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Bucher et al.'s Comment (2007) questioned the validity of our 247.2 Ma age estimate for the Early-Middle Triassic (Olenekian-Anisian, O-A) boundary based on a comparison of recent data from Lower Guandao section presented by us (Lehrmann et al., 2006) with preliminary data reported from the adjacent Upper Guandao section from a field-trip guide (Lehrmann et al.,

2005). The ages presented in the field guide were provided without supporting data, and were not intended to be used for boundary age assignments or cited, as specified in the field guide (Lehrmann et al., 2005).

Bucher et al. suggest that the first appearance of the conodont *Chiosella timorensis*, which we used as a proxy for the O-A boundary, is diachronous based on comparison of the preliminary geochronology from Upper Guandao section (Lehrmann et al., 2005) and the high-precision dates presented in Lehrmann et al. (2006). Below we demonstrate that the conodont occurrences are isochronous within the constraints of paleomagnetic-reversal and carbon-isotope stratigraphy between the sections.

Figure 1 illustrates the correlation between Lower and Upper Guandao sections. The depiction of the Lower Guandao section is the same as our Figure 2 (Lehrmann et al., 2006) with the addition of high-resolution conodont data that resulted in a 2.6 m downward shift of the O-A boundary. The O-A boundary remains bracketed by volcanic-ash horizons PGD-2 and PGD-3. Adjustment in the boundary position yields a new interpolated boundary age of 247.24 Ma. The Upper Guandao section has been updated from the very preliminary form given in our field guide (Lehrmann et al., 2005) by integrating stratigraphic thicknesses of several measurements, adding high-resolution conodont data, paleomagnetic-reversals, and carbon-isotope data.

Lower and Upper Guandao sections occur in the deep-marine slope (Lower Guandao) to toe of slope (Upper Guandao) facies adjacent to a carbonate platform (Lehrmann et al., 2005). Rapid facies changes are the norm in such

transitions. The thicker volcanic units in Upper Guandao section are tuffaceous siliciclastic mudstone. Thicker volcanoclastic units at Upper Guandao, and correspondingly thinner carbonate units, resulted from lower rates of carbonate accumulation and more rapid siliciclastic accumulation at the basin margin farther from the platform source of carbonate.

The argument of Bucher et al. that the first appearance of *Cs. timorensis* was diachronous in our sections is flawed because it rests on the preliminary age of sample GDGB-O from Upper Guandao section. Correlation between the two sections (Fig. 1) is corroborated by paleomagnetic reversals and a large positive isotope excursion, showing that the first occurrence of *Cs. timorensis*, and the occurrences of associated conodonts, are isochronous within the constraints of the data. In both sections, the O-A boundary is delineated by the first occurrence of *Cs. timorensis* (and faunal turnover of several associated species; Fig. 1) that occurs below the peak of the positive carbon isotope excursion near the base of the Aegean, and the shift from predominantly reversed to normal polarity near the base of the Bithynian. We agree with Bucher et al.'s suggestion that a boundary age should not be constrained solely by the first occurrence of one species, and we have used several conodont species in delineating the boundary.

We chose not to use the Upper Guandao section for delineation of the O-A boundary in Lehrmann et al. (2006) because the geochronological data for GDGB-O indicated a great deal of complexity. However, as discussed in Ramezani et al.'s Reply (2007) to Bucher et al.'s Comment, we can now confidently assign a depositional age to this ash.

Ovtcharova et al. (2006) interpreted the O-A boundary to lie between 248.1 Ma and 247.8 Ma on the basis of a single new age of 248.1 ± 0.4 Ma they obtained from the Upper Spathian, and the citation of a preliminary age date (GDGB-O) from our field trip guide (Lehrmann et al., 2005). The extensive and integrated chronostratigraphic and geochronological data presented by us (Lehrmann et al., 2006) provide a far more robust constraint on the boundary age at 247.2 (± 0.4).

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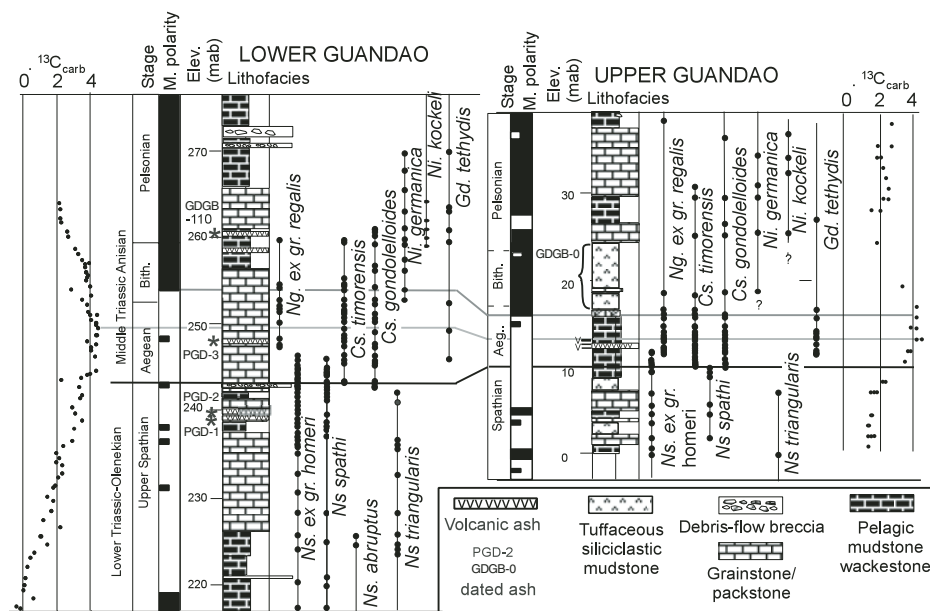


Figure 1. Olenekian-Anisian boundary at Lower and Upper Guandao section showing correlation of biostratigraphy, magnetostratigraphy, and carbon isotope data. mab—meters above base.

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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 $^{206}\text{Pb}/^{238}\text{U}$ dates between 244 and 248 Ma. A coherent population of 17 analyses that overlap within uncertainty yields a weighted mean $^{206}\text{Pb}/^{238}\text{U}$ date of $246.301 \pm 0.073(0.11)[0.38]$ 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 $246.302 \pm 0.064(0.10)[0.37]$ 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 be-

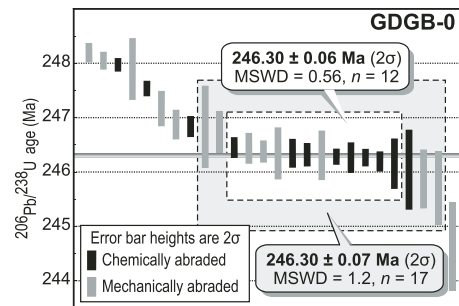


Figure 1. U-Pb geochronologic results for sample GDGB-0, Upper Guandao section, south China. Dashed boxes delineate data used for age calculation. Not all analyses are shown; see Table 1 for complete data.

tween 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.

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