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Research Advances

New Nb-Ta Mineralization Age of the Dajishan W-Nb-Ta Deposit in Jiangxi Province, South China

LIU Feng, CHE Xudong*, HU Huan, ZHANG Wenlan and LU Jianjun

State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing 210023, Jiangsu, China

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Objective

The Dajishan W-Ta-Nb deposit is located in the junction of southern Jiangxi and Guangdong Provinces (Fig. 1a). This deposit contains about 190, 000 tons of WO_3 reserves, belonging to a super-large W deposit. Most W mineralization (mainly wolframite) at Dajishan occurred in quartz veins, with also some disseminated wolframite in the No. 69 granite. The estimated reserves in the No. 69 granite-hosted W-Ta-Nb ores are 65, 000 tons of WO_3, 2, 000 tons of Ta_2O_5 and 1, 300 tons of Nb_2O_5. The No. 69 granite, mainly a fine-grained muscovite albite granite, intruded the Cambrian metasedimentary rocks as a tabular sill. A two-mica granite and the Wuliting biotite granite batholith lie at depth of the No. 69 granite, but have no contact relationship with the No. 69 granite (Fig. 1b; Wu et al., 2017). The Dajishan deposit has mainly experienced two stages of magmatic activities in the Late Triassic and Late Jurassic, respectively. The Wuliting granite is Late Triassic granite, while both the two-mica granite and the No. 69 granite are Late Jurassic granite (Zhang Wenlan et al., 2006). The quartz-type W mineralization occurred in the Late Jurassic (Zhang Wenlan et al., 2006), while the age of Nb-Ta mineralization in the No. 69 granite has not yet been constrained. In this work, a new Nb-Ta mineralization age related to the No. 69 granite was obtained by using LA-ICP-MS columbite U-Pb dating method, which benefits the understanding of ore-forming processes in the Dajishan deposit.

Methods

All fine-grained muscovite albite granite samples were collected from the No. 69 granite. They were ground to 100 μm thick slices and were polished. Fresh columbite grains were selected by back-scattered electron images (BSE), which were obtained by using a JEOL JXA-8100 electron-microprobe (EMPA) at the State Key Laboratory for Mineral Deposits Research in Nanjing University. The U-Pb isotopic dating of columbite was conducted using a Resolution S-155 193 nm excimer ArF laser ablation system (LA) attached to a Thermal Fisher ICP-Q quadrupole-inductively coupled plasma-mass spectrometer (ICP-MS) at the same laboratory. In this study, 30 μm laser spot sizes were used at 4 Hz repetition rate with an energy of 7.2 J/cm^2. In order to avoid the matrix effect, one BGR-internal columbite standard (Coltan 139) was used as external standard. The fractionation correction and U-Pb ages were calculated using GLITTER 4.0 (GEMOC, Macquarie University). The U-Pb ages were calculated by using ISOPLOT/EX 3.23 software package. We used ^{207}Pb to do correction for the common Pb by using upper intercepts obtained from Tera–Wasserburg diagrams. The detailed analytical procedures for columbite U-Pb dating are described in Che et al. (2015).

Results

The fine-grained muscovite albite granite samples, collected from the No. 69 granite, were mainly composed of quartz, albite, K-feldspar, and muscovite, as well as wolframite and columbite as mainaccessory minerals. Columbite occurs inside quartz crystals or intergranular with quartz, muscovite, albite, K-feldspar as well as wolframite. EMPA data show that most columbite belongs to manganocolumbite, with atomic Mn/(Mn+Fe) ratios ranging from 0.5 to 0.7 and atomic Ta/(Nb+Ta) ratios ranging from 0.1 to 0.2. The columbite coexisting with wolframite contain high W content (up to 7.14 wt.%). Most columbite in quartz crystals is fresh, while outer zones of some intergranular columbite were altered. Therefore, by the text structures and compositions, these columbite at Dajishan mostly mineralized in magmatic and magmatic–hydrothermal transition stage, some grains were altered by the late hydrothermal fluids. The fresh columbite grains were selected to do U-Pb dating. They are non-transparent, subhedral to euhedral, with length and width ranging from 50–100 μm, mainly coexist with quartz, wolframite and other rock-forming minerals (Fig. 1c). These analytical grains normally with high U contents (up to 4518 ppm; Appendix 1), which is benefit to get reliable dating data. Twenty-three U-Pb isotopic analyses of the columbite grains yields discordant ages (Appendix 1) that produce a lower intercept age of 149.9 ± 1.7 Ma (Fig.1d) and a ^{207}Pb-corrected $^{206}Pb/^{238}U$ weighed age of 149.8 ± 1.5 Ma (2*s*, MSWD = 0.47, *n* = 23; Fig. 1e).

* Corresponding author. E-mail: xdche@nju.edu.cn

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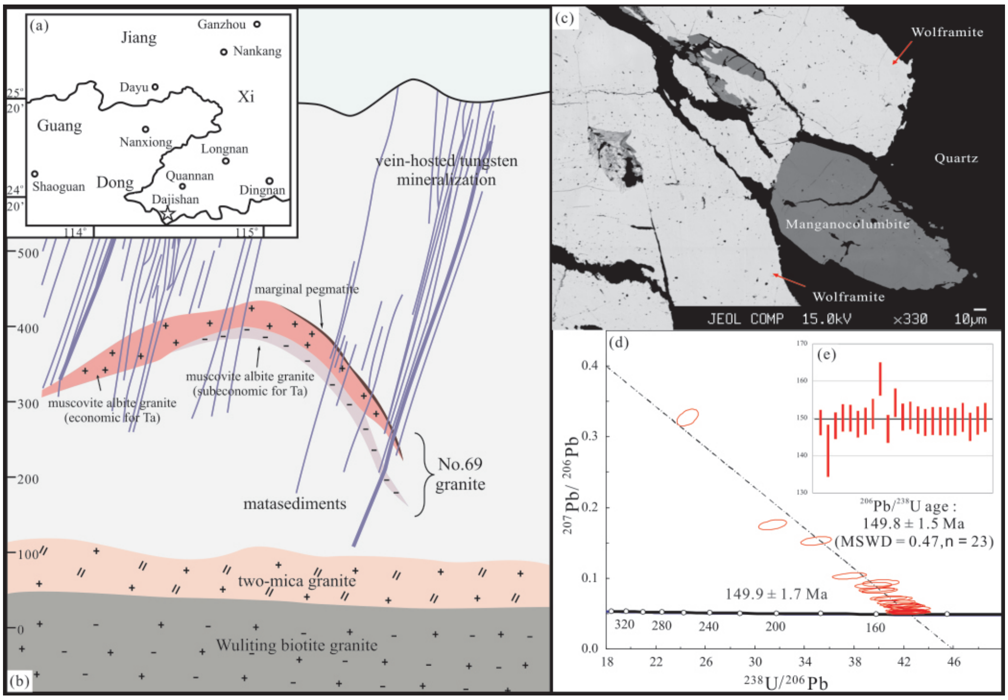

Fig. 1. (a) Location of the Dajishan deposit; (b) north-south cross section through the Dajishan deposit (modified by Wu et al., 2017); (c) BSE image of the columbite grain in the sample from the No. 69 granite. Lower intercept columbite age by Tera–Wasserburg diagram (d) and ^{207}Pb-corrected $^{206}Pb/^{238}U$ columbite age (e) of the samples from No. 69 granite by LA-ICP-MS.

Conclusions

In this work, the age of 149.9 ± 1.7 Ma, which is Nb-Ta mineralization age of No. 69 granite in Dajishan, agrees well with the age of 151.7 ± 1.6 Ma, which is emplacement age of No. 69 granite by TIMS zircon age (Zhang et al., 2006). Therefore, the diagenesis and Nb-Ta mineralization of the No. 69 granite in Dajishan both occurred during the late Jurassic. The Nb-Ta mineralization in the No. 69 granite is also coeval with the mainly W mineralization age of 147–143 Ma by the $^{40}Ar-^{39}Ar$ ages of mica from the wolframite bearing quartz veins within errors (Zhang et al., 2006), which further indicates that the mineralization in the Dajishan deposit were related to the Late Jurassic magma movement rather than the Late Triassic magma movement.

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Appendix 1 LA-ICP-MS U-Pb dating results of columbite from the Dajishan deposit

Spot	Contents (ppm)			U/Th	Isotope ratio						^{207}Pb corrected age (Ma)	
	Pb	Th	U		$^{207}Pb/^{206}Pb$	1σ	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ	$^{206}Pb/^{238}U$	1σ
1	82	262	4518	17	0.05443	0.00130	0.17681	0.00454	0.02358	0.00053	148.9	3.3
2	380	66	1858	28	0.32705	0.00761	1.83349	0.04556	0.04070	0.00095	141.4	6.9
3	52	94	2268	24	0.06072	0.00182	0.19816	0.00623	0.02369	0.00056	148.1	3.5
4	52	44	1693	38	0.08281	0.00225	0.28465	0.00825	0.02495	0.00059	150.2	3.6
5	38	66	2308	35	0.05524	0.00154	0.18111	0.00539	0.02380	0.00056	150.1	3.5
6	34	40	1514	38	0.06121	0.00194	0.20053	0.00667	0.02378	0.00057	148.5	3.6
7	69	52	1576	30	0.06050	0.00181	0.19900	0.00628	0.02388	0.00057	149.3	3.6
8	57	63	1765	28	0.15331	0.00388	0.60436	0.01656	0.02862	0.00068	151.2	4.0
9	190	71	1747	25	0.17609	0.00426	0.77238	0.02046	0.03184	0.00076	160.6	4.5
10	82	124	1956	16	0.09330	0.00303	0.32009	0.01083	0.02491	0.00061	147.2	3.7
11	113	136	2392	18	0.10354	0.00255	0.37909	0.01031	0.02658	0.00064	154.2	3.8
12	53	55	2234	41	0.07203	0.00187	0.24341	0.00694	0.02453	0.00059	150.4	3.6
13	98	86	2964	35	0.08403	0.00208	0.29065	0.00798	0.02511	0.00060	150.8	3.6
14	46	59	1883	32	0.06651	0.00198	0.22145	0.00704	0.02417	0.00059	149.6	3.7
15	30	54	1897	35	0.05160	0.00160	0.16685	0.00554	0.02348	0.00057	149.0	3.6
16	32	60	2005	33	0.05403	0.00174	0.17589	0.00602	0.02363	0.00058	149.3	3.7
17	23	17	998	60	0.06333	0.00219	0.20929	0.00760	0.02399	0.00060	149.3	3.8
18	31	111	1218	11	0.07087	0.00203	0.23719	0.00739	0.02430	0.00060	149.3	3.7
19	16	46	1093	24	0.05228	0.00176	0.16947	0.00605	0.02353	0.00058	149.1	3.7
20	41	76	1094	14	0.08964	0.00274	0.31202	0.01023	0.02527	0.00063	150.3	3.8
21	24	97	1606	17	0.05699	0.00205	0.18445	0.00697	0.02350	0.00059	147.8	3.7
22	15	10	1014	101	0.05287	0.00183	0.17199	0.00631	0.02361	0.00059	149.5	3.7
23	14	25	858	34	0.05181	0.00195	0.16917	0.00665	0.02370	0.00060	150.3	3.8