UPDATED CORRELATION OF THE GERMANIC TRIASSIC WITH THE TETHYAN SCALE AND ASSIGNED NUMERIC AGES

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The correlation of the Germanic Triassic with the Tethyan Triassic is well constrained biostratigraphically. However, radiometrical data are lacking and have to be imported for numerical calibration of lithostratigraphic units. These imported data can be extended to intervals without primary numerical data by astronomical calibration with Milankovitch cycles that are well recognisable in continental lake deposits of the Germanic Triassic, and correlated to the marine realm. Such cross-correlation is a powerful method for improving numerical stage ages in the marine realm.

The numerical ages (in Ma) of Figs. 1–3 were calculated by KOZUR (2003), KOZUR & BACHMANN (2003) and BACHMANN & KOZUR (2004), and for the base Jurassic by KOZUR & WEEMS (2007), by improved biostratigraphic dating of radiometric data in continental magmatics and by cross correlation of marine beds (with radiometric data) with lake deposits (containing well recognisable Milankovitch cycles). Our calculations are remarkably close to the subsequently published most recent radiometric data of different authors (Figs. 1, 4, FURIN et al., 2006; GALFETTI et al., 2007, LEHRMANN et al., 2006; OVTCHAROVA et al., 2006). A particularly good example is the numerical age (improved by astronomic calibration) of 252.6 Ma for the Permian-Triassic boundary (PTB) that was published by KOZUR (2003), which age was later confirmed with new radiometric data by MUNDIL et al. (2004).

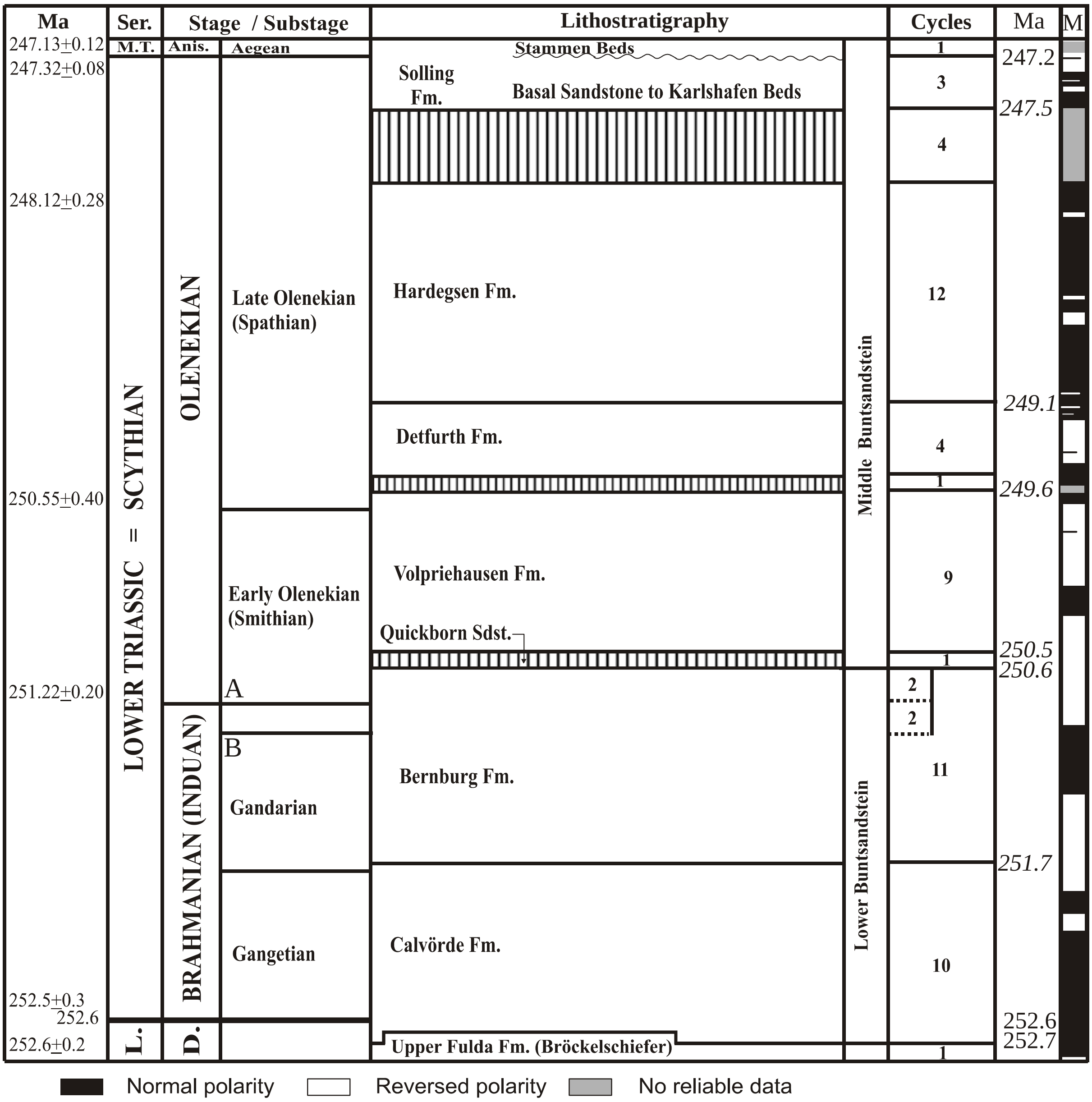

Figure 1: Numeric ages, cyclicity and palaeomagnetic of the Lower Triassic in the Germanic Basin. Slightly modified after Kozur & Bachmann (2003) und Bachmann & Kozur (2004). Palaeomagnetic and cyclicity after Szurlies (2007), but 11 cycles in the Bernburg Fm. Left column: Compiled new radiometric ages of the marine Lower Triassic after Galfetti et al. (2007), Lehrmann et al. (2006), Mundil et al. (2004) and Ovtcharova et al. (2006). Right column: Extrapolated numerical ages of the Germanic Triassic in italic script.
A: Biostratigraphically correlated base of the Olenekian after Kozur & Seidel (1983) and Kozur (1999).
B: Olenekian base by palaeomagnetic correlation (Bachmann & Kozur, 2004; Szurlies, 2007).

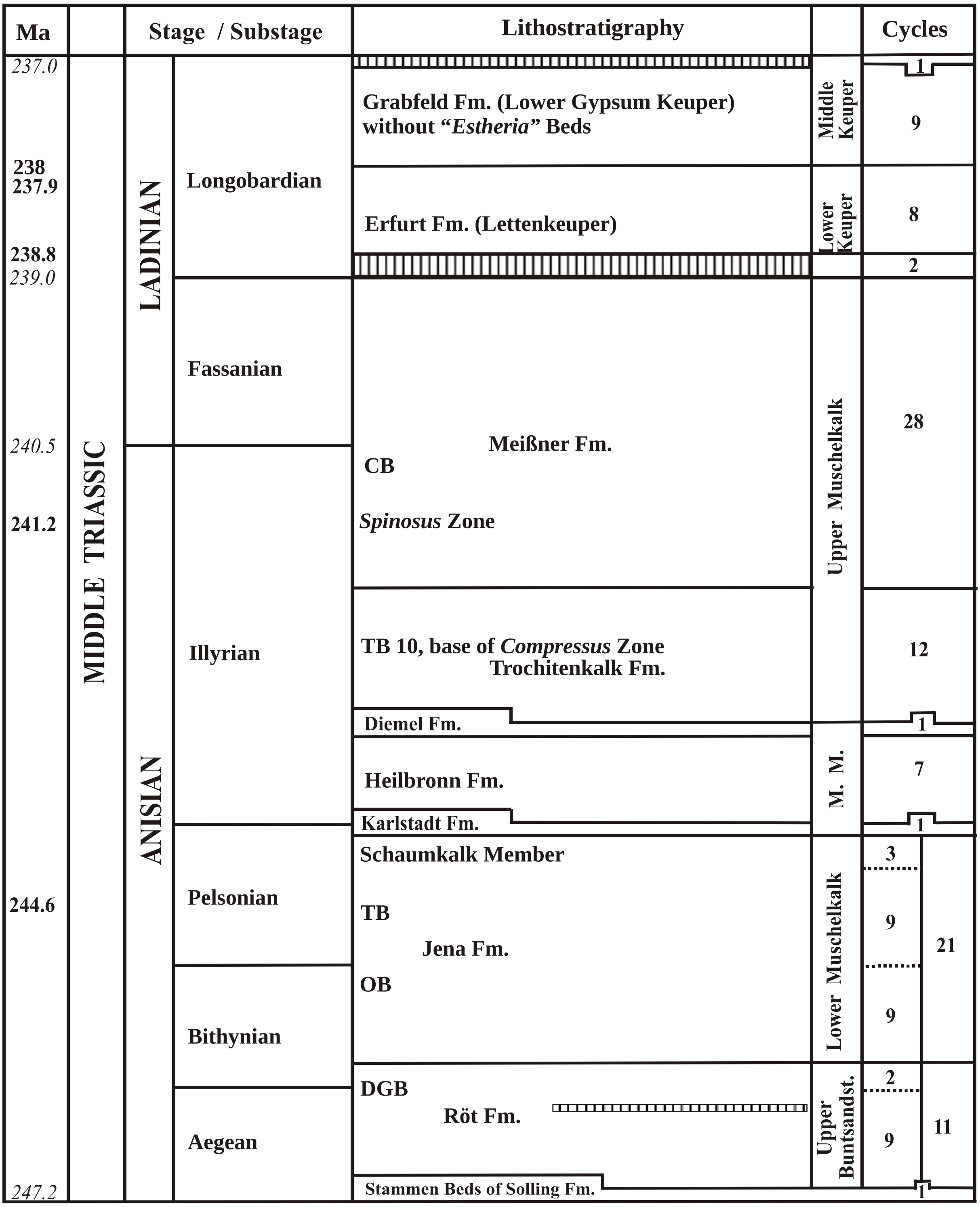

Figure 2: Numeric ages of the Germanic Middle Triassic after Bachmann & Kozur (2004), slightly modified.
DGB: Dolomitische Grenzbank, LO of Costatoria costata, FAD of Myophoria vulgaris. OB: Oolithbänke. TB: Terebratelbänke. CB: Cycloidesbank. TB: Trochitenbank. M. M.: Middle Muschelkalk.
Numeric ages in bold script: Compiled measured radiometric data.
Numeric ages in italic script: Calculated numeric ages for the base of the Anisian, Ladinian and Carnian stages as well as Longobardian substage.

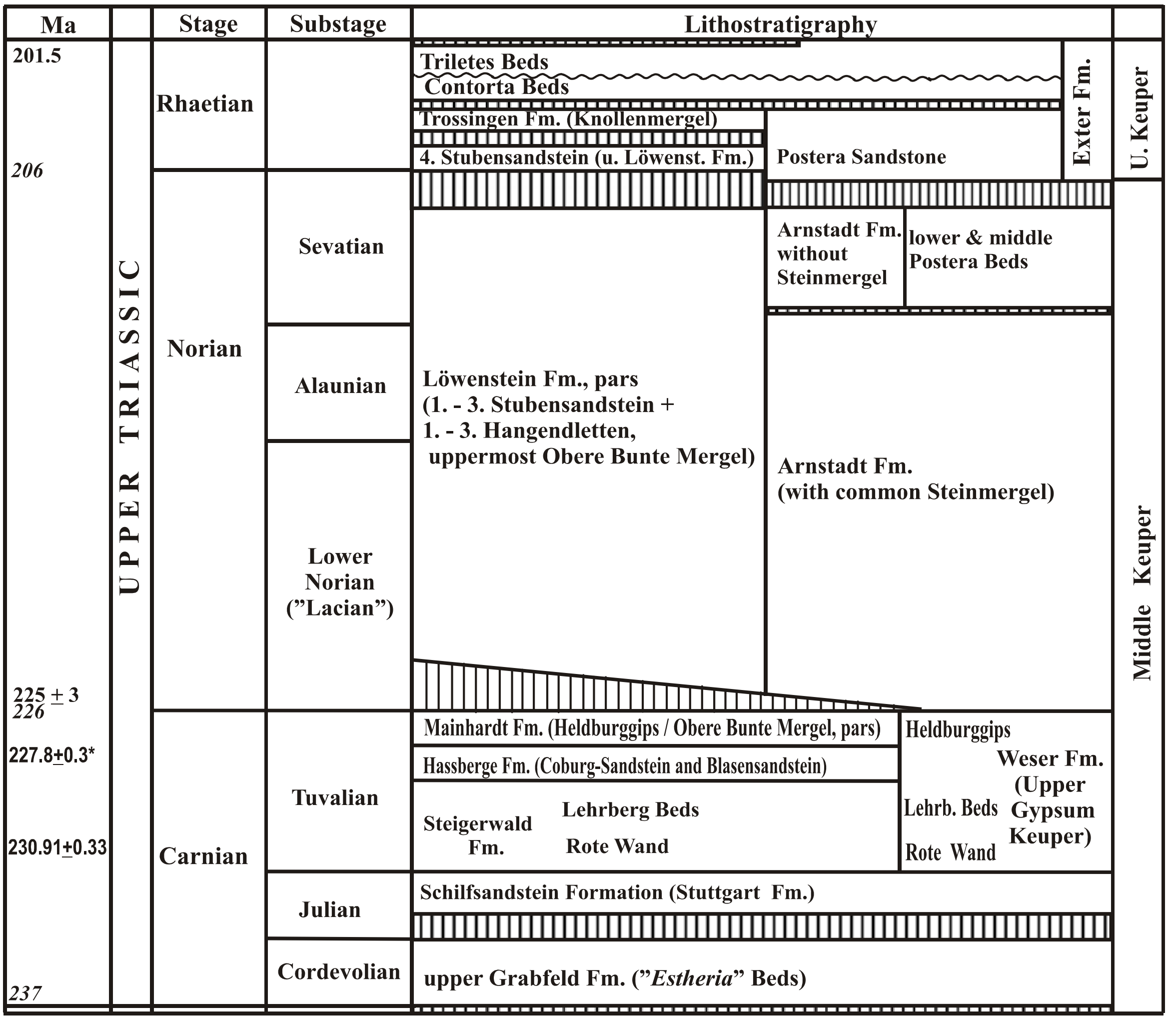

Figure 3: Numeric ages of the Germanic Upper Triassic, modified after Bachmann & Kozur (2004).

*^{40}Ar/^{39}Ar data from the Adamanian of Ischigualasto, Argentina (Rogers et al.1993), corresponding to a middle to late Tuvalian level between the Lehrberg Beds and the top of the Weser Fm. Only very few radiometric data are known from the Late Triassic. The 230.91±0.33 Ma of Furin et al. (2006) is from the basal *Carnepigondolella zoae* Zone, a level somewhat older than the Lehrberg Beds of the Weser Fm. The 225±3 Ma (Gehrels et al., 1986, 1987) is from volcanics in the lower Norian *E. quadrata* Zone in SE Alaska. The 201.5 Ma for the Triassic-Jurassic boundary is based on a biostratigraphic re-dating (Kozur & Weems, 2007) as latest Rhaetian of the lower lava flow of the CAMP volcanics in the Newark Supergroup, and on new radiometric data from a well-dated Rhaetian-Hettangian boundary section in Peru by Schaltegger et al. (2008). Calculated numeric ages for the base of the Carnian, Norian and Rhaetian stages in italic script.

Figure 4 (next page): Calculated numeric ages for selected lithostratigraphic units of the Germanic Triassic and most important radiometric ages of the marine Triassic. Not to scale. Gaps not shown.

* = ^{40}Ar/^{39}Ar age; all other radiometric ages are zircon U-Pb ages.

The first numeric ages for the lithostratigraphic units of the Germanic Triassic were estimated by Menning (1991–2002). Menning did not take into account the late Tuvalian (Adamanian) ^{40}Ar/^{39}Ar age of 227.8±0.3 Ma from Ishigualasto (Argentina) by Rogers et al. (1993), the basal Norian 225±0.3 Ma age from SE Alaska (Gehrels e al., 1986, 1987), and the estimated duration of the lithostratigraphic units was partly arbitrary. Such caused a jitter of several million years in the assumed numeric ages of Menning (1991) to Menning et al. (2005 a, b), referred to as "paternoster stratigraphy" by Menning et al. (2005b). Later, Bachmann & Kozur (2004) calculated the duration of the lithostratigraphic units by using Milankovitch cycles; data that seem to have been adopted by Menning et al. (2005a).

Menning 1991	Menning 1995	Menning 1997	Menning et al. 2002	Bachm. & Kozur 2004	Menning et al. 2005a	This paper	Selected Lithostratigraphic Units	Radiometric data outside Germanic B.
208	208	206	199.6	199.6	199.6	**201.5**		201.5
	208.5		201.5		201.4		Triletes Beds	
	210		203.5		203.3		Contorta Beds	Rhaetian
			206.5		206.5		Trossingen Fm.	
							4. Stubensandstein	
	212	210	207	206	207	206		
							Arnstadt Fm., pars, with common Steinmergel/ 1.-3. Stubensandstein + Hangendletten, upperm. Obere Bunte Mergel	Norian
222	220	218	221	226	226	226		225 ± 3
							Weser Fm: Heldburggips	227.8 ± 0.3*
							Lehrberg Beds	
							Rote Wand	230.91 ± 0.33 Carnian
224.5	224	222	224.5	231	230	232		
							Schilfsandstein Fm. (Stuttgart Fm.)	
225.5	225	223	226		231			
							"*Estheria*" Beds	
	229	226	231	237	237	237		
							Grabfeld Fm.	238.0 + 0.4/-0.7
228.5	230	228.5	232.5	238	239	238		
230	232	231	235	238.8	240	238.8	Erfurt Fm	Ladinian 238.8 + 0.5/-02
234	234	234	235.8	240.5	241	240.5	Meißner Fm.	
							Upper Muschelkalk	241.2 ± 0.8
			237	241.8	242	241.8	Trochitenkalk Fm.	242.6 ± 0.7
234.5	235.5	235	238.5	243.0	343.4	243	Middle Muschelkalk	
236	237	236.5	240	243.9	244.6	243.9	Lower Muschelkalk (Jena Fm.)	Anisian 244.6 ± 0.36
239.5	240	240	243	246	246.6	246	Röt Fm.	246.77 ± 0.13
	242	242	244.5	246.9	247.4	247.1	Stammen Beds	247.13 ± 0.12
				247		247.2	Solling Fm.	247.32 ± 0.08
242	243		245	247.4	247.8	247.5	Hardegsen Fm.	248.12 ± 0.28
	245	245	247	248.6	249	249.1		Olenekian
	246		247.5	248.9	249.4	249.5	Detfurth Fm.	250.55 ± 0.4
244.5	247.6	247.7	249	250.2	250.6	250.5	Volpriehausen Fm.	251.22 ± 0.2
	249.2		250	251.6	251.6	251.7	Bernburg Fm.	Brahmanian (Induan)
				252.6		252.6	Calvörde Fm.	252.5± 0.3
247	251	251	251	252.7	252.6	252.7		252.6 ± 0.2
							Zechstein, pars	Changhsing. pars

Figure 4

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