



Supplement of

Precise age for the Permian–Triassic boundary in South China from high-precision U-Pb geochronology and Bayesian age–depth modeling

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Supplement S1: Samples

The Dongpan section is situated at 22°16'11.80"N and 107°41'31.30"E, north-east of Liuqiao. The Penglaitan section is situated at 23°41'8.4"N and 109°18'21.0"E, east of Laibin.



Figure S1. Studied volcanic ash beds (in black), radiolarian samples (in yellow), and their associated beds of the Changhsingian Dalong Formation at the Dongpan section. Both pictures present the continuous Dongpan section, where the upper picture is stratigraphically above the lower one. The Permian-Triassic boundary (PTB) in Dongpan is marked by the lithological boundary between the Permian Dalong Formation and the Triassic Ziyun Formation.



Figure S2. Studied volcanic ash beds and volcaniclastic sandstones (in black), and conodont samples (in yellow) of the Penglaitan section. The Permian-Triassic boundary (PTB) is marked by the lithological boundary between the Permian Dalong Formation and the Triassic Ziyun Formation.

Supplement S2: U-Pb zircon CA-ID-TIMS analysis

The samples were crushed and milled, and the powder was wet-sieved to remove the clay fraction. Heavy minerals were isolated using methylene iodide. Single zircons were microscopically inspected and euhedral crystals were picked for annealing at 900°C for ~48 h, followed by chemical abrasion with 40 % HF and trace HNO₃ in pressurized 200 µl Savillex mini-capsules at 180°C for 18 h to minimize Pb loss effects (Mattinson, 2005). Since Ovtcharova et al. (2015) still revealed apparent Pb loss in some zircon grains after 15 h of chemical abrasion, this study was optimized to the longer duration of 18 h to effectively overcome this obstacle.

After several washing steps with water, 6 N HCl, and 3 N HNO₃, single crystals were loaded in 200 µl Savillex capsules, spiked with ~4 mg of the EARTHTIME ²⁰²Pb-²⁰⁵Pb-²³³U-²³⁵U tracer solution (hereafter referred to as ET2535; Condon et al., 2015) and dissolved in ~70 µl 40 % HF and trace HNO3 at 210°C for 48 h. After dissolution, samples were dried and redissolved in 6 N HCl at 180°C for 12 h, dried down again and re-dissolved in 3 N HCl. U and Pb were collected in 3 ml Savillex beakers after separation in a modified single 50 µl column anion exchange chemistry (Krogh, 1973) and dried down with a drop of 0.05 M H₃PO₄. They were loaded on a single outgassed Re filament with a Si-gel emitter modified from Gerstenberger and Haase (1997). Measurements of U and Pb isotopes were performed on a Thermo TRITON thermal ionization mass spectrometer utilizing the ET2535 tracer calibration version 3.0 defined by Condon et al. (2015). Pb isotopes were measured in dynamic mode on a MasCom secondary electron multiplier with a deadtime of 23 ns. Instrumental mass fractionation was corrected using the fractionation factor derived from the measured ²⁰²Pb/²⁰⁵Pb ratio relative to a true value of 0.99924. BaPO₂ interferences on mass 202 to 205 were corrected by determining ¹³⁸Ba³¹P¹⁶O¹⁶O concentration on mass 201 assuming natural abundance of ¹³⁸Ba of 71.7 %. No correction was applied for isobaric interference of Tl on mass 205 (natural abundance of $^{205}Tl = 70.48$ %, $^{203}Tl = 29.52$ %) since routine check of the Re filaments yielded negligible concentrations on mass 203. U isotopes were measured in static mode on Faraday cups equipped with $10^{12} \Omega$ resistors as UO_2^+ and measured ratios were corrected for isobaric interferences of $^{233}U^{18}O^{16}O$ on $^{235}U^{16}O^{16}O$ using $^{18}O/^{16}O$ of 0.0020, measured on large U500 loads, and for mass fractionation using the measured ²³³U/²³⁵U ratio relative to a value of 0.99506, assuming a sample 238 U/ 235 U ratio of 137.818 ± 0.045 (2 σ ; Hiess et al., 2012). Raw data were statistical filtered by using the Tripoli program, followed by data reduction including correct uncertainty propagation and online data visualization using U-Pb Redux software (Bowring et al., 2011; McLean et al., 2011). U-Pb ratios and dates were calculated relative to a tracer 235 U/ 205 Pb ratio of 100.23 ± 0.046 % (2 σ ; Condon et al., 2015). All common Pb in the analyses was assumed to be procedural blank yielding a long-term average ${}^{206}\text{Pb}/{}^{204}\text{Pb}$ ratio of 18.469 ± 0.458 , ${}^{207}\text{Pb}/{}^{204}\text{Pb}$ ratio of 15.471 ± 0.320 , ${}^{208}\text{Pb}/{}^{204}\text{Pb}$ ratio of 38.011 ± 0.484 (uncertainties are given as 2σ) and an average of 0.52 pg during the course of this study.

I		Dates (I	Ma)			U	ompositior	_			lsoto	pic Ratios			
Fraction and	206Pb/238U	±2σ 2	207Pb/235U	±2σ	Disc. (%)	Th/U	Pb (pg) Pl	bc (pg)	206Pb/204Pb	206Pb/238U	±2σ 2	:07Pb/235U	±2σ 20	7Pb/206Pb	±2σ
sample	*a °°	(absolute)	*a	(absolute)	q_*	°*	p_*	*е	+Ł	*g	(%)	<i>*</i> g	(%)	*g	(%)
Dongpan-18															
DGP 18.1	253.253	0.142	253.517	0.994	1.38	0.63	20.12	0.74	1618	0.0401	0.06	0.2836	0.44	0.0514	0.43
DGP 18.2	254.900	0.186	254.789	1.518	-0.10	0.59	11.39	0.66	1036	0.0403	0.07	0.2852	0.67	0.0513	0.66
DGP 18.3	257.274	0.689	257.017	2.366	-0.70	0.69	6.29	0.50	750	0.0407	0.27	0.2880	1.04	0.0513	0.99
DGP 18.4	255.159	0.364	254.345	2.676	-3.01	0.62	5.09	0.50	619	0.0404	0.15	0.2847	1.19	0.0512	1.16
DGP 18.5	254.752	0.568	253.430	1.742	-5.24	0.64	8.27	0.48	1025	0.0403	0.23	0.2835	0.78	0.0510	0.72
DGP 18.6	252.559	0.261	252.422	0.560	-0.22	0.64	35.48	0.51	4061	0.0399	0.11	0.2822	0.25	0.0513	0.21
DGP 18.7	256.837	0.275	256.141	2.378	-2.48	0.61	4.78	0.43	677	0.0406	0.11	0.2869	1.05	0.0512	1.03
DGP 18.8	253.456	0.184	253.776	1.592	1.61	0.58	13.80	0.86	973	0.0401	0.07	0.2839	0.71	0.0514	0.71
Dongpan-21															
DGP 21.2	252.677	0.241	252.499	0.494	-0.38	0.59	52.48	0.51	6089	0.0400	0.10	0.2823	0.22	0.0513	0.18
DGP 21.4	252.715	0.084	252.668	0.412	0.15	0.55	42.44	0.52	4883	0.0400	0.03	0.2825	0.18	0.0513	0.17
DGP 21.5	252.265	0.163	252.503	0.442	1.25	0.95	29.07	0.38	4114	0.0399	0.07	0.2823	0.20	0.0513	0.18
DGP 21.6	252.586	0.117	252.523	0.339	0.07	0.69	43.39	0.44	5721	0.0399	0.05	0.2824	0.15	0.0513	0.13
DGP 21.8	251.908	0.134	251.934	0.875	0.45	0.61	19.59	0.57	2053	0.0398	0.05	0.2816	0.39	0.0513	0.39
DGP 21.10	252.145	0.120	252.108	0.438	0.19	0.62	29.98	0.41	4356	0.0399	0.05	0.2818	0.20	0.0513	0.18
DGP 21.12	251.969	0.229	251.711	0.720	-0.73	0.67	26.37	0.46	3340	0.0398	0.09	0.2813	0.32	0.0512	0.25
DGP 21.13	251.975	0.077	252.032	0.715	0.58	0.52	17.62	0.49	2206	0.0398	0.03	0.2817	0.32	0.0513	0.33
DGP 21.14	252.240	0.157	252.369	0.850	0.84	0.77	13.19	0.40	1877	0.0399	0.06	0.2822	0.38	0.0513	0.37
DGP 21.15	251.929	0.080	251.955	0.694	0.46	0.53	19.68	0.54	2197	0.0398	0.03	0.2816	0.31	0.0513	0.31
DGP 21.17	251.945	0.113	251.963	0.480	0.42	0.56	39.56	0.63	3736	0.0398	0.05	0.2816	0.22	0.0513	0.20
DGP 21.18	251.896	0.230	251.998	1.429	0.75	0.61	11.49	0.61	1119	0.0398	0.09	0.2817	0.64	0.0513	09.0
DGP 21.20	251.976	0.074	252.081	0.523	0.77	0.57	29.35	0.59	2997	0.0398	0.03	0.2818	0.23	0.0513	0.23
DGP 21.21	251.940	0.172	252.109	1.486	1.02	0.62	10.01	0.58	1028	0.0398	0.07	0.2818	0.67	0.0513	0.65
Dongpan-17															
DGP 17.1	252.018	0.091	252.079	0.325	0.61	0.43	64.38	0.69	5792	0.0399	0.04	0.2818	0.15	0.0513	0.13
DGP 17.2	252.896	0.108	252.753	0.473	-0.23	0.50	36.24	0.51	4303	0.0400	0.04	0.2826	0.21	0.0513	0.19
DGP 17.3	251.899	0.096	252.006	0.514	0.80	0.44	31.56	0.60	3230	0.0398	0.04	0.2817	0.23	0.0513	0.22
DGP 17.4	251.871	0.120	252.189	0.623	1.64	0.44	25.52	0.56	2837	0.0398	0.05	0.2819	0.28	0.0514	0.26
DGP 17.5	251.990	0.131	251.620	0.505	-1.16	0.46	35.56	0.52	4195	0.0398	0.05	0.2812	0.23	0.0512	0.20
DGP 17.6	252.001	0.063	252.195	0.323	1.15	0.41	48.16	0.53	5661	0.0399	0.03	0.2819	0.14	0.0513	0.13
DGP 17.7	251.933	0.120	252.166	0.897	1.30	0.51	16.80	0.58	1773	0.0398	0.05	0.2819	0.40	0.0513	0.39
DGP 17.8	251.927	0.193	252.158	2.208	1.31	0.33	15.56	1.53	663	0.0398	0.08	0.2819	0.99	0.0513	0.99
DGP 17.9	251.929	0.101	252.328	0.493	1.96	0.41	30.66	0.54	3543	0.0398	0.04	0.2821	0.22	0.0514	0.21
DGP 17.10	252.003	0.210	252.585	0.637	2.67	0.41	20.82	0.51	2568	0.0399	0.08	0.2824	0.28	0.0514	0.27
DGP 17.11	251.938	0.118	252.124	0.330	1.13	0.36	42.18	0.49	5401	0.0398	0.05	0.2819	0.15	0.0513	0.13
DGP 17.12	251.866	0.158	251.890	0.478	0.46	0.45	29.58	0.52	3536	0.0398	0.06	0.2816	0.21	0.0513	0.20
Dongpan-16															
DGP 16.1	252.074	0.177	250.746	0.953	-5.34	0.37	20.74	0.73	1809	0.0399	0.07	0.2801	0.43	0.0510	0.41
DGP 16.3	252.008	0.113	251.757	1.091	-0.67	0.49	17.10	0.76	1388	0.0399	0.05	0.2814	0.49	0.0512	0.48
DGP 16.4	251.959	0.074	252.180	0.469	1.28	0.22	27.97	0.53	3469	0.0398	0.03	0.2819	0.21	0.0513	0.20

 Table S1. U-Pb single grain zircon dates and isotopic data.

		Dates (N	(a)			S	mposition				lsoto	oic Ratios			
06Pb/238U ±2σ 207Pb/235U	±2σ 207Pb/235U	07Pb/235U		±2σ l	Disc. (%)	Th/U	Pb (pg) P	bc (pg)	206Pb/204Pb 2	206Pb/238U	±2σ	07Pb/235U	±2σ 20	7Pb/206Pb	±20
*a°° (absolute) *a (al	(absolute) * <i>a</i> (al	* <i>a</i> (al	a	osolute)	q_*	*c	p_*	в*	*f	*g	(%)	*g	(%)	<i>b</i> *	(%)
252.018 0.149 251.175	0.149 251.175	251.175		1.164	-3.19	0.45	16.74	0.71	1456	0.0399	0.06	0.2807	0.52	0.0511	0.50
251.959 0.134 252.150 (0.134 252.150 (252.150 (U	0.937	1.17	0.19	14.52	0.58	1673	0.0398	0.05	0.2819	0.42	0.0513	0.41
251.926 0.102 252.727 0	0.102 252.727 0	252.727 0	0	.668	3.54	0.24	20.15	0.51	2607	0.0398	0.04	0.2826	0.30	0.0515	0.29
251.471 0.160 251.540 0.	0.160 251540 0.	251.540 0.	0	778	0.67	0.27	21.37	0.66	2095	0.0398	0.06	0.2811	0.35	0.0513	0.33
252.030 0.168 252.627 1.5	0.168 252.627 1.5	252.627 1.5	<u> </u>	555	2.73	0.39	12.30	0.75	1041	0.0399	0.07	0.2825	0.70	0.0514	0.68
252.023 0.107 251.841 0.5	0.107 251.841 0.5	251.841 0.5	0.5	80	-0.35	0.26	24.27	0.49	3228	0.0399	0.04	0.2815	0.23	0.0512	0.21
251.897 0.158 252.166 0.7	0.158 252.166 0.7	252.166 0.7	0.7	,03	1.47	0.27	18.84	0.51	2396	0.0398	0.06	0.2819	0.31	0.0514	0.30
252.103 0.104 252.698 0.8	0.104 252.698 0.8	252.698 0.8	0.8	59	2.73	0.36	22.62	0.83	1727	0.0399	0.04	0.2826	0.38	0.0514	0.38
252.079 0.069 252.151 0.2	0.069 252.151 0.2	252.151 0.2	0.2	46	0.66	0.41	60.43	0.41	9091	0.0399	0.03	0.2819	0.11	0.0513	0.0
252.174 0.104 252.415 0.8	0.104 252.415 0.8	252.415 0.8	0.8	2	1.33	0.43	14.18	0.51	1738	0.0399	0.04	0.2822	0.39	0.0513	0.38
252.118 0.153 252.094 0.6	0.153 252.094 0.6	252.094 0.6	0.6	91	0.27	0.42	20.60	0.55	2331	0.0399	0.06	0.2818	0.31	0.0513	0.29
252.086 0.115 252.042 0.36	0.115 252.042 0.36	252.042 0.36	0.36	60	0.21	0.29	31.43	0.37	5516	0.0399	0.05	0.2817	0.17	0.0513	0.12
252.067 0.081 252.029 0.51	0.081 252.029 0.51	252.029 0.51	0.51	8	0.21	0.46	23.69	0.47	3095	0.0399	0.03	0.2817	0.23	0.0513	0.22
252.155 0.123 251.914 0.77	0.123 251.914 0.77	251.914 0.77	0.77	6	-0.63	0.45	18.88	0.57	2056	0.0399	0.05	0.2816	0.35	0.0512	0.34
252.146 0.107 252.081 0.699	0.107 252.081 0.699	252.081 0.699	0.69	~	0.10	0.45	16.28	0.43	2346	0.0399	0.04	0.2818	0.31	0.0513	0.30
252.131 0.112 252.317 0.855	0.112 252.317 0.855	252.317 0.855	0.855		1.10	0.55	13.00	0.42	1864	0.0399	0.05	0.2821	0.38	0.0513	0.37
252.065 0.093 251.950 0.506	0.093 251.950 0.506	251.950 0.506	0.506		-0.09	0.35	25.11	0.44	3646	0.0399	0.04	0.2816	0.23	0.0513	0.21
252.032 0.112 252.101 0.777	0.112 252.101 0.777	252.101 0.777	0.777		0.63	0.54	13.84	0.41	2033	0.0399	0.05	0.2818	0.35	0.0513	0.33
252.159 0.090 252.536 0.804	0.090 252.536 0.804	252.536 0.804	0.804	_	1.86	0.50	12.34	0.39	1925	0.0399	0.04	0.2824	0.36	0.0514	0.35
252.102 0.094 252.185 0.586	0.094 252.185 0.586	252.185 0.586	0.586		0.66	0.69	19.34	0.40	2786	0.0399	0.04	0.2819	0.26	0.0513	0.25
252.224 0.148 251.873 0.892	0.148 251.873 0.892	251.873 0.892	0.892		-1.11	0.63	9.37	0.25	2253	0.0399	0.06	0.2815	0.40	0.0512	0.37
252.142 0.075 252.212 0.485	0.075 252.212 0.485	252.212 0.485	0.485		0.66	0.33	17.96	0.34	3371	0.0399	0.03	0.2820	0.22	0.0513	0.21
252.458 0.208 252.299 1.063	0.208 252.299 1.063	252.299 1.063	1.063		-0.26	0.31	10.86	0.43	1626	0.0399	0.08	0.2821	0.48	0.0513	0.45
251.912 0.224 251.970 0.94	0.224 251.970 0.94	251.970 0.94	0.94	m	0.62	0:30	11.81	0.40	1889	0.0398	0.09	0.2817	0.42	0.0513	0.40
251.661 0.263 251.688 0.95	0.263 251.688 0.95	251.688 0.95	0.95	2	0.47	0.48	12.56	0.39	1957	0.0398	0.11	0.2813	0.43	0.0513	0.39
252.924 0.352 251.794 3.26	0.352 251.794 3.26	251.794 3.26	3.26	52	-4.43	0.43	2.37	0.31	498	0.0400	0.14	0.2814	1.46	0.0511	1.4
251.861 0.202 251.725 1.02	0.202 251.725 1.02	251.725 1.02	1.0	6	-0.17	0.29	11.14	0.43	1692	0.0398	0.08	0.2813	0.46	0.0513	0.45
252.881 0.571 252.626 6.50	0.571 252.626 6.50	252.626 6.50	6.50	0	-0.68	0.48	1.78	0.46	253	0.0400	0.23	0.2825	2.91	0.0513	2.88
252.039 0.210 251.722 1.79	0.210 251.722 1.79	251.722 1.79	1.79	86	-0.91	0.27	5.43	0.36	982	0.0399	0.09	0.2813	0.81	0.0512	0.78
251.884 0.274 252.117 2.95	0.274 252.117 2.95	252.117 2.95	2.95	m	1.32	0.31	5.30	0.66	528	0.0398	0.11	0.2818	1.32	0.0513	1.31
252.635 0.218 252.640 2.34	0.218 252.640 2.34	252.640 2.34	2.34	S	0.39	0.44	5.50	0.54	644	0.0400	0.09	0.2825	1.05	0.0513	1.04
252.155 0.257 252.014 2.25	0.257 252.014 2.25	252.014 2.25	2.25	4	-0.21	0.41	6.27	0.55	723	0.0399	0.10	0.2817	1.01	0.0513	0.99
252.580 0.316 252.776 3.29	0.316 252.776 3.29	252.776 3.29	3.29	95	1.16	0.35	4.95	0.59	545	0.0399	0.13	0.2827	1.47	0.0513	1.44
252.088 0.150 251.900 0.	0.150 251.900 0.	251.900 0.	0	762	-0.40	0.40	19.51	0.51	2402	0.0399	0.06	0.2816	0.34	0.0512	0.32
252.126 0.317 252.075 2.2	0.317 252.075 2.2	252.075 2.2	2.2	243	0.16	0.44	6.97	0.62	708	0.0399	0.13	0.2818	1.00	0.0513	0.99
252.142 0.121 252.084 0.8	0.121 252.084 0.8	252.084 0.87	0.8	15	0.14	0.38	11.87	0.38	1965	0.0399	0.05	0.2818	0.37	0.0513	0.35
252.770 0.183 252.896 1.8	0.183 252.896 1.8	252.896 1.8	1.8	47	0.87	0.45	4.97	0.39	807	0.0400	0.07	0.2828	0.82	0.0513	0.82

		Dates (N	Ma)			C	mposition				lsotop	oic Ratios			
action and	206Pb/238U	±2σ 2	207Pb/235U	±2σ [Disc. (%)	Th/U	Pb (pg) Pł	oc (pg)	206Pb/204Pb 20	06Pb/238U	±2σ 2	07Pb/235U	±2σ 20	7Pb/206Pb	±2σ
mple	*0 00	(absolute)	*a	(absolute)	q_*	*c	p_*	*е	*f	*g	(%)	*g	(%)	*g	(%)
GP 10.7	252.147	0.091	252.590	0.708	2.13	0.40	14.72	0.42	2199	0.0399	0.04	0.2824	0.32	0.0514	0.31
GP 10.8	252.769	0.204	252.740	1.368	0.25	0.42	8.93	0.48	1180	0.0400	0.08	0.2826	0.61	0.0513	0.59
GP 10.9	252.254	0.242	252.244	1.725	0.33	0.39	6.12	0.43	904	0.0399	0.10	0.2820	0.77	0.0513	0.76
GP 10.11	252.366	0.181	252.211	1.025	-0.26	0.43	10.91	0.41	1669	0.0399	0.07	0.2820	0.46	0.0513	0.44
GP 10.12	252.201	0.159	252.379	0.861	1.06	0.55	12.49	0.42	1802	0.0399	0.06	0.2822	0.39	0.0513	0.37
GP 10.13	252.826	0.424	252.481	2.031	-1.06	0.47	5.98	0.40	933	0.0400	0.17	0.2823	0.91	0.0512	0.86
englaitan-22															
EN 22.2	251.909	0.073	251.819	0.444	0.00	0.44	36.92	0.50	4573	0.0398	0.03	0.2815	0.20	0.0513	0.20
EN 22.3	251.405	0.174	251.671	0.358	1.44	0.43	46.73	0.53	5494	0.0398	0.07	0.2813	0.16	0.0513	0.13
EN 22.4	251.895	0.080	252.071	0.360	1.09	0.35	38.18	0.46	5207	0.0398	0.03	0.2818	0.16	0.0513	0.14
EN 22.6	251.910	0.055	252.004	0.366	0.77	0.28	29.59	0.46	4155	0.0398	0.02	0.2817	0.16	0.0513	0.16
EN 22.7	251.964	0.237	251.667	1.108	-0.86	0.48	13.37	0.51	1614	0.0398	0.10	0.2813	0.50	0.0512	0.46
EN 22.8	252.166	0.123	252.092	1.220	0.10	0.17	8.09	0.44	1248	0.0399	0.05	0.2818	0.55	0.0513	0.54
EN 22.9	252.166	0.123	252.210	1.229	0.53	0.55	13.03	0.63	1252	0.0399	0.05	0.2820	0.55	0.0513	0.54
EN 22.10	251.939	0.156	252.332	1.313	1.93	0.51	14.37	0.72	1229	0.0398	0.06	0.2821	0.59	0.0514	0.57
EN 22.11	251.891	0.082	251.861	0.715	0.25	0.40	20.94	0.62	2139	0.0398	0.03	0.2815	0.32	0.0513	0.31
PEN 22.12	251.913	0.157	251.527	0.818	-1.19	0.18	6.21	0.14	2866	0.0398	0.06	0.2811	0.37	0.0512	0.33
PEN 22.13	251.923	0.205	251.163	1.490	-2.82	0.35	4.24	0.14	1895	0.0398	0.08	0.2806	0.67	0.0511	0.63
⁹ englaitan-28															
PEN 28.1	252.511	0.198	251.772	1.001	-2.75	09.0	18.86	0.67	1668	0.0399	0.08	0.2814	0.45	0.0511	0.43
PEN 28.2	252.078	0.083	252.151	0.760	0.64	0.59	22.29	0.64	2081	0.0399	0.03	0.2819	0.34	0.0513	0.34
PEN 28.3	252.057	0.106	252.080	0.597	0.43	0.65	25.69	0.52	2916	0.0399	0.04	0.2818	0.27	0.0513	0.25
PEN 28.4	252.096	0.086	252.096	0.536	0.35	0.57	25.37	0.52	2913	0.0399	0.03	0.2818	0.24	0.0513	0.23
PEN 28.5	252.364	0.156	252.603	1.227	1.25	0.96	10.94	0.47	1277	0.0399	0.06	0.2825	0.55	0.0513	0.54
PEN 28.6	252.045	0.119	251.936	1.366	-0.10	0.58	14.53	0.82	1074	0.0399	0.05	0.2816	0.61	0.0513	0.62
PEN 28.7	251.989	0.144	252.023	0.676	0.49	0.56	28.93	0.62	2784	0.0399	0.06	0.2817	0:30	0.0513	0.28
PEN 28.8	252.174	0.367	251.129	2.321	-4.10	0.59	4.11	0.37	680	0.0399	0.15	0.2806	1.04	0.0511	1.02
PEN 28.9	252.430	0.286	252.213	1.763	-0.56	0.69	6.03	0.40	898	0.0399	0.12	0.2820	0.79	0.0512	0.77
PEN 28.10	252.413	0.245	252.919	2.130	2.32	0.80	6.63	0.53	724	0.0399	0.10	0.2829	0.95	0.0514	0.94
PEN 28.11	251.994	0.167	252.168	0.996	1.04	0.63	10.75	0.39	1621	0.0399	0.07	0.2819	0.45	0.0513	0.43
PEN 28.12	252.403	0.284	252.540	1.982	0.89	0.61	6.77	0.52	789	0.0399	0.11	0.2824	0.89	0.0513	0.87
PEN 28.13	253.090	0.375	252.838	2.764	-0.69	0.64	3.87	0.42	559	0.0400	0.15	0.2828	1.24	0.0513	1.22
englaitan-70															
EN 70.1	253.371	0.165	253.002	1.461	-1.21	0.87	16.24	0.87	1054	0.0401	0.07	0.2830	0.65	0.0512	0.64
EN 70.2	252.917	0.220	252.968	0.711	0.54	0.61	36.74	0.98	2233	0.0400	0.09	0.2829	0.32	0.0513	0.30
EN 70.3	252.778	0.270	252.955	1.111	1.04	0.64	17.72	0.65	1618	0.0400	0.11	0.2829	0.50	0.0513	0.47
EN 70.4	252.137	0.200	252.078	0.967	0.10	0.62	16.95	0.57	1769	0.0399	0.08	0.2818	0.43	0.0513	0.41
PEN 70.6	252.519	0.125	252.436	0.510	0.01	0.57	34.71	0.65	3223	0.0399	0.05	0.2822	0.23	0.0513	0.22
EN 70.7	253.079	0.283	253.701	1.493	2.70	1.22	20.94	1.04	1039	0.0400	0.11	0.2838	0.67	0.0515	0.64
PEN 70.8	253.309	0.231	253.620	1.294	1.55	0.81	13.88	0.67	1180	0.0401	0.09	0.2837	0.58	0.0514	0.57
PEN 70.9	252.156	0.147	252.327	0.404	1.03	0.64	52.32	0.56	5516	0.0399	0.06	0.2821	0.18	0.0513	0.16

$\begin{array}{ccccc} (\frac{1}{100}) & \overline{g} & (\frac{1}{100}) & \overline{g} \\ 0.35 & 0.0513 & 0.0513 & 0.0513 & 0.0513 & 0.0513 & 0.0513 & 0.0513 & 0.0513 & 0.0513 & 0.0512 & 0.0512 & 0.0512 & 0.0512 & 0.0511 & 0.0513$	$\begin{array}{ccccccc} (\psi_0) & \cdot g & \cdot (\psi_0) \\ 0.35 & 0.0513 & 0.3 \\ 0.20 & 0.0513 & 0.3 \\ 0.54 & 0.0513 & 0.4 \\ 0.50 & 0.0513 & 0.4 \\ 0.16 & 0.0512 & 0.1 \\ 0.24 & 0.0512 & 0.1 \\ 0.11 & 0.0513 & 0.0 \\ 0.17 & 0.0513 & 0.1 \\ 0.17 & 0.0513 & 0.1 \\ 0.17 & 0.0511 & 0.2 \\ 0.37 & $	(%) ''g (%) ''g 0.355 0.0513 0.31 0.31 0.20 0.0513 0.31 0.31 0.50 0.0513 0.45 0.45 0.50 0.0513 0.45 0.17 0.16 0.0513 0.46 0.01 0.16 0.0512 0.13 0.45 0.11 0.0512 0.13 0.16 0.11 0.0513 0.12 0.12 0.11 0.0513 0.12 0.12 0.13 0.0513 0.16 0.12 0.14 0.0513 0.12 0.12 0.17 0.0513 0.12 0.12 0.17 0.0513 0.12 0.12 0.37 0.0514 1.35 0.13 0.75 0.0514 0.0514 0.75	(%) g (%) g 0.35 0.0513 0.31 0.31 0.20 0.0513 0.31 0.31 0.51 0.0513 0.49 0.49 0.50 0.0513 0.49 0.49 0.50 0.0513 0.49 0.49 0.87 0.0513 0.49 0.01 0.16 0.0512 0.013 0.49 0.17 0.0513 0.09 0.01 0.11 0.0513 0.02 0.13 0.17 0.0513 0.05 0.13 0.17 0.0513 0.21 0.23 0.37 0.0514 0.0514 0.73 0.75 0.0514 0.0513 0.94 0.31 0.0513 0.94 0.30 0.31 0.0513 0.0513 0.30	(v_0) g (v_0) v_0 0.35 0.0513 0.31 0.31 0.20 0.0513 0.31 0.31 0.54 0.0513 0.451 0.51 0.50 0.0513 0.61 0.61 0.86 0.0513 0.451 0.13 0.16 0.0513 0.09 0.13 0.11 0.0513 0.09 0.013 0.11 0.0513 0.09 0.12 0.11 0.0513 0.02 0.12 0.11 0.0513 0.02 0.12 0.11 0.0513 0.73 0.02 0.12 0.0514 0.73 0.73 0.75 0.0513 0.73 0.73 0.71 0.0513 0.23 0.30 0.27 0.0513 0.25 0.118	(ψ_0) g (ψ_0) ψ_0 0.35 0.0513 0.31 0.50 0.0513 0.31 0.51 0.0513 0.31 0.50 0.0513 0.49 0.51 0.0513 0.49 0.50 0.0513 0.49 0.16 0.0513 0.49 0.17 0.0513 0.13 0.19 0.0513 0.13 0.11 0.0513 0.13 0.11 0.0513 0.12 0.11 0.0513 0.12 0.11 0.0513 0.12 0.11 0.0513 0.12 0.14 0.0513 0.13 0.17 0.0514 0.73 0.25 0.0513 0.24 0.21 0.0513 0.26 0.21 0.0516 1.18 0.22 0.0513 0.26 0.28 0.0513 0.26	(ψ_0) g (ψ_0) ψ_0 0.35 0.0513 0.31 0.50 0.0513 0.31 0.50 0.0513 0.49 0.50 0.0513 0.49 0.50 0.0513 0.49 0.51 0.0513 0.49 0.16 0.0513 0.49 0.17 0.0513 0.38 0.11 0.0513 0.36 0.11 0.0513 0.36 0.11 0.0513 0.12 0.11 0.0513 0.12 0.11 0.0513 0.25 0.12 0.0514 0.73 0.25 0.0514 0.73 0.27 0.0513 0.26 0.21 0.0513 0.26 0.21 0.0513 0.26 0.22 0.0513 0.26 0.28 0.0513 0.26 0.58 0.0513 0.56 0.58 0.0513 0.57	(ψ_0) $-g_0$ (ψ_0) 0.35 0.0513 0.31 0.20 0.0513 0.31 0.50 0.0513 0.51 0.50 0.0513 0.51 0.50 0.0513 0.46 0.87 0.0513 0.48 0.16 0.0513 0.48 0.16 0.0513 0.48 0.11 0.0513 0.12 0.11 0.0513 0.12 0.11 0.0513 0.12 0.11 0.0513 0.12 0.12 0.0514 0.73 0.12 0.0514 0.73 0.12 0.0513 0.25 0.12 0.0514 0.73 0.12 0.0513 0.26 0.12 0.0513 0.26 0.25 0.0513 0.26 0.26 0.0513 0.52 0.26 0.0513 0.52 <th>(ψ_0) g (ψ_0) 0.35 0.0513 0.31 0.50 0.0513 0.31 0.50 0.0513 0.49 0.50 0.0513 0.49 0.50 0.0513 0.49 0.87 0.0513 0.49 0.16 0.0513 0.49 0.11 0.0513 0.13 0.11 0.0513 0.13 0.11 0.0513 0.12 0.11 0.0513 0.12 0.11 0.0514 0.23 0.12 0.0514 0.26 0.12 0.0514 0.26 0.12 0.0514 0.26 0.12 0.0513 0.26 0.21 0.0513 0.26 0.22 0.0513 0.26 0.23 0.0513 0.26 0.26 0.0513 0.26 0.26 0.0513 0.57</th> <th>(ψ_0) ϕ_0 (ψ_0) 0.35 0.0513 0.31 0.50 0.0513 0.17 0.51 0.513 0.49 0.50 0.0513 0.49 0.51 0.0513 0.49 0.51 0.0513 0.49 0.51 0.0513 0.49 0.16 0.0513 0.13 0.11 0.0513 0.13 0.11 0.0513 0.13 0.11 0.0513 0.12 0.11 0.0513 0.12 0.12 0.0514 0.73 0.141 0.0514 0.73 0.25 0.0513 0.26 0.19 0.0513 0.25 0.19 0.0513 0.25 0.19 0.0513 0.26 0.28 0.0513 0.26 0.53 0.0513 0.53 0.54 0.0513 0.57 0.55 0.0513 0.57 0.55</th>	(ψ_0) g (ψ_0) 0.35 0.0513 0.31 0.50 0.0513 0.31 0.50 0.0513 0.49 0.50 0.0513 0.49 0.50 0.0513 0.49 0.87 0.0513 0.49 0.16 0.0513 0.49 0.11 0.0513 0.13 0.11 0.0513 0.13 0.11 0.0513 0.12 0.11 0.0513 0.12 0.11 0.0514 0.23 0.12 0.0514 0.26 0.12 0.0514 0.26 0.12 0.0514 0.26 0.12 0.0513 0.26 0.21 0.0513 0.26 0.22 0.0513 0.26 0.23 0.0513 0.26 0.26 0.0513 0.26 0.26 0.0513 0.57	(ψ_0) ϕ_0 (ψ_0) 0.35 0.0513 0.31 0.50 0.0513 0.17 0.51 0.513 0.49 0.50 0.0513 0.49 0.51 0.0513 0.49 0.51 0.0513 0.49 0.51 0.0513 0.49 0.16 0.0513 0.13 0.11 0.0513 0.13 0.11 0.0513 0.13 0.11 0.0513 0.12 0.11 0.0513 0.12 0.12 0.0514 0.73 0.141 0.0514 0.73 0.25 0.0513 0.26 0.19 0.0513 0.25 0.19 0.0513 0.25 0.19 0.0513 0.26 0.28 0.0513 0.26 0.53 0.0513 0.53 0.54 0.0513 0.57 0.55 0.0513 0.57 0.55
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a Isotopic dates calculated using the decay constants λ238 = 1.55125E-10 and λ235 = 9.8485E-10 (Jaffey et al., 1971). b % discordance = 100 - (100 * (206Pb/238U date) / (207Pb/206Pb date)). c Th contents calculated from radiogenic 208Pb and the 207Pb/206Pb date of the sample, assuming concordance between U-Th and Pb systems. d Total mass of radiogenic Pb. e Total mass of common Pb.

f Measured ratio corrected for fractionation and spike contribution only. g Measured ratio corrected for fractionation, tracer and blank. ^{oo} Corrected for initial Th/U disequilibrium using radiogenic 208Pb and Th/U_{magma} = 3.00. * Samples marked in red are from a previous study (Baresel et al., 2016).

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Supplement S3: Bayesian method Bchron modeling

The age-depth models of Dongpan, Penglaitan and Meishan have been run under the free and open-source software RStudio Desktop version 1.0.44 using the free Bchron R package version 4.1.1 (Haslett and Parnell, 2008; Parnell et al., 2008). Detailed documentation of available program commands is provided in the embedded description file of the Bchron package.

Bchron R scripts

Dongpan model

Input parameter:	"id"	age [ka] 1s [ka]	position [cm]	thickness [cm]	"calCurves"
	"DGP-18"	252560 260	52	2	"normal"
	"DGP-21"	251953 19	93	2	"normal"
	"DGP-17"	251956 17	368	8	"normal"
	"DGP-16"	251978 20	426	4	"normal"
	"DGP-13"	252101 19	743	6	"normal"
	"DGP-12"	252121 18	833	5	"normal"
	"DGP-11"	251924 48	894	5	"normal"
	"DGP-10"	252170 28	1075	2	"normal"

Script: data (Dongpan)

DGPOut=Bchronology(ages=Dongpan\$ages,ageSds=Dongpan\$ageSds, calCurves=Dongpan\$calCurves,positions=Dongpan\$position,positionThicknesses=Dongpan\$thickness, ids=Dongpan\$id,predictPositions=seq(0,1075,by=1),iterations=10000,extractDate=251700) plot(DGPOut,main="Dongpan",xlab='Age (Ma)',ylab='Depth (cm)',las=1) predictAges=predict(DGPOut, newPositions=c(100,415),newPositionThicknesses=c(0,0)) summary(DGPOut) summary(DGPOut, type='convergence') summary(DGPOut, type='outliers')

Dongpan model (rescaled)

Input parameter:	"id"	age [ka] 1s [ka]	position [cm]	thickness [cm]	"calCurves"
	"DGP-18"	252560 260	50	0	"normal"
	"DGP-21"	251953 19	89	0	"normal"
	"DGP-17"	251956 17	356	0	"normal"
	"DGP-16"	251978 20	410	0	"normal"
	"DGP-13"	252101 19	682	0	"normal"

"DGP-12"	252121 18	767	0	"normal"
"DGP-11"	251924 48	819	0	"normal"
"DGP-10"	252170 28	988	0	"normal"

Script:

data (Dongpan)

DGPOut=Bchronology(ages=Dongpan\$ages,ageSds=Dongpan\$ageSds, calCurves=Dongpan\$calCurves,positions=Dongpan\$position,positionThicknesses=Dongpan\$thickness, ids=Dongpan\$id,predictPositions=seq(0,988,by=1),iterations=10000,extractDate=251700) plot(DGPOut,main="Dongpan",xlab='Age (Ma)',ylab='Depth (cm)',las=1) predictAges=predict(DGPOut, newPositions=c(96,399),newPositionThicknesses=c(0,0)) summary(DGPOut) summary(DGPOut, type='convergence') summary(DGPOut, type='outliers')

Penglaitan model

Input parameter:	"id"	age [ka]	1s [ka]	position [cm]	thickness [cm]	"calCurves"
	"PEN-22"	251907	17	53	1	"normal"
	"PEN-28"	252062	22	131	1	"normal"
	"PEN-70"	252125	35	161	1	"normal"
	"PEN-6"	252137	41	209	1	"normal"
Script:	data (Penglaitan))				

Script:

PENOut=Bchronology(ages=Penglaitan\$ages,ageSds=Penglaitan\$ageSds, calCurves=Penglaitan\$calCurves,positions=Penglaitan\$position, positionThicknesses=Penglaitan\$thickness,ids=Penglaitan\$id, predictPositions=seq(0,212,by=1),iterations=10000,extractDate=251700) plot(PENOut,main="Penglaitan",xlab='Age (Ma)',ylab='Depth (cm)',las=1) predictAges=predict(PENOut, newPositions=c(100),newPositionThicknesses=c(0)) summary(PENOut) summary(PENOut, type='convergence') summary(PENOut, type='outliers')

Penglaitan model (rescaled)

Input parameter:	"id"	age [ka] 1s [ka]	position [cm]	thickness [cm]	"calCurves"
	"PEN-22"	251907 17	53	0	"normal"
	"PEN-28"	252062 22	131	0	"normal"

	"PEN-70"	252125	35	157	0	"normal"
	"PEN-6"	252137	41	205	0	"normal"
Script:	data (Penglait	an)				
	PENOut=Bch	ronology(ag	es=P	englaitan\$ages	,ageSds=Penglait	an\$ageSds,
	calCurves=Pe	nglaitan\$cal	Curv	es,positions=P	englaitan\$positio	n,
	positionThick	nesses=Peng	glaita	n\$thickness,ids	s=Penglaitan\$id,	
	predictPositio	ons=seq(0,13	1,by=	=1),iterations=	10000,extractDate	e=251700)
	plot(PENOut,	main="Peng	laita	n",xlab='Age (l	Ma)',ylab='Depth	(cm)',las=1)
	predictAges=	predict(PEN	Out,	newPositions=	c(99),newPosition	nThicknesses=c(0))
	summary(PEI	NOut)				
	summary(PE)	NOut, type='	conv	ergence')		

summary(PENOut, type='outliers')

Meishan model (rescaled)

Input parameter:	"id"	age [ka]	1s [ka]	position [cm]	thickness [cm]	"calCurves"
	"BED 34"	251495	32	1	0	"normal"
	"BED 33"	251583	43	420	0	"normal"
	"BED 28"	251880	16	580	0	"normal"
	"BED 25"	251941	19	602	0	"normal"
	"BED 22"	252104	45	1035	0	"normal"

Script: data (Meishan)

MEIOut=Bchronology(ages=Meishan\$ages,ageSds=Meishan\$ageSds,

calCurves=Meishan\$calCurves,positions=Meishan\$position,

positionThicknesses=Meishan\$thickness,ids=Meishan\$id,

predictPositions=seq(0,1040,by=1),iterations=10000,extractDate=251200)

plot(MEIOut,main="Meishan",xlab='Age (Ma)',ylab='Depth (cm)',las=1)

predictAges=predict(MEIOut, newPositions=c(602), newPositionThicknesses=c(0))

summary(MEIOut)

summary(MEIOut, type='convergence')

summary(MEIOut, type='outliers')



Figure S3. Comparison of the two different Bchron models for Dongpan using (a) the real stratigraphic thickness of each volcanic ash and (b) the rescaled lithostratigraphy to remove the thickness of the volcanic horizons. Each age-depth model is presented with its median (middle grey line) and its associated 95 % confidence interval (grey area). Radioisotopic dates, used in the age-depth models, together with their uncertainty (red horizontal bars) are presented as 206 Pb/ 238 U weighted mean dates of the volcanic ash beds. U-Pb data of DGP-21 is taken from Baresel et al. (2016). Predicted dates (blue horizontal bars) for the onset of the radiolarian decline (RD) and the Permian-Triassic Boundary (PTB) in Dongpan are calculated with their associated uncertainty using the different age-depth models.



Figure S4. Comparison of the two different Bchron models for Penglaitan using (a) the real stratigraphic thickness of each volcanic ash and (b) the rescaled lithostratigraphy to remove the thickness of the volcanic horizons. Each age-depth model is presented with its median (middle grey line) and its associated 95 % confidence interval (grey area). Radioisotopic dates, used in the age-depth models, together with their uncertainty (red horizontal bars) are presented as 206 Pb/ 238 U weighted mean dates of the volcanic ash beds. U-Pb data of PEN-22 and PEN-28 are taken from Baresel et al. (2016). Predicted dates (blue horizontal bars) for the Permian-Triassic Boundary (PTB) in Penglaitan are calculated with their associated uncertainty using the different age-depth models.

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Supplement S4: Dongpan radiolarians

Feng et al. (2007) suggested that radiolarian faunas underwent two successive extinction phases in Dongpan. Their first radiolarian crisis (FRC) occurs in bed 6 and their second radiolarian crisis (SRC) in bed 8 (Fig. 7). Hence, these authors proposed that the decline of radiolarians preceded a late Permian mass extinction (LPME; Fig. 7) placed in bed 9 on the basis of impoverished brachiopod, foraminifera and ostracod faunas (He et al., 2007; Yin et al., 2007) and of a negative excursion of the $\delta^{13}C_{org}$ record (Zhang et al., 2006). Subsequently, Feng and Algeo (2014) published a new radiolarian diversity curve showing the initiation of a protracted decline ("preliminary extinction": PE) starting in the middle part of bed 5. The second radiolarian crisis as initially recognized by Feng et al. (2007) is no longer visible in this progressive diversity reduction at the species level.

As radiolarians are well known to be highly sensitive to selective preservation bias, the comparison of this apparent diversity change with excess SiO_2 brings further insights. Shen et al. (2012) plotted excess SiO_2 along the Dongpan section but it is unclear how much biogenic or volcanogenic silica respectively contributed to these values. Above bed 9, Shen et al. (2012) also indicate absence of kaolinite in the clay fraction, suggesting that a lack of volcaniclastic input did contribute to the low levels of excess SiO_2 . This drop of kaolinite and excess SiO_2 corresponds to the LPME of Feng et al. (2007) and to a lesser degree to the "main extinction" (ME) of Feng and Algeo (2014), which they placed in bed 8. The coincidence between the drop of excess SiO_2 and the LPME and/or the ME does not enable distinguishing a real extinction event of the radiolarians from a selective preservation bias.

Feng and Algeo (2014) interpreted the onset of the radiolarian decline in bed 5 as being morphologically selective, with long-spined species of the orders *Spumellaria* and *Entactinaria* preferentially going extinct relative to short-spined species. However, such a statement requires precise investigation of the effects of diagenesis on a bed by bed basis, as post-depositional dissolution can be extremely heterogeneous and guided by minor differences of available amount of SiO₂ in each bed. The model proposed by Feng and Algeo (2014) for the evolution of radiolarian-bearing rocks calls upon changes of oceanic redox conditions during the Permo-Triassic transition. This model is based on the assumption that Permian radiolarians can be divided into three paleoecological assemblages based on proportions between four orders (*Entactinaria, Spumellaria, Latentifistularia* and *Albaillellaria*), each restricted to shallow-, intermediate-, and deep-water environments. Dongpan was one of the main examples used to support the claim that radiolarians were differentially affected around the PTB events by an expansion of the oxygen minimum zone (OMZ). According to their scenario, deep-water taxa declined

earlier than shallow-water taxa as a result of an expansion of the OMZ. This ecological model of radiolarian stratification with partial mutual taxonomic exclusion is only loosely supported by well-constrained Late Permian data worldwide and is not supported when compared to the present-day planktonic mixing and diversity at any depth. Present-day studies on the silica cycle (e.g., Tréguer and De La Rocha, 2013) show that biosiliceous deposits are affected by post-depositional dissolution at the water-sediment interface and during diagenesis. Last but not least, evidences supporting a rise of the OMZ in Dongpan are lacking.



Figure S5. Plate of Dongpan radiolarians ordered by taxon, sample, database number, and maximum dimension. 1) Albaillella yaoi Kuwahara, DGP-2, n°20, 200 μm. 2) Albaillella triangularis Ishiga, Kito & Imoto, DGP-2, n° 21, 210 μm. 3) Albaillella triangularis Ishiga, Kito & Imoto, DGP-1, n° 11, 190 μm. 5) Albaillella levis

Ishiga, Kito & Imoto, DGP-1, n°07, 190 μm. 6) Foremanhelena circula Shang, Caridroit & Wang, DGP-2, n°02, 260 μm. 7) Triplanospongos musashiensis Sashida & Tonishi, DGP-2, n°03, 260 μm. 8) Foremanhelena robusta Feng, DGP-2, n°05, 220 μm. 9) Foremanhelena robusta Feng, DGP-2, n°12, 230 μm. 10) Ishigaum tristylum Feng, DGP-2, n°11, 700 μm. 11) Ishigaum fusinum Feng, DGP-2, n°10, 400 μm. 12) Ishigaum sp., DGP-2, n°13, 270 μm. 13) Cauletella delicata Caridroit & Shang, DGP-5, n°03, 260 μm. 14) Cauletella paradoxa Shang, Caridroit & Wang, DGP-2, n°07, 400 μm. 15) Cauletella paradoxa Shang, Caridroit & Wang, DGP-2, n°07, 400 μm. 15) Cauletella paradoxa Shang, Caridroit & Wang, DGP-2, n°09, 300 μm. 16) Nazarovella gracilis De Wever & Caridroit, DGP-5, n°04, 350 μm. 17) Cauletella manica De Wever & Caridroit, DGP-2, n°14, 210 μm. 18) Hegleria mammilla Sheng & Wang, DGP-2, n°30, 290 μm. 19) Hegleria sp. aff. mammilla Sheng & Wang, DGP-5, n°15, 300 μm. 20) Paracopycintra ziyunensis Feng & Gu, DGP-5, n°18, 270 μm. 21) Copicyntroides sp., DGP-5, n°01, 310 μm. 22) Paracopycintra sp., DGP-5, n°12, 300 μm. 23) Paracopycintra akikawaensis Sashida & Tonishi, DGP-2, n°36, 280 μm. 24) Paracopycintra akikawaensis Sashida & Tonishi, DGP-2, n°36, 280 μm. 24) Paracopycintra akikawaensis Sashida & Tonishi, DGP-2, n°33, 300 μm.

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Supplement S5: Penglaitan conodonts

