Research Advances

New Discovery and Zircon Hf Isotopic Composition of the Early Yanshannian Monzogranite in the Yingyangguan Group of Eastern Guangxi, China

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Objective

The Yingyangguan Group is widely exposed in the southwestern segment of boundary belt between Yangtze and Cathaysian blocks and is mainly composed of a suit of lower-grade metamorphic marine volcanoclastic-sedimentary rocks (Zhou Hanwen et al., 2002). Its forming age and petrogenesis are critical for better understanding the orogenic process and relationship of the Yangtze and Cathaysian blocks since the Neoproterozoic. However, few zircon U-Pb ages of samples from the Yingyangguan Group have been reported, which are much debated, such as the metamorphic spilite (819±11 Ma), keratophyre (415.1±2.1 Ma) and ignimbrite (821.3±3.9 Ma) (Tian Yang et al., 2015 and references in). In this study, we focus on the new discovered Early Yanshannian monzogranite and its mafic enclaves from the Yingyangguan Group, and conducted zircon U-Pb dating and in-situ Hf isotopic analyses to constrain their petrogenesis.

Methods

Fresh monzogranite (D1355-1Z) and mafic enclave (D1355-2Z) samples were collected near Pingtouling village, eastern Guangxi (24°45′21″N, 111°58′28″E). Samples were crushed to fine powder and then zircons were picked. Be casted in an epoxy mount, zircons were documented with cathodoluminescence (CL) images to reveal their internal structures. LA-ICP-MS U-Pb dating and Hf isotopic analyses of these zircons were conducted at the State Key Laboratory of Mineral Deposits Research in Nanjing University. The detailed analytical methods are documented by Meng Yuanku et al. (2018).

Results

(1) The sample D1355-1Z is a porphyritic biotite-hornblende monzogranite and composed mainly of plagioclase (35wt %), K-feldspar (30wt %), quartz (20wt%), with small amounts of hornblende (9wt%) and biotite (6wt%). Accessory phases are magnetite, apatite, titanite and zircon. Magma mixing between mafic and felsic magma are widespread in the monzogranitic body. In the field, mafic enclaves as the residue of mafic magma, commonly have striped or irregular shapes and a few euhedral K-feldspar phenocrysts within.

(2) Zircon from the monzogranite (No. D1355-1Z) and mafic enclave (No. D1355-2Z) are mainly colorless and transparent, stumpy or long-column in shape. As shown by CL images and high Th/U ratios (1.38–3.77), all analyzed zircon grains are of a magmatic origin. The LA-ICP-MS dating yielded concordant $^{206}Pb/^{238}U$ ages of 159.3±1.0 Ma for monzogranite, 158.3±0.6 Ma for mafic enclave, respectively (Appendix 1).

(3) The zircon grains from monzogranite have initial $^{176}Hf/^{177}Hf$ ratios ranging from 0.282665 to 0.282750, the $\varepsilon_{Hf}(t)$ values from –0.7 to 2.3, the calculated two-stage Hf model ages (T_{DM2}) from 1.04 Ga to 1.23 Ga. In contrast, the mafic enclave sample has relatively higher initial $^{176}Hf/^{177}Hf$ ratios (ranging from 0.282719 to 0.282761, except one abnormal low value) and $\varepsilon_{Hf}(t)$ values (1.2–2.7), corresponding to younger two-stage Hf model ages (T_{DM2}) of 1.01 Ga to 1.11 Ga. The relative high $\varepsilon_{Hf}(t)$ values of zircons from the mafic enclaves indicate that the mafic magma was originated from a relatively depleted mantle source.

Conclusions

(1) The new discovered monzogranite and its mafic

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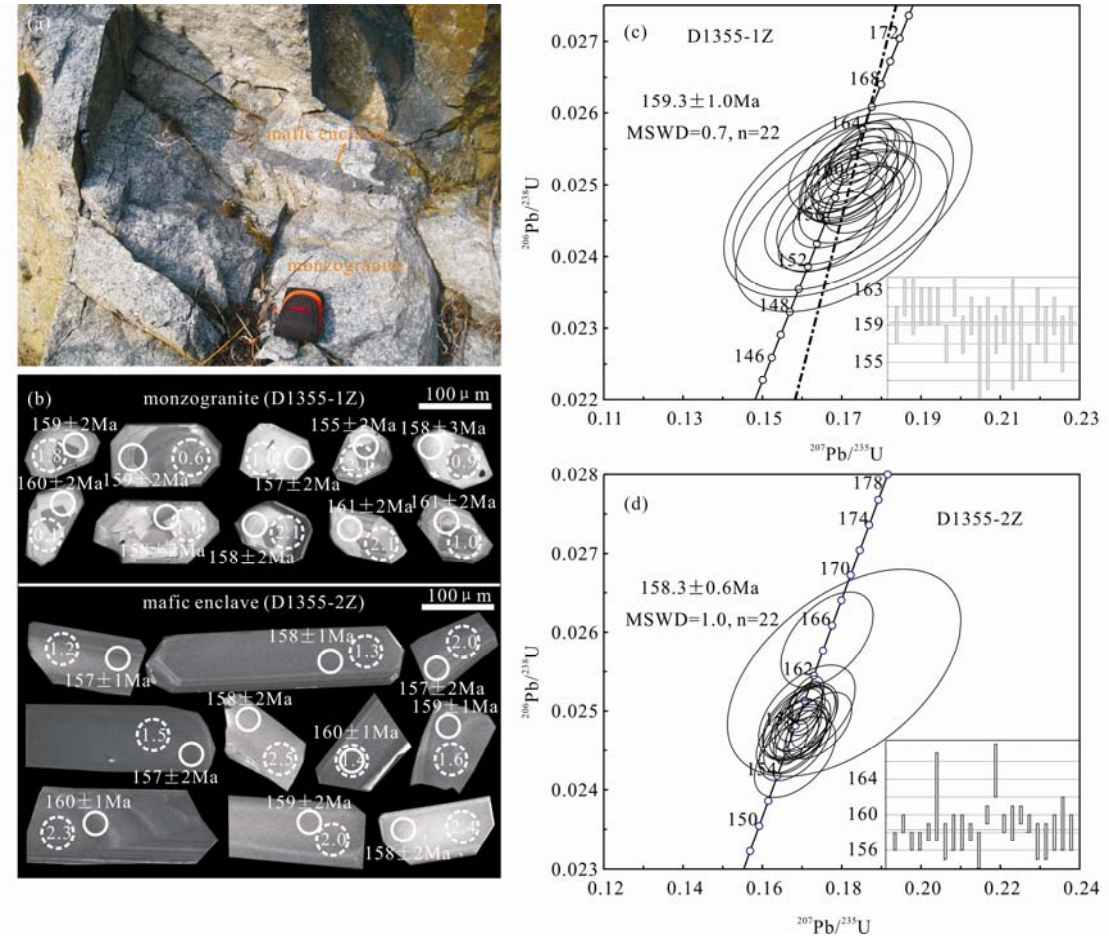

Fig. 1. Contact relation in field (a), CL images of representative zircons (b) and U-Pb concordia diagram (c and d) of new discovered monzogranite and its mafic enclaves from Yingyangguan group in eastern Guangxi, China. Small solid circles are spots for U-Pb isotope analyses, and big dashed circles are spots for Hf isotope analyses.

enclave in the Yingyangguan group in eastern Guangxi were formed in the Early Yanshannian as indicating by zircon U-Pb dating. Their crystalization ages were 159.3±1.0 Ma and 158.3±0.6 Ma, identical to the emplacement age of the adjacent Huashan-Guposhan granitic batholith.

(2) Considering the contact relation in the field, almost the same intrusive age of monzogranite with its mafic enclave further provide evidence for mafic-felsic magma mixing processes. The monzogranite were formed by complete mixing of mantle-derived and crust-derived magmas, while the mafic enclaves are considered as remains of mantle-derived magma during mixing processes.

(3) The Hf isotopic compositions of zircons indicate that the monzogranite may have similar petrogenesis with the Niumiao diorite and Tong'an monzonite and the mafic enclaves might be originated from a relatively depleted mantle source, which was similar to the magma source of the MMEs in the Lisong granite.

Acknowledgements

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Appendix 1 LA-ICP-MS zircon U-Pb analysis data of monzogranite and its maifc enclave from Yingyangguan Formation in eastern Guangxi

Spot No.	Th/ppm	U/ppm	Th/U	$^{207}Pb/^{206}Pb$	1σ	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ	$^{206}Pb/^{238}U$ (age, Ma)
monzogranite (D1355-1Z)										
1	244	127	1.93	0.04994	0.00239	0.17239	0.00783	0.02504	0.00037	159±2
2	216	117	1.85	0.04991	0.00167	0.17525	0.00547	0.02547	0.00028	162±2
3	160	89	1.81	0.04933	0.00312	0.17211	0.01039	0.02530	0.00046	161±3
4	247	116	2.13	0.04951	0.00237	0.17273	0.00785	0.02531	0.00037	161±2
5	201	105	1.92	0.05012	0.00243	0.17434	0.00803	0.02523	0.00037	161±2
6	450	170	2.65	0.04984	0.00156	0.17380	0.00508	0.02529	0.00026	161±2
7	188	98	1.91	0.04985	0.00241	0.16940	0.00779	0.02465	0.00035	157±2
8	276	144	1.92	0.04970	0.00154	0.17407	0.00500	0.02540	0.00026	162±2
9	175	127	1.38	0.05062	0.00196	0.17359	0.00634	0.02488	0.00029	158±2
10	242	117	2.06	0.04959	0.00155	0.17165	0.00499	0.02511	0.00026	160±2
11	257	89	2.89	0.05046	0.00554	0.16991	0.01782	0.02443	0.00079	156±5
12	169	116	1.46	0.04997	0.00565	0.17041	0.01849	0.02473	0.00079	157±5
13	237	105	2.26	0.05136	0.00209	0.17561	0.00675	0.02480	0.00031	158±2
14	234	170	1.38	0.04994	0.00192	0.17210	0.00621	0.02500	0.00030	159±2
15	161	98	1.63	0.05015	0.00634	0.17148	0.02080	0.02480	0.00090	158±6
16	156	81	1.94	0.05010	0.00402	0.17029	0.01310	0.02465	0.00056	157±4
17	216	109	1.98	0.04957	0.00258	0.16640	0.00825	0.02435	0.00037	155±2
18	270	141	1.91	0.05029	0.00291	0.17422	0.00958	0.02513	0.00044	160±3
19	144	87	1.67	0.05080	0.00298	0.17391	0.00972	0.02483	0.00042	158±3
20	234	111	2.11	0.04964	0.00253	0.17172	0.00830	0.02509	0.00039	160±2
21	240	103	2.34	0.04993	0.00322	0.16925	0.01043	0.02459	0.00046	157±3
22	285	142	2.01	0.04926	0.00156	0.16975	0.00501	0.02500	0.00025	159±2
mafic enclave (D1355-2Z)										
1	1121	384	2.92	0.05015	0.00116	0.17082	0.00355	0.02471	0.00021	157±1
2	834	332	2.51	0.04924	0.00122	0.16935	0.00381	0.02495	0.00022	159±1
3	1041	722	1.44	0.0493	0.00093	0.16727	0.00272	0.02461	0.00019	157±1
4	883	333	2.65	0.04948	0.00123	0.16837	0.00381	0.02468	0.00022	157±1
5	956	416	2.30	0.05022	0.00109	0.17206	0.00333	0.02485	0.00021	158±1
6	260	178	1.46	0.05136	0.00583	0.18062	0.01959	0.02549	0.00087	162±5
7	1364	505	2.70	0.04957	0.00192	0.16808	0.00603	0.0246	0.00032	157±2
8	535	210	2.54	0.05091	0.00174	0.17419	0.00552	0.02482	0.00028	158±2
9	671	259	2.59	0.04925	0.00139	0.16824	0.00436	0.02478	0.00024	158±2
10	3161	1172	2.70	0.04921	0.00116	0.16841	0.00359	0.02483	0.00022	158±1
11	509	279	1.82	0.04993	0.00216	0.1681	0.00683	0.02442	0.00034	156±2
12	2627	832	3.16	0.04945	0.00087	0.1712	0.00254	0.02511	0.00018	160±1
13	1734	459	3.77	0.04937	0.0023	0.17624	0.00774	0.02591	0.0004	165±3
14	1149	409	2.81	0.04962	0.00103	0.17103	0.00314	0.025	0.0002	159±1
15	870	320	2.72	0.04955	0.00168	0.17017	0.00535	0.02491	0.00028	159±2
16	1754	600	2.92	0.04931	0.00096	0.17101	0.00289	0.02516	0.00019	160±1
17	1134	440	2.58	0.04934	0.00105	0.17033	0.0032	0.02504	0.0002	159±1
18	2498	843	2.96	0.04951	0.00167	0.16813	0.00523	0.02463	0.00028	157±2
19	711	250	2.85	0.04921	0.0019	0.16738	0.00603	0.02468	0.00031	157±2
20	652	213	3.06	0.04942	0.00191	0.16937	0.00612	0.02485	0.00031	158±2
21	1290	361	3.57	0.04968	0.00252	0.17107	0.00812	0.02498	0.0004	159±3
22	385	137	2.82	0.04937	0.00197	0.1694	0.00633	0.02488	0.00032	158±2