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Research Advances

The Discovery of Late Ordovician Granodiorite in the Xiemisitai Area, Xinjiang and its Geological Significance

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Objective

The Xiemisitai area located in the northern part of the West Junggar, Xinjiang is an important component of the central Asian metallogenic domain. Recent studies show that the formation age of acid volcanic and intrusive rocks in the Xiemisitai area mainly ranges from the Late Silurian to the Early Devonian, and the age of the mineralized dacite porphyry is Early Silurian. These rocks are the principal part of the Early Paleozoic arc magmatic belt, which are related to the Paleo-Asian Ocean slab subduction. However, there have been no reports of the pre-Silurian arc granitoid, which has restricted the discussion on the Early Paleozoic tectonic evolution in the area. This work studied the newly discovered granodiorite mass near Yinisala in the Xiemisitai area to determine its formation age and tectonic environment, magma source and petrogenesis, providing new information for the discussion on the Early Paleozoic tectonic evolution in the Xiemisitai area.

Methods

Zircons were separated from representative samples and made into a target sample. Their internal structure was revealed by Cathodoluminescence (CL) imaging techniques. U, Th and Pb of zircon grains were analyzed using LA-ICP-MS. Bulk rock major, trace and rare earth element concentrations were obtained by X-ray fluorescence and inductively coupled plasma mass spectrometry (ICP-MS). Bulk rock Sr and Nd isotopes were obtained by multi-collector plasma mass spectrometry. Zircon Hf isotope analysis was carried out in-situ using multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) with laser-ablation microprobe and quadrupole plasma mass spectrometer. All analysis was carried out at the State Key Laboratory of Continental Dynamics, Northwest University.

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Samples for analysis are relatively even-textured and weakly altered rocks, which were taken from 46°34′36.3″ N–46° 34′ 39.2″ N, 85° 18′ 39.1″ E–85° 18′ 49.4″ E near Yinisala in the southern margin of the Xiemisitai Mountain. The granodiorite is greyish white, massive structure, fine-medium grained and hypidiomophic-granular texture, suffered from stronger ductile deformation, and exposed in the volcanic rocks of the Xiemisitai Formation ($S_{1\text{-}4}x$), which was determined by the former researchers (Fig. 1a). The granodiorite is mainly composed of quartz (20%–25%), plagioclase (50%–55%, An=25–35), potassium feldspar (8% –13%) and amphibolites (7%–12%), and contains a small amount of biotite (1% –5%) and accessory minerals such as magnetite, apatite and zircon. Zircon grains for dating are colorless and light yellow, dominated by self-shaped column, and develop typical magma oscillation zone. The grains are 100–200 μm long and 70–100μm wide, with clear and flat boundary, which were selected from the sample XM2-99.

Results

The results of zircon U-Pb analysis are shown in Appendix 1. The age of $^{206}Pb/^{238}U$ mainly focuses on (447±5) Ma–(459±5) Ma, and the weighted average age is 452.0±1.9 Ma (Fig. 1b). It shows that the Yinisala granodiorite was formed in the Late Ordovician.

The granodiorite is characterized by (1) relatively higher SiO_2 (67.15%–69.84%), Al_2O_3 (14.88%–16.15%) with Na_2O/K_2O ratios ranging from 1.01 to 2.42 and A/CNK ratios ranging from 1.03 to 1.21; (2) enrichment in LREE and Rb, Ba, Th, U, K etc., depletion in HREE and Nb, Ta, P, Ti etc., with weak Eu anomaly (δEu=0.90–1.23) (Figs. 1c and 1d); (3) relatively lower I_{Sr} (0.704463–0.704516, n=3), relatively higher $\varepsilon_{Nd}(t)$ (−0.62–4.37, n=3) and relatively younger one-stage model ages (t_{DM1}) ranging from 0.84 Ga to 1.27 Ga; (4) relatively higher $\varepsilon_{Hf}(t)$ (10.7–14.1) and relatively younger two-stage model ages (t_{DM2}=533–749 Ma) of zircons. All these geochemical

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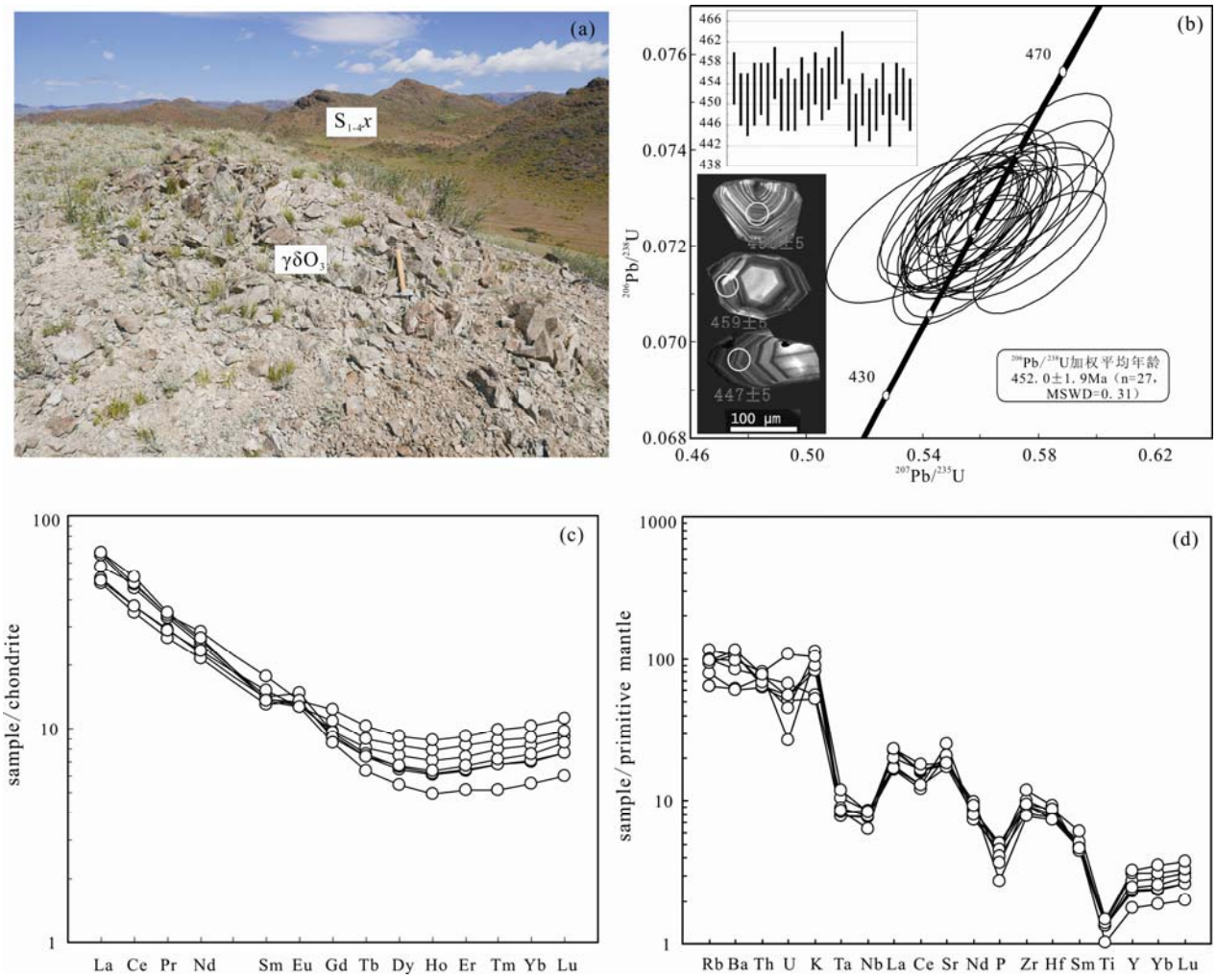

Fig. 1. Outcrop of the Yinisala granodiorite (a) in the Xiemisitai area, zircon CL images and U-Pb dating concordia age (b), chondrite-normalized REE patterns (c) and primary mantle-normalized spider diagram (d).
$\gamma\delta O_3$, Late Ordovician granodiorite; $S_{1-4}x$, Silurian Xiemisitai Formation.

characteristics indicate that the Yinisala granodiorite is calcalkaline and high-K calcalkaline peraluminous granitoids with arc granitoid geochemical features and derived from partial melting of the new-born lower crust.

Conclusions

(1) The crystallization age of the Yinisala granodiorite is 452.0±1.9 Ma, formed in Late Ordovician and, which is the earliest granitoid discovered so far in Xiemisitai and its adjacent areas.

(2) The Yinisala granodiorite was formed in the tectonic setting of continental margin arc, which was derived from partial melting of the young lower crust.

(3) The Paleo-Asian Ocean slab subduction took place in Late Ordovician downward to the northern West Junggar, and the starting time of Boshchekul-Chingiz magmatic arc construction in China can be advanced to the Late Ordovician at least.

Acknowledgements

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Appendix 1 Zircon U-Pb dating results of the Yinisala granodiorite

Sample number	Element content			Th/U	Isotopic ratio						Isotopic age (Ma)					
	^{206}Pb (ppm)	^{238}U (ppm)	^{232}Th (ppm)		$^{207}Pb/^{206}Pb$	1σ	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ	$^{207}Pb/^{206}Pb$	1σ	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ
XM2-99-01	45.09	150.33	73.19	0.30	0.05826	0.00284	0.61608	0.02896	0.07670	0.00100	539	110	487	18	476	6
XM2-99-02	86.34	293.31	137.84	0.29	0.05615	0.00164	0.56657	0.01292	0.07318	0.00082	458	31	456	8	455	5
XM2-99-03	113.84	405.49	260.6	0.28	0.05597	0.00200	0.55925	0.01705	0.07246	0.00089	451	46	451	11	451	5
XM2-99-04	68.76	237.99	113.74	0.29	0.05754	0.00222	0.57403	0.01933	0.07234	0.00092	512	52	461	12	450	6
XM2-99-05	134.68	482.22	292.26	0.28	0.05515	0.00210	0.55205	0.01830	0.07259	0.00092	418	51	446	12	452	6
XM2-99-06	45.13	148.19	53.21	0.30	0.05670	0.00222	0.59966	0.02056	0.07670	0.00096	480	53	477	13	476	6
XM2-99-07	66.85	226.27	115.34	0.30	0.05679	0.00200	0.57055	0.01707	0.07285	0.00088	483	45	458	11	453	5
XM2-99-08	65.79	212.82	127.3	0.31	0.05663	0.00249	0.56662	0.02240	0.07257	0.00099	477	63	456	15	452	6
XM2-99-09	102.75	341.28	286.67	0.30	0.05525	0.00170	0.55841	0.01385	0.07329	0.00084	422	35	450	9	456	5
XM2-99-10	95.92	327.92	190.59	0.29	0.05633	0.00172	0.56210	0.01373	0.07237	0.00082	465	34	453	9	450	5
XM2-99-11	64.99	201.97	73.39	0.32	0.05416	0.00249	0.54074	0.02256	0.07241	0.00101	378	69	439	15	451	6
XM2-99-12	75.88	265.76	148.97	0.29	0.05708	0.00183	0.56955	0.01495	0.07237	0.00084	495	37	458	10	450	5
XM2-99-13	84.81	280.24	156.11	0.30	0.05603	0.00176	0.56314	0.01433	0.07289	0.00084	454	36	454	9	454	5
XM2-99-14	91.48	311.7	123.73	0.29	0.05547	0.00167	0.55382	0.01327	0.07242	0.00081	431	34	447	9	451	5
XM2-99-15	96.68	331.31	169.77	0.29	0.05542	0.00170	0.55863	0.01377	0.07310	0.00083	429	35	451	9	455	5
XM2-99-16	94.48	311.41	176.79	0.30	0.05574	0.00162	0.55778	0.01262	0.07258	0.00080	442	31	450	8	452	5
XM2-99-17	91.42	306.19	169.92	0.30	0.05628	0.00172	0.56561	0.01390	0.07289	0.00082	463	35	455	9	454	5
XM2-99-18	98.34	305.33	178.78	0.32	0.05748	0.00196	0.58082	0.01664	0.07329	0.00088	510	42	465	11	456	5
XM2-99-19	67.78	226.06	106.31	0.30	0.05710	0.00187	0.58164	0.01578	0.07388	0.00086	495	39	466	10	459	5
XM2-99-20	73.36	250.74	160.41	0.29	0.05523	0.00186	0.55121	0.01556	0.07238	0.00085	422	42	446	10	450	5
XM2-99-21	82.99	286.2	144.85	0.29	0.05597	0.00190	0.55349	0.01577	0.07172	0.00085	451	42	447	10	447	5
XM2-99-22	93.43	321.69	180.6	0.29	0.05530	0.00171	0.55212	0.01379	0.07241	0.00082	424	36	446	9	451	5
XM2-99-23	78.8	275.86	183.67	0.29	0.05856	0.00188	0.58074	0.01524	0.07192	0.00083	551	37	465	10	448	5
XM2-99-24	150.04	506.39	304.03	0.30	0.05619	0.00211	0.56035	0.01825	0.07234	0.00091	460	50	452	12	450	5
XM2-99-25	152.43	520.98	264.97	0.29	0.05634	0.00155	0.56552	0.01171	0.07280	0.00079	466	27	455	8	453	5
XM2-99-26	91.17	308.53	162.84	0.30	0.05609	0.00181	0.55556	0.01476	0.07184	0.00083	456	38	449	10	447	5
XM2-99-27	93.13	307.43	132.02	0.30	0.05500	0.00163	0.55179	0.01289	0.07277	0.00081	412	32	446	8	453	5
XM2-99-29	143.96	486.7	366.36	0.30	0.05419	0.00151	0.54271	0.01157	0.07264	0.00079	379	29	440	8	452	5
XM2-99-30	79.21	271.05	142.49	0.29	0.05600	0.00188	0.55792	0.01564	0.07226	0.00085	452	41	450	10	450	5