	0.017836672	0.000670952	318.5	26.5	114.0	4.2	89.4	4.2
YBC01-3	5.56	0.05817095	0.008966736	0.105954719	0.013015649	0.016940072	0.000751172	102.3	11.9	108.3	4.8	106.5	4.8
YBC01-4	2.51	0.355548373	0.039294814	1.151371416	0.128320744	0.029904395	0.001688626	777.9	60.6	189.9	10.6	94.9	10.6
YBC01-5	3.71	0.123326312	0.018084131	0.270058733	0.041444002	0.019322668	0.000937115	242.7	33.1	123.4	5.9	108.3	5.9
YBC01-6	2.47	0.083522684	0.012502986	0.160366092	0.027144042	0.017264269	0.001051109	151.0	23.8	110.3	6.7	104.0	6.7
YBC01-7	5.01	0.029520722	0.004530502	0.113261433	0.040676619	0.016321841	0.000863817	108.9	37.1	104.4	5.5	107.5	5.5
YBC01-8	7.44	0.091368799	0.010386885	0.205481253	0.027791058	0.018097227	0.000671795	189.8	23.4	115.6	4.3	107.5	4.3
YBC01-9	9.81	0.050668867	0.006064041	0.10599364	0.015387474	0.0162216	0.000520938	102.3	14.1	103.7	3.3	103.3	3.3
YBC01-10	5.17	0.215166433	0.022722036	0.609972895	0.065443719	0.022991533	0.000964754	483.5	41.3	146.5	6.1	106.7	6.1
YBC01-11	2.16	0.103941991	0.019983321	0.157429653	0.021116163	0.015694639	0.001143946	148.5	18.5	100.4	7.3	91.2	7.3
YBC01-12	1.42	0.373140309	0.040470637	1.667863827	0.214108779	0.033331959	0.002429576	996.4	81.5	211.4	15.2	99.6	15.2
YBC01-13	0.88	0.489527149	0.050714164	3.510131054	0.464208792	0.052033021	0.005650023	1529.5	104.5	327.0	34.6	92.0	34.6
YBC01-14	2.30	0.266017666	0.023051325	0.953444724	0.109219888	0.026097211	0.001540476	679.9	56.8	166.1	9.7	107.2	9.7
YBC01-15	4.23	0.076920207	0.011267888	0.181199726	0.042089514	0.015782813	0.000930055	169.1	36.2	100.9	5.9	96.2	5.9
YBC01-16	9.01	0.094068261	0.01063746	0.248789797	0.027269773	0.016521011	0.000687744	225.6	22.2	105.6	4.4	97.7	4.4
YBC01-17	7.62	0.051589961	0.005614104	0.102123077	0.011462049	0.014489051	0.0005347	98.7	10.6	92.7	3.4	92.2	3.4
YBC01-18	12.51	0.05303764	0.011536738	0.199796986	0.084423544	0.016494787	0.001122812	185.0	71.4	105.5	7.1	104.6	7.1
YBC01-19	2.53	0.128372941	0.019218265	0.341230539	0.034048562	0.020231389	0.001284496	298.1	25.8	129.1	8.1	112.3	8.1
YBC01-20	1.74	0.090473415	0.023481105	0.189852159	0.033348184	0.017787873	0.001185335	176.5	28.5	113.7	7.5	105.8	7.5
YBC01-21	5.13	0.049393578	0.006333085	0.106319449	0.012910841	0.015743821	0.000739421	102.6	11.8	100.7	4.7	100.5	4.7
YBC01-22	16.44	0.049048249	0.004495494	0.106940118	0.009111194	0.015033447	0.000500637	103.2	8.4	96.2	3.2	96.0	3.2
YBC01-23	3.14	0.137071635	0.016534463	0.390146467	0.04873766	0.019001773	0.001184812	334.5	35.6	121.3	7.5	103.8	7.5
YBC01-24	0.76	0.341095616	0.049171341	1.172713323	0.101218146	0.029105051	0.002017713	787.9	47.3	184.9	12.6	96.7	12.6
YBC01-25	13.47	0.069360464	0.006104205	0.160661612	0.014408621	0.015786515	0.000417398	151.3	12.6	101.0	2.6	97.5	2.6
YBC01-26	3.07	0.05406237	0.012134952	0.114954576	0.038906042	0.014976248	0.000773849	110.5	35.4	95.8	4.9	94.9	4.9
YBC01-27	2.59	0.200828612	0.021295074	0.484579775	0.042681727	0.018636181	0.000940926	401.2	29.2	119.0	6.0	89.4	6.0
YBC01-28	1.58	0.333125523	0.036760485	1.033796244	0.085477682	0.025381769	0.001603553	720.8	42.7	161.6	10.1	86.6	10.1
YBC01-29	0.15	0.59436408	0.097353129	7.264458665	0.757924891	0.09026136	0.008145011	2144.5	93.1	557.1	48.2	Uncorrected	
YBC01-30	1.62	0.380666322	0.060122526	0.952100282	0.088799024	0.023633145	0.001552567	679.2	46.2	150.6	9.8		
YBC01-31	1.12	0.377790671	0.040276638	1.584894126	0.171024426	0.029103686	0.002143618	964.3	67.2	184.9	13.4		
YBC01-32	1.80	0.274082928	0.024627855	1.121786183	0.099523065	0.0298131	0.001945224	763.8	47.6	189.4	12.2		
YBC01-33	4.73	0.453961963	0.0271011	3.648464266	0.258696165	0.055713179	0.002704806	1560.2	56.5	349.5	16.5		
YBC01-34	4.41	0.320048103	0.025350632	1.806576982	0.274953266	0.0330763	0.002839363	1047.8	99.5	209.8	17.7		