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Discussion

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]

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Abstract

Kent et al. report on new magnetostratigraphic data obtained from the Middle Triassic Latemar carbonate platform (Dolomites, Italy). The result is important because it addresses the so-called 'Latemar controversy,' and appears to corroborate radioisotope-dated ash beds in the Latemar platform indicating that the buildup must have taken place in 2–4 million years, but not the 9–12 million years of Milankovitch forcing inferred from cyclostratigraphic analyses. Unfortunately, Kent et al. omit basic information that runs contrary to the conclusion that the Latemar carbonates have yielded a primary paleomagnetic signal. Here, the missing details are supplied by "zooming in" on the chronostratigraphic interval that was investigated. In sum, Kent et al.'s results do not confirm a "faster tempo for sea level change" for the Latemar as much as raise questions about the magnetization of these carbonate rocks. There are also shortcomings in Kent et al.'s reappraisal of the cyclic content of the Cimon del Latemar (CDL) series that need clarification. Finally, the Latemar controversy is examined in the context of the distribution of time in Middle Triassic stratigraphy of the Dolomites.

Keywords: Triassic; Dolomites; Latemar; magnetostratigraphy; cyclostratigraphy

1. The case for magnetostratigraphic correlation

Fig. 1 shows that at high resolution, the proposed Latemar magnetostratigraphy of Kent et al. [1] conflicts with two other magnetostratigraphies from nearby basinal Buchenstein beds [7,8]. According to the magnetostratigraphy at Seceda (Chron SC1r), the lower half of the Latemar (in the Reitzi Zone) should have reversed polarity. This is not the case, and the reversal that straddles the Tc ash bed at Frötschbach (Chron F1n.1r), which projects into the Latemar's UCF, is also missing.

Major misalignments are also evident between the two basinal magnetostratigraphies. F1n.1r may correspond to SC1r, but it is only ca. 1 m thick. Tc occurs above SC1r, but is within F1n.1r (Fig. 4 in [7] and Fig. 6 in [8]), which suggests that the two chrons are not related. The normal event within SC1r may correspond to F1n.1n, but this can only be resolved by recovering polarity information from the lowermost beds (i.e., the Plattenkalke) (Fig. 1, "?" in Column 7) and/or defining

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the ammonite subzones at Frötschbach. In fact, the Buchenstein has long been recognized as a "starved basin" (e.g., [15]), and there could be significant hiatuses and/or strong reduction that are affecting the mismatches in both of these sections. Presently it is not known where hiatuses or reduction might have occurred in the Buchenstein. In addition, paleomagnetic analysis of organic-rich rocks (such as the Buchenstein's Plattenkalke) is often problematic [16]. Therefore, the total number of magnetic reversals in this stratigraphic interval has yet to be determined. Research on expanded sections is needed to settle these issues. In this respect, the 470-m thick Latemar platform succession would appear to be an excellent candidate.

As noted, however, the Latemar magnetostratigraphy cannot be reconciled with the basinal data. In fact, in their argument for a basin-platform correspondence, Kent et al. depart from the chronostratigraphic constraints of Fig. 1 and discuss their evidence as if the Secedensis zone in the Latemar extends to the base of the LCF. This is indicated by the lower correlation line in Fig. 2 of [1], which connects the SC1r/SC2n boundary to the lowermost LCF. Their decision takes advantage of the fact that the Reitzi/Secedensis boundary has not been directly confirmed by fossils in the Latemar (Fig. 1 shows where the boundary is constrained to fall according to the ammonite subzones, which are based on Latemar fossils, and dated tephrastratigraphy). As a consequence, Tc projects from the Buchenstein into the lower LCF, where its age of 241.2 + 0.8/− 0.6 Ma is in poor agreement with the older 242.6 ± 0.7 Ma ash bed (LAT-31 of [2]). In comparison, Tc is in excellent agreement with either of the ash beds in the UCF (LAT-32 and LAT-30, see Fig. 1). In sum, there is little evidence that the Latemar succession exhibits anything other than normal polarity, where according to the basinal data, multiple reversals are expected, with an exact number yet to be determined. No specific information is given about the paleomagnetic properties of the single "intermediate" sample (LA40?) at ca. meter

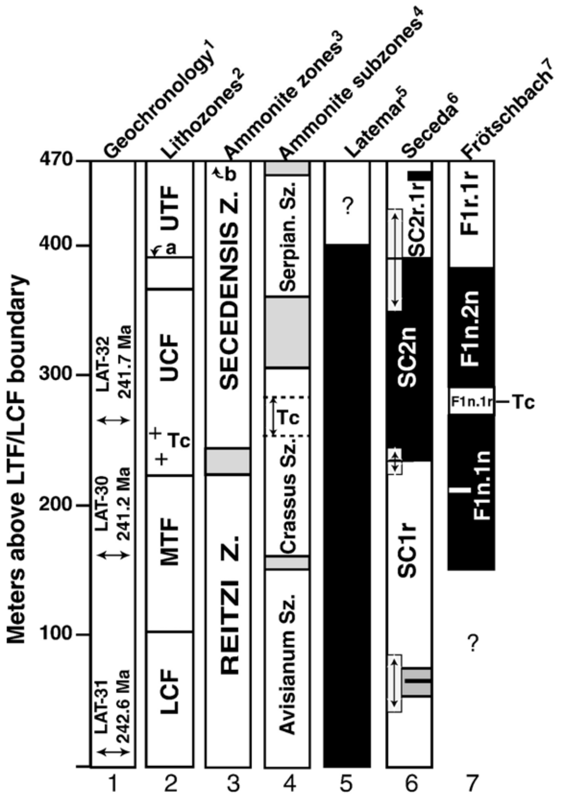

Fig. 1. Incompatible magnetostratigraphic relations among three biostratigraphically calibrated uppermost Anisian/lowermost Ladinian sections in the western Dolomites, from Latemar, Seceda and Frötschbach (see Fig. 1 in [1] for locations). Magnetostratigraphies from the Buchenstein beds at Seceda and Frötschbach [7,8] are projected into the Latemar chronostratigraphic framework according to the ammonite zones of [9] and ammonite subzones of [10]. Details are given in the figure footnotes. Notes: [1]Geochronology from single zircon U/Pb dating at Latemar by [2]: LAT-32 = 241.7 + 1.5/− 0.7 Ma, LAT-30 = 241.2 + 0.7/− 0.6 Ma, and LAT-31 = 246.2 ± 0.7 Ma (2σ uncertainties). [2]Lithozones from Egenhoff et al. [11]. LCF=Lower Cyclic Facies, MTF=Middle Tepee Facies, UCF=Upper Cyclic Facies, UTF=Upper Tepee facies. Line "a" denotes the UCF/UTF boundary according to [1] and [2]. Crosses labeled "Tc" indicate projection of the 241.2 + 0.8/− 0.6 Ma Buchenstein ash bed Tc [12] into the Latemar interior by [2]. [3]Ammonite zones in the Latemar. The Secedensis Zone is projected graphically into the platform according to its position relative to the Crassus Subzone defined at Seceda [13]. The shaded boundary intervals denote uncertainties imposed by uncertainties in the Crassus Subzone upper and lower boundaries in the Latemar (shaded intervals in Column 4). The top of the section ("b") indicates the start of the Curionii Zone inferred by Zühlke et al. [3], who also place the Reitzi/Secedensis boundary at the base of the LCF based on the Lastei fossil locality of [9]. Ammonites that define the position of the Reitzi/Secedensis boundary have not been identified in the platform interior. [4]Ammonite subzones in the Latemar platform interior according to De Zanche et al. [13] and Manfrin et al. [14]. Buchenstein ash bed Tc [12] is projected into the Latemar relative to its position in the Crassus Subzone at Seceda [13]. The uncertainties of the Crassus Subzone in the Latemar impose an uncertainty on its projected location (dashed lines). [5]Latemar magnetostratigraphy of Kent et al. [1]. [6]Projection of Seceda magnetostratigraphy into the Latemar. The chrons have been transferred graphically into the Latemar relative to the Crassus Subzone at Seceda [13]. Grey rectangles with vertical arrows indicate uncertainties in the positions of the chron boundaries imposed by the Crassus Subzone boundary uncertainties in the Latemar (shaded intervals in Column 4). [7]Projection of Frötschbach magnetostratigraphy into the Latemar according to its correlation to Seceda in [8]. Ammonite subzones are not defined at Frötschbach. Chron boundary uncertainties are not shown, but probably reflect those in the projected Seceda chrons.

400 to support the interpretation by Kent et al. that it signals a reversal.

One explanation for the disagreement is that the Latemar carbonates have been remagnetized. There are a number of events that could have caused widespread remagnetization within the platform (acknowledged but discounted by Kent et al.): (1) the platform experienced hydrothermal dolomitization that involved fluids exceeding temperatures of 100 °C; (2) volcanic explosions ripped through the platform core, leaving diatremes and volcanic-carbonate breccias embedded in the remnant platform; (3) innumerable basaltic dikes intruded the platform as part of a large ring complex emanating from the adjacent Predazzo pluton. These thermally active events took place prior to, or at the latest, contemporaneously with the deposition of the overlying late Ladinian Wengen volcaniclastics [17]. Remagnetization of the Latemar platform caused by any one of these events would have recorded a paleopole that is indistinguishable from the only slightly older early Ladinian paleopole measured in the Buchenstein. This issue of remagnetization might have been settled had Kent et al. collected control data from the Latemar's dolomite and dike intrusions.

2. Cyclostratigraphy of the Latemar platform

Accumulation rates of carbonate platforms can vary significantly and rapidly (e.g., [18]). Despite this, a possible time-varying accumulation of the Latemar buildup was not considered by Kent et al., who instead replicated and uncritically interpreted the untuned spectrum of the CDL series from p. 4 in Data Repository Item 2002129 [6]. In contrast, Preto et al. [6] examined the time-frequency characteristics of the CDL series using high-resolution spectrograms. They found dramatic frequency shifts throughout the 160 m long series, which they interpreted as evidence for accumulation rate variations ranging over nearly a factor of two. These variations may be attributed to major long-term changes in the interplay between tectonics and eustasy that have been proposed to explain the alternating ca. 100 m scale cyclic and tepee facies [19,20,21,22].

Kent et al. focus on a high-magnitude, 10-m peak in the CDL spectrum (Peak "B" in Fig. 4 of [1]), and suggest that this is a characteristic frequency of the Latemar succession, and that the origins of this frequency are from precession index modulation of an as yet undiscovered millennial tide. However, the spectra in Fig. 2, together with the spectrograms of Preto et al. in [6], show that Peak "B" is confined to the upper half of the CDL series (Fig. 2B). Its presence is related to the

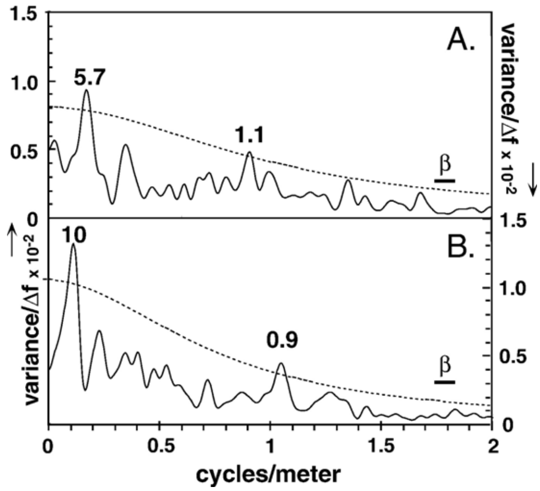

Fig. 2. Results of Blackman–Tukey (B–T) spectral analysis of the CDL series of [6] sampled at 0.5 cm intervals, and calculated using *Analyseries 1.2* [23] with 30% autocorrelation and a Tukey window producing an averaging bandwidth β. The lower 95% confidence limits of the spectra are shown (solid lines), compared with AR(1) ("red-noise") models of equivalent variance [24] (dashed lines). All spectra are normalized to unit variance. Red noise spectra provide a measure of the expected background continuum for natural processes, and have elevated power at low frequencies so that spectral peaks must register considerable power in order to be regarded as statistically significant. Labeled peaks indicate wavelengths (in meters) that exceed the red noise. A: The lower CDL series, meters 0–80. Meter scale Latemar cycles exceed the red noise, as do the megacycles at 5.7 m, which consist of thinning-upward bundles of predominantly 5 Latemar cycles [4]. B: The upper CDL series, meters 80–160. The peak at 10 m corresponds to Peak "B" in Fig. 4 of [1], and is discussed further in the text.

bundling of Latemar cycles into groups of 5 (4 to 6) thinning-upward "megacycles" which persists throughout the Latemar succession [3–5,20–22,25]. When cycles are on the order of 1 m thick, 5 : 1 megacycles will be picked up in the spectral analysis at $f = 0.2$ cycles/m (e.g., Fig. 2A); if the cycles become substantially thicker, as they do in the upper CDL series where they average ca. 2 m thick (cf. UCF cycle thickness series in Figs. 2 and 5 of [3]), megacycle frequency will shift accordingly to a lower position (as in Fig. 2B). There are sporadic occurrences of 10:1 megacycles in the Latemar succession, including the UCF (see Fig. 6 in [3]), which could account for some of the power at 1 / (10 m) where cycles are in the 1 m range, but the 5 : 1 megacycling in the upper CDL series where cycles are thickest is the most likely source of power.

Kent et al. also argue that the 1 / (10 m) frequency appears to vary somewhat regularly in amplitude in the spectogram of Preto et al. [6]. However, the windowing of that spectrogram is 10 m, and the lowest resolvable frequency is 1 / (10 m); variations at and lower than 1/(10 m) that are not removed by linear-detrending are lumped together in this frequency bin. The implication of Kent et al. that this bin reflects the harmonic amplitude of a 1/(10 m) frequency component only is incorrect.

Finally, Kent et al. raise concern that "the depth-rank series analyzed by Preto et al. is inadequate to establish periodicity with any degree of confidence at the meter scale (p. 375)". This belief stems from a misunderstanding about how the CDL observations were made. The CDL data are reported, in stratigraphic order, as successive thicknesses of observed lithofacies, keyed to depth rank (an integer from 1 to 4). This produces a list with 472 entries (Data Repository, pp. 2–3 in [6]). From this, Kent et al. infer that the average sample interval of the CDL series must be 160 m/(472 entries) = 0.34 m, and that this is insufficient to resolve meter-scale Latemar cycles. Consequently, they decline to interpret the meter-scale range of the CDL spectrum. (Nonetheless, they assign a specific timing of 1.7 kyrs to the individual Latemar cycles and propose a tidal origin.) However, each of the 472 reported lithofacies was based upon many field and laboratory observations; lithofacies thicknesses were measured to the nearest centimeter [6]. That is, CDL observations are supplied virtually continuously throughout the section, and so any fine-scale sampling is guaranteed to retrieve real information. It is left to the analyst to decide what sample rate is sufficient to capture all of the observed lithofacies variations. Preto et al. [6] found that a 0.5 cm sample interval was sufficient to assimilate all of the recorded information and capture lithofacies variations as small as 1 cm, i.e., the thinnest dolomite crusts.

The Latemar cycles themselves appear in the meter-scale range of the CDL spectrum with statistically significant power (Fig. 2, peaks labeled 1.1 and 0.9). Power in this range is low relative to the lower megacycle frequency band because variable accumulation rates have caused the recorded frequencies to become misaligned. When realigned, as in Fig. 3 of [6], power in this frequency range rises to levels that are double that of the megacycle power. The portrayal by Kent et al. of the tuning by Preto et al. [6] as a simple assignment of the $f = 1$ cycles/m bin to the long precession frequency is incorrect: the realigning involved tracking a significant line drifting across a frequency band from 0.7 to 1.1 cycles/m. It should also be noted that the frequency scales of power spectra are nonlinear: power from a larger range of cycle wavelengths are cumulated into single frequency bins at low frequencies than at high frequencies. This accounts for some of the high power at the very low frequencies, e.g., 1/(10 m). Conversely, at high frequencies, relatively small drifts in signal frequency resulting from changes in accumulation rate will cause power to be distributed over a larger number of adjacent frequency bins, and the power level will appear to be very low when in truth, as with the Latemar, it is not. This is a common problem in the analysis of cyclostratigraphic data, and has served to discourage many a researcher seeking to study high-frequency processes in stratigraphy.

3. The 'Latemar controversy' and Middle Triassic time in the Dolomites

In the original Milankovitch interpretation the Latemar cycles were thought to originate from sea-level oscillations forced by ca. 20-kyr-long precession cycles, with the entire succession representing 9 to 12 myrs [4,5]. The interpretation was made in the absence of high-resolution geochronology, and was based on comparative sedimentology combined with statistical observations for a non-random signal in the cycle stacking pattern. Subsequently, high-precision U/Pb-dating of zircons from volcaniclastics in coeval Buchenstein beds [2] and the Latemar platform proper [12] indicated that the Latemar must have accumulated in only 2 to 4 myrs, or at a rate of 125 to 250 m/myrs. This much shorter duration is in serious conflict with the Milankovitch interpretation and therein lies the 'Latemar controversy'. Interpreting Latemar magnetostratigraphy as a true reversal signal, Kent et al. now have proposed an even higher accumulation rate of ca. 500 m/myr for the platform, which is at the extreme high end of rates documented for Phanerozoic carbonate platforms. In fact, the fastest growing platforms have been those that were "keeping up" or "drowning" [27]. But the Latemar never drowned, on the contrary, it spent much– if not most – of its time subaerially exposed, replete with facies and tepees associated with vadose and subaerial diagenesis with growth rates known from Recent and Pleistocene analogs to be only a few meters per myrs [4,26]. Therefore, the net accumulation rate of the Latemar must have been relatively slow. In this respect, the Milankovitch-calibrated 50 m/myr rate [6,26] is consistent with rates normally associated with aggrading platforms [18].

It is instructive to examine the distribution of time imposed by the zircon-versus Milankovitch-calibrated Latemar on the Middle Triassic stratigraphy of the Dolomites. The new geologic time scale of Gradstein et al. [28] assigns 17 million years (13.5 to 20.5 million years) to the Middle Triassic, for which both Anisian and Ladinian stage boundary ages are estimated and/or represent compromises among multiple data sources.

Middle Triassic aggraded-platform stratigraphy of the Dolomites is on the order of 1000 m thick [15,29]. The 9 to 12 myrs of time taken up by a 500 m thick Milankovitch-calibrated Latemar leaves 5 to 8 myrs (maximum of 11.5 myrs) for the remaining ca. 500 m of Middle Triassic platform stratigraphy, while the zircon-calibrated 2 to 4 myrs leaves 13 to 15 myrs (maximum of 18.5 myrs). The mere 0.8 myr duration for the Latemar of Kent et al. requires that practically all of the 17 million years of Middle Triassic time must be accounted for in this same remaining 500 m of platform stratigraphy.

4. Conclusions

Results from zircon geochronology were found to conflict with the Milankovitch calibration of the Middle Triassic Latemar platform [2,12]. At the same time, these results raised questions about the zircons themselves, i.e., do the zircon ages reflect true stratigraphic age [30,26]. This problem is known as the 'Latemar controversy' and has yet to be resolved. In the present case, Kent et al. intended to contribute to the resolution of the Latemar controversy with magnetostratigraphic data. However, when taking into account all of the available chronostratigraphic information (Fig. 1), the Latemar platform magnetostratigraphy of Kent et al. fails to correlate with coeval Buchenstein basin magnetostratigraphy, and so cannot be interpreted as a true magnetic reversal record. The reassessment of the Latemar cycle signal of Kent et al. is premised on misunderstandings about the CDL data and analysis of [6], and about platform accumulation processes in general. Finally, the proposed 0.8 myr duration for the ca. 500 m of Latemar platform cycles of Kent et al. is at serious odds with prevailing knowledge about the rates of carbonate platform aggradation and facies development, and heavily skews the distribution of time in Middle Triassic stratigraphy of the Dolomites.

References

[1] D.V. Kent, G. Muttoni, P. Brack, Magnetostratigraphic confirmation of a much faster tempo for sea-level change for the Middle Triassic Latemar platform carbonates, Earth Planet. Sci. Lett. 228 (2004) 369–377.

[2] R. Mundil, R. Zühlke, T. Bechstädt, A. Peterhänsel, S.O. Egenhoff, F. Oberli, M. Meier, P. Brack, H. Rieber, Cyclicities in Triassic platform carbonates: synchronizing radio-isotopic and orbital clocks, Terra Nova 15 (2003) 81–87.

[3] R. Zühlke, T. Bechstädt, R. Mundil, Sub-Milankovitch and Milankovitch forcing on a model carbonate platform — the Latemar (Middle Triassic, Italy), Terra Nova 15 (2003) 69–80.

[4] R.K. Goldhammer, P.A. Dunn, LA. Hardie, High frequency glacio-eustatic sealevel oscillations with Milankovitch characteristics recorded in Middle Triassic platform carbonates in Northern Italy, Am. J. Sci. 287 (1987) 853–892.

[5] L.A. Hinnov, R.K. Goldhammer, Spectral analysis of the Middle Triassic Latemar Limestone, J. Sedimen. Petrol. 61 (1991) 1173–1193.

[6] N. Preto, L.A. Hinnov, L.A. Hardie, V. De Zanche, V., A Middle Triassic orbital signature recorded in the shallow-marine Latemar carbonate buildup (Dolomites, Italy), Geology 29 (2001) 1123–1126.

[7] P. Brack, G. Muttoni, High-resolution magnetostratigraphic and lithostratigraphic correlations in Middle Triassic pelagic carbonates from the Dolomites (northern Italy), Palaeogeogr. Palaeoclimatol. Palaeoecol. 161 (2000) 361–380.

[8] G. Muttoni, A. Nicora, P. Brack, D.V. Kent, Integrated Anisian/Ladinian boundary chronology, Palaeogeogr. Palaeoclimatol. Palaeoecol. 208 (2004) 85–102.

[9] P. Brack, H. Rieber, Towards a better definition of the Anisian/Ladinian boundary: new biostratigraphic data and correlations of boundary sections from the Southern Alps, Eclogae Geol. Helv. 86 (1993) 415–527.

[10] P. Mietto, S. Manfrin, A high resolution Middle Triassic ammonoid standard scale in the Tethys realm. A preliminary report, Bull. Soc. Geol. Fr. 5 (1995) 539–563.

[11] S.O. Egenhoff, A. Peterhänsel, T. Bechstädt, R. Zühlke, J. Grötsch, Facies architecture of an isolated carbonate platform: tracing the cycles of the Latemàr (Middle Triassic, northern Italy), Sedimentology 46 (1999) 893–912.

[12] R. Mundil, P. Brack, M. Meier, H. Rieber, F. Oberli, High resolution U–Pb dating of Middle Triassic volcaniclastics; time-scale calibration and verification of tuning parameters for carbonate sedimentation, Earth Planet. Sci. Lett. 141 (1996) 137–151.

[13] V. De Zanche, P. Gianolla, S. Manfrin, P. Mietto, G. Roghi, A Middle Triassic backstepping carbonate platform in the Dolomites (Italy): sequence stratigraphy and biochronostratigraphy, Mem. Sci. Geol. 47 (1995) 135–155.

[14] S. Manfrin, P. Mietto, N. Preto, Ammonoid biostratigraphy of the Middle Triassic Latemar platform (Dolomites, Italy) and its correlation with Nevada and Canada, Geobios 38 (4) (2005) 477–504.

[15] A. Bosellini, Geologia delle Dolomiti, Athesina, Bozen, 1996, 192 pp.

[16] G. Muttoni, D.V. Kent, P. Brack, A. Nicora, M. Balini, Middle Triassic magneto-biostratigraphy from the Dolomites and Greece, Earth Planet. Sci. Lett. 146 (1997) 107–120.

[17] E.N. Wilson, L.A. Hardie, O.M. Phillips, Dolomitization front geometry, fluid flow patterns, and the origin of massive dolomite: the Triassic Latemar buildup, northern Italy, Am. J. Sci. 290 (1990) 741–796.

[18] D.F. McNeill, Accumulation rates from well-dated late Neogene carbonate platforms and margins, Sediment. Geol. 175 (2005) 73–87.

[19] L.A. Hardie, A. Bosellini, R.K. Goldhammer, Repeated subaerial exposure of subtidal carbonate platforms, Triassic, northern Italy: evidence for relative sea level change on a 10,000 yr. scale, Paleoceanography 1 (1986) 447–457.

[20] R.K. Goldhammer, P.A. Dunn, L.A. Hardie, Depositional cycles, composite sea-level changes, cycle stacking patterns, and the hierarchy of stratigraphic forcing: examples from Alpine Triassic platform carbonates, Geol. Soc. Amer. Bull. 102 (1990) 535–562.

[21] R.K. Goldhammer, M.T. Harris, Eustatic controls on the stratigraphy and geometry of the Latemar Buildup (Middle Triassic), the Dolomites of northern Italy, in: P. Crevello, et al., (Eds.), Controls on Carbonate Platform to Basin Development, SEPM Spec. Publ., vol. 44, 1989, pp. 323–338.

[22] R.K. Goldhammer, L.A. Hardie, M.T. Harris, P.A. Dunn, Sequence stratigraphy and systems tract development of the Latemar platform, Middle Triassic of the Dolomites: outcrop calibration keyed by cycle stacking patterns, in: R.G. Loucks, J.F. Sarg (Eds.), Recent Advances and Applications of Carbonate Sequence Stratigraphy, Amer. Assoc. Petrol. Geol. Bull. Memoir, vol. 57, 1993, pp. 353–388.

[23] D. Paillard, L. Labeyrie, P. Yiou, MacIntosh performs time series analysis, Eos 77 (1996) 379.

[24] G.E.P. Box, G.M. Jenkins, Time Series Analysis Forecasting and Control, Holden-Day, 1970, 575 pp.

[25] L.A. Hinnov, A. Cozzi, D.A. Bazykin, The Milankovitch origin of the Middle Triassic Latemar platform cycles: a review of the sedimentologic criteria and results of a new evolutive spectral analysis of the entire Latemar succession, IAS Regional Meeting Abstracts, Gaia Heidelbergensis, vol. 3, 1997, pp. 164–165, abstract.

[26] N. Preto, L.A. Hinnov, V. DeZanche, P. Mietto, L.A. Hardie, The Milankovitch interpretation of the Latemar plafrom cycles (Dolomites, Italy): implications for geochronology, biostratigraphy and Middle Triassic carbonate accumulation, in: B. D'Argenio, A.G. Fischer, I. Premoli Silva, H. Weissert, V. Ferreri (Eds.), Cyclostratigraphy: Approaches and Case Histories, SEPM Special Publication, vol. 81, 2004, pp. 167–182.

[27] W. Schlager, Scaling of sedimentation rates and drowning of reefs and carbonate platforms, Geology 27 (1999) 183–186.

[28] F. Gradstein, J. Ogg, A. Smith (Eds.), A Geologic Time Scale 2004, Cambridge University Press, 2004, 589 pp.

[29] A. Bosellini, P. Gianolla, M. Stefani, Geology of the dolomites, Episodes 26 (2004) 181–185.

[30] L.A. Hardie, L.A. Hinnov, Biostratigraphic and radiometric age data question the Milankovitch characteristics of the Latemar cycles (Southern Alps, Italy), Discussion, Geology 12 (1997) 470–472.