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Research Advances

LA-ICP-MS Zircon U-Pb Dating of Tuffs in the Taining Basin: Constraints on the Ages of the Danxia Red Beds

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Objective

Cretaceous terrestrial red beds, as a major component of the Danxia Landform, are widespread in South China. However, the lack of fossils with absolute ages as well as scarce volcanic rocks for isotopic dating to constraint the boundary ages of the red beds results in unclear formation ages of the Danxia red beds. Recently, we have conducted a study of LA-ICP-MS zircon U-Pb dating on the tuffs present at the basal part of the Cretaceous red beds in the Taining Basin, Fujian Province, and obtained high precision age. The new age not only can precisely constrain the formation age of the Danxia red beds in the Taining Basin, but also provide important evidence for the study of regional stratigraphic correlation, paleoclimate, basin evolution and tectonic setting.

Methods

Sample crush, zircon separation and target fabrication were conducted at the Xinhang Surveying and Mapping Institute of Hebei Province. Cathodoluminescence (CL) imiging, reflected light and transmitted light were performed at the Institute of Mineral Resources, Chinese Academy of Geological Sciences. Zircon U-Pb dating was accomplished at the National Analytical Center of China. The detailed experimental process, analysis steps and data analysis method can follow some references.

Results

The dated zircons of tuff samples show crystal forms that are mostly euhedral, long columnar to columnar in shape, with obvious magmatic concussion band (Fig. 1). Combined with the Th/U ratios (0.31–0.86), it is suggested that the zircons are magmatic in origin, and the $^{206}Pb/^{238}U$ ages can represent the crystallization age (Appendix 1). Dating results show that the age of tuff beds present at the basal part of the Cretaceous Shaxian Formation in the Taining Basin is 100.5±0.77 Ma (Fig. 1). This age is consistent with the international boundary age of the Lower and Upper Cretaceous, implying that the terrestrial Albian-Cenomanian boundary may be located at the base of the Shaxian Formation. The formation age of the Danxia red beds in the Taining Basin should be the Early to Late Cretaceous transition or the earliest Late Cretaceous, earlier than other Danxia red beds present in the Late Cretaceous basins in southeastern South China. Large numbers of studies proposed that rapid aridification and hot climate occurred in the continent during the Early to Late Cretaceous transition (Zhang et al., 2018). The presence of the earliest Late Cretaceous Danxia red beds composed dominantly of alluvial sedimentation and paleosols in South China witnessed paleoclimatic change from the relative humid Early Cretaceous to the arid Late Cretaceous. This aridity progressively reached its climax in the middle Late Cretaceous characterized by widespread eolian deposits.

A regional compressional tectonic event took place in South China during the late Early Cretaceous, and resulted in the tectonic inversion of the Early Cretaceous rift basins (Li et al., 2014). This compressional tectonic event characterized by angular unconformity between the Upper Cretaceous and the Lower Cretaceous or underlying basement has been assigned as the result of subduction of Paleo-Pacific plate to the East Asia continent. During the Early to Late Cretaceous transition, intensive extension occurred and led to the basin subsidence and occurrence of numerous A-type granites and bimodal volcanic rocks. The initiation of the Taining Basin filled with the Shaxian Formation consisting of volcanic rocks and alluvial cobble -boulder conglomerate was a sedimentary response to this extensional tectonic event, possibly resulting from the rollback of the subducted Paleo-Pacific Plate (Dmitrienko et al., 2018).

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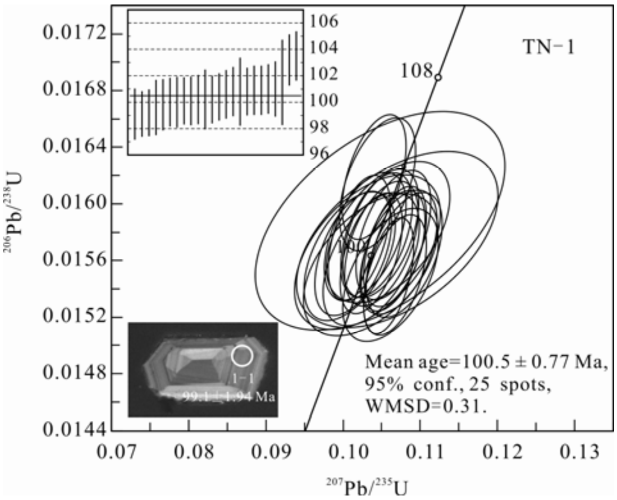

Fig. 1. U-Pb concordia diagram and CL image of zircons for the tuff bed in the Taining Basin.

Conclusion

Zircon U-Pb ages of tuff beds present at the basal part of the Shaxian Formation in the Taining Basin have been constrained at 100.5±0.77 Ma, which is consistent with the international boundary age of Albian to Cenomanian, suggesting that the Danxia red beds were formed during the Early Cretaceous-Late Cretaceoustransition or the earliest Late Cretaceous. These red beds mainly consisting of alluvial sedimentation and paleosols are in accordance with the paleoclimatic change from relative humid to aid condition during the Early to Late Cretaceous transition. The subsidence of the Taining Basin filled with volcanic rocks and alluvial boulder-cobble conglomerate not only represent the initial extension of South China in the Late Cretaceous, but also is in agreement with the termination of the subduction of the Paleo-Pacific plate beneath East Asia.

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References

Dmitrienko, L.V., Wang, P.C., Li, S.Z., Cao, X.Z., Ian, S., Zhou, Z.Z., Hu, M.Y., Suo, Y.H., Guo, L.L., Wang, Y.M., Li, X.Y., Liu, X., Yu, S.Y., Zhu, J.J., 2018. Meso-Cenozoic evolution of earth surface system under the East Asian tectonic superconvergence. Acta Geologica Sinica (English Edition), 92(2): 814–849.

Li, J.H., Zhang, Y.Q., Dong, S.W., and Johnston, S.T. 2014. Cretaceous tectonic evolution of South China: a preliminary synthesis. Earth-Science Reviews, 134: 98–136.

Zhang, M.Z., Dai, S., D, B.X., Ji, L.M., and Hu, S.S., 2018. Mid-Cretaceous hothouse climate and the expansion of early angiosperms. Acta Geologica Sinica (English Edition), 92(5): 2004–2025.

Appendix 1 LA-ICP-MS zircon U-Pb analytical results of sample TN-1 from Shaxian Formation in the Taining Basin, Fujian Province

Spots	Pb (ppm)	Th (ppm)	U (ppm)	Th/U	Ratios						Age (Ma)						Disc. (%)
					$^{207}Pb/^{206}Pb$	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	
TN-1-1	4.9	152.3	282.0	0.54	0.05034	0.00198	0.10618	0.0041	0.0155	0.00031	210.6	88.53	102.5	3.76	99.1	1.94	3.3
TN-1-2	27.9	628.7	1688.4	0.37	0.04947	0.00105	0.10591	0.00213	0.01549	0.00027	170.3	48.69	102.2	1.95	99.1	1.73	3
TN-1-3	10.9	306.0	635.1	0.48	0.05011	0.0013	0.10673	0.00268	0.0155	0.00028	200.2	59.23	103	2.46	99.2	1.78	3.7
TN-1-4	4.5	165.1	246.8	0.67	0.04851	0.00274	0.10354	0.00575	0.01557	0.00033	124.2	128.1	100	5.29	99.6	2.1	0.4
TN-1-5	3.9	88.8	233.2	0.38	0.04785	0.00195	0.10364	0.00414	0.01561	0.00031	91	94.68	100.1	3.81	99.8	1.95	0.3
TN-1-6	7.4	220.0	430.1	0.51	0.04929	0.00153	0.10793	0.00327	0.01564	0.00029	161.8	70.97	104.1	3	100	1.85	3.9
TN-1-7	4.7	137.7	276.2	0.50	0.04624	0.00182	0.10084	0.0039	0.01563	0.0003	10.3	92.01	97.6	3.6	100	1.93	2.4
TN-1-8	11.1	325.2	644.1	0.50	0.04865	0.00129	0.10367	0.00265	0.01565	0.00028	130.9	60.99	100.2	2.44	100.1	1.8	0.1
TN-1-9	6.7	218.4	388.8	0.56	0.04781	0.00157	0.10133	0.00327	0.01565	0.00029	89.1	77.23	98	3.01	100.1	1.85	2.1
TN-1-10	6.3	171.2	363.3	0.47	0.0506	0.0016	0.10717	0.00331	0.01566	0.00029	222.6	71.58	103.4	3.03	100.2	1.87	3.1
TN-1-11	2.3	72.6	130.0	0.56	0.04953	0.00304	0.10315	0.00625	0.01566	0.00036	172.9	137.2	99.7	5.75	100.2	2.27	0.5
TN-1-12	9.2	249.1	534.8	0.47	0.04988	0.00133	0.10646	0.00275	0.01567	0.00028	189.4	60.91	102.7	2.52	100.2	1.81	2.4
TN-1-13	9.7	246.6	574.1	0.43	0.04977	0.0013	0.10675	0.00269	0.0157	0.00028	184.4	59.6	103	2.46	100.4	1.8	2.5
TN-1-14	6.7	184.2	390.0	0.47	0.04883	0.0015	0.10494	0.00314	0.01572	0.00029	139.9	70.62	101.3	2.89	100.6	1.85	0.7
TN-1-15	11.0	321.8	638.3	0.50	0.04922	0.00171	0.10288	0.0035	0.01577	0.0003	158.3	79.25	99.4	3.22	100.8	1.87	1.4
TN-1-16	3.8	176.8	205.3	0.86	0.04935	0.00398	0.10702	0.0086	0.01575	0.00041	164.6	178.1	103.2	7.89	100.8	2.58	2.3
TN-1-17	11.3	268.2	653.3	0.41	0.04818	0.0013	0.10208	0.00266	0.01576	0.00029	108	62.43	98.7	2.45	100.8	1.81	2.1
TN-1-18	9.8	246.3	575.4	0.43	0.04928	0.00148	0.10433	0.00306	0.01578	0.00029	161.1	68.96	100.8	2.82	100.9	1.87	0.1
TN-1-19	7.7	213.3	438.4	0.49	0.0487	0.0015	0.1065	0.0032	0.01578	0.0003	133.3	70.85	102.8	2.94	100.9	1.87	1.8
TN-1-20	7.6	235.9	431.3	0.55	0.04924	0.00156	0.10489	0.00324	0.01579	0.0003	159.5	72.31	101.3	2.97	101	1.88	0.3
TN-1-21	2.8	89.8	152.8	0.59	0.04939	0.0025	0.10581	0.00529	0.0158	0.00033	166.2	114.4	102.1	4.85	101	2.1	1.1
TN-1-22	2.3	67.8	126.5	0.54	0.05026	0.00515	0.10478	0.01067	0.01588	0.00051	207	221.5	101.2	9.81	101.5	3.24	0.3
TN-1-23	12.2	223.2	713.5	0.31	0.04957	0.00158	0.10444	0.00325	0.01614	0.00031	175.1	72.55	100.9	2.99	103.2	1.94	2.2
TN-1-24	12.1	286.5	683.2	0.42	0.04723	0.00127	0.10401	0.00272	0.01619	0.00029	60.5	63.44	100.5	2.5	103.5	1.87	2.9