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Discussion

Reply to 'Discussion of "Magnetostratigraphic confirmation of a much faster tempo for sea-level change for the Middle Triassic Latemar platform carbonates" by D. V. Kent, G. Muttoni and P. Brack [Earth Planet. Sci. Lett. 228 (2004), 369-377]' by L. Hinnov

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Hinnov [1] disputes our interpretation of magnetostratigraphic evidence [2] supporting the notion that the carbonate cyclic succession at Latemar represents less than a million year (Myr) interval of accumulation in Middle Triassic time and maintains that it instead represents 9–12 Myr based on the attribution of the ~600 meter-scale beds to 20 thousand year (Kyr) Milankovitch precessional forcing [4,3]. In response, we must first stress that the precession model for the cyclic bedding conflicts with virtually all other stratigraphic elements of the Latemar controversy, which can be summarized as follows. (1) Zircon U–Pb isotopic dates from three volcanoclastic layers distributed over 250 m of the Latemar cyclic succession are hardly distinguishable within the 95% confidence levels of 0.6 to 1.5 Myr [5]. (2) A magnetostratigraphic survey conducted at Latemar showed the existence of essentially one normal magnetic polarity zone [2]. (3) Biostratigraphic data from Latemar indicate that deposition straddled at most the upper Reitzi–lowermost Curionii ammonoid zones, that is to say, over little more than one (Secedensis) ammonoid zone [5,7,6]. (4) All these observations are substantially confirmed by data from the coeval basinal deposits because the thick (~500 m) Latemar cyclic succession interfingers with a very thin (~10 m) interval of Buchenstein sediments, as suggested by several authors (e.g., [8,9]) and not contested by Hinnov [1]. Near Latemar in the Seceda core and outcrop [10], this interval of the Buchenstein beds also straddles the Secedensis Zone as well as a normal polarity chron (SC2n), and according to an age model based on zircon U–Pb isotopic dates on volcanoclastic layers in the basinal sediments, encompasses less than 1 Myr [11–13].

In response to this overwhelming evidence, one of the main points that Hinnov [1] tries to make is that the available fossil evidence allows (but doesn't require) that the cyclic succession at Latemar extends well

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down into the Reitzi Zone, which at Seceda is associated with reverse magnetic polarity Chron SC1r and would thus conflict with the predominantly normal polarity magnetizations we reported from the Latemar. Rather than criticizing the details of the proposed realignment, for example, the inconsistent use of the U–Pb zircon dates beyond their analytical precision for correlation before discrediting them entirely, we would simply point out that the possibility of remagnetization at Latemar suggested by Hinnov would not materially affect the overall conclusion that the Latemar cyclic succession corresponds to only a thin basinal interval of latest Anisian age in the Buchenstein record. The only evidence that this interval could be as much as 9–12 Myr long comes from the precession cycle model long advocated by R.K. Goldhammer, L. Hinnov and co-workers [15,16,4,3,14,1].

In analyzing the frequency spectrum of the CDL series [3], we indeed may not have adequately considered a time-varying accumulation of the Latemar succession, which on closer inspection is more poorly behaved than we had appreciated. The CDL series has only 472 entries of depth-rank (integer values from 1 to 4) for successive intervals of a 159 m-thick section (Data Repository Item 2002129, ref. [3]); this provides a depth-rank value every 34 cm on average, which we suggested is too coarse to systematically resolve meter-scale variations. Hinnov [1] counters that the CDL observations should be regarded as virtually continuous down to the 0.5 cm level of resolution, which is not obvious from the listing nor is it evident what to do with 13 intervals (all depth-rank of 1) that are listed as being only 0.1 cm thick. At face value, intervals of uniform facies (i.e., depth-rank) in the CDL series range in thickness by a factor of more than 3000 (0.1 cm to 330 cm), which suggests a very inhomogeneous record. Moreover, the Latemar cyclic succession, with alternating supratidal and subtidal facies and meter-scale bedding that is mainly defined by exposure surfaces, is unlikely to be a continuous depositional record. The supratidal facies (depth-ranks 1 and 2) tend to be thinner and account for only ~27% (43/159 m) of the overall CDL section but these intervals are more frequent (295/472, or 63%) than the subtidal facies (depth-ranks 3 and 4), which account for almost 75% of the CDL section (116/159 m) even though designated for only 37% (177/472) of the intervals. Such asymmetries in frequency and relative thicknesses of supratidal and subtidal facies intervals, and the varying sediment accumulation rates they imply, pose challenging problems in spectral analysis, which are recognized by Hinnov. More troubling is evidence for frequent discontinuities in the CDL series: over 50% (270/471) of the depth-rank values jump by 2 or 3 between adjacent intervals with over 30% (147/471) jumping by 3, the maximum possible; in fact, only 35% (165/471) of the changes are a unit depth-rank (and 36 adjacent intervals are for some reason listed as having the same depth-rank). Accordingly, we are increasingly skeptical of the meaning of findings of frequency peaks in spectral analyses of the CDL series, including our efforts in the untuned depth domain [2] (see also [1]) and certainly those resulting from realignments and tuning employed in the conversion to a time series [3]. The origin of the repetitive meter-scale bedding, whose characteristic timing (average but not necessarily periodic) of ~1.7 Kyr [2] falls well below Milankovitch precessional (20 Kyr) forcing, remains unclear but we speculated that tidal amplitude variations [18,17,20,19] may play a role in such cyclic platform carbonates.

It is difficult to shoe-horn the 9–12 Myr duration estimate for the Latemar into the geologic time scale but Hinnov [1] suggests that the most recent version of the time scale assigns ostensibly sufficient time (17 Myr) to the Middle Triassic [21] to allow this. This comparison, however, is misleading because the Latemar cyclic succession clearly represents only a small fraction of the Middle Triassic (Anisian and Ladinian), for example, only ~15% (by correlation) of the uppermost Anisian to upper Ladinian Seceda section (see Fig. 2 in [2]), only 1 or 2 of the 25 magnetic polarity chrons recognized in the Middle Triassic (e.g., [22]), and only 1 or 2 of the dozen or so ammonoid zones recognized in the Middle Triassic (e.g., [21]), small proportions that are much more consistent with a short duration from a straightforward appraisal of the U–Pb zircon dating [11,12,5,23]. Moreover, the long Latemar time scale is made even more problematical because the Middle Triassic is most likely considerably shorter than given by Gradstein et al. [21], who placed the Middle/Late Triassic (Ladinian/Carnian) boundary at 228 Ma and the Early/Middle Triassic (Olenekian/Anisian) boundary at 245 Ma. The Middle/Late Triassic boundary has to be considerably older, perhaps 235–237 Ma [23,26,24,25], in part because U–Pb zircon dates from marine beds on Gravina Island, southeastern Alaska, give 225±3 Ma for a level described as latest Carnian or earliest Norian according to conodonts [27]. The age from Gravina Island is to our knowledge the only available age calibration point for the marine Late Triassic and needs corroboration. Nevertheless, the date is consistent with an age of 227–228 Ma that has been inferred recently from magnetostratigraphic correlations of the Carnian/Norian boundary in Tethyan marine sections to the astronomically calibrated Newark continental section [29,28], which in turn can be correlated by vertebrate biostratigraphy to a bentonite in the Ischigualasto Formation of Argentina that yielded an $^{40}Ar/^{39}Ar$ sanidine plateau date of 227.8±0.3 Ma [30]. The entire Middle Triassic may thus be as short as, and cannot therefore accommodate, the 9–12 Myr cycle-count duration of the Latemar [1], which represents only a small fraction of the Middle Triassic.

With regard to carbonate accumulation rates, the straightforward application of an age model based on U–Pb zircon dates would suggest values on the order of 500 m/Myr for the Latemar cyclic succession, as recently suggested also by [31] and which is not unusually high considering rates of 600 m/Myr estimated (with loose age constraints) by Keim and Schlager [32] from the nearby Sella platform. The 20 Kyr durations for the meter-scale bedding cycles would reduce the carbonate accumulation rate estimates by about an order of magnitude to values that Hinnov [1] says are more within an acceptable range but the long duration model would also reduce accumulation rates of coeval basinal sedimentation at Seceda and elsewhere to exceptionally low rates of 1 m/Myr or less. Such extreme condensation would likely result in the formation of hiatuses and biostratigraphic correlation would hardly be consistent, but that is not what is observed (e.g., [25]).

A more general consequence of the ongoing Latemar controversy is that most of the U–Pb zircon dates on volcanoclastic horizons in the Alps have been largely ignored even in the most recent GTS2004 time scale compilation [21]. Ignoring these data just because they could not be reconciled with age estimates based on the conventional cycle counting at Latemar has, in our opinion, contributed to a poorly calibrated and distorted Triassic chronology that requires significant revision, as is already underway [25]. It is time to move on.

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