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REPLY: doi:10.1130/G23942Y.1

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Bucher et al.'s Comment (2007) on our recently reported age for the Olenekian-Anisian boundary in south China (Lehrmann et al., 2006) concerns a discrepancy between our results and a preliminary age from a nearby section reported in a field excursion guide (Lehrmann et al., 2005). Specifically, the controversy concerns the age of a volcanic layer from the Lower Anisian of the Upper Guandao section (Nanpanjiang Basin, south China). We welcome this opportunity to address the geochronology in detail by presenting new U-Pb zircon data for the volcanic layer (sample GDGB-0) and to demonstrate the unequivocal correlation between the Upper and Lower Guandao sections.

Forty U-Pb analyses of single zircons are presented for sample GDGB-0 (Table 1). The sample was collected from a ~7-m-thick layer of dominantly volcaniclastic tuff that occurs a short distance above the Olenekian-Anisian boundary in Guandao (Lehrmann et al., 2006, 2007). Figure 1 shows 26 out of 40 analyses, including new CA-TIMS analyses, which yield concordant $^{206}Pb/^{238}U$ dates between 244 and 248 Ma. A coherent population of 17 analyses that overlap within uncertainty yields a weighted mean $^{206}Pb/^{238}U$ date of 246.301 ± 0.073(0.11)[0.38] Ma with a MSWD of 1.17. A subset of 12 most precise analyses from this group (including 8 CA-TIMS analyses), produce an identical date of 246.302 ± 0.064(0.10)[0.37] Ma with a MSWD of 0.56. Thus, we interpret 246.30 Ma as the best estimate for the age of the dominant volcanic component in sample GDGB-0, and inferentially its (maximum) depositional age.

The 246.30 ± 0.07 Ma date for sample GDGB-0 is consistent with its position above the Olenekian-Anisian boundary and with our estimate of 247.2 Ma for the boundary itself determined in the Lower Guandao section (Lehrmann et al., 2006). It unequivocally substantiates the correlation between the two Guandao sections as constrained by conodont biostratigraphy and carbon isotopes (Lehrmann et al., 2007).

In their ammonoid and ash bed U-Pb study of the nearby Jinya section (Nanpanjiang Basin, south China), Ovtcharova et al. (2006) placed the Spathian-Anisian boundary between 248.1 Ma and 247. 8 Ma, using our preliminary date for sample GDGB-0 reported in a non–peer reviewed field excursion guide (Lehrmann et al., 2005). This was despite a clear assertion in the guide that the date was "preliminary" and that it "should not be cited" (Lehrmann et al., 2005, p. 179 and Fig. 17). The cited date, however, provided Ovtcharova et al. (2006) with an age constraint on the boundary and thereby substantiated their estimate of 4.5 ± 0.6 m.y. for the minimal duration of Early Triassic. Our combined age and stratigraphic results from Guandao provides a more refined estimate of 5.4 ± 0.6 m.y. for the duration of the Early Triassic, given a similar age of 252.6 Ma for the base of the Triassic. Furthermore, considering the occurrence of ~10 m of "Transition Beds" of unknown biozonal affinity and evidence of drastic changes in depositional environment at the Spathian–Anisian boundary interval in the Jinya section (Ovtcharova et al., 2006), the Guandao uniform pelagic carbonate sections provide a more reliable constraint on the boundary age.

In summary, our new U-Pb data and refined stratigraphic results from the Upper Guandao section invalidate the argument of Bucher et al. regarding correlation inconsistencies between the two Guandao sections. We further believe that our estimate for the age of the Olenekian-Anisian boundary (and duration of the Early Triassic) supersedes all previous estimates because it is based on a set of internally consistent geochronologic data from a single stratigraphic section with excellent biostratigraphic, chemostratigraphic, and magnetostratigraphic controls.

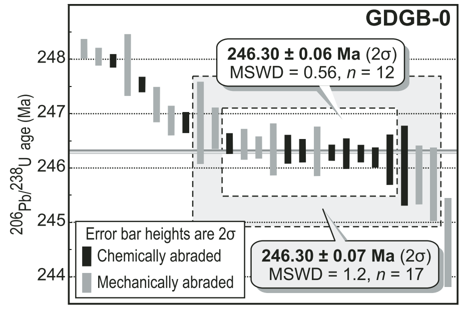

Figure 1. U-Pb geochronologic results for sample GDGB-0, Upper Guandao section, south China. Dashed boxes delineate data used for age calculation. Not all analyses are shown; see Table 1 for complete data.

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TABLE 1. U-PB ZIRCON DATA FOR TUFF SAMPLE GDGB-0, UPPER GUANDAO SECTION.

Sample Fractions (a)	Pb_c (pg) (b)	Pb^*/Pb_c (b)	Th/U	$^{206}Pb/^{204}Pb$ (c)	$^{208}Pb/^{206}Pb$ (d)	Ratios $^{206}Pb/^{238}U$ (e)	(err) 2σ%	$^{207}Pb/^{235}U$ (e)	(err) 2σ%	$^{207}Pb/^{206}Pb$ (e)	(err) 2σ%	Age (Ma) $^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$	corr. coef.
z2 aa	5.3	16.7	0.297	1087.9	0.096	0.038946	(.19)	0.27511	(.30)	0.05123	(.22)	**246.30**	**246.77**	**251.2**	0.675
z3 aa	7.4	9.4	0.337	613.9	0.110	0.039031	(.31)	0.27607	(.38)	0.05130	(.21)	246.83	247.54	254.3	0.829
z4 aa	2.5	14.3	0.539	873.8	0.173	0.038876	(.22)	0.27426	(.43)	0.05117	(.35)	245.87	246.10	248.3	0.577
z5 aa	2.3	19.5	0.273	1265.6	0.093	0.039142	(.17)	0.27820	(.27)	0.05155	(.20)	247.51	249.23	265.4	0.678
z8 aa	3.7	11.0	0.440	694.2	0.140	0.038849	(.28)	0.27392	(.40)	0.05114	(.27)	245.70	245.82	247.0	0.733
z15 aa	2.0	21.8	0.445	1356.7	0.143	0.038676	(.34)	0.27286	(.38)	0.05117	(.16)	244.62	244.98	248.4	0.906
z16 aa	2.1	28.8	0.463	1780.3	0.148	0.038967	(.12)	0.27493	(.20)	0.05117	(.15)	**246.43**	**246.63**	**248.6**	0.632
z17 aa	2.3	42.0	0.323	2685.1	0.103	0.039038	(.11)	0.27539	(.20)	0.05116	(.16)	246.87	246.99	248.2	0.606
z18 aa	0.6	68.6	0.231	4493.1	0.074	0.039227	(.07)	0.27700	(.11)	0.05121	(.08)	248.04	248.28	250.5	0.660
z22 aa	0.8	21.6	0.358	1346.7	0.139	0.043055	(.16)	0.31504	(.30)	0.05307	(.24)	271.74	278.08	331.8	0.597
z24 aa	0.9	27.1	0.455	1679.8	0.147	0.039085	(.14)	0.27605	(.21)	0.05122	(.16)	247.16	247.52	250.9	0.652
z25 aa	5.3	7.8	0.299	516.7	0.095	0.039215	(.37)	0.27674	(.47)	0.05118	(.27)	247.97	248.07	249.0	0.813
z26 aa	0.9	48.1	0.201	2943.9	0.145	0.041299	(.08)	0.33927	(.11)	0.05958	(.07)	260.88	296.62	588.4	0.760
z28 aa	0.5	26.1	0.238	1718.1	0.076	0.039203	(.23)	0.27653	(.30)	0.05116	(.17)	247.89	247.90	248.1	0.811
z29 aa	0.9	17.1	0.395	1082.5	0.125	0.038953	(.20)	0.27445	(.40)	0.05110	(.34)	**246.34**	**246.25**	**245.4**	0.552
z30 aa	0.8	51.8	0.947	2583.9	0.412	0.095816	(.09)	0.87750	(.13)	0.06642	(.09)	589.84	639.63	819.7	0.725
z31 aa	2.1	18.6	0.170	1250.4	0.055	0.039015	(.16)	0.27587	(.21)	0.05128	(.14)	246.73	247.38	253.6	0.753
z32 aa	0.9	30.6	0.562	1792.8	0.208	0.055516	(.12)	0.42022	(.22)	0.05490	(.17)	348.30	356.21	408.1	0.599
z33 aa	1.1	34.2	0.437	2079.2	0.164	0.047864	(.23)	0.35422	(.28)	0.05367	(.16)	301.40	307.89	357.4	0.826
z34 aa	0.9	43.1	0.338	2742.8	0.108	0.038958	(.08)	0.27497	(.15)	0.05119	(.12)	**246.37**	**246.66**	**249.4**	0.609
z35 aa	8.6	53.1	0.380	2845.1	0.229	0.204833	(.07)	4.20132	(.08)	0.14876	(.05)	1201.2	1674.3	2331.7	0.831
z36 aa	17.5	10.1	0.284	605.8	0.185	0.087263	(.11)	0.92251	(.32)	0.07667	(.29)	539.33	663.68	1112.7	0.429
z38 aa	1.7	145.3	0.214	8939.5	0.131	0.061483	(.07)	0.54200	(.12)	0.06393	(.10)	384.64	439.74	739.5	0.581
z42 aa	0.5	84.8	0.269	5488.9	0.086	0.039251	(.07)	0.27702	(.13)	0.05119	(.11)	248.19	248.29	249.3	0.567
z43 ca	0.5	156.2	0.434	9637.7	0.139	0.039215	(.05)	0.27701	(.08)	0.05123	(.07)	247.97	248.28	251.3	0.622
z44 ca	0.6	84.2	0.290	5418.7	0.093	0.039032	(.08)	0.27545	(.13)	0.05118	(.10)	246.83	247.05	249.1	0.624
z45 ca	0.8	20.7	0.415	1301.4	0.133	0.038922	(.19)	0.27456	(.29)	0.05116	(.21)	**246.15**	**246.34**	**248.2**	0.685
z46 ca	2.8	13.7	0.380	874.1	0.122	0.039718	(.23)	0.28102	(.36)	0.05132	(.26)	251.09	251.47	255.1	0.675
z48 ca	1.2	31.5	0.483	1930.3	0.156	0.038952	(.11)	0.27504	(.17)	0.05121	(.13)	**246.34**	**246.71**	**250.3**	0.662
z49 ca	0.6	86.6	0.241	5645.7	0.077	0.038942	(.06)	0.27475	(.10)	0.05117	(.07)	**246.27**	**246.49**	**248.5**	0.646
z52 ca	0.7	136.0	0.232	8886.9	0.074	0.039145	(.06)	0.27619	(.09)	0.05117	(.07)	247.53	247.63	248.6	0.628
z53 ca	0.3	55.5	0.551	3336.0	0.176	0.038970	(.08)	0.27485	(.21)	0.05115	(.19)	**246.45**	**246.56**	**247.7**	0.448
z54 ca	0.4	22.1	0.472	1371.2	0.148	0.040407	(.15)	0.28567	(.33)	0.05127	(.29)	255.36	255.14	253.2	0.494
z55 ca	0.3	53.3	0.706	3077.9	0.225	0.038948	(.09)	0.27472	(.18)	0.05116	(.15)	**246.31**	**246.46**	**247.9**	0.535
z56 ca	0.3	60.1	0.519	3624.9	0.170	0.039026	(.08)	0.27608	(.16)	0.05131	(.14)	246.80	247.54	254.6	0.516
z57 ca	1.7	10.1	0.479	629.8	0.154	0.038904	(.31)	0.27467	(.44)	0.05121	(.31)	246.03	246.42	250.1	0.723
z58 ca	0.4	24.2	0.500	1482.5	0.158	0.040409	(.13)	0.28591	(.27)	0.05132	(.23)	255.37	255.33	255.1	0.529
z59 ca	0.6	48.7	0.297	3128.6	0.096	0.038928	(.08)	0.27501	(.15)	0.05124	(.12)	**246.19**	**246.69**	**251.4**	0.547
z60 ca	0.3	63.6	0.493	3870.1	0.159	0.038939	(.07)	0.27495	(.12)	0.05121	(.10)	**246.26**	**246.64**	**250.3**	0.577
z61 ca	0.4	28.8	0.518	1753.6	0.165	0.038940	(.12)	0.27461	(.23)	0.05115	(.20)	**246.26**	**246.37**	**247.4**	0.525

(a) All analyses are single zircon grains. Data used in age calculations are in bold. aa—air-abraded; ca—treated by the CA-TIMS technique of Mattinson (2005). At the time of the International Symposium on Triassic Chronostratigraphy and Biotic Recovery (23–25 May 2005, Chaohu, China), only the first 24 analyses were available, indicating inherited grains and possibly Pb loss. Our preliminary estimate of 247.8 Ma relied on limited and complex data, and was hence excluded from Lehrmann et al. (2006). For complex samples, a large number of analyses are necessary to unravel the dominant age population.

(b) Pb_C is total common Pb in analysis. Pb* is radiogenic Pb concentration.

(c) Measured ratio corrected for spike and fractionation only.

(d) Radiogenic Pb ratio.

(e) Corrected for fractionation, spike, blank, and initial common Pb. Mass fractionation correction of 0.25%/amu ± 0.04%/amu (atomic mass unit) was applied to single-collector Daly Pb analyses. Total procedural blank in average was less than 1.0 pg for Pb and less than 0.1 pg for U. Corr. coef.—correlation coefficient.

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