Research Advances

New Discovery of the Devonian Orthoclase Granite of Nenjiang–Heihe Structural belt, China and its Zircon U-Pb Data

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Objective

The Nenjiang–Heihe structural belt is located in the eastern Xing'anling Mongolian Orogenic Belt between the Songnen block and Xiang'an block. This structural belt has long been the focus of geological scholars (Miao Laicheng et al., 2003; Liang Chenyue et al., 2011; Li Chao et al., 2017), which has complex geological condition, strong metamorphism and deformation and serious vegetation cover. There is a great dispute about the time limit of collage of the structural belt. In order to solve the problem, this paper reports a newly discovered Devonian orthoclase granite near Hadayang in Molidawa banner in the middle of this structural belt, which will provide evidence for the tectonic evolution of Nenjiang-Heihe structural and Xing'anling Mongolian Orogenic Belt.

Methods

Samples for zircon dating, whole rock geochemistry and zircon Hf isotopic analyses in this work were collected from orthoclase granite near Hadayang（49°18′ 24 " N，125° 06′ 31 " E）in Molidawa banner, Inner Mongolia. The U-Pb dating of zircons was performed using the LA-ICP-MS dating techniques at the Key Laboratory of Mineral Resources Evaluation in Northeast Asia,Ministry of Land and Resources,Jinlin University,Changchun,China. The whole rock geochemistry was performed with X-ray fluorescence and ICP-MS at the Laboratory Center, Shenyang Center of Geological Survey, Shenyang. The zircon Hf isotopic analyses were conducted using a New Wave UP193FX laser ablation microprobe attached to a Neptune multi-collector ICP-MS in the State Key Laboratory for Mineral Deposits Research at Nanjing University. The detailed experiment principles and technological processes can be referred to related references.

Results

Zircon grains from orthoclase granite are generally euhedral to subhedral columnar ranging from 50 to 150 μm in diameter and aspect rations between 1:1 and 3:1. Zircon grains show clear oscillatory zoning in CL images and high Th/U ratios (0.24 to 0.73) indicate the zircons are of a typical magmatic origin. All analyzed zircon grains are concordant except two grains which have large deviation with the ages of $^{206}Pb/^{238}U$ (Fig. 1a). There are six grains (Appendix 1) have older ages of 401 to 413 Ma and 21 young zircon grains give a weighted mean $^{206}Pb/^{238}U$ age of 380.8±1.8 Ma (2σ) with a MSWD value of 0.40 (Fig. 1b), which is regarded as the magma crystallization age of orthoclase granite. This is the firstly discovered Devonian orthoclase granite in the Nenjiang-Heihe structural belt, China. The orthoclase granite samples are characterized by (1) High Si (SiO_2=73.41 to 75.89wt %), K (K_2O=3.91 to 5.37wt %), alkaline (Na_2O+K_2O=7.95 to 9.06wt%), poor Al (Al_2O_3=12.72 to 13.39wt%) and A/CNK=0.97 to 1.18; (2) The shape of chondrite-normalized REE patterns inclines towards the right and Eu element is negative anomaly; (3) Relative deletion of element Ba, Sr, P, Ti and relative high contents of La, Ce, Zr and Zr+Nb+Ce+Y and $10^4Ga/Al$ ratios, showing the feature of typical A-type granite may formed in a post-orogenic setting. Furthermore, the orthoclase granite have positive $\varepsilon_{Hf}(t)$ values(2.90 to 8.81) and relatively young Hf model ages (T_{DM}=747 to 908 Ma), suggesting that the primary magmas originated from a depleted mantle or newly underplated basaltic crust.

Conclusions

(1) Our new research on the zircon spot analyses of Th and U content and Th/U ratios and the weighted-mean

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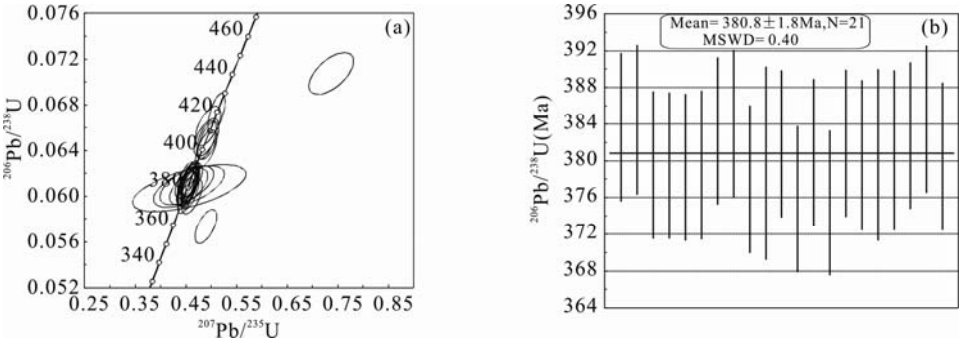

Fig. 1. LA-ICPMS zircon U-Pb concordia diagrams for orthoclase cataclasite in the Hadayang area.

$^{206}Pb/^{238}U$ age of 380.8±1.8Ma reflects the magma crystallization age. This is the firstly discovered Devonian orthoclase granite of Nenjiang-Heihe structural belt. The geochemical characteristics and Hf isotopic analyses reflect the orthoclase granite were formed in the environment of post-collision and stretching tension and the primary magmas originated from a depleted mantle or newly underplated basaltic crust.

(2) Comprehensive chronology, geochemical characteristics and regional geological features indicate that the Nenjiang–Heihe structural belt has been closed in the late Paleozoic era. The newly discovered orthoclase granite is the product of the post-collision, which indicates that the region has already entered the stretching environment in the Late Devonian.

Acknowledgments

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Appendix 1 LA-ICP-MS U-Pb dating data of the zircons from orthoclase granite in the Hadayang area

Spot	$^{207}Pb/^{206}Pb$		$^{207}Pb/^{235}U$		$^{206}Pb/^{238}U$		$^{207}Pb/^{206}Pb$		$^{207}Pb/^{235}U$		$^{206}Pb/^{238}U$		Th/U
No.	Ratio	±1σ	Ratio	±1σ	Ratio	±1σ	Age (Ma)	±1σ	Age(Ma)	±1σ	Age(Ma)	±1σ	
1	0.0540	0.0012	0.4561	0.0110	0.0613	0.0006	369	52	382	9	384	4	0.2909
2	0.0543	0.0007	0.4600	0.0064	0.0615	0.0007	383	28	384	5	384	4	0.5297
3	0.0543	0.0009	0.4536	0.0083	0.0606	0.0006	382	38	380	7	380	4	0.3977
4	0.0540	0.0009	0.4517	0.0081	0.0606	0.0006	372	38	379	7	379	4	0.4298
5	0.0546	0.0007	0.4563	0.0064	0.0606	0.0006	396	28	382	5	379	4	0.7305
6	0.0542	0.0008	0.4534	0.0075	0.0606	0.0006	380	34	380	6	380	4	0.8042
7	0.0543	0.0006	0.4584	0.0061	0.0613	0.0006	383	26	383	5	383	4	0.3339
8	0.0534	0.0008	0.4519	0.0075	0.0614	0.0006	346	35	379	6	384	4	0.2883
9	0.0551	0.0008	0.4585	0.0072	0.0604	0.0006	415	32	383	6	378	4	0.3605
10	0.0546	0.0055	0.4572	0.0457	0.0607	0.0008	398	225	382	38	380	5	0.4145
11	0.0620	0.0010	0.4899	0.0087	0.0573	0.0006	674	36	405	7	359	4	0.5039
12	0.0540	0.0009	0.4542	0.0086	0.0610	0.0006	370	38	380	7	382	4	0.2844
13	0.0543	0.0007	0.4499	0.0067	0.0600	0.0006	385	31	377	6	376	4	0.3960
14	0.0544	0.0007	0.4569	0.0068	0.0609	0.0006	390	30	382	6	381	4	0.4004
15	0.0559	0.0009	0.4622	0.0082	0.0600	0.0006	449	37	386	7	375	4	0.4391
16	0.0555	0.0009	0.4903	0.0085	0.0641	0.0007	431	37	405	7	401	4	0.3422
17	0.0546	0.0009	0.4593	0.0076	0.0610	0.0006	395	35	384	6	382	4	0.3181
18	0.0542	0.0011	0.4942	0.0102	0.0661	0.0007	380	44	408	8	413	4	0.3310
19	0.0544	0.0017	0.4558	0.0153	0.0608	0.0007	386	71	381	13	381	4	0.6312
20	0.0544	0.0033	0.4565	0.0285	0.0608	0.0007	389	137	382	24	381	5	0.8283
21	0.0553	0.0008	0.4945	0.0082	0.0649	0.0007	424	34	408	7	405	4	0.4062
22	0.0551	0.0007	0.5110	0.0068	0.0672	0.0007	418	27	419	6	419	4	0.2461
23	0.0547	0.0011	0.4907	0.0100	0.0651	0.0007	398	44	405	8	407	4	0.2461
24	0.0539	0.0025	0.4524	0.0217	0.0609	0.0007	365	106	379	18	381	4	0.4659
25	0.0756	0.0018	0.7373	0.0180	0.0707	0.0007	1085	47	561	14	440	5	0.3706
26	0.0540	0.0006	0.4555	0.0061	0.0612	0.0006	371	27	381	5	383	4	0.2685
27	0.0542	0.0008	0.4590	0.0075	0.0615	0.0006	377	34	384	6	385	4	0.2567
28	0.0548	0.0008	0.4909	0.0079	0.0649	0.0007	406	33	406	6	405	4	0.3619
29	0.0538	0.0008	0.4508	0.0071	0.0608	0.0006	362	32	378	6	380	4	0.4792