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Research Advances

Zircon U-Pb age of pegmatite veins in Dahongliutan lithium deposit, western Kunlun

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1. Objective

The western Kunlun in Xinjiang is located on the northwestern margin of the Qinghai-Tibet Plateau. In terms of geotectonic location, it lies in the western segment of the Central Orogenic Belt and on the southwestern edge of the Tarim Block (Fig. 1a), thus featuring special tectonic position and favorable metallogenic conditions. In recent years, great progress has been made in the geological prospecting of the pegmatite-type rare metal deposits in this area (Wang DH et al., 2020). In detail, many rare metal deposits have been discovered in this area, such as the Dahongliutan lithium deposit (Figs. 1b, 1c), Akshay lithium deposit, 509 Daobanxi lithium deposit, and Huangcaogou lithium deposit, which rank as super-large deposits according to their predicted resources. Furthermore, their metallogenic geological characteristics have been presently researched, achieving many results. However, the understanding of their metallogenic epochs is yet to be deepened, with no clear chronological data available. This paper aims to determine the crystallization age of the rare metal-bearing granitic pegmatite in the Dahongliutan lithium deposit by zircon U-Pb dating, in order to provide new information for the research into the tectonic evolution of the western Kunlun-Karakoram and the relationship between diagenesis and mineralization in this area.

2. Method

LA-ICP-MS zircon U-Pb dating was employed in this paper. The sample crushing, zircon particle separation, and zircon target preparation were conducted at the Hebei Institute of Geological Survey, China. The cathodoluminescence (CL) imaging, the analysis of reflected light and transmitted light, and the LA-ICP-MS zircon U-Pb dating were undertaken by the Wuhan Sample Solution Analytical Technology Co., Ltd., Wuhan, China. Zircon CL images were obtained using an Analytical Scanning Electron Microscope (JSM IT100) connected to a GATAN MINICL system. Laser ablation was performed using a GeolasPro laser ablation system that consists of a COMPexPro 102 ArF excimer laser (wavelength: 193 nm; maximum energy: 200 mJ) and a MicroLas optical system. Meanwhile, ion signal intensities were acquired using an Agilent 7700e ICP-MS instrument. In the process of the laser ablation, helium and argon were utilized as the carrier gas and the make-up gas, respectively, and they were mixed via a T-connector before entering the ICP. Meanwhile, the laser beam diameter and laser frequency were set to 32 μm and 5 Hz, respectively. The LA-ICP-MS zircon U-Pb dating was conducted as follows with the standard zircon 91500 being used as an external standard. Each analysis incorporated a background acquisition of approximately 20−30 s followed by 50 s of data acquisition from the samples. Then off-line selection and integration of background and analyte signals, time-drift correction, and quantitative calibration for trace element analysis and U-Pb dating were successively performed using an Excel-based software ICPMSDataCal. Afterwards, U-Pb concordia diagrams and weighted mean calculations were made using Isoplot/Ex_ver3.

3. Results

The Dahongliutan lithium deposit in the western Kunlun is located on the southern bank of Kalakashi River, with the Triassic Bayankalashan Group being exposed (Fig. 1b) and Late Triassic monzogranites being distributed in the southern part. Meanwhile, a large number of granitic pegmatite veins have developed in the external contact zone of the rock mass in this deposit. They occur in the wall rocks in the NW−SE trending, with their long axes being in the same direction as

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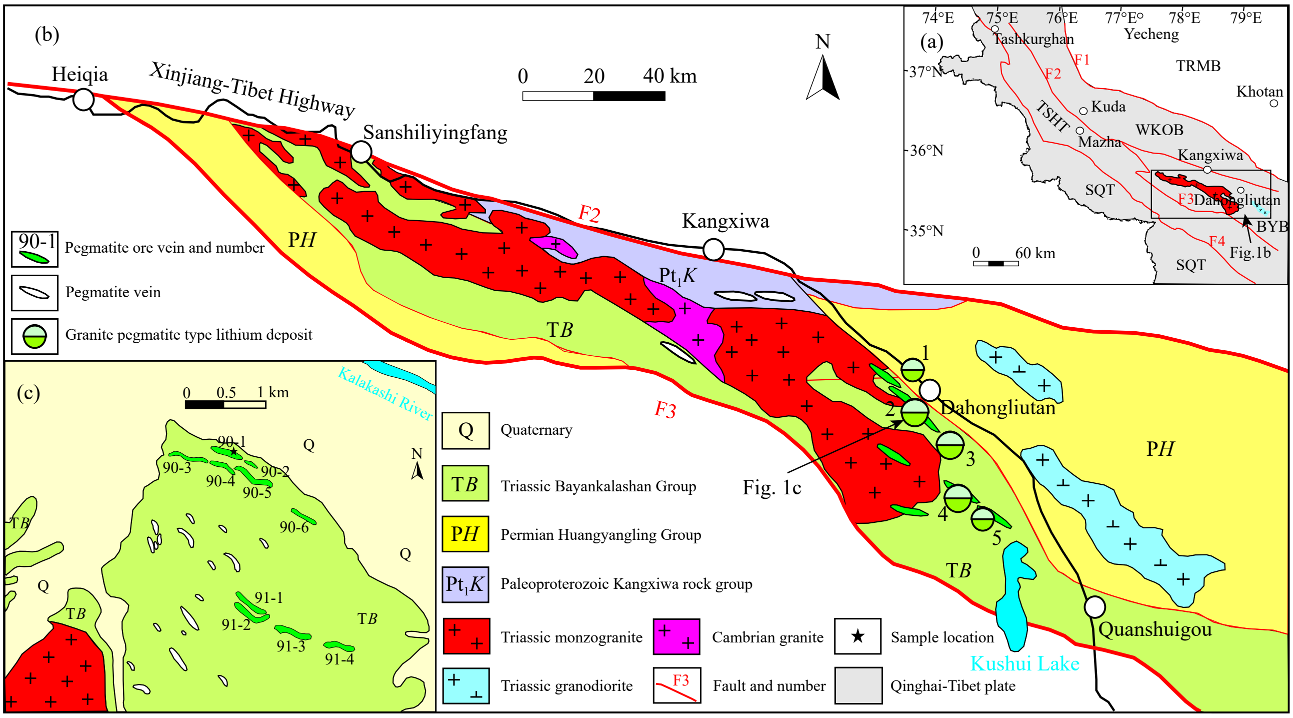

Fig. 1. Geotectonic position (a) and mineral resource map (b) of the western Kunlun, Xinjiang and the geologic map (c) of Dahongliutan lithium deposit in the western Kunlun. Abbreviations: TRMB−Tarim Block, WKOB−West Kunlun Orogenic Belt, TSHT−Tianshuihai Terrane, BYB−Bayankala Block, SQT−Southern Qiangtang Block. Main Faults: F1−Kongur-Kegang fault zone, F2−Kangxiwa-Jingyuhu fault zone, F3−Dahongliutan fault zone, F4−Karakorum fault zone. Main Deposits: 1−Akshay lithium deposit, 2−Dahongliutan lithium deposit, 3−South Dahongliutan lithium deposit, 4−509 Daobanxi lithium deposit, 5−Huangcaogou lithium deposit. Predicted resources in Dahongliutan area: Li_2O−3.7556×10^6 t, BeO−106.4×10^3 t.

the strata. In this study, samples were taken from ore-bearing pegmatite vein No.90-1 (Fig. 1c), a rare metal-bearing pegmatite vein with massive structure and pegmatitic texture, whose geographical coordinates are 35°58′31″N and 79°10′52″E and elevation is 4225 m. The pegmatite in the pegmatite vein is mainly composed of spodumene (48%), plagioclase (22%), quartz (18%), and muscovite (10%). Among them, the spodumene crystals are columnar, with a grain size of 5.0−9.0 mm. Their first-order interference color is orange, featuring positive high protrusion, Ng∧C=25º, biaxial positive photonics, and positive ductility. The plagioclase crystals are granular, with a grain size of 3.0−5.5 mm. Their mineral type is chessboard albite. The quartz crystals are also granular, with a grain size of 3.5−5.5 mm. The muscovite is scattered flaky, with a grain size of 0.3−1.5. It shows obvious cleavage bending and undulatory extinction (Qiao GB et al., 2020).

As shown in the CL images, the dated zircons in the pegmatite samples were mostly euhedral and long columnar-columnar, with obvious oscillatory zoning (Fig. 2a). Their Th/U ratios were >0.4 (0.85–1.90), revealing their magmatic origin. Laser ablation tests were carried out on 20 zircon targets, which yielded 16 sets of age data that met the computational accuracy (Table 1). The points of all these age data fell on the concordia curve (Fig. 2b), indicating that the zircons had suffered no obvious Pb loss. The 16 ablation spots yielded a weighted mean age of 144.2±1.9 Ma (MSWD= 1.9, confidence level: 95%; Fig. 2c), which is regarded as the crystallization age of the pegmatite vein in the Dahongliutan lithium deposit.

4. Conclusion

Given the intrusive contact relationship between the pegmatite veins and their wall rocks (formation age 220−208 Ma; Qiao GB et al., 2015), the metallogenic epochs of the pegmatite veins in the Dahongliutan lithium deposit should not be earlier than the Late Triassic. The above-mentioned zircon U-Pb isotopic age (144.2±1.9 Ma) ranges from Late Jurassic to Early Cretaceous, which is later than the formation ages of strata and granitoids. Furthermore, the age 144.7±4.3 Ma was obtained based on the $^{40}Ar/^{39}Ar$ tests of muscovite in the same samples (Qiao GB et al., 2020), indicating that the age data obtained by the two methods are consistent. Therefore, it can be determined that the age of diagenesis and mineralization of the Dahongliutan pegmatite-type rare metal deposit is 144.2±1.9 Ma.

CRediT authorship contribution statement

Geng-biao Qiao and Yue-zhong Wu conceived of the presented idea. Geng-biao Qiao performed the computations and verified the analytical methods. Tuo Liu encouraged Geng-biao Qiao to investigate the pegmatite veins in Dahongliutan lithium deposit and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

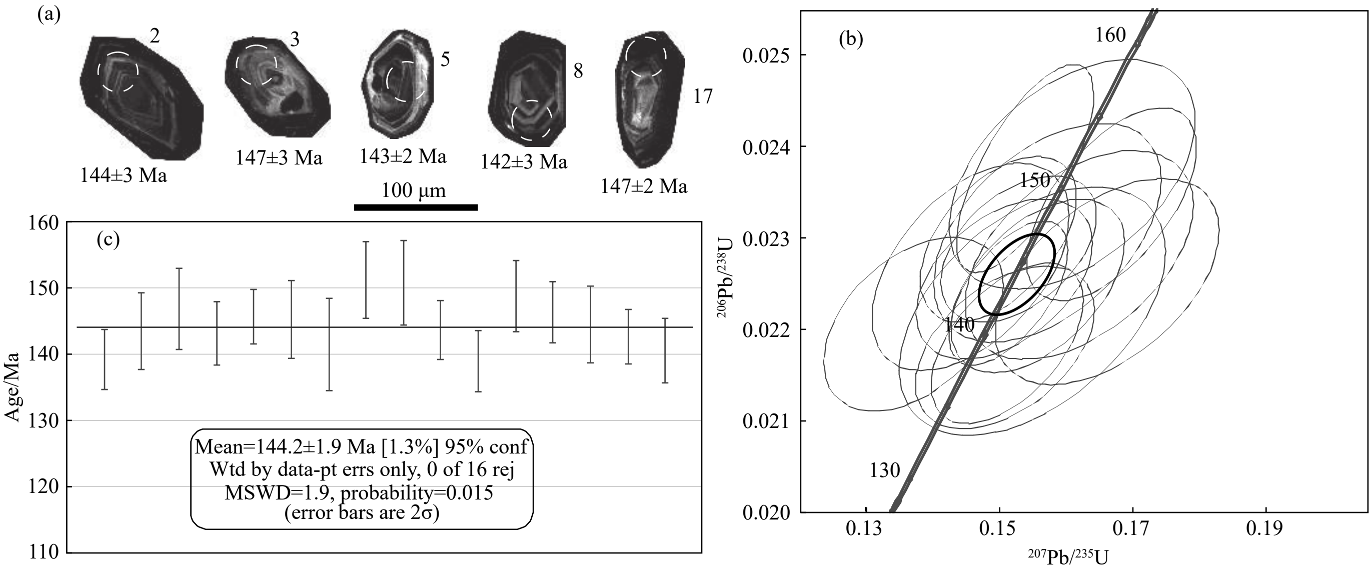

Fig. 2. Zircon CL images of spots analyzed (a), zircon U-Pb concordia diagram (b), and $^{206}Pb/^{238}U$ weighted mean age (c) of the pegmatite vein in Dahongliutan lithium deposit.

Table 1. LA-ICP-MS zircon U-Pb analytical results of the samples from the pegmatite vein in the Dahongliutan lithium deposit.

Spot	Pb/10^{-6}	Th/10^{-6}	U/10^{-6}	Th/U	Ratio						Age/Ma			
					$^{207}Pb/^{206}Pb$	±1σ	$^{207}Pb/^{235}U$	±1σ	$^{206}Pb/^{238}U$	±1σ	$^{207}Pb/^{235}U$	±1σ	$^{206}Pb/^{238}U$	±1σ
HL01	15.64	487	504	0.97	0.0501	0.0016	0.1512	0.0047	0.0218	0.0004	143	4	139	2
HL02	8.34	355	235	1.51	0.0544	0.0024	0.1662	0.0069	0.0225	0.0005	156	6	144	3
HL03	6.95	196	211	0.93	0.0497	0.0024	0.1572	0.0070	0.0231	0.0005	148	6	147	3
HL05	14.90	565	456	1.24	0.0508	0.0020	0.1557	0.0053	0.0225	0.0004	147	5	143	2
HL06	15.85	437	512	0.85	0.0488	0.0018	0.1528	0.0048	0.0229	0.0003	144	4	146	2
HL07	8.73	437	230	1.90	0.0531	0.0025	0.1620	0.0070	0.0228	0.0005	152	6	145	3
HL08	5.79	225	171	1.31	0.0511	0.0027	0.1549	0.0081	0.0222	0.0006	146	7	142	3
HL10	15.01	464	460	1.01	0.0476	0.0014	0.1538	0.0042	0.0238	0.0005	145	4	151	3
HL11	10.49	359	313	1.15	0.0500	0.0027	0.1609	0.0075	0.0237	0.0005	151	7	151	3
HL13	11.17	357	358	1.00	0.0485	0.0017	0.1507	0.0054	0.0226	0.0004	143	5	144	2
HL14	10.05	371	306	1.21	0.0498	0.0021	0.1508	0.0055	0.0218	0.0004	143	5	139	2
HL15	10.64	292	333	0.88	0.0519	0.0016	0.1668	0.0052	0.0234	0.0004	157	4	149	3
HL17	16.51	522	490	1.06	0.0477	0.0016	0.1498	0.0048	0.0230	0.0004	142	4	147	2
HL19	10.30	431	291	1.48	0.0479	0.0024	0.1457	0.0060	0.0227	0.0005	138	5	145	3
HL20	18.79	542	582	0.93	0.0494	0.0014	0.1513	0.0036	0.0224	0.0003	143	3	143	2
HL21	8.14	301	245	1.23	0.0455	0.0019	0.1371	0.0055	0.0221	0.0004	130	5	141	2

Declaration of competing interest

The authors declare no conflicts of interest.

Acknowledgment

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