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Research Advances

The Age of the Original Silurian Badangshan Formation and its Ductile Deformation in the Northern Margin of North China Craton: New Evidence from Zircon SHRIMP U-Pb Ages

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Objective

Many previous researches have documented the tectonic evolution of the northern margin of North China Craton. However, whether the age of original Silurian Badangshan Formation in the study area belongs to the Archean, Silurian or Devonian remains controversial, and the ductile deformation time of this formation also lack of chronological study. This work focused on the composition of the rocks in the original Silurian Badangshan Formation of the Jiefangyingzi and Dachaoyanggou area of Chifeng, and the U-Pb dating of rhyolite and late intrusive rocks, and then discussed the age of ductile deformation in order to provide new basic information for the structural evolution of this area.

Methods

Geological mapping at a scale of 1:50000 was performed on the original Silurian Badangshan Formation in the study area. Detailed study about the characteristics of rocks association was conducted, and the contact relations and deformation characteristics of each geological body was also determined.

We collected samples of rhyolite and fine-grained granite that intruded into rhyolite and experienced ductile deformation in the Dachaoyanggou area. Zircons for SHRIMP U-Pb dating were extracted using heavy liquid and magnetic separation from coarsely crushed samples (60 mesh), and finally zircons with good crystalline form and transparency were selected by hand picking under a binocular microscope. The selected zircons were mounted onto an epoxy resin disc together with standard zircons and then ground down and polished to expose their interior structure. Cathodoluminescence (CL) images, reflected light and transmitted light images were taken and observed to check the internal structures of each grain and then potential target domains which avoid internal cracks and inclusions were selected for subsequent SHRIMP U-Pb dating. Zircon SHRIMP U-Pb dating was conducted at the Beijing SHRIMP Center, Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China. Uncertainties for each analysis were at 1σ, and the weighted mean age was quoted at 2σ, with confidence of 95%. Concordia diagrams and weighted mean age calculations were both conducted using Isoplot.

Results

Detailed geological mapping suggests that the original Silurian Badangshan Formation has a main rock association of rhyolite, with tonalite, diorite, fine-grained granite, medium- and coarse-grained granodiorite intruding into rhyolite. The rocks experienced ductile deformation under an extension mechnism. Rhyolite developed A-type fold, stretching lineation and rolled porphyroblasts. Tonalite, diorite, fine-grained granite, medium- and coarse-graied granodiorite developed stretching lineation, porphyroblasts, etc. In general, typical L tectonite is generated, and the trend of A-type lineation is 50°–70°, and the dip angle is 5°–30° due to the influence of continuous folding.

The zircon grains are euhedral to subhedral, and develop typical oscillatory zoning. The Th/U ratios are >0.1, indicative of a magmatic origin. The results of SHRIMP zircon U-Pb dating for the rhyolite samples No. D0059 (n=18) and the fine-grained granite No. D0141 (n=17) yield a weighted mean $^{206}Pb/^{238}U$ age of 277.3± 3.1 Ma (MSWD =1.03) and 236.6±2.5 Ma (MSWD=0.48), respectively (Fig. 1).

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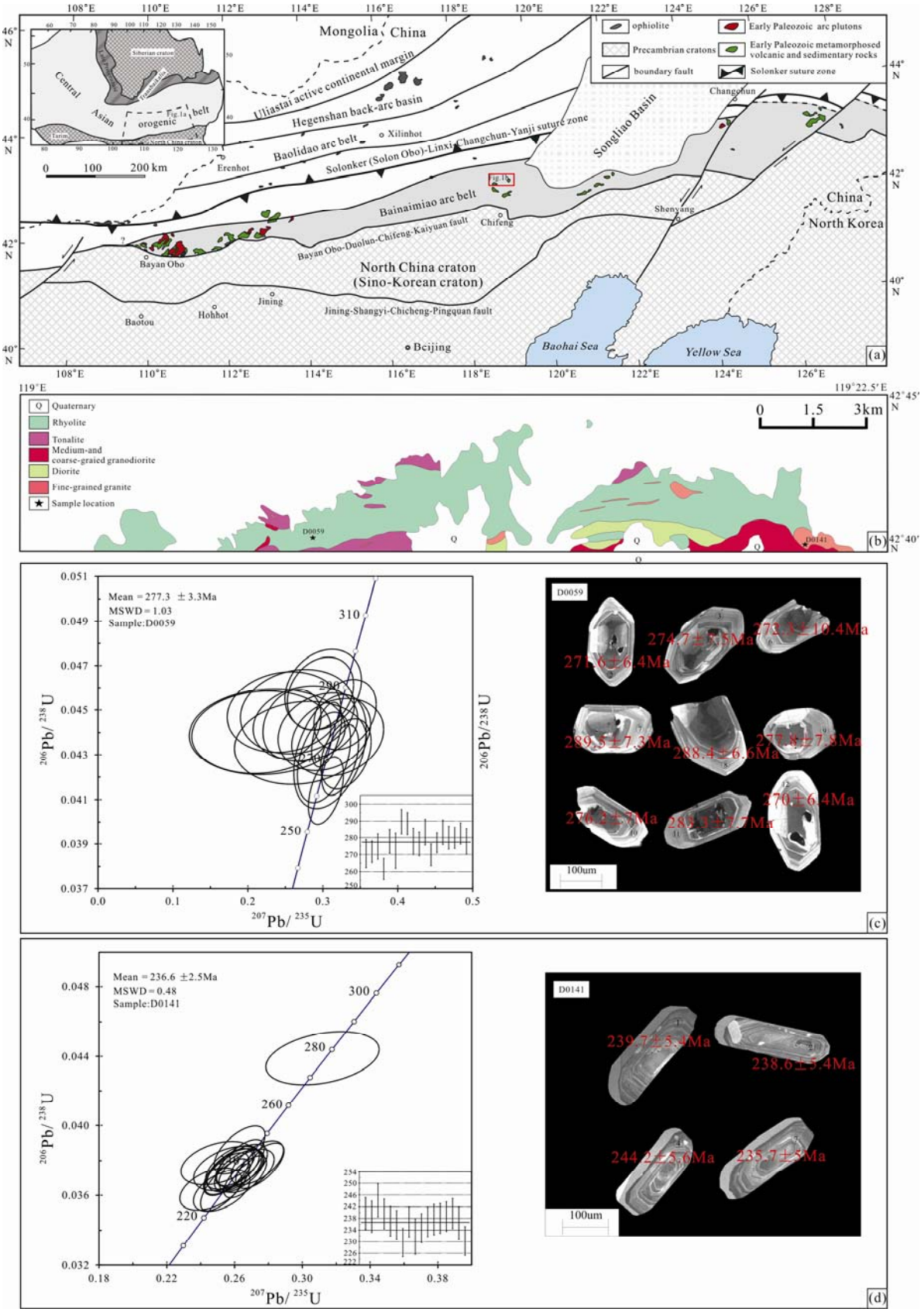

Fig. 1. (a), Structural sketch map of the study area; (b), Distribution of geological bodies in the original Silurian Badangshan Formation in the study area; (c, d), Cathodoluminescence images and concordia diagrams of rhyolite and fine-grained granite.

Conclusions

The age of the original Silurian Badangshan Formation rhyolite is Early Permian (277.3±3.3 Ma), and the age of fine-grained granite that intruded into rhyolite is Middle Triassic (236.6±2.5 Ma).

The ductile deformation time of the original Silurian Badangshan Formation rhyolite and fine-grained granite is after Middle Triassic (236.6±2.5 Ma). Combining the report of some east-westward ductile deformation in northern margin of the North China Craton, we infer that the age of ductile deformation in this region is Late Triassic, or ductile deformation is the record of the Indosinian movement.

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Appendix 1 SHRIMP U-Pb data for zircons of rhyolite and fine-grained granite from the original Silurian Badangshan formation in the Northern Margin of North China Craton

Spot No.	U (ppm)	Th (ppm)	Th/U	$^{206}Pb^{*}$ (ppm)	$^{207}Pb^{*}/^{206}Pb^{*}$	±%	$^{207}Pb^{*}/^{235}U$	±%	$^{206}Pb^{*}/^{238}U$	±%	$t^{206}Pb/^{238}U$ (Ma)
Rhyolite sample D0059											
D0059-1	122	145	1.24	4.50	0.0510	7.1	0.302	7.8	0.0429	3.1	270.7 ± 8.2
D0059-2	221	226	1.06	8.20	0.0557	6.3	0.331	6.7	0.0430	2.4	271.6 ± 6.4
D0059-3	85	83	1.00	3.24	0.0450	21	0.270	22	0.0435	2.8	274.7 ± 7.5
D0059-4	132	132	1.03	4.70	0.0533	4.5	0.304	5.1	0.04140	2.4	261.5 ± 6.2
D0059-5	92	93	1.04	3.53	0.0497	13	0.302	13	0.0440	2.6	277.8 ± 7.1
D0059-6	87	82	0.97	3.25	0.0520	9.5	0.310	10	0.0431	3.9	272 ±10
D0059-7	82	78	0.99	3.23	0.0474	11	0.300	11	0.0459	2.6	289.5 ± 7.3
D0059-8	167	195	1.21	6.64	0.0471	9.5	0.297	9.8	0.0458	2.4	288.4 ± 6.6
D0059-9	77	68	0.92	2.99	0.037	30	0.226	30	0.0440	2.9	277.8 ± 7.8
D0059-10	87	87	1.04	3.30	0.0530	12	0.320	13	0.0438	2.6	276.2 ± 7.0
D0059-11	93	93	1.04	3.66	0.0429	19	0.266	19	0.0449	2.8	283.3 ± 7.7
D0059-12	113	84	0.76	4.16	0.0548	4.4	0.323	5.0	0.0428	2.4	270.0 ± 6.4
D0059-13	403	823	2.11	15.3	0.0504	3.7	0.305	4.3	0.04390	2.2	277.0 ± 5.9
D0059-14	91	121	1.38	3.61	0.0401	20	0.248	20	0.0449	2.7	283.2 ± 7.4
D0059-15	149	147	1.02	5.83	0.0452	16	0.277	17	0.0444	2.5	280.1 ± 6.8
D0059-16	284	503	1.83	11.0	0.0423	9.6	0.259	9.9	0.0444	2.3	279.9 ± 6.3
D0059-17	195	245	1.30	7.60	0.0534	8.0	0.330	8.3	0.0448	2.3	282.5 ± 6.4
D0059-18	95	86	0.94	3.72	0.036	28	0.218	28	0.0440	2.8	277.6 ± 7.5
Fine-grained granite sample D0141											
D0141-1	479	184	0.40	15.6	0.0504	2.7	0.2635	3.5	0.03788	2.3	239.7 ±5.4
D0141-2	422	180	0.44	13.6	0.0529	2.6	0.2749	3.4	0.03770	2.3	238.6 ±5.4
D0141-3	177	92	0.54	6.77	0.0515	6.7	0.312	7.1	0.0439	2.3	276.9 ±6.3
D0141-4	442	149	0.35	14.7	0.0494	3.0	0.2629	3.8	0.03860	2.4	244.2 ±5.6
D0141-5	487	187	0.40	15.9	0.0479	5.3	0.250	5.7	0.03785	2.2	239.5 ±5.1
D0141-6	378	117	0.32	12.2	0.0503	3.4	0.260	4.1	0.03745	2.2	237.0 ±5.1
D0141-7	484	147	0.32	15.5	0.0497	2.6	0.2554	3.4	0.03725	2.1	235.7 ±5.0
D0141-8	388	128	0.34	12.1	0.0505	3.8	0.252	4.4	0.03627	2.2	229.7 ±4.9
D0141-9	298	99	0.34	9.61	0.0518	3.4	0.267	4.0	0.03741	2.2	236.7 ±5.1
D0141-10	402	184	0.47	12.6	0.0504	2.6	0.2544	3.8	0.03661	2.7	231.8 ±6.1
D0141-11	552	243	0.45	17.6	0.0521	2.3	0.2663	3.1	0.03707	2.2	234.6 ±5.0
D0141-12	431	210	0.50	13.9	0.0510	3.0	0.2628	3.7	0.03740	2.2	236.7 ±5.0
D0141-13	434	131	0.31	14.1	0.0495	4.8	0.256	5.3	0.03755	2.2	237.6 ±5.2
D0141-14	410	178	0.45	13.3	0.0499	3.4	0.259	4.1	0.03761	2.2	238.0 ±5.2
D0141-15	460	198	0.45	14.9	0.0508	3.2	0.264	3.8	0.03771	2.2	238.6 ±5.1
D0141-16	430	150	0.36	14.0	0.0523	3.0	0.273	3.7	0.03787	2.2	239.6 ±5.2
D0141-17	530	167	0.33	17.0	0.0498	2.9	0.2563	3.8	0.03734	2.4	236.3 ±5.5
D0141-18	477	164	0.35	15.0	0.0491	4.4	0.246	4.9	0.03636	2.2	230.2 ±5.0

Note: Pb^{*} is radiogenic Pb; Using the measured ^{204}Pb values for common Pb correction.