



Short Communications (Research Advances)

Discovery of Late Triassic (217 Ma) gabbro in the Yabulai District: Constraints on the Early Mesozoic evolution of the Alxa Block

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1. Objectives

A nearly E-W trending Early Mesozoic alkaline and mafic rock belt is exposed on the northern margin of the North China Craton (NCC), and geochemistry and isotope studies indicate that the magmas were originated from the depleted lithospheric mantle, implying the thinning and destruction of the lithosphere in the northern margin and eastern of the NCC (Zhang SH et al., 2012). The Alxa Block is located in the westernmost part of the NCC, which plays a significant part in understanding the tectonic evolution of the NCC. This paper mainly reports a firstly discovered 217 Ma gabbro from the Yabulai district in the western Alxa Block, where widely exposes Late Paleozoic intermediate-acid intrusive rocks and volcanic rocks (Liu Q et al., 2017). Ren KX et al. (2005) also discovered the Late Paleozoic–Early Mesozoic alkaline intrusive rocks in the eastern Alxa Block and considered them as the western extension of the alkaline belt in the northern NCC in the Indosinian epoch. Based on this study and together with previous data, the authors argue that the Late Triassic (217 Ma) Yabulai gabbro might be formed in the same tectonic setting as the alkaline and mafic rock belt in the northern NCC, and the discovery of 217 Ma gabbro indicates that this belt can extend westward by about 200 km to the Yabulai district in the western Alxa Block. Therefore, the Alxa Block was probably in the same geodynamic system as the NCC in the Indosinian period.

2. Methods

This study mainly carried out field geological surveys,

petrological and zircon geochronological investigations on the Yabulai gabbro. Zircon U-Pb isotope dating was carried out at Wuhan Sample Solution Analytical Technology Co., Ltd. in Wuhan, China. Zircon U-Pb dating was implemented on the Agilent Inductively Coupled Plasma Mass Spectrometer (Agilent 7900) with a 193 nm ArF-excimer laser. Zircon 91500, GJ-1 and NIST610 were used as the reference standards for the U-Pb dating.

3. Results

The gabbro sample in this study was collected from the Yabulai district in the western Alxa Block, early Permian igneous rocks are widely exposed in the study area (Fig. 1a). Field investigations revealed that the gabbro intruded into the Proterozoic gneiss and was in an unconformity relationship with the overlying Middle–Late Jurassic strata (Fig. 1a; 102°46'4.8" E, 39°27'2.6" N). It is greyish–green to dark green in color with medium to coarse grain in size (Fig. 1b), and mainly composed of plagioclase (50%–55%), augite (35%–40%) (Fig. 1c), with minor accessory minerals of magnetite and apatite.

LA-ICP-MS zircon U-Pb dating results for the gabbro are shown in Table 1. Zircons grains from the gabbro are prismatic or elliptical with well-developed oscillating zone structure, 50–150 μm in size. The Dating results show that zircons can be divided into three groups except for nine analyses with concordance less than 90% or variable radiogenic Pb loss (Fig. 1d; Table 1). Two groups of captured zircons yield the ²⁰⁶Pb/²³⁸U ages ranging from 483.7 Ma to 450.1 Ma and 285.1 Ma to 265.8 Ma with the weighted ²⁰⁶Pb/²³⁸U mean ages of 457±14 Ma (MSWD = 5.6) and 273.6±5.6 Ma (MSWD = 2.8) (Fig. 1d), respectively. The former zircon group may be captured from the detrital zircons of the gneiss country rocks, while the latter was probably captured from the igneous rocks with same ages that widely exposed in the Yabulai district (Fig. 1a). The last group

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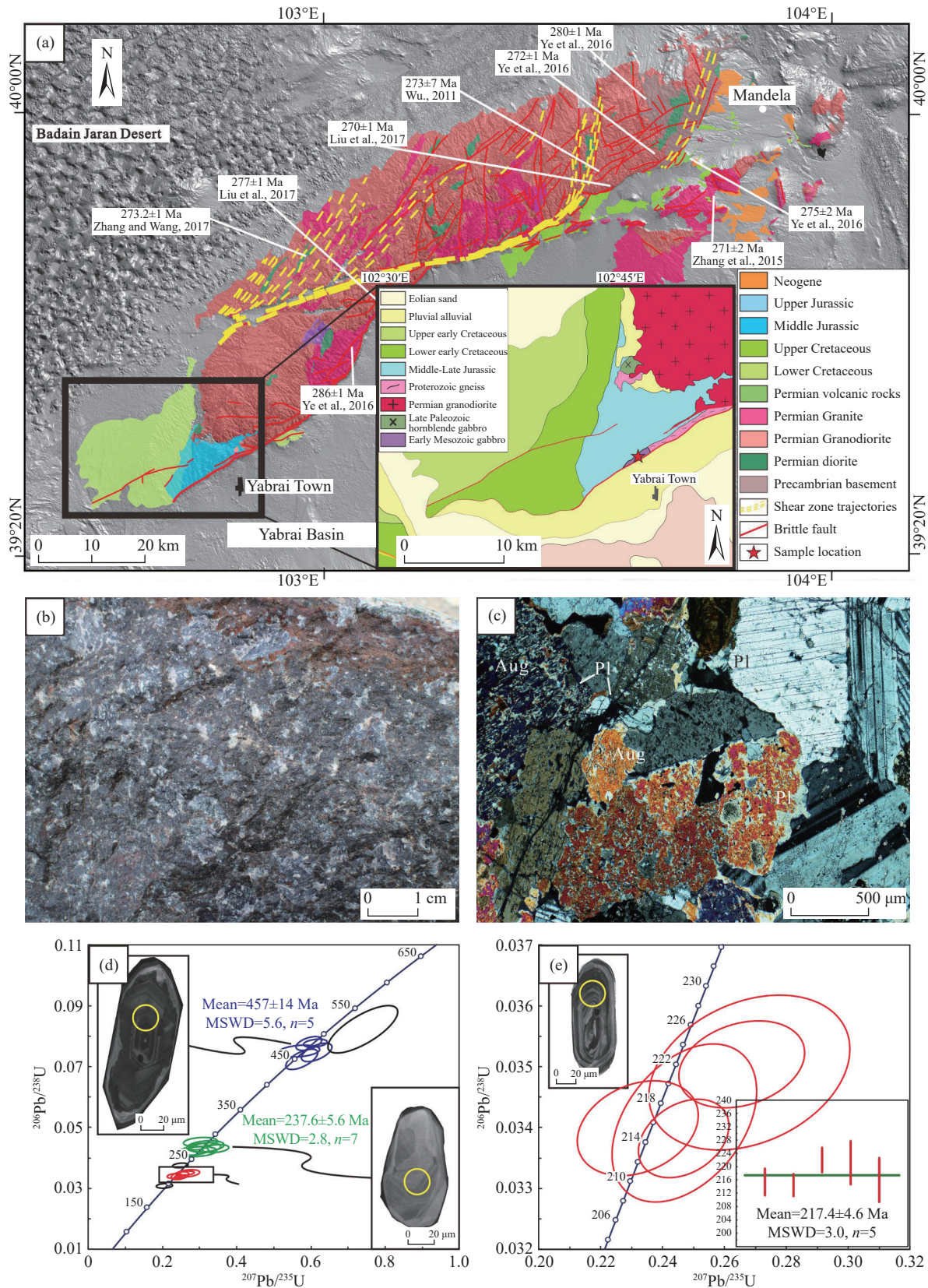


Fig. 1. a–Simplified geological map of the Yabulai district and previous data; b–field outcrops of the Yabulai gabbro; c–microphotograph of the Yabulai gabbro; d–e–U–Pb Concordia diagram of zircons from the Yabulai gabbro. Aug–augite; Pl–plagioclase.

includes five analyses that from zircon cores and yield the $^{206}\text{Pb}/^{238}\text{U}$ age from 215.4 Ma to 221.9 Ma, with the weighted $^{206}\text{Pb}/^{238}\text{U}$ mean age of 217.4 ± 4.6 Ma (MSWD = 3.0) in the

case of 95% confidence interval (Fig. 1e), which is interpreted as the magma crystallization age of the Yabulai gabbro and means that the gabbro was formed in the Late Triassic.

Table 1. Zircon U-Pb dating results of the Yabulai gabbro in the Alxa Block.

Spots No.	$^{206}\text{Pb}/^{238}\text{U}$		$^{207}\text{Pb}/^{235}\text{U}$		$^{207}\text{Pb}/^{206}\text{Pb}$		$^{206}\text{Pb}/^{238}\text{U}$		Concordance
	Ratios	1 σ	Ratios	1 σ	Ratios	1 σ	Age/Ma	1 σ	
1	0.033984	0.000318	0.2320	0.0080	0.0493	0.0018	215	2	98%
2	0.072323	0.001361	0.5752	0.0172	0.0569	0.0013	450	8	97%
3	0.043701	0.000462	0.2957	0.0099	0.0490	0.0017	276	3	95%
4	0.291030	0.002858	4.4818	0.1153	0.1109	0.0028	1647	14	95%
5	0.043035	0.000520	0.3426	0.0145	0.0576	0.0023	272	3	90%
6	0.042351	0.000585	0.2838	0.0165	0.0486	0.0030	267	4	94%
7	0.153966	0.001212	1.5412	0.0365	0.0722	0.0018	923	7	97%
8	0.043354	0.000625	0.3163	0.0166	0.0530	0.0028	274	4	98%
9	0.220208	0.002857	2.7722	0.0638	0.0904	0.0017	1283	15	95%
10	0.111072	0.001315	1.0096	0.0220	0.0656	0.0013	679	8	95%
11	0.043888	0.000748	0.3151	0.0206	0.0531	0.0038	277	5	99%
12	0.033821	0.000262	0.2469	0.0060	0.0526	0.0013	214	2	95%
13	0.082323	0.003170	0.7395	0.0387	0.0633	0.0019	510	19	90%
14	0.074686	0.001204	0.6154	0.0171	0.0592	0.0014	464	7	95%
15	0.042091	0.000631	0.2965	0.0199	0.0513	0.0036	266	4	99%
16	0.077758	0.000516	0.6117	0.0132	0.0568	0.0013	483	3	99%
17	0.035034	0.000292	0.2656	0.0083	0.0548	0.0017	222	2	92%
18	0.034904	0.000521	0.2680	0.0133	0.0567	0.0031	221	3	91%
19	0.075050	0.000787	0.5683	0.0227	0.0548	0.0022	467	5	97%
20	0.077582	0.000928	0.5945	0.0141	0.0554	0.0012	482	6	98%
21	0.034076	0.000529	0.2471	0.0096	0.0530	0.0023	216	3	96%
22	0.015094	0.000452	0.1366	0.0093	0.0668	0.0062	97	3	70%
23	0.045217	0.000635	0.3028	0.0187	0.0485	0.0030	285	4	94%
24	0.030765	0.000283	0.2060	0.0090	0.0487	0.0022	195	2	97%
25	0.043959	0.000519	0.4112	0.0149	0.0676	0.0028	277	3	76%
26	0.037502	0.000344	0.2484	0.0086	0.0480	0.0017	237	2	94%
27	0.301545	0.006026	6.4436	0.1751	0.1536	0.0026	1699	30	81%
28	0.378075	0.004438	8.6701	0.2162	0.1649	0.0034	2067	21	89%

Note: “Concordance” indicates the consistent degree between $^{206}\text{Pb}/^{238}\text{U}$ age and $^{207}\text{Pb}/^{235}\text{U}$ age, which is defined as $(^{206}\text{Pb}/^{238}\text{U} \text{ age})/(^{207}\text{Pb}/^{235}\text{U} \text{ age}) \times 100\%$ if $^{207}\text{Pb}/^{235}\text{U}$ age is older than $^{206}\text{Pb}/^{238}\text{U}$ age, otherwise $(^{207}\text{Pb}/^{235}\text{U} \text{ age})/(^{206}\text{Pb}/^{238}\text{U} \text{ age}) \times 100\%$.

4. Conclusions

(i) The zircon U-Pb ages of the gabbro from Yabulai district in the western Alxa Block are 217.4 ± 4.6 Ma, which represent the gabbro was formed in the Late Triassic.

(ii) Based on the previous studies, we considered that the newly discovered Late Triassic gabbro might be formed in an intracontinental extensional setting which was related to the lithospheric thinning and destruction after the closure of the Paleo-Asian Ocean.

(iii) The discovery of the Yabulai gabbro probably indicates that the Alxa Block was in the same geodynamic system as the NCC in the Indosinian period. This represents the first discovery in this area.

CRedit authorship contribution statement

Peng-fei Niu, Jun-feng Qu and Jin Zhang conceived of the presented idea. Heng Zhao and Bei-hang Zhang collected and analyzed the samples. Peng-fei Niu wrote the original draft, Jun-feng Qu and Jin Zhang reviewed and edited the manuscript. All authors provided valuable suggestions and contributed to the final manuscript.

Declaration of competing interest

The authors declare no conflict of interest.

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