Research Advances

First Identification of ~2.65 Ga Tonalite in the Jiefangyingzi Area, Inner Mongolia

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Citation: Cui et al., 2019. First Identification of ~2.65 Ga Tonalite in the Jiefangyingzi Area, Inner Mongolia. *Acta Geologica Sinica* (English Edition), 93(2): 493–495. DOI: 10.1111/1755-6724.13892

Objective

The northern margin of the North China Craton (NCC), as an adjacent part between the northern NCC and the southeastern Central Asian Orogenic Belt (CAOB), has recorded multi-stage tectonic evolution information. The Bainaimiao arc belt is sandwiched between the E–W trending Chifeng fault and Xar Moron fault in the northern of the NCC. There are controversies about the existence and nature of the basement beneath the Bainaimiao arc belt. Previous researchers inferred that there were some Precambrian basement rocks beneath the Bainaimiao arc belt based on zircon U-Pb ages and Sr-Nd-Hf isotopic compositions of the metamorphic sedimentary and igneous rocks (Zhang et al., 2014). However, there were no exposed Precambrian basement rocks discovered on the Bainaimiao arc belt (Zhang et al., 2014). In addition, there are different views about the northern boundary of the NCC. The Chifeng fault used to be suggested the northern boundary of the NCC. However, some different points, north to Chifeng fault, and south to Chifeng fault (e.g., Jining–Longhua fault and Yinshan–Yanshan belt) were suggested.

This work focused on the zircon U-Pb dating of fine-grained tonalite in the Jiefangyingzi area of Chifeng from Silurian Badangshan Formation in order to provide petrologic and chronologic constraints for whether there is an ancient basement beneath the Bainaimiao arc belt or not, and supply direct evidence for the northern boundary of the NCC in the Jiefangyingzi area.

Methods

A 1:50000 detailed geological mapping and a 1:2000 geological section were performed on the Silurian Badangshan Formation in the study area. We collected samples of tonalite for zircon LA-ICP-MS U-Pb dating in the Jiefangyingzi area, Chifeng (sample location: 119°16′21″E, 42°40′46.5″N). Zircon grains were obtained by a combination of standard heavy liquid and magnetic separation techniques. The selected zircons were mounted onto an epoxy resin disc together with standard zircons. Cathodoluminescence (CL) images, reflected light and transmitted light images were taken and then potential target domains were selected for subsequent U-Pb dating. Analyses of the zircons were carried out using a laser ablation inductively coupled plasma mass spectrometer (LA-ICP-MS) at State Key Laboratory of Geological Processes and Mineral Resource, China University of Geoscience, Beijing, China. Weighted mean U-Pb ages and concordia plots were processed using Isoplot, with uncertainties quoted at 1σ and 95% confidence levels.

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Results

According to the detailed mapping and geological section, the Silurian Badangshan Formation is divided into rhyolite, diorite, medium- and coarse-grained granodiorite, fine-grained granite and tonalite (Fig. 1a). The rocks experienced ductile deformation by extension at earlier stage, and later developed middle-broad -plunging uplight fold whose fold axis trend was NEE.

Field observation shows that the distribution area of fine-grained tonalite is more than ~2 km^2. The fine-grained tonalite is mainly composed of quartz (20%–25%), plagioclase (70%–75%), potassium feldspar (5%–10%) and minor accessory minerals, which developed extensional ductile deformation that led to the development of asymmetric rotation porphyroclast, stretching lineation and mineral lineation. The lineation with an average trend and dip angle are 65° and 10°, respectively. In general, the tonalite formed the typical L tectonite and being tectonic lens occured in the Badangshan Formation rhyolite.

The long columnar zircon grains of tonalite are euhedral to subhedral, and the long diameter of them are ~120–150 μm with length/width ratios of ~2:1–3:1. The zircon grains develop typical oscillatory zoning and the Th/U ratios are >0.1 (Appendix 1), which indicate a magmatic origin. The results of zircon LA-ICP-MS U-Pb dating for the fine-grained tonalite samples No. TW102 (n=50) yield a weighted mean $^{207}Pb/^{206}Pb$ age of 2649.6±3.7 Ma (MSWD=0.99) (Fig. 1b). The Neoarchean tonalite is first recognized in the Jiefangyingzi area in the northern margin of the NCC. In fact, abundant ~2.6–2.7 Ga rocks distribute in the NCC (Wan et al., 2014; Li et al., 2018), which is possibly a major phase of crustal growth at ~2.7

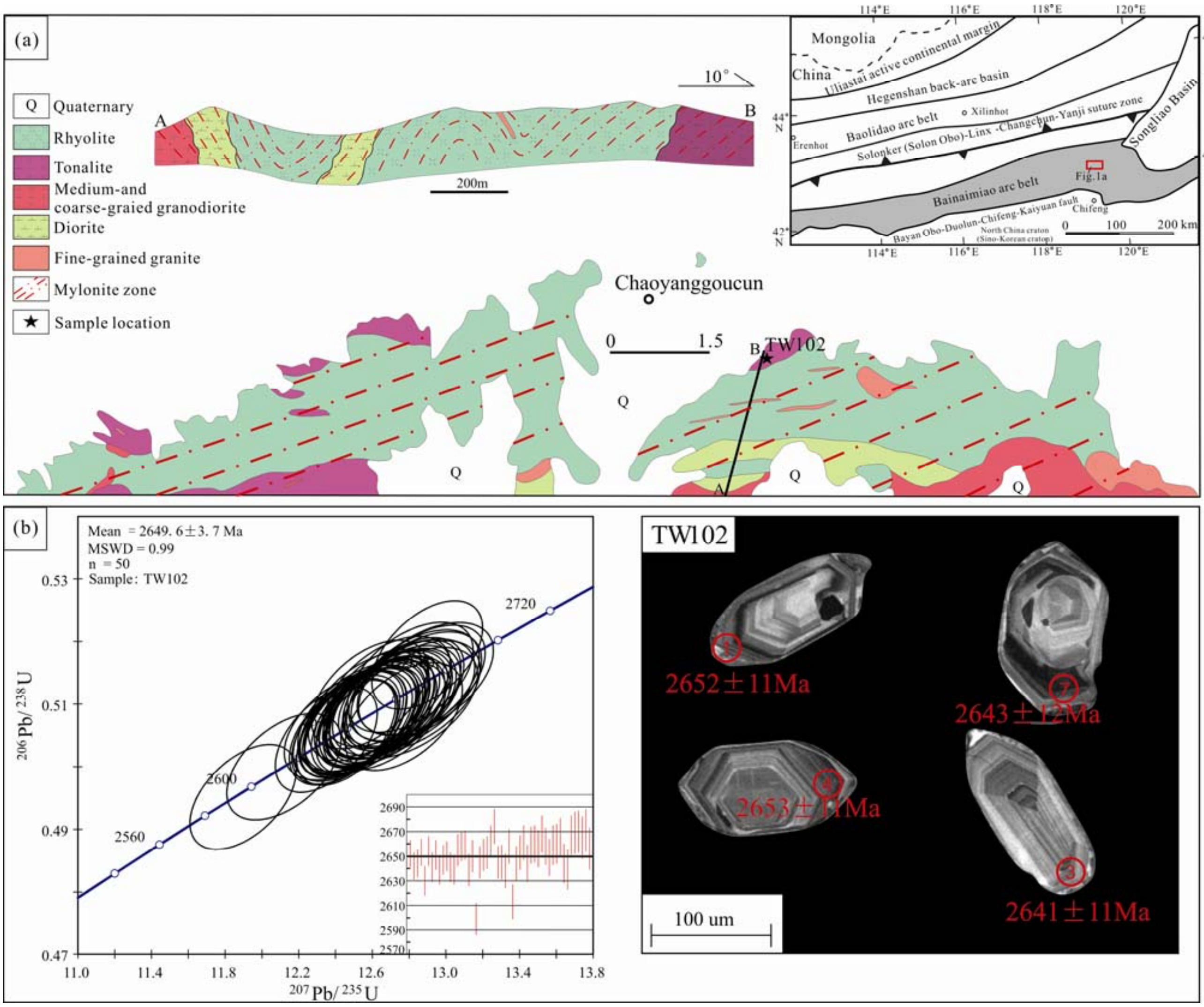

Fig. 1. (a) Distribution of geological bodies in the Silurian Badangshan Formation in the study area (A-B is geological section); (b) Cathodoluminescence image and concordia diagram of tonalite.

Ga but ~2.5 Ga crust-forming may have strongly superimposed.

Conclusions

The fine-grained tonalite at the age of 2649.6±3.7 Ma is disintegrated from the Silurian Badangshan Formation in the Jiefangyingzi area of Chifeng, and its distribution area is over ~2 km^2. We infer that there is a Precambrian basement beneath the Bainaimiao arc belt and the northern boundary of NCC is north to Chifeng–Kaiyuan fault in the Jiefangyingzi area.

Acknowledgement

This work is granted by the geological survey project of China Geological Survey (grant No. DD20160155 and DD20190021)

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Appendix 1 Zircon LA-ICP-MS U-Pb data of tonalite in the Jiefangyingzi area

Spot No.	Th/U	Isotopic ratios						Age (Ma)					
		$^{207}Pb/^{206}Pb$	1σ	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ	$^{207}Pb/^{206}Pb$	1σ	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ
TW102-1	0.6536	0.17986	0.00258	12.62215	0.18466	0.50888	0.0056	2652	11	2652	14	2652	24
TW102-2	0.5128	0.17881	0.00254	12.46333	0.18102	0.50543	0.00554	2642	11	2640	14	2637	24
TW102-3	0.4831	0.17902	0.00257	12.5111	0.18323	0.50677	0.00557	2644	11	2644	14	2643	24
TW102-4	0.3067	0.18004	0.00258	12.63223	0.18454	0.50877	0.00558	2653	11	2653	14	2651	24
TW102-5	0.4082	0.17757	0.00258	12.35025	0.18283	0.50433	0.00556	2630	12	2631	14	2632	24
TW102-6	0.4167	0.18017	0.00262	12.65128	0.18763	0.50919	0.00561	2654	12	2654	14	2653	24
TW102-7	0.5650	0.17869	0.00261	12.48759	0.18602	0.50676	0.00559	2641	12	2642	14	2643	24
TW102-8	0.6329	0.17976	0.00261	12.57641	0.18633	0.50732	0.00558	2651	12	2648	14	2645	24
TW102-9	0.4525	0.17847	0.00262	12.44462	0.18598	0.50564	0.00557	2639	12	2639	14	2638	24
TW102-10	0.2632	0.17938	0.00264	12.62195	0.18943	0.51024	0.00563	2647	12	2652	14	2658	24
TW102-11	0.3953	0.17973	0.00267	12.60126	0.19082	0.5084	0.0056	2650	12	2650	14	2650	24
TW102-12	0.3268	0.17876	0.00273	12.49204	0.19356	0.50675	0.00563	2641	12	2642	15	2643	24
TW102-13	0.4717	0.17852	0.0027	12.46056	0.19182	0.50614	0.0056	2639	12	2640	14	2640	24
TW102-14	0.2725	0.1802	0.00277	12.66716	0.19744	0.50974	0.00567	2655	13	2655	15	2656	24
TW102-15	0.2247	0.18055	0.00272	12.73501	0.19534	0.51147	0.00564	2658	12	2660	14	2663	24
TW102-16	0.3891	0.18062	0.00273	12.89847	0.19865	0.51785	0.00571	2659	12	2672	15	2690	24
TW102-17	0.3311	0.1785	0.00276	12.4452	0.19523	0.50557	0.00561	2639	13	2639	15	2638	24
TW102-18	0.3333	0.17966	0.00282	12.57113	0.1998	0.50741	0.00566	2650	13	2648	15	2646	24
TW102-19	0.3401	0.17424	0.00275	11.89791	0.19042	0.49515	0.00553	2599	13	2596	15	2593	24
TW102-21	0.2933	0.17918	0.00281	12.53419	0.19935	0.50726	0.00564	2645	13	2645	15	2645	24
TW102-22	0.6024	0.17979	0.00281	12.61203	0.19992	0.50868	0.00564	2651	13	2651	15	2651	24
TW102-23	0.6098	0.18001	0.00282	12.6354	0.20104	0.50899	0.00564	2653	13	2653	15	2652	24
TW102-24	0.4329	0.18102	0.00287	12.77126	0.20524	0.51161	0.00569	2662	13	2663	15	2663	24
TW102-27	0.5952	0.1823	0.00296	12.77182	0.20999	0.50802	0.00569	2674	14	2663	15	2648	24
TW102-28	0.2941	0.1791	0.00288	12.54036	0.2043	0.50773	0.00565	2645	13	2646	15	2647	24
TW102-29	0.3788	0.1792	0.0029	12.53249	0.2053	0.50715	0.00565	2645	14	2645	15	2644	24
TW102-30	0.3067	0.17841	0.00291	12.58514	0.20785	0.51153	0.00571	2638	14	2649	16	2663	24
TW102-32	0.3378	0.18054	0.00302	12.67039	0.2142	0.50893	0.00572	2658	14	2655	16	2652	24
TW102-33	0.5348	0.17578	0.00294	12.12006	0.20491	0.5	0.00561	2613	14	2614	16	2614	24
TW102-34	0.2915	0.179	0.003	12.52949	0.21239	0.50759	0.00569	2644	14	2645	16	2646	24
TW102-35	0.4167	0.18006	0.00304	12.62316	0.21559	0.50838	0.00571	2653	14	2652	16	2650	24
TW102-36	0.3425	0.18089	0.00303	12.77027	0.21635	0.51193	0.00572	2661	14	2663	16	2665	24
TW102-37	0.2370	0.17902	0.00305	12.58132	0.21654	0.50962	0.00573	2644	15	2649	16	2655	24
TW102-38	0.3145	0.18062	0.00309	12.70222	0.21982	0.50998	0.00574	2659	15	2658	16	2657	25
TW102-39	0.5650	0.18078	0.0031	12.66651	0.21971	0.50808	0.00571	2660	15	2655	16	2648	24
TW102-40	0.1517	0.18031	0.00307	12.6783	0.21869	0.50988	0.00571	2656	15	2656	16	2656	24
TW102-41	0.5051	0.18163	0.00317	12.86972	0.22689	0.51381	0.00581	2668	15	2670	17	2673	25
TW102-42	0.2732	0.18058	0.00315	12.8067	0.22538	0.51427	0.0058	2658	15	2666	17	2675	25
TW102-43	0.3509	0.17963	0.00316	12.68358	0.22508	0.51203	0.00579	2649	15	2656	17	2665	25
TW102-45	0.3704	0.18068	0.00321	12.71119	0.22765	0.51015	0.00578	2659	16	2658	17	2657	25
TW102-46	0.3802	0.18083	0.00323	12.73155	0.22926	0.51057	0.00579	2660	16	2660	17	2659	25
TW102-47	0.3125	0.18132	0.00329	12.82693	0.23437	0.513	0.00585	2665	16	2667	17	2669	25
TW102-48	0.5128	0.17902	0.00322	12.54027	0.22782	0.50798	0.00576	2644	16	2646	17	2648	25
TW102-49	0.5556	0.17848	0.00326	12.46999	0.22977	0.50664	0.00579	2639	16	2640	17	2642	25
TW102-50	0.8850	0.18159	0.00328	12.83963	0.2342	0.51273	0.00581	2667	16	2668	17	2668	25
TW102-51	0.4762	0.1818	0.00342	12.88807	0.24424	0.51408	0.0059	2669	17	2672	18	2674	25
TW102-52	0.2809	0.18182	0.00341	12.81844	0.24229	0.51125	0.00584	2670	17	2666	18	2662	25
TW102-53	0.4115	0.18129	0.00344	12.78695	0.24447	0.51146	0.00588	2665	17	2664	18	2663	25
TW102-54	0.2618	0.18197	0.00345	12.80286	0.24442	0.5102	0.00584	2671	17	2665	18	2657	25
TW102-55	0.3831	0.18033	0.00345	12.65434	0.24354	0.50885	0.00584	2656	17	2654	18	2652	25