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Research Advances

Zircon LA-ICP-MS U-Pb Age and Island-Arc Origin of the Bayanhua Gabbro in the Hegenshan Suture Zone, Inner Mongolia

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Objective

The Bayanhua Nb-enriched gabbro is newly discovered in the Diyanmiao-Meilaotewula SSZ-type ophiolitic mélange belt of the Hegenshan suture zone, Inner Mongolia. Nb-enriched arc gabbros are usually believed to result from partial melting of the mantle wedge peridotites metasomatized by slab melts derived from the subducting oceanic slab, which represent arc magmatic markers of the oceanic subduction zone. However, whether the Hegenshan ocean basin of the Paleo-Asian Ocean was in its subduction stage in the Early Permian requires further study for a final conclusion, and what is the evolution process of the oceanic subduction and lithospheric mantle of the Hegenshan suture zone remains speculative for the lack of further definitely petrological and chronological evidence and constraints. Therefore, this study carried out zircon LA-ICP-MS U-Pb geochronology and geochemistry on the Bayanhua Nb-enriched gabbro to discuss its origin, in order to provide new evidence for the tectonic evolution of the Hegenshan suture zone of the eastern Central Asian Orogenic Belt.

Methods

Representative fresh samples were collected from the Nb-enriched gabbro strip pit near the Bayanhua township located about 60 km northeast of the Xiwuqi County, Inner Mongolia. Zircon LA-ICP-MS U-Pb dating was performed using a laser ablation inductively coupled mass spectrometer (LA-ICPMS) at the Experimental Laboratory of Tianjin Geological Survey Center of China Geological Survey. Major, trace and rare earth element analyses were all carried out at the Laboratory Center, Institute of Regional Geological and Mineral Resources Survey, Hebei, China. Major element determinations were by X-ray fluorescence spectroscopy. Trace and rare earth element abundances were determined by inductively-coupled plasma mass spectrometry (ICP-MS).

Results

The Bayanhua Nb-enriched gabbro intruded into the bathyal-abyssal flusch matrix of the Late Carboniferous Diyanmiao–Meilaotewula SSZ-type ophiolitic mélange belt in the eastern Hegenshan suture zone. The zircons are euhedral to subhedral bipyramid or prismatic crystals, with length/width ratios of 2 and well developed oscillatory zoning (Fig. 1a), and an average Th/U ratio of 0.32 (Appendix 1), indicating a magmatic origin. The zircon LA-ICP-MS U-Pb dating for the gabbro yield a weighted mean $^{206}Pb/^{238}U$ age of 284.4±2.1 Ma with MSWD of 2.3 (Figs. 1b and 1c; Table 1), formed during the Early Permian. The gabbro is characterized by relatively high Na_2O (3.26wt%–4.9wt%), TiO_2 (2.42wt%–3.53wt%), P_2O_5 (0.78wt%–1.12wt%) and Nb (8.57wt%–14.46wt%) but low K_2O (0.62wt%–1.42wt%) content, high Nb/La (0.56–0.99, >0.5) and Nb/U (10.2–17.8, <50) ratios, and slight negative to positive anomalies in Nb, Ba, Ti and P, with the enrichment of such large ion lithophile elements as Rb, Th, U and K. The total REE ranges from 112.93 ppm to 189.26 ppm. The chondrite-normalized REE distribution patterns are of flat slightly right-inclined type (La_N/Yb_N=2.16–2.66), without obvious negative Eu anomaly. All of the geochemical characteristics indicate that the Bayanhua pluton belongs to island-arc magmatite generated in subduction zone, being similar to the typical Nb-enriched arc basalts but differing obviously from classic island-arc basalts in chemical composition, source and petrogenesis. Combined with the temporal and spatial distribution characteristics of the boninites, Nb-enriched basalts, adakites (granodiorites) (294.7±1.7 Ma–279.3±1.4 Ma) and High-Mg diorites (281.38±0.98 Ma) within the Meilaotewula SSZ-type ophiolitic melange, it is suggested that in Early Permian the Hegenshan ocean basin of the Paleo-Asian Ocean was not closed in study area but as in its subduction stage. It is inferred that the Bayanhua Nb-enriched gabbro might be generated by partial melting of the mantle wedge peridotites metasomatized or interacted by high silica adakitic melts (slab melts) derived from the

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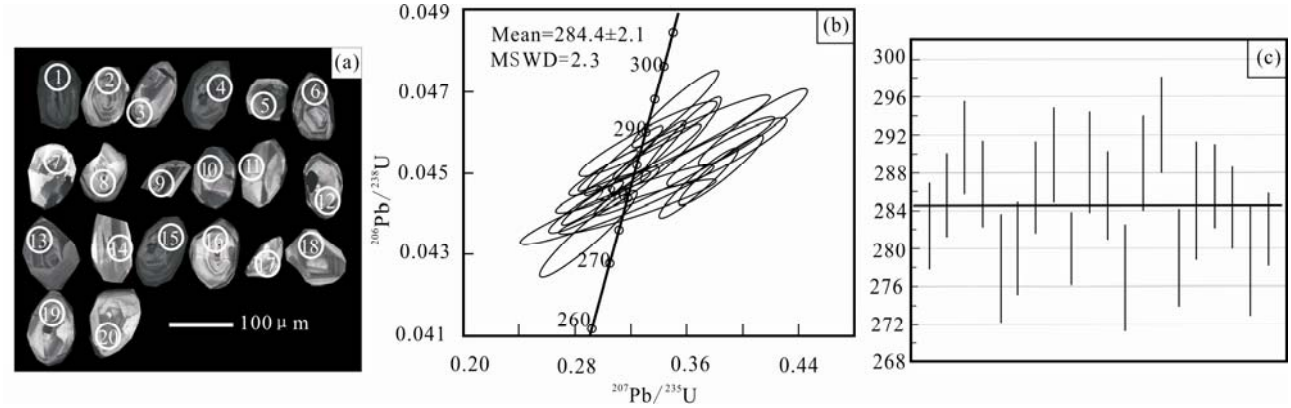

Fig. 1. Cathodoluminescent images (a), concordia diagrams (b and c) of zircon LA-ICP-MS U-Pb of the Bayanhua Nb-enriched gabbro.

subducted oceanic crust during the Paleo-Asian Ocean subduction northward.

Conclusions

Based on geochronological and geochemical data, this study determines the Early Permian (284.4±2.1Ma) Bayanhua Nb-enriched arc gabbro in the Hegenshan suture zone, which is similar to Nb-enriched arc basalts and produced by partial melting of the mantle wedge peridotites metasomatized and enriched in Nb by high silica adakitic melts (slab melts) derived from the subducted oceanic crust.

The discovery and confirmation of the Early Permian Bayanhua Nb-enriched arc gabbro provide new evidence for the presence of the Early Permian oceanic basin and oceanic subduction in Hegenshan.

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Appendix 1 Zircon LA-ICP-MS U-Pb data of the Bayanhua Nb-enriched gabbro

pot No.	$w_{B/}$(ppm)		Th/U	Isotopic ratios						Apparent ages (Ma)	
	Pb	U		$^{207}Pb^*/^{206}Pb^*$	1σ	$^{207}Pb^*/^{235}U$	1σ	$^{206}Pb^*/^{238}U$	1σ	$^{206}Pb/^{238}U$	$^{207}Pb^*/^{206}Pb^*$
1	11	240	0.3561	0.0598	3.03	0.3692	3.17	0.0448	0.81	282	±2
2	10	220	0.3555	0.0506	3.51	0.3160	3.56	0.0453	0.77	286	±2
3	7	157	0.3290	0.0643	6.16	0.4087	6.33	0.0461	0.84	291	±2
4	8	174	0.4241	0.0653	4.26	0.3900	4.32	0.0455	0.78	287	±2
5	9	199	0.3036	0.0545	6.34	0.2905	5.34	0.0435	0.76	278	±3
6	10	228	0.3872	0.0532	1.83	0.3050	1.96	0.0444	0.65	280	±2
7	6	141	0.3717	0.0526	5.79	0.3298	5.84	0.0455	0.82	287	±2
8	9	196	0.4975	0.0585	5.43	0.3707	5.58	0.0460	0.86	290	±3
9	10	234	0.3505	0.0540	3.04	0.2973	3.08	0.0445	0.69	280	±2
10	10	235	0.2347	0.0565	3.16	0.3573	3.33	0.0459	0.92	289	±3
11	7	149	0.3043	0.0518	5.89	0.3235	5.93	0.0453	0.82	286	±2
12	5	119	0.3015	0.0506	4.16	0.3243	8.31	0.0442	1.19	277	±3
13	7	150	0.3721	0.0685	3.17	0.3331	4.07	0.0458	0.87	289	±3
14	13	275	0.3971	0.0705	2.74	0.3527	2.80	0.0466	0.86	293	±3
15	10	233	0.0329	0.0573	5.31	0.3106	5.59	0.0442	0.85	279	±3
16	8	186	0.2993	0.0738	5.65	0.3598	5.76	0.0452	1.09	285	±3
17	14	325	0.0628	0.0535	2.90	0.3356	3.00	0.0455	0.76	287	±2
18	14	306	0.3497	0.0620	3.04	0.3852	3.17	0.0451	0.76	284	±2
19	7	161	0.3015	0.0549	3.94	0.3020	4.02	0.0443	0.63	279	±3
20	10	219	0.3484	0.0510	2.02	0.3077	1.05	0.0447	0.68	282	±2

Note: Errors are quoted at 1σ level for individual analyses, and Pb* denotes radiogenic lead.