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Research Advances

U-Pb Geochronology of Hydrothermal Zircons from the Nyainqentanglha Ductile Shear Zone: Constraints on Inception of Cenozoic East–West Extension in the Tibetan Plateau

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Objective

The giant Nyainqentanglha granitic batholith, located in the Lhasa Terrane, is the youngest granite pluton emplaced at 18.3–11.0 Ma during the Miocene epoch. A series of NE -striking sinistral normal ductile shear zones developed on its north and south sides. The ductile shear zones are considered to be the western boundary faults of the Yadong-Gulu rift system and have the potential to provide critical temporal constraints for the large-scale East–West extension event in the Tibetan Plateau. Based on deformation ages of the southern Nyainqentanglha ductile shear zone, it was suggested that the E–W extension took place no later than 8.6 Ma, probably at 11 Ma, and reached the peak at around 8 Ma. We have performed a high-precision geochronological analysis of hydrothermal zircons from the northern Nyainqentanglha ductile shear zone collected, to the best of our knowledge, for the first time. The new data provide satisfying constraints on the inception of the EW extension and the tectonic evolutionary history of the Tibetan Plateau during the Cenozoic.

Methods

Three samples, one from a monzonitic granite (P36) and two from syn-tectonic quartzofeldspathic veins (D10 and P33) were collected from the Labupu area on the west side of the Nyainqentanglha Mountains (Fig. 1a). Zircon grain separation, mounting, photographing, and cathodoluminescence (CL) imaging were performed at Chengxin Geological Services Co. Ltd. Laser ablation inductively coupled mass spectrometry (LA-ICP-MS) U-Pb analysis was carried out at the State Key Laboratory of Ore Deposit Geochemistry. The weighted mean U-Pb age and Concordia plots were obtained with ISOPLOT 3.0.

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Results

The new zircon U-Pb data are shown in Appendix 1. Zircon grains from the monzonitic granite (P36) are euhedral with a short prismatic shape. They are typically 50–190 μm small, with length/width ratios of 1:1 to 3:1. All the zircon grains are colorless to light gray with regular oscillatory zonings and have variable Th (406–2642 ppm), U (712–1638 ppm), and Th/U ratios (0.41–1.79), implying magmatic origin. The $^{206}Pb/^{238}U$ ages of nine zircon grains range from 11.89 Ma to 14.26 Ma, yielding a weighted mean $^{206}Pb/^{238}U$ age of 12.97 ± 0.58 Ma (MSWD = 0.73, Fig. 1b), which reflects the magmatic age of the monzonitic granite.

Zircon grains from a quartzofeldspathic vein (D10) are euhedral–subhedral with short prismatic or irregular shape. Their grain size ranges from 50 to 150 μm, with length to width ratios of 1:1 to 2.5:1. The zircon grains are dark gray with an extremely narrow white altered edge outside and a mass of tiny inclusions inside. In addition, they have very high contents of Th (634–3124 ppm) and U (1724–11127 ppm), indicating that they are hydrothermal in origin. Fifteen zircon grains yield a weighted mean $^{206}Pb/^{238}U$ age of 9.24 ± 0.06 Ma (MSWD = 0.84, Fig. 1c), indicative of the crystallization age of the hydrothermal zircon grains.

Zircon grains from a quartzofeldspathic vein (P33) are subhedral–anhedral with an irregular shape. They are typically 60–200 μm small, with length/width ratios of 1:1 to 2:1. The zircon grains are dark gray and sponge-like with many holes inside. They also have extremely high contents of Th (189–32231 ppm) and U (3964–66481

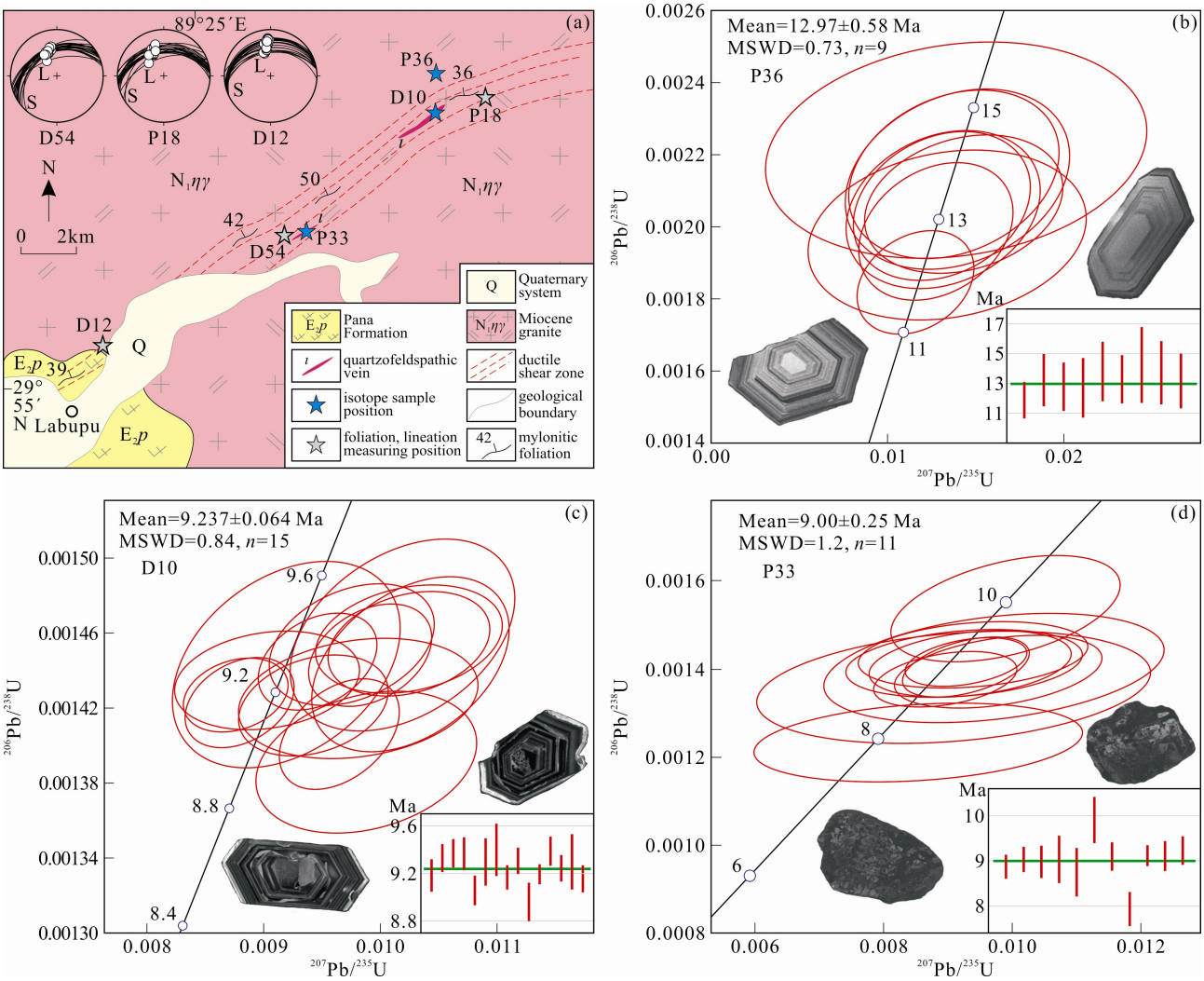

Fig. 1. Simplified geological map of the Labupu area, western Nyainqentanglha (a); zircon U-Pb Concordia, weighted mean age, and representative CL images of the zircon grains selected from a monzonitic granite (b); and syn-tectonic quartzofeldspathic veins (c and d).

ppm), indicating that they are hydrothermal in origin. The total of eight analyzed zircon grains yielded a weighted mean $^{206}Pb/^{238}U$ age of 9.00 ± 0.25 Ma (MSWD = 1.2, Fig. 1d), representing the crystallization age of the quartzofeldspathic vein.

Conclusions

A high-precision U-Pb geochronological analysis of hydrothermal zircons collected from syn-tectonic quartzofeldspathic veins in the northern Nyainqentanglha ductile shear zone is reported here for the first time. Our results demonstrate that the syn-tectonic quartzofeldspathic veins were formed from 9.00 to 9.24 Ma, which indicates the timing of the northern Nyainqentanglha normal ductile shear zone. The age presents new constraints on the inception of the large-scale Cenozoic East–West extension in Tibetan Plateau.

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Appendix 1 Zircon LA-ICP-MS U-Pb dating results

Analysis spots	Th ppm	U ppm	Th/U	$^{207}Pb/^{235}U$ Ratio	3σ	$^{206}Pb/^{238}U$ Ratio	3σ	$^{207}Pb/^{235}U$ Age (Ma)	3σ	$^{206}Pb/^{238}U$ Age (Ma)	3σ
Monzonitic granite, P36											
1	963	1638	0.59	0.0116	0.0022	0.0018	0.0001	11.72	2.18	11.89	0.61
2	625	929	0.67	0.0130	0.0033	0.0021	0.0001	13.16	3.31	13.25	0.87
3	525	1270	0.41	0.0128	0.0029	0.0020	0.0001	12.87	2.90	12.79	0.81
4	706	712	0.99	0.0134	0.0052	0.0020	0.0002	13.49	5.20	12.73	1.00
5	2642	1476	1.79	0.0138	0.0039	0.0021	0.0002	13.90	3.94	13.82	1.00
6	1022	1030	0.99	0.0143	0.0037	0.0021	0.0001	14.46	3.72	13.29	0.81
7	406	714	0.57	0.0139	0.0071	0.0022	0.0002	14.02	7.14	14.26	1.27
8	584	721	0.81	0.0140	0.0042	0.0021	0.0002	14.10	4.20	13.73	1.06
9	817	1033	0.79	0.0132	0.0037	0.0020	0.0001	13.29	3.66	13.18	0.92
Quartzofeldspathic vein, P33											
1	4647	30911	0.15	0.0090	0.0007	0.0014	0.0000	9.06	0.74	8.87	0.27
2	22005	66481	0.33	0.0093	0.0007	0.0014	0.0000	9.38	0.65	9.03	0.28
3	4251	30639	0.14	0.0098	0.0011	0.0014	0.0001	9.89	1.06	8.98	0.36
4	276	5608	0.05	0.0097	0.0017	0.0014	0.0001	9.82	1.76	9.03	0.53
5	1622	9163	0.18	0.0091	0.0020	0.0014	0.0001	9.19	2.03	8.75	0.54
6	705	8262	0.09	0.0099	0.0012	0.0015	0.0001	10.01	1.18	9.91	0.51
7	1994	9694	0.21	0.0093	0.0010	0.0014	0.0000	9.44	1.05	9.10	0.32
8	32231	21289	1.51	0.0085	0.0017	0.0012	0.0001	8.64	1.70	7.93	0.38
9	2881	25023	0.12	0.0093	0.0006	0.0014	0.0000	9.38	0.62	9.11	0.23
10	189	3964	0.05	0.0093	0.0012	0.0014	0.0001	9.36	1.22	9.11	0.33
11	214	6000	0.04	0.0094	0.0012	0.0014	0.0000	9.50	1.18	9.23	0.32
Analysis spots	Th ppm	U ppm	Th/U	$^{207}Pb/^{235}U$ Ratio	1σ	$^{207}Pb/^{238}U$ Ratio	1σ	$^{207}Pb/^{235}U$ Age (Ma)	1σ	$^{206}Pb/^{238}U$ Age (Ma)	1σ
Quartzofeldspathic vein, D10											
1	1871	5785	0.32	0.0098	0.0020	0.0014	0.0001	9.92	0.68	9.18	0.14
2	3123	8087	0.39	0.0099	0.0010	0.0014	0.0001	10.01	0.35	9.33	0.12
3	2164	6903	0.31	0.0102	0.0014	0.0015	0.0001	10.35	0.46	9.37	0.12
4	1220	6015	0.20	0.0098	0.0014	0.0015	0.0001	9.86	0.47	9.36	0.14
5	3124	11127	0.28	0.0097	0.0010	0.0014	0.0001	9.75	0.34	9.06	0.12
6	2162	5749	0.38	0.0103	0.0017	0.0014	0.0001	10.37	0.56	9.30	0.20
7	1867	3554	0.53	0.0102	0.0019	0.0015	0.0001	10.30	0.64	9.40	0.22
8	2031	5670	0.36	0.0088	0.0009	0.0014	0.0000	8.90	0.31	9.17	0.10
9	1699	4528	0.38	0.0095	0.0010	0.0014	0.0001	9.57	0.33	9.31	0.11
10	1703	4279	0.40	0.0099	0.0019	0.0014	0.0001	9.98	0.62	8.96	0.16
11	2047	6662	0.31	0.0088	0.0009	0.0014	0.0000	8.86	0.30	9.19	0.08
12	978	3335	0.29	0.0102	0.0016	0.0015	0.0001	10.35	0.53	9.39	0.12
13	1178	4354	0.27	0.0090	0.0016	0.0014	0.0001	9.13	0.52	9.24	0.11
14	634	1724	0.37	0.0092	0.0019	0.0014	0.0001	9.30	0.65	9.30	0.23
15	1234	3215	0.38	0.0094	0.0013	0.0014	0.0001	9.53	0.42	9.15	0.11