

6th International Field Workshop on the Triassic of Germany

**Buntsandstein Cyclicity and
Conchostracan Biostratigraphy
of the Halle (Saale) Area, Central Germany**

September 12 – 13, 2009

Compiled and guided by

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Introduction

The 6th International Triassic Field Workshop takes place September 7–11, 2009 in Tübingen and Ingelfingen, Southwest Germany, to celebrate the 175th anniversary of the foundation of the Triassic System by FRIEDRICH VON ALBERTI. The aim of the field workshop is to exhibit the stratigraphy and facies of Buntsandstein, Muschelkalk and Keuper in the classic type area. The Workshop is being organised by THOMAS AIGNER, Tübingen, HANS HAGDORN, Ingelfingen, EDGAR NITSCH and THEO SIMON, Freiburg. The Geological Survey of Baden-Württemberg (Landesamt für Geologie, Rohstoffe und Bergbau) and its Director RALPH WATZEL are kindly supporting the Workshop.

In addition September 12 and 13 are dedicated to the Upper Permian/Lower Triassic Buntsandstein in near Halle, its cyclicity and unique conchostracan biostratigraphy. This part of the Workshop is being organised by GERHARD H. BACHMANN, NORBERT HAUSCHKE, Halle (Saale) and HEINZ W. KOZUR, Budapest.

This Guidebook is a modified version of the Buntsandstein part of a Guidebook prepared for the “2nd International Field Workshop on the Triassic of Germany and surrounding countries” by G. H. BACHMANN, G. BEUTLER, M. SZURLIES, J. BARNASCH & M. FRANZ that was held on July 14 – 20, 2005 in the Halle (Saale) area (<http://www.stratigraphie.de/perm-trias/> -- Triassic Workshops).

A more comprehensive description of the Buntsandstein in the states of Sachsen-Anhalt and Thüringen (Thuringia) is given by BACHMANN et al. (2008) and SEIDEL (2003), respectively. The evolution of the Central European Basin is described in ZIEGLER (1990) and LITTKE et al. (2008).

Buntsandstein Group

In Central Germany, the ~1 km thick mainly clastic Buntsandstein, which represents the lower group of the tripartite classic Germanic Trias, was deposited in the large intracratonic Central European Basin (CEB), also referred to as the Triassic “Germanic Basin”. Characteristic are predominantly fluvio-lacustrine environments with some marine influences that concentrate on parts of the Middle and Upper Buntsandstein (**Fig. 1**). The lithostratigraphic framework of the Buntsandstein Group consists of seven formations, each of which consists of several mostly informal Members. Furthermore, the Buntsandstein reveals a distinct cyclicity of numerous mostly 10 to 30 m thick small-scale fining-upward cycles, which are considered to reflect variations in precipitation in the large lacustrine system of the CEB due to astronomically induced 100 000 myrs short eccentricity Milankovitch cycles. The fining-upward cycles are used for correlations in outcrops, cores and wireline logs (e.g. gamma-ray logs). With the latter they can be mapped in large parts of the CEB. The correlations are additionally supported by numerous well-known lithological and gamma-ray markers, providing a robust high-resolution log- and lithostratigraphic framework.

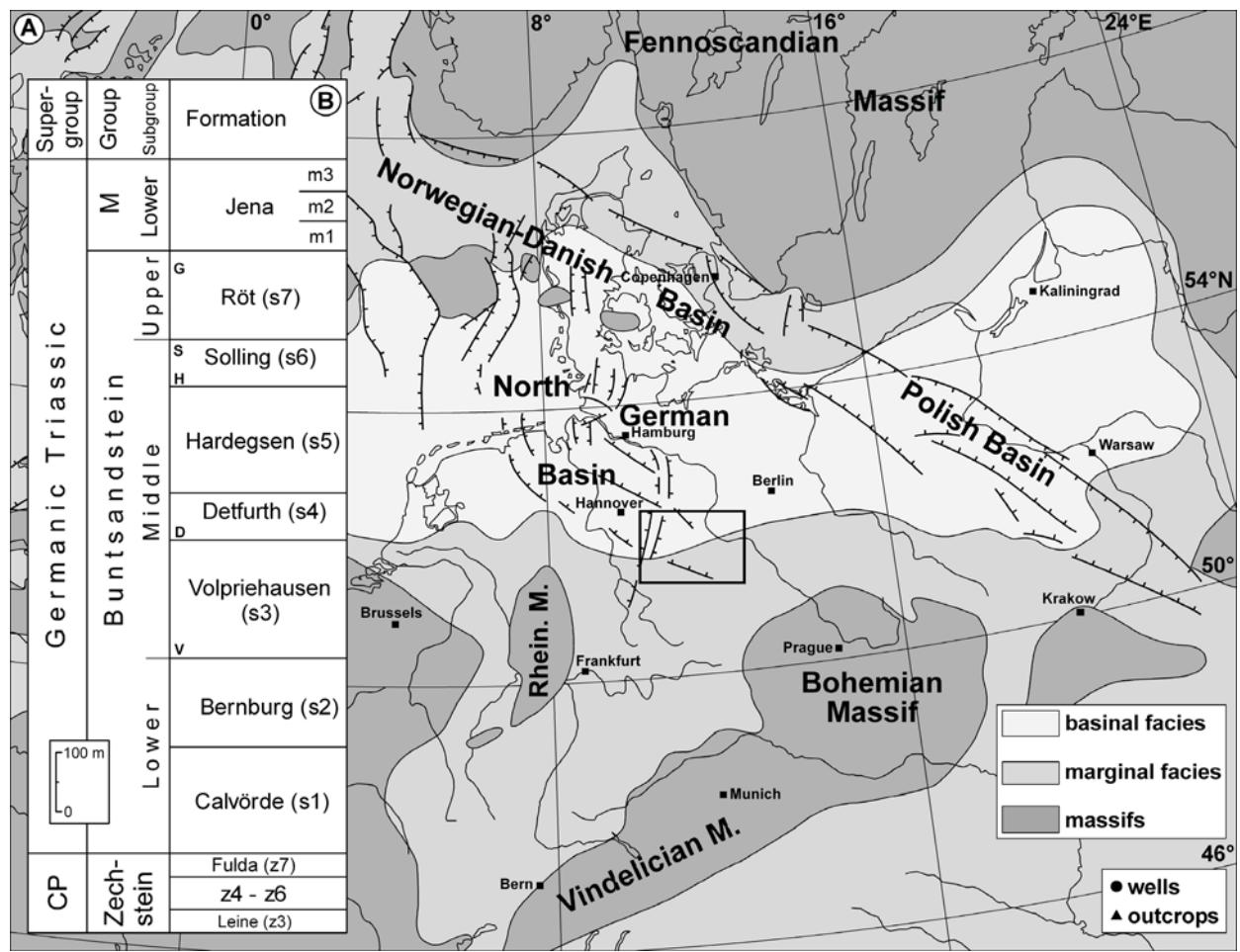


Fig. 1: (a) Buntsandstein paleogeography of the Central European Basin (modified after RÖHLING et al 2002). Insert: Excursion area. Lithostratigraphy of the upper Zechstein to Lower Muschelkalk in Central Germany. V = Volpriehausen Unconformity; D = Detfurth Unconformity; H = Hardegsen Unconformity; S = Intra-Solling Unconformity; G = Intra-Röt Unconformity; M = Muschelkalk.

The correlation of the Buntsandstein with the marine scale is mainly based on conchostracans. Along with magnetostratigraphy, the Buntsandstein can be correlated in detail with the ammonoid- and conodont-calibrated Tethyan Lower Triassic (Figs. 2–6). Figs. 2–4 show the lithostratigraphic subdivision and correlation of the uppermost Zechstein, Buntsandstein, Muschelkalk and Keuper, Fig. 5 and 6 the conchostracan zonation of the uppermost Zechstein to Upper Buntsandstein. It is important to note that the Permian/Triassic boundary event (base of the Boundary Clay) seems to coincide with the Zechstein/Buntsandstein boundary as suggested by the beginning of the *Falsisca postera* fauna, more clastic influx due to higher precipitation and the occurrence and distribution of volcanic and cosmic microsphaerules. The biostratigraphic Permian/Triassic boundary, however, is some 15 m higher within the Lower Buntsandstein (BACHMANN & KOZUR 2004).

The **Lower Buntsandstein Subgroup** (200 – 350 m) overlies the red evaporitic mudstones of the Upper Permian (Zechstein) with sandstones prograding from the southeast into the basin. The facies comprise channel sandstones, various flood-plain and lacustrine deposits. Two large-scale fining-upward cycles can be recognized (**Calvörde Formation, Bernburg Formation**). In the states of Sachsen-Anhalt and northern Thüringen (Thuringia) the Lower Buntsandstein contains oolitic limestone horizons suggesting a southward pointing embayment of the large shallow lakes of the central Germanic Basin (USDOWSKI 1961, SEIDEL 2003).

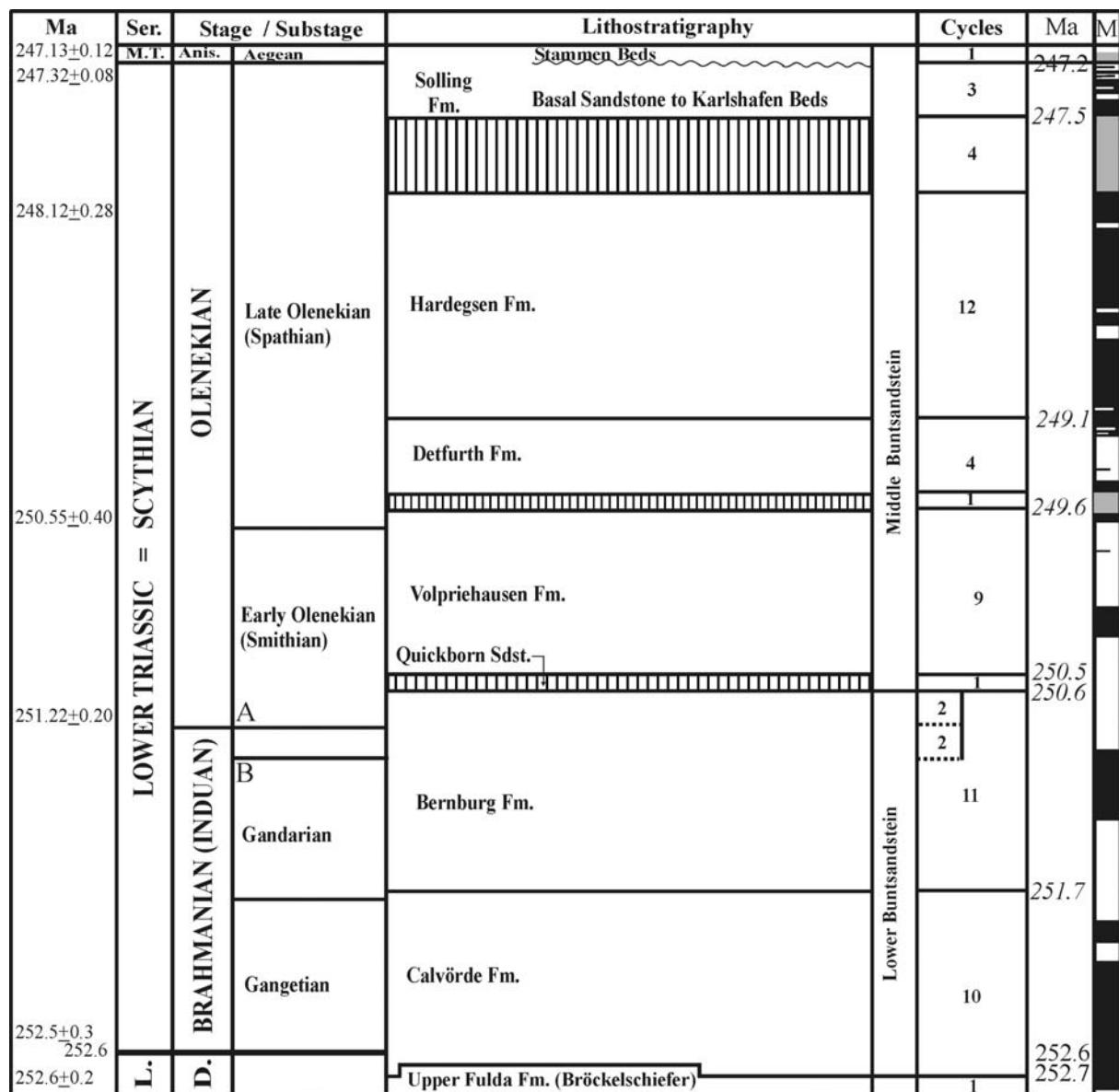
The sedimentary environment of the **Middle Buntsandstein Subgroup** is fluvial to lacustrine, with more proximal facies in the south, general transport from S to N or NNE, and with transition to more lacustrine facies to the north. Distinct fining-upward cycles allow characterize four formations of regional distribution, starting with predominantly fluvial channel sandstones and passing to floodplain or even lacustrine, and partly brackish, deposits. The typical stacking pattern of the Middle Buntsandstein is interpreted to be either the result of reorganisation of the basin (pronounced uplift of the source area), changes in climate (i. e. precipitation) or sea-level changes (e.g., SEIDEL 1965, 2003, WURSTER 1965, AIGNER & BACHMANN 1992).

The **Volpriehausen** and the **Detfurth formations** of the Middle Buntsandstein are easy to define due to their well-developed fining-upward cyclicity. The bases of both the Volpriehausen and Detfurth formations are characterized by the widespread Volpriehausen unconformity and the Detfurth unconformities, respectively. The whole succession is dominated by sandy deposits of braided rivers. Towards the top of both formations the floodplain/channel ratio increases. The tops of the fining-upward cycles are dominated by lacustrine deposits often characterized by abundant conchostracans and brackish bivalves. In contrast to the Lower Buntsandstein, no oolitic limestones or stromatolites were formed in this part of the basin. The maximum extension of the central, partly brackish lake is indicated in the upper Volpriehausen Formation by the occurrence of bivalves (mainly *Bakevillia murchisoni*).

While the stratigraphy of the older four formations of the Buntsandstein is, in general, simple, the **Hardegsen Formation** comprises some minor cycles and is locally incised into older deposits.

The **Solling Formation** starts with coarse fluvial deposits, resting on a widespread and pronounced erosional unconformity that is somewhat misleading referred to as Hardegsen Unconformity (TRUSHEIM 1961, PUFF 1976). Of particular interest is the reduced thickness of pre-Solling formations on top of the intrabasinal Eichsfeld-Altmark Swell with erosion of several hundred meters of older deposits under the Hardegsen Unconformity (TRUSHEIM 1961, WYCISK 1984). Climatic change to more precipitation is indicated by plant fossils

(*Pleuromeia*, *Voltzia*, *Schizoneura*), calcretes and large-scale channels of perennial streams. Well-known are the famous reptile footprints *Chiotherium barthii* (see HAUBOLD & PUFF 1976).



█ Normal polarity □ Reversed polarity ■ No reliable data

Figure 2: Numeric ages, cyclicity and palaeomagnetic of the Lower Triassic in the Germanic Basin. After Kozur & Bachmann (2008).

Palaeomagnetic and cyclicity after Szuradies (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); Kozur (1999) and Kozur & Weems (2007). B: Olenekian base by palaeomagnetic correlation (Bachmann & Kozur, 2004; Szuradies, 2007).

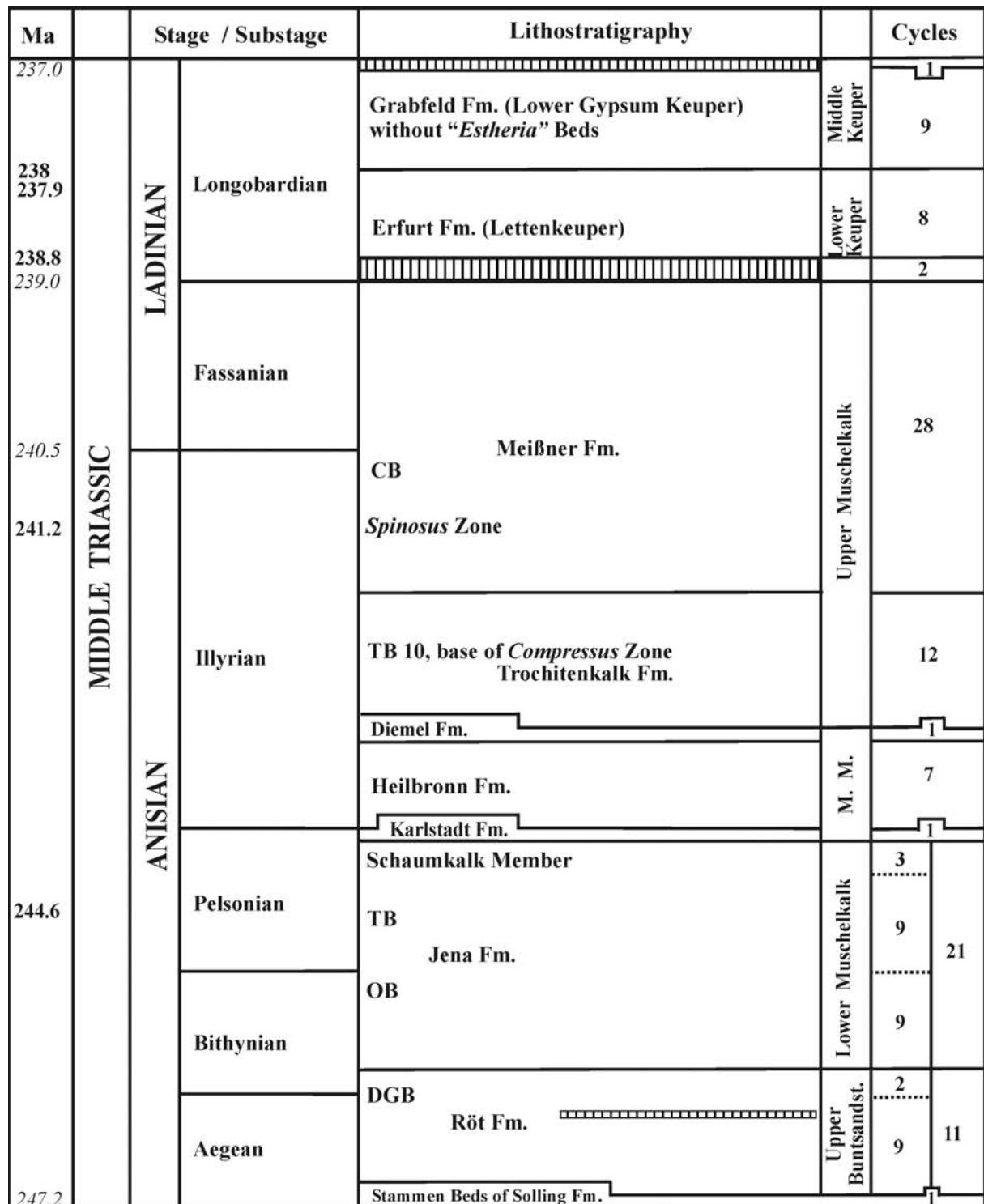


Figure 3: Numeric ages of the Germanic Middle Triassic after Bachmann & Kozur (2008).
DGB: Dolomitische Grenzbank, LO of *Costatoria costata*, FAD of *Myophoria vulgaris*. OB: Oolithbänke.
TB: Terebratelbänke. CB: Cycloidesbank. TB: Trochitenbank. M. M.: Middle Muschelkalk.
Numeric ages in bold script: 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 substages.

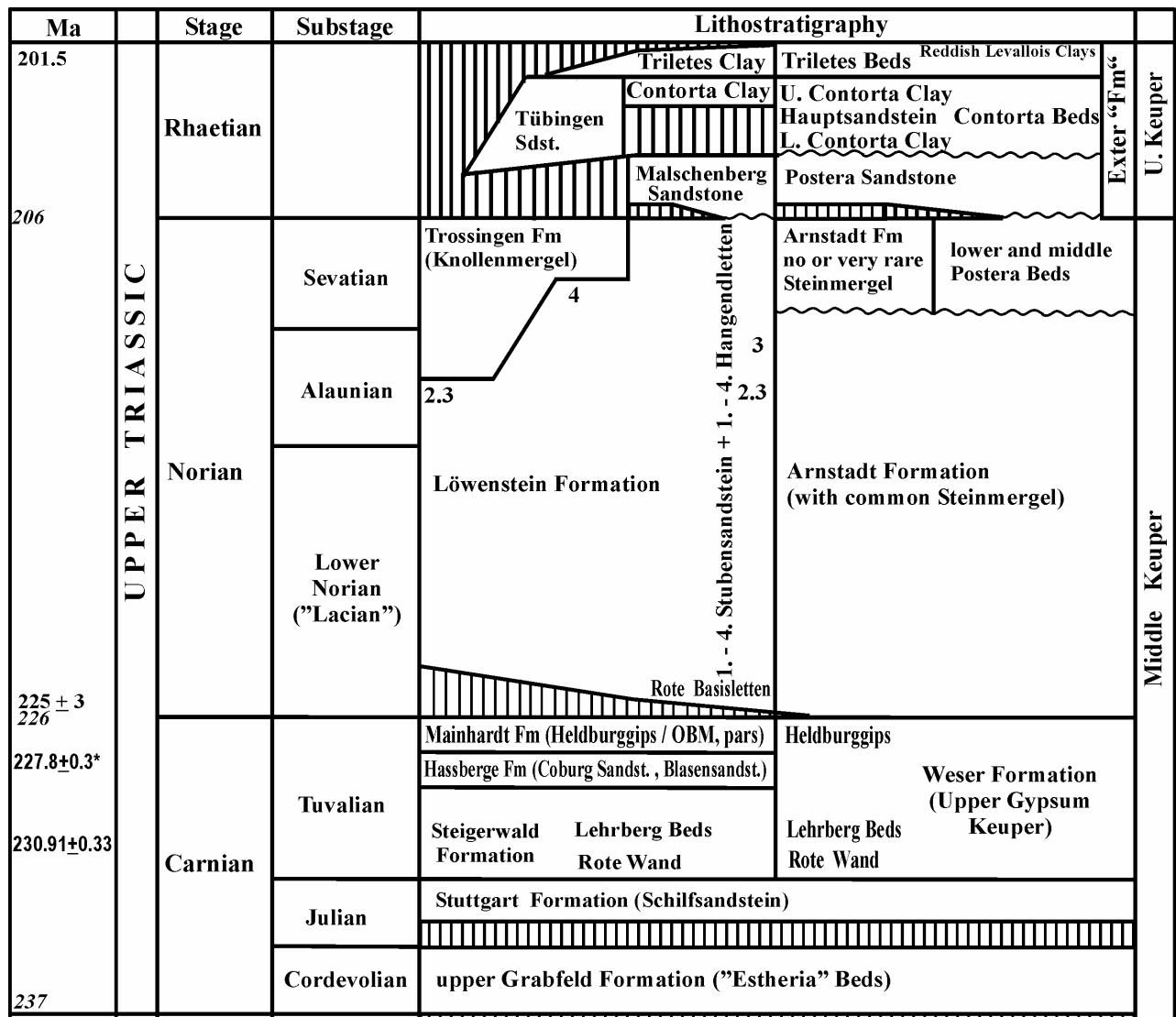


Fig. 4: Lithostratigraphic subdivisions of the Germanic Upper Triassic and their correlation with the international marine time scale and numeric ages. From Kozur & Weems (in press), modified after Kozur & BACHMANN (2008). Date with an asterisk mark [*] is $^{40}\text{Ar}/^{39}\text{Ar}$ data from the 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 Formation. The 230.91 ± 0.33 Ma date of FURIN et al. (2006) is from the basal *Carneipigondolella zoae* Zone, a level somewhat older than the Lehrberg Beds of the Weser Formation. The 225 ± 3 Ma date (GEHRELS et al. 1986, 1987) is from volcanics in the lower Norian *E. quadrata* Zone in SE Alaska. The 201.5 Ma date 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 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 are in italic script. Wavy line in the upper Arnstadt Formation represents an unconformity of short duration underlain by pedogenic sediments. Wavy line below the Contorta Beds represents an unconformity of short duration, especially where the Lower Contorta Clay is missing. Abbreviations: 2.3, 3, 4 = Stratigraphic position of the Stubensandstein subdivisions designated as Stubensandstein 2.3, Stubensandstein 3 and Stubensandstein 4. OBM = Obere Bunte Mergel. U. = Upper. L. = Lower.

The **Upper Buntsandstein Subgroup (Röt Formation)** is sharply separated from the underlying Solling Formation, and is characterized by the first clearly marine ingressions into the Germanic basin since the Upper Permian. The Röt Formation is dominated by various

mudstone facies ranging from shallow-marine dolomitic claystones to sabkha-type mudplain environments. The marine ingressions led to basinal gypsum and halite deposits, while playa and sabkha environments prevailed in the marginal areas. Short periods of dessication were followed by short ingressions of sea water, during which even cephalopods like the ammonoid *Beneckeia tenuis* migrated into the basin. The maximum southern extension of the shoreline is marked by the marginal-marine to fluvial “Plattensandstein” of southern Germany. During sea-level lowstands, thin sand layers with a complex depositional history reached central Thuringian. Monotonous red mudstones with layers of nodular gypsum characterize the Middle Röt, which is often interpreted as a mud plain with ephemeral lakes. Towards the north, these sabkha sulphates correspond to thick marine gypsum beds (JUBITZ 1959). The Upper Röt (*Myophoria Beds*) starts with an alternation of fossiliferous limestones and marls, overlain by mudstones of the topmost Röt. Above, the sedimentation turns to the marine limestones and marls of the Muschelkalk facies. It is important to note that the base of the Myophoria Beds in Germany corresponds with the base of the Muschelkalk in Upper Silesia (Poland).

Fig. 5 : Conchostracan zonation of the Lower Buntsandstein of the Germanic Basin. This is the standard conchostracan zonation for the upper Changhsingian to lower Smithian interval in the Boreal realm, the low and middle latitudes of the northern hemisphere and in northern to central Gondwana. Vertical distances not to scale. Updated after KOZUR & WEEMS (2007). The ranges of the index species and some selected other species are shown. For *Magniestheria rybinskensis*, only the range below the Volpriehausen Formation is shown. Scale = 1 mm. Arrows indicate times of conchostracan immigration into the Germanic Basin following facies-controlled conchostracan-free intervals (Sabkha deposits) that are present throughout the entire Germanic Basin. Q.S.= Quickborn Sandstein. 1 = *Falsisca eotriassica* KOZUR & SEIDEL; 2 = *Falsisca postera* KOZUR & SEIDEL; 3 = *Falsisca verchojanica* (NOVOZHILOV); 4: *Molinestheria seideli* KOZUR; 5 = *Vertexia tauricornis* LJUTKEVICH; 6 = *Estheriella bachmanni* KOZUR & HAUSCHKE n. sp.; 7 = *Cornia germari* (BEYRICH); 8 = *Estheriella marginostriata* KOZUR; 9 = *Estheriella nodosocostata* (GIEBEL); 10 = *Estheriella costata* Weiss; 11 = *Magniestheria subcircularis* (CHERNYSHEV); 12 = *Magniestheria truempyi* KOZUR & SEIDEL; 13 = *Lioleaiina radzinskii* KOZUR & SEIDEL; 14 = *Magniestheria rybinskensis* (NOVOZHILOV), for illustration and upper range see Fig. 5.

Fig. 6: Conchostracan zonation of the Middle (Volpriehausen and Solling formations) and Upper Buntsandstein (Röt Formation) in the Germanic Basin. This standard conchostracan zonation applies to the Olenekian to lower Anisian of Eurasia and also the upper Spathian and lower Anisian of North and (partly) South America. The ranges and illustrations (except *Hornestheria sollingensis* Kozur & Lepper n. gen. n. sp.) of the index species and of some selected species are shown. Scale = 1 mm. Updated after KOZUR & WEEMS (2007). Vertical distances not to scale. QS = Quickborn-Sandstone. 13 = *Lioleaiina radzinskii* Kozur & Seidel; 14 = *Magniestheria rybinskensis* (Novozhilov); 15 = *Magniestheria mangaliensis* (Jones); 16 = *Magniestheria deverta* (Novozhilov); 17 = *Palaeolimnadia alsatica detfurthensis* Kozur & Seidel; 18 = *Palaeolimnadia nodosa* (Novozhilov); 19 = *Euestheria exsecta* (Novozhilov); 20 = *Euestheria albertii mahlerselli* Kozur & Lepper n. subsp., slender morphotyp; 21 = *Euestheria albertii mahlerselli* Kozur & Lepper n. subsp., stout morphotyp; 22 = *Hornestheria sollingensis* Kozur & Lepper n. sp., because of space limitations, only the range is shown; 23 = *Palaeolimnadia alsatica alsatica* Reible; 24 = *Euestheria albertii albertii* (Voltz); 25 = *Dictyonatella dictyonata* (Reible).

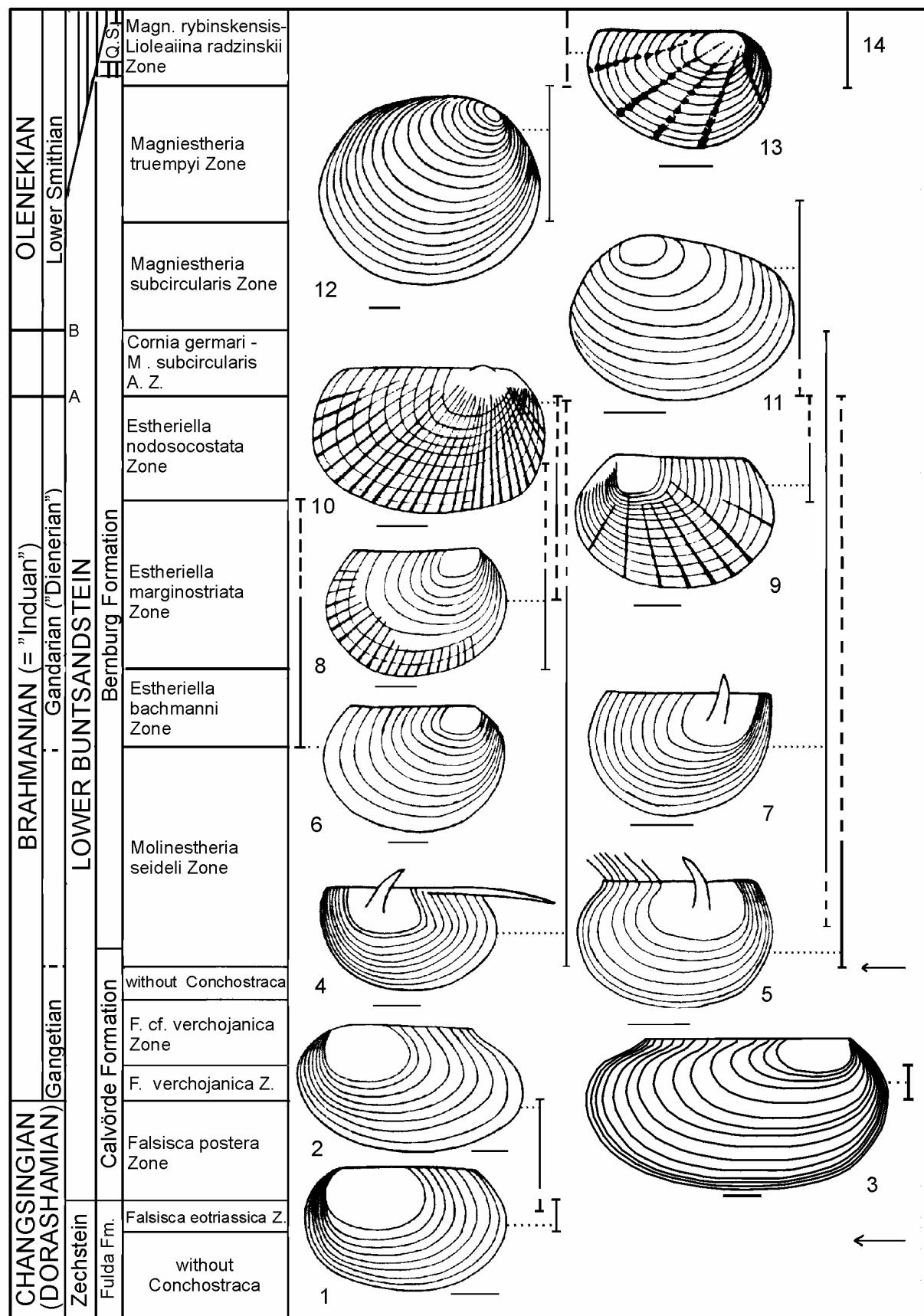


Fig. 5

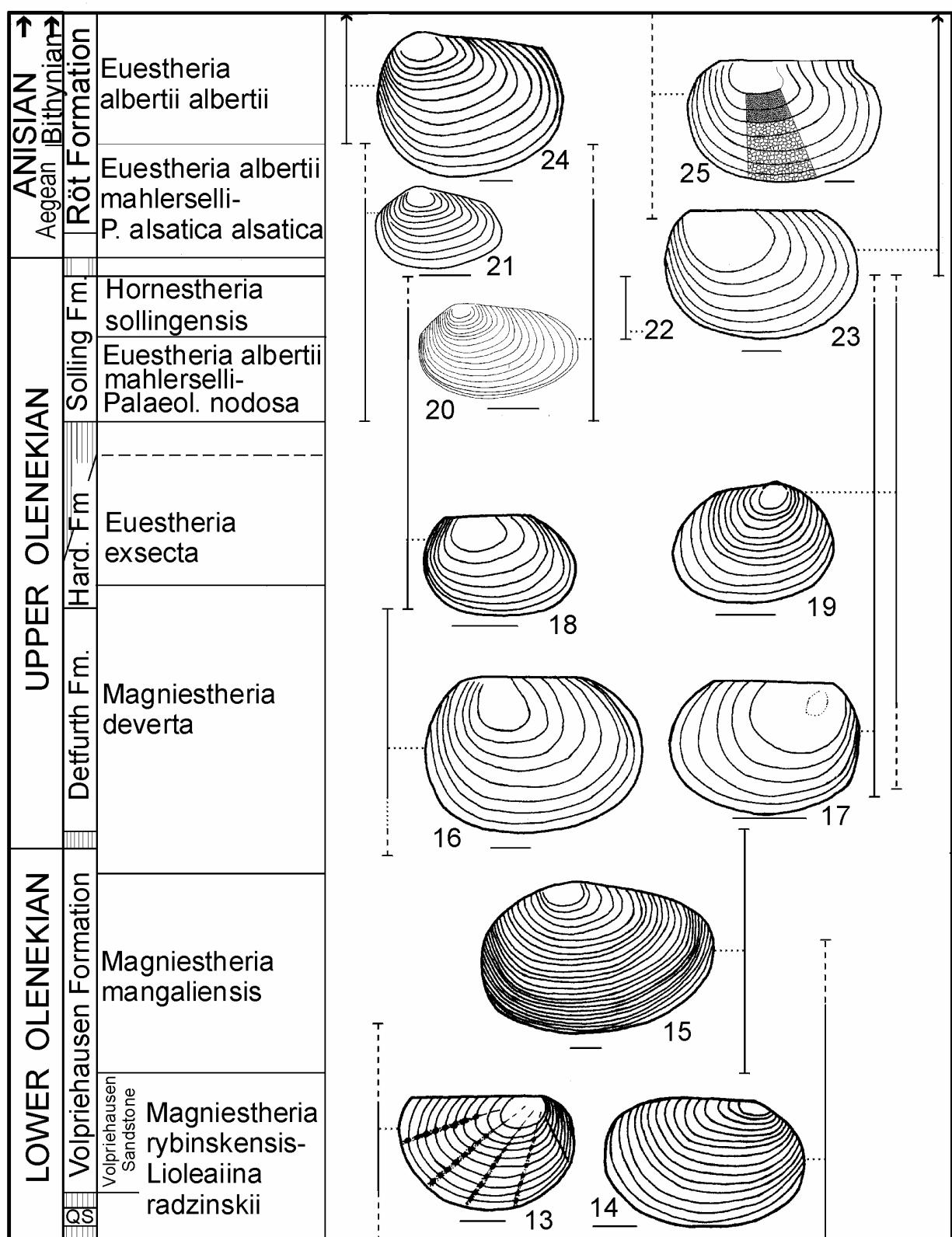


Fig. 6

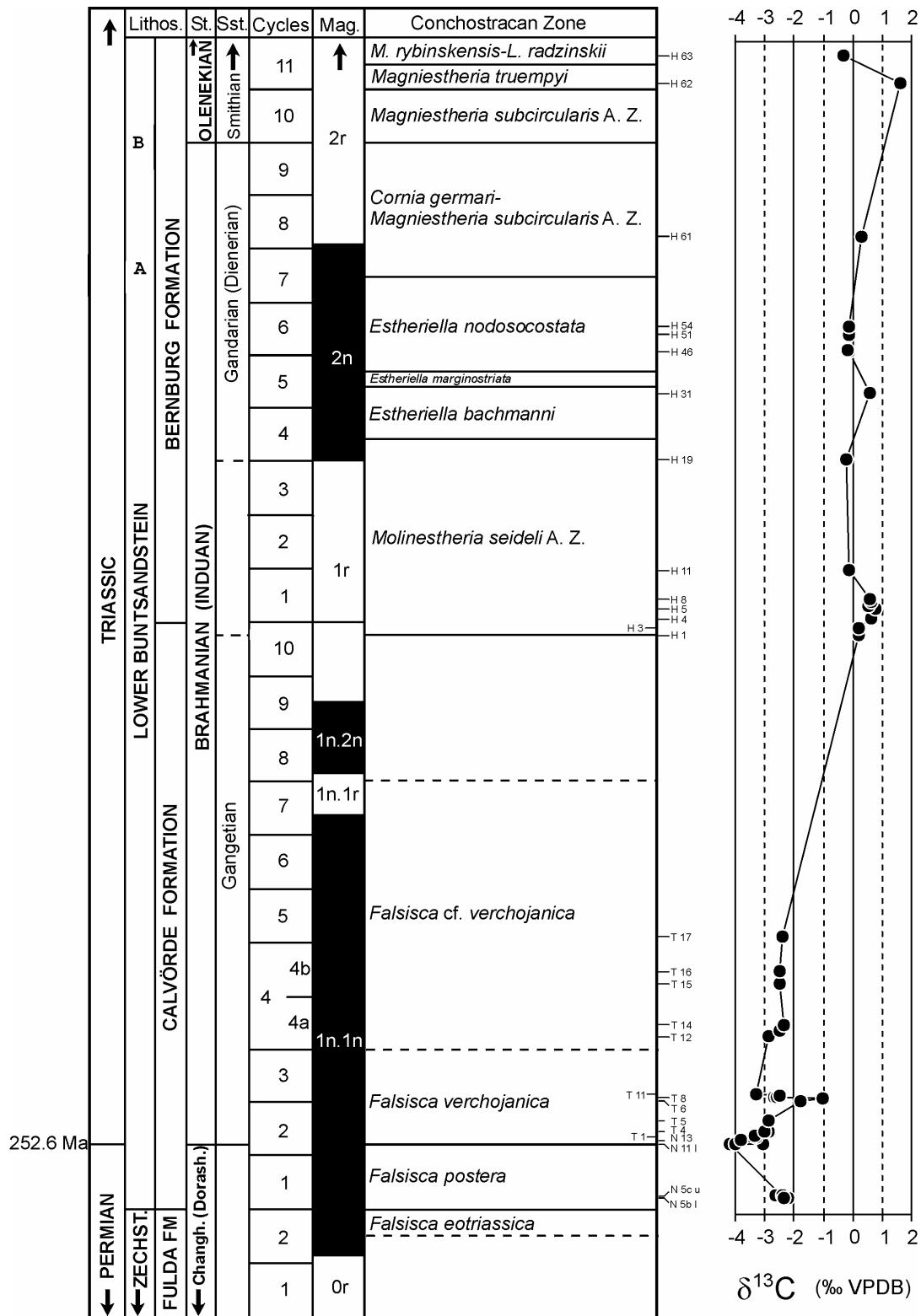


Fig. 7: Correlation of the uppermost Permian to lower Smithian conchostracan zonation with the palaeomagnetic zones of SZURLIES (2001), re-numbered by BACHMANN & KOZUR (2004), the short eccentricity Milankovitch cycles after BACHMANN & KOZUR (2004) and the carbon isotope record from lake limestones after KORTE & KOZUR (2005). After KOZUR & WEEMS (2007). The biostratigraphic lower boundary of the Olenekian (B) at the base of the *M. subcircularis* A. Z. at the base of cycle 10 of the Bernburg Formation marks one of the two biggest conchostracan turnovers in the Triassic. According to the palaeomagnetic correlation with Chaohu in South China, the base of the Olenekian (A) lies deeper, within the Gandarian (Dienerian) conchostracan fauna.

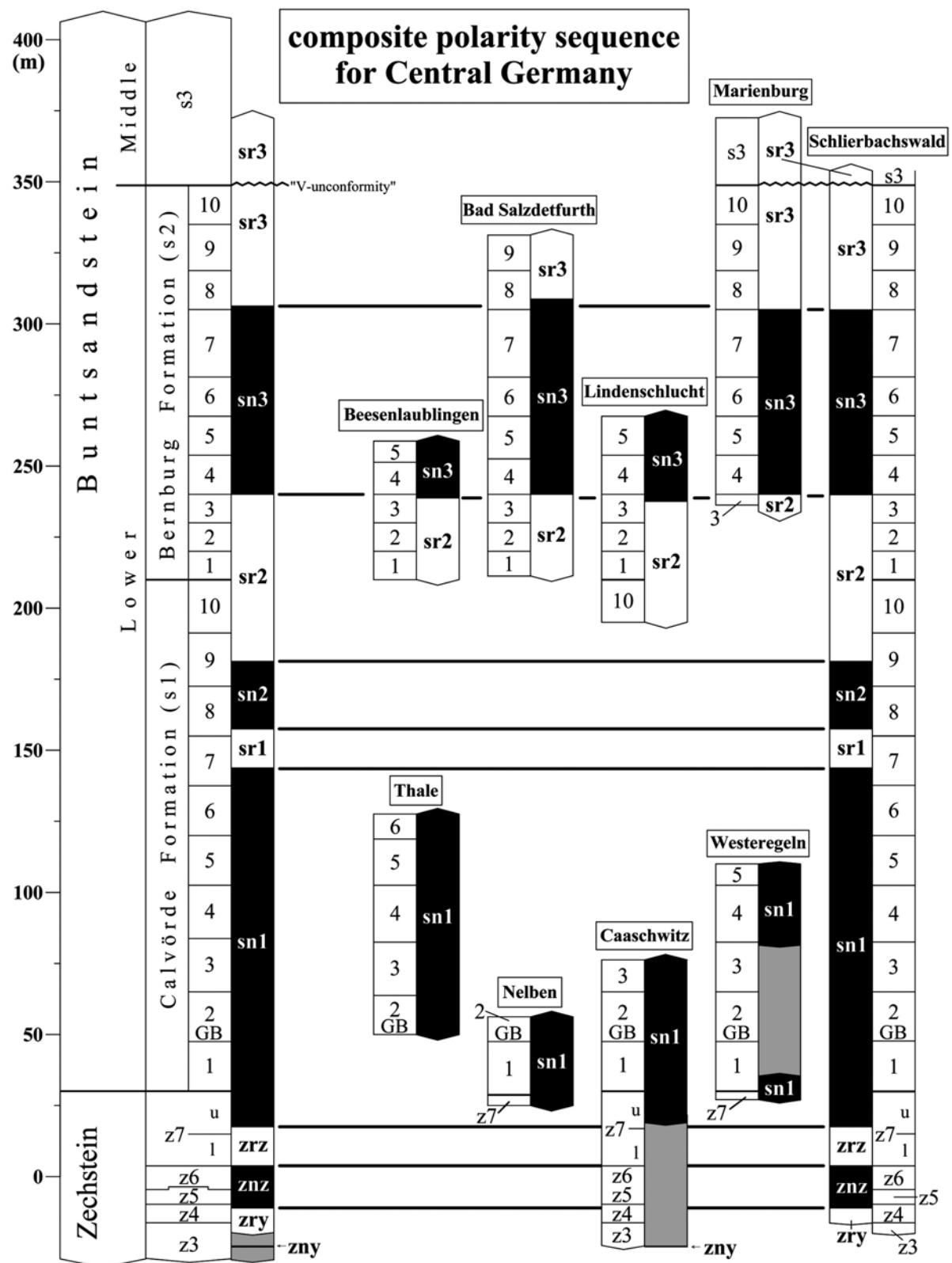


Fig. 8: Upper Zechstein to Lower Buntsandstein composite magnetostratigraphy (SZURLIES 2001, SZURLIES et al. 2003).

Exkursion

Day 1 (Saturday, September 12, 2009)

Stops 1 to 3 are located north of Halle in the so-called Subhercynian Syncline. This region to the north of the Paleozoic uplift of the Harz Mountains is dominated by outcropping Triassic to Cretaceous. Most present-day structural elements are the result of the Late Cretaceous (Coniacian-Campanian) inversion tectonics that affected much of Central Europe to the north of the Alps.

Stop 1: Uppermost Zechstein to lowermost Buntsandstein near Nelben

(Figs. 8–10)

Locality:

Abandoned shale pit 1 km west of Könnern.

Stratigraphy and sediments:

- The section comprises about 25 m of Fulda Formation (Zechstein) to lowermost Calvörde Formation (Lower Buntsandstein), which are latest Changhsingian (latest Permian) to earliest Induan (Triassic) in age.
- The Zechstein/Buntsandstein boundary is characterized by an approx. 1 m thick interval of sandstones. The *Hindeodus parvus*-calibrated Permian-Triassic boundary in the Central European Basin indicated by the FAD of the conchostracean *F. verchojanica* in grey shales of the so-called “Graubankbereich”. In terms of magnetostratigraphy, the section encompasses the lower part of the distinctive thick normal polarity interval sn1, which straddles the base of the Buntsandstein.
- The mainly clastic succession is composed of predominantly red-brown claystones and sandstones, which are interpreted to represent playa and braided river deposits, respectively. The characteristic features are gray oolitic limestones (so-called “Rogensteine”, roestones), which formed in playa lakes.

Points of discussion:

- Lithostratigraphic Zechstein-Buntsandstein boundary vs. biostratigraphic Permian-Triassic boundary using, e.g. biostratigraphy, magnetostratigraphy
- Lithofacies, sedimentary cycles, C-isotopes
- Cosmic vs. volcanic microsperules

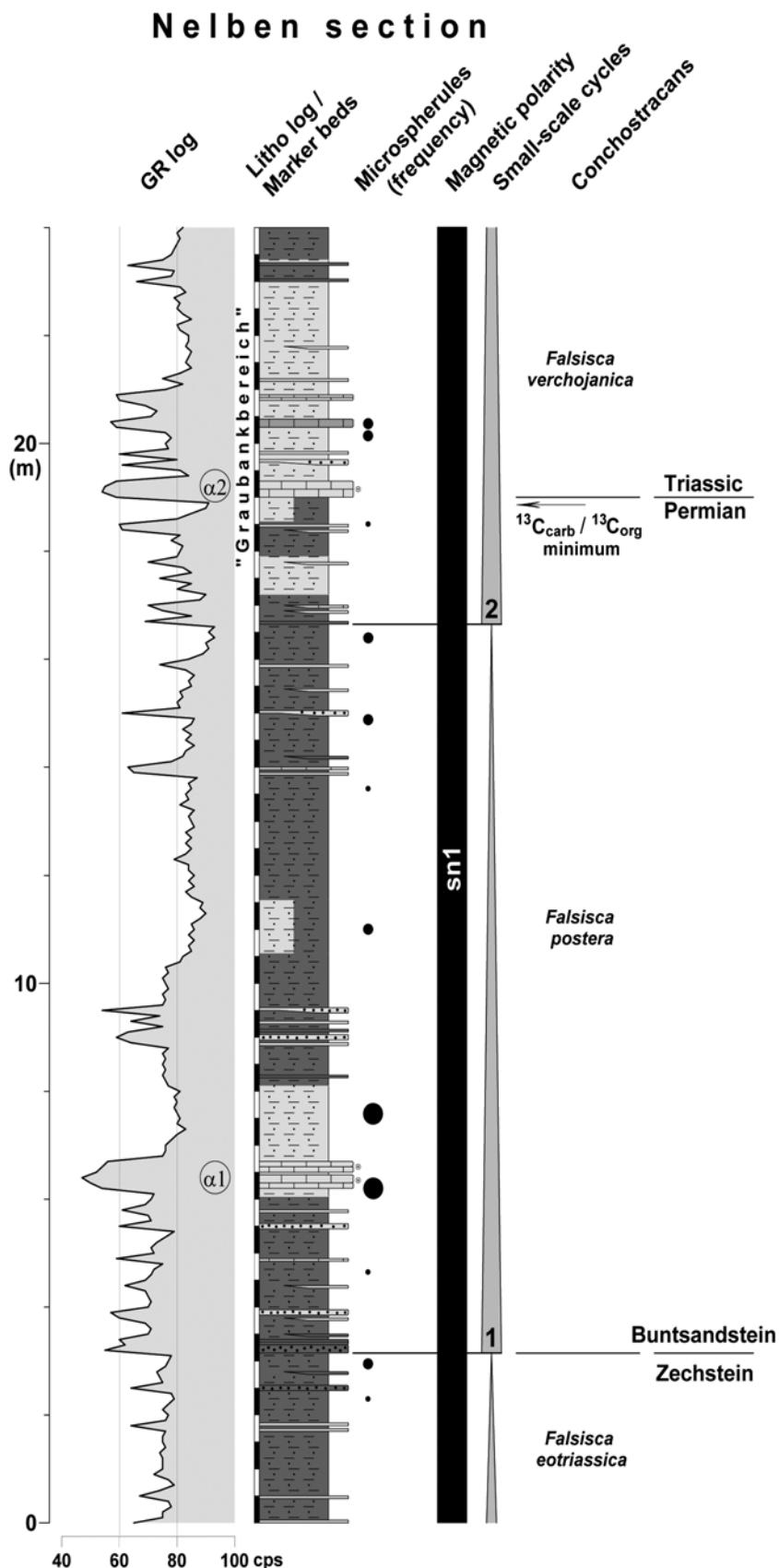


Fig. 9: Litho-log and gamma-ray log of Nelben section, which spans the uppermost (modified after SZURLIES 1997, using data from KOZUR 1999, BACHMANN & KOZUR 2004).

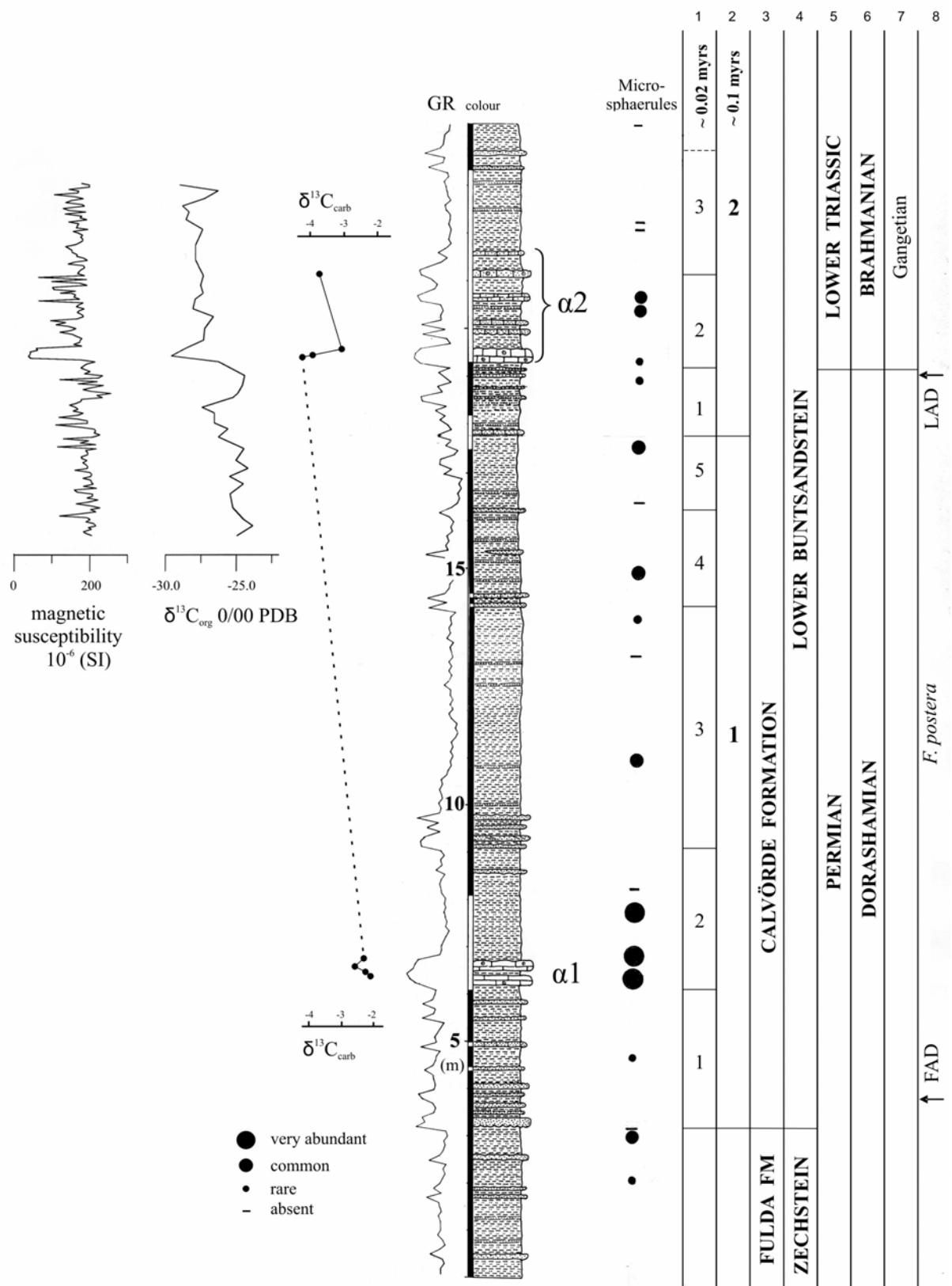


Fig. 10: Uppermost Zechstein (Fulda Formation) and lowermost Buntsandstein (lower Calvörde Formation) at Nelben section near Könnern, 25 km NW of Halle (BACHMANN & KOZUR 2004).

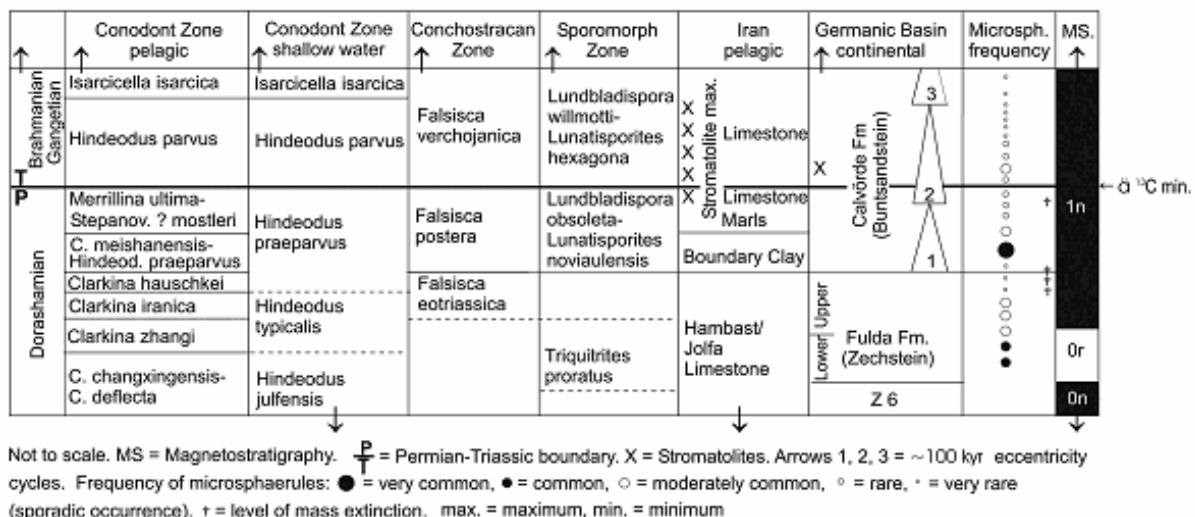


Fig. 11: Conodont, conchostracan, sporomorph zonation and microsphaerule frequency around the Permian-Triassic boundary in Germany and Iran. Not to scale (from BACHMANN & KOZUR 2004).

Key literature:

KOZUR & SEIDEL (1983), HAUSCHKE & SZURLIES (1998), SZURLIES (1999), KOZUR (1999), SZURLIES et al. (2003), BACHMANN & KOZUR (2004), KOZUR & WEEMS (2007)

Stop 2: Lower Buntsandstein near Beesenlaublingen

(Figs. 8, 12, 13)

Locality:

Quarry “Tontagebau Beesenlaublingen” at Bundesstraße B 6, 5 km north of Könnern.

Stratigraphy and sediments:

- The section spans the lower 50 m of the Bernburg Formation (Lower Buntsandstein). The mainly pelitic succession is characterized by intercalations of oolitic limestones (Rogensteine). Especially prominent is the several metres thick “Hauptrogenstein” at the base of the Bernburg Formation. In terms of magnetostratigraphy, the section encompasses most of polarity intervals sr2 and sn3. Along with conchostracan biostratigraphy, the section can be dated as late Induan (Lower Triassic) in age.

Points of discussion:

- Biofacies (conchostracans, trace fossils)
- High-resolution log- and lithostratigraphy of the Buntsandstein

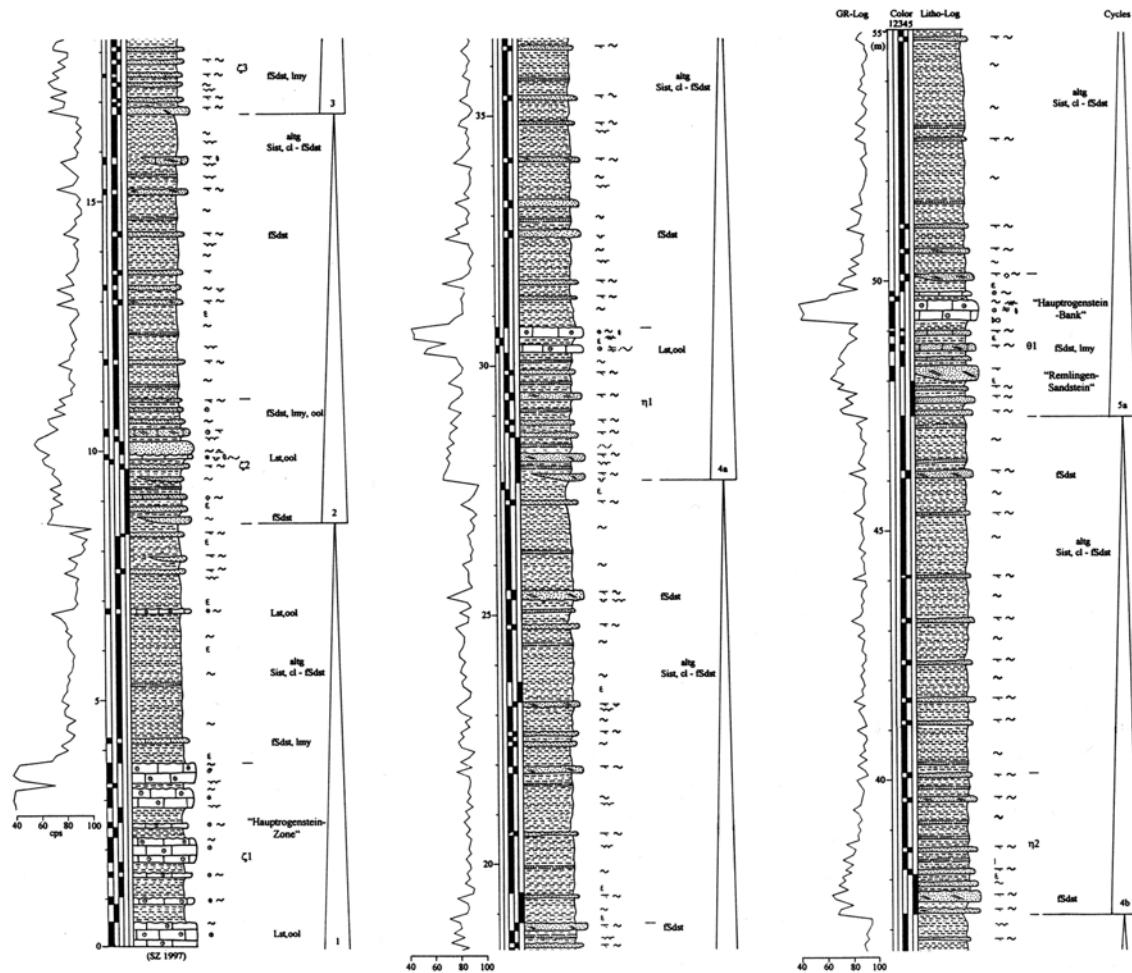


Fig. 12: Litho-log and gamma-ray log of Beesenlaublingen section (SZURLIES 1997).

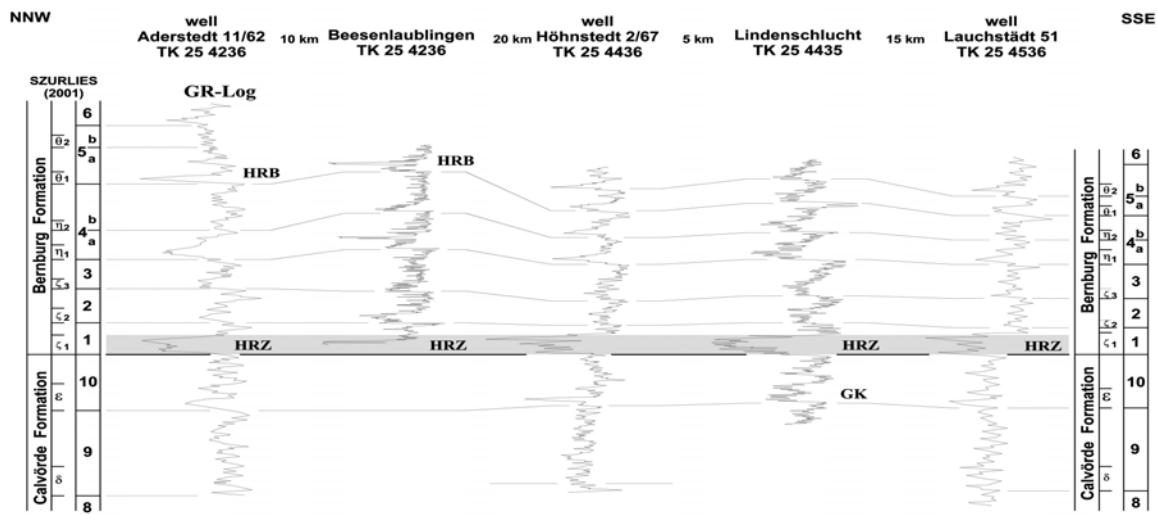


Fig. 13: Gamma-ray log correlation of the uppermost Calvörde Formation to lower Bernburg Formation (Sachsen-Anhalt) (Szurlies 2001). HRZ = Hauptrogensteinzone (= main oolitic interval 1, HRB = Hauptrogensteinbank (= main oolitic interval 2).

Key literature:

KOZUR & SEIDEL (1983), HAUSCHKE & SZURLIES (1998), SZURLIES (1999), KOZUR (1999), HAUSCHKE & WILDE (2000), SZURLIES et al. (2003), KNAUST & HAUSCHKE (2004, 2005), KOZUR & WEEMS (2007), VOIGT et al. (2008)

Stop 3: Middle Buntsandstein near Baalberge
(Fig. 14)**Locality:**

Shale pit “Ziegelwerke Baalberge”, 2 km SE of Bernburg

Stratigraphy and sediments:

- The section comprises about 25 m red-brown and grey-green shales of the lower Volpriehausen Formation (Middle Buntsandstein) just above the Volpriehausen Sandstone (so-called Volpriehausen Wechselfolge). The mainly pelitic succession contains intercalations of sandstones some of which show interesting sedimentary structures and trace fossils on the bedding planes. The sandstone bodies are interpreted as deltaic sediments prograding into a fluctuating lake system. The cosmopolitan conchostracan *Magniestheria mangaliensis* (Jones) is found in the shales; acritarchs occur in some grey-green shales. Based on conchostracan biostratigraphy, the succession is early Olenekian (Smithian) in age.

Points of discussion:

- Cyclicity
- Conchostracan biostratigraphy
- Sedimentary structures and trace fossils

Key literature:

KOZUR & SEIDEL (1983), ROMAN (2003, 2005), KOZUR & WEEMS (2007), HAUSCHKE & KNAUST (in prep.)

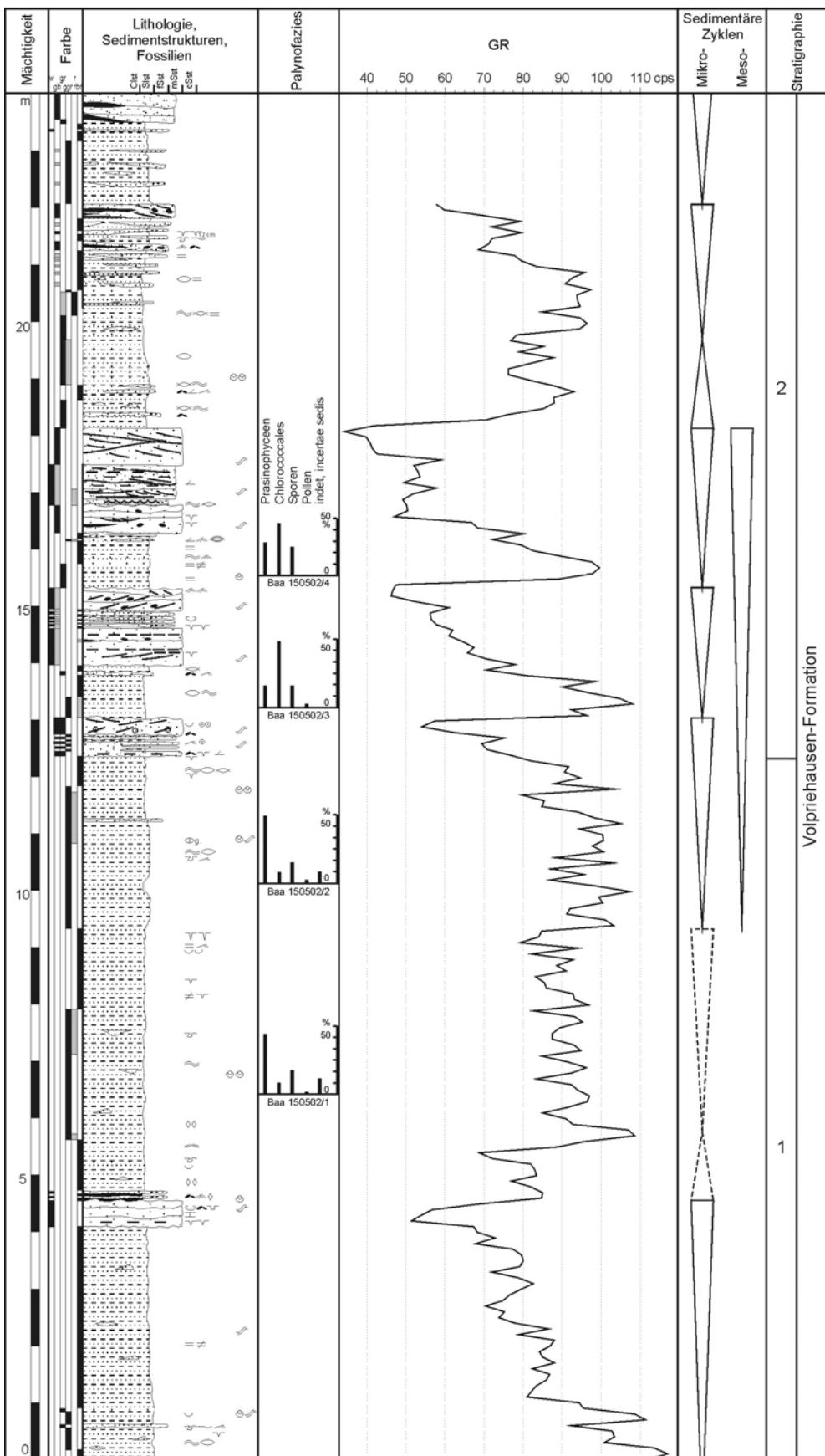


Fig. 14: Litho-log and gamma-ray log of Baalberge section (ROMAN 2003, 2005).

Day 2 (Sunday, September 13, 2009)

Stops 4 ff. are located west and southwest of Halle in the southeastern foreland of the Harz mountains. The area is characterized by outcropping Rotliegend, Zechstein, Buntsandstein and Muschelkalk. Outcrops 4, 5, and 6 (optional) are small, but very interesting from the standpoint of conchostracan biostratigraphy. Outcrops 7 and 8 are optional depending on time.

Stop 4: Lower Buntsandstein at Wormsleben (near Eisleben)

Locality:

Northern slope of the road Wormsleben to Hedersleben, 1 km NE of Wormsleben

Stratigraphy and sediments:

- Middle Bernburg Formation
- Thin-bedded variegated shales with thin sandstone layers, unusually rich in *Estheriella nodosocostata* (Giebel). Additionally present is *Cornia germari* (Beyrich), but rarely in the same layer, as well as *Molinestheria seideli* Kozur.

Points of discussion:

- Conchostracan biostratigraphy

Key literature:

KOZUR & SEIDEL (1983), BACHMANN & KOZUR (2004), KOZUR & WEEMS (2007)

Stop 5: Lower Buntsandstein at Oberrißdorf (near Eisleben)

Locality:

Poorly exposed northern slope of the unpaved road along Fressbach creek, immediately southwest of Oberrißdorf, leaving main road downslope at eastern end of village.

Stratigraphy and sediments:

- Lowermost Volpriehausen Sandstone and uppermost Bernburg Formation (*truempyi* Zone and lower 3 m of the *Magniestheria rybinskensis-Lioleaiina radzinskii* Zone) consisting of sandstones and underlying thin-bedded grey and red shales with sandstone layers. This one of the few locations in the Germanic Basin with conchostracans of the *Magniestheria truempyi* Zone and the lower part of the *Magniestheria rybinskensis-Lioleaiina radzinskii* Zone starting below the Volpriehausen Sandstone. Often this part is completely or partly removed by the hiatus below the Volpriehausen Sandstone. In the most complete development of the Bernburg Formation (Solling Mountains) the *Magniestheria rybinskensis-Lioleaiina radzinskii* Zone begins 6 m below the base of the Volpriehausen Sandstone in the uppermost Bernburg Formation. In the Wangen section (Stop 7) the *Magniestheria rybinskensis-Lioleaiina radzinskii* Zone begins only 0.5 m below the Volpriehausen Sandstone.

- The thicknesses are unknown, but there should be several metres be present above small-scale cycle 10 of the Bernburg Formation (= upper *Magniestheria subcircularis* Zone). The strata are a special facies of the uppermost Bernburg Formation and are overlain by the Volpriehausen Sandstone or an equivalent of the Quickborn-Formation (see Stop 6) that was preserved in the northeastern rim syncline of the Teutschenthal salt pillow.

Points of discussion:

- Conchostracan biostratigraphy
- Preservation of uppermost Bernburg Formation.

Key literature:

KOZUR & SEIDEL (1983), BACHMANN & KOZUR (2004), KOZUR & WEEMS (2007)

Stop 6: Middle Buntsandstein (Detfurth Formation) at Beesenstedt (optional)

Locality:

Cliff of creek NNE of Beesenstedt (“Beesenstedter Grund”)

Stratigraphy:

- Detfurth Formation

Points of discussion:

- Conchostracan biostratigraphy

Key literature:

KOZUR & SEIDEL (1983), BACHMANN & KOZUR (2004), KOZUR & WEEMS (2007)

Stop 7: Lower/Middle Buntsandstein boundary at Großwangen (optional)

(Figs. 15–17)

Locality:

Abandoned quarry immediately west of Großwangen

Stratigraphy:

- Upper part of the Bernburg Formation, ?Quickborn Sandstone and lower part of the Volpriehausen Sandstone
-

Main features to be observed:

- White to grey, completely dolomitized oolitic sandstones in the lower quarry walls reflect the beach and nearshore of a large lake or marginal sea
- Transition Bernburg to Volpriehausen Formation: red clays with intercalated thin sandsheets, dessication cracks, ripples, mud-clasts
- Basal Volpriehausen Formation: medium-grained, poorly sorted sandstones, clay-partings with mud cracks, linsen- and flaser-bedding, rare channels
- Superbly exposed synsedimentary half-graben with associated fault scarps, water escape structures, described in detail by SCHÜLER et al. (1989)

Facies succession:

- Probably shallowing from a marginal lake to a lagoonal and playa environment
- Shallowing-upward from oolitic limestones of shoreline to lagoonal sediments, terrigenous deposition is indicated by the overlaying sandstone unit

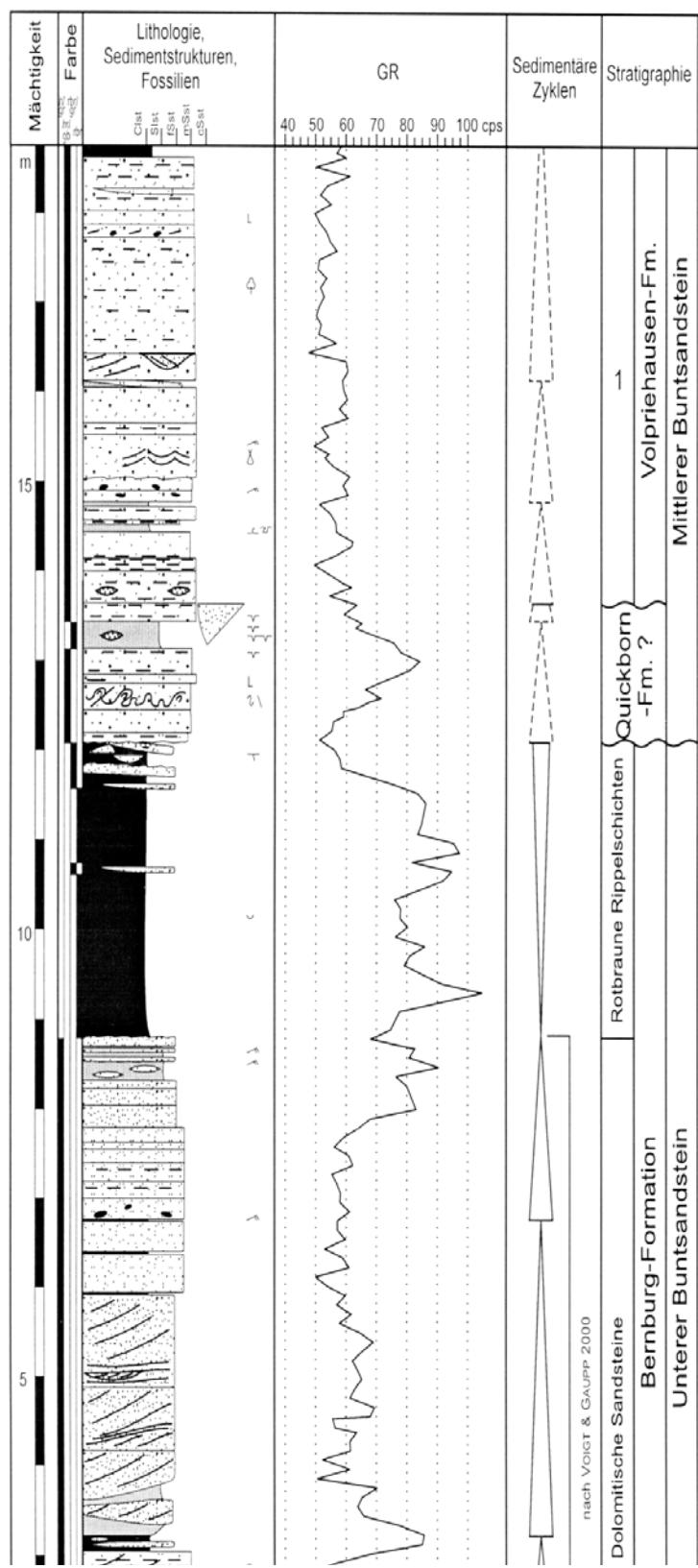


Fig. 15: Großwangen section, after ROMAN (2003, 2005).

- Both increasing quartz-content of oolite beds and intercalation of sandstone beds with increasing thickness in the red-brown clay bed point to basinward shifting of the lake shoreline
- Formation of large floodplain areas dissected by shallow channels with temporary fluvial deposition (sheet-floods) and minor eolian redeposition (Volpriehausen Formation)

Facies geometries:

- Comparisons of single units across the large quarries on both sides of the Unstrut valley and with boreholes in the centre of the Querfurt syncline (RADZINSKI 1995) indicate the regional distribution of marker beds. A regional correlation for the oolitic limestone horizons was established by PAUL & KLARR (1987) and RADZINSKI (1995)
- Regional distribution of the red-brown lacustrine claystones with rippled sandsheets indicates low-relief morphology
- Changing thicknesses and facies of marker beds indicate a much more complicated depositional pattern than previously expected
- The good correlation of the single units across the Germanic Basin is most likely not the expression of synchronous events but evidence for migrating facies belts depending on fluctuating lake level

Sedimentology:

- Sandy oolitic limestones in lower quarry walls
- Red clays with conchostracans, mud cracks and sand layers
- Basal Volpriehausen Formation: medium-grained, poorly-sorted sandstones
- Large, gentle hummocks, second order structures: rippled beds, low angle bedding, scours
- Shallowing to green clays with thin sand-oolite-sheets and oscillation ripples, increasing sand content
- Cyclicity (2-5 m) with fining- and thinning-upward tendencies in the oolitic sequence, top with mud cracks

Points of discussion:

- Tidal influence during deposition of the oolitic limestones
- Correlation of oolitic horizons in the Germanic Basin (timelines, marker horizons or migration of facies belts?)
- Lack of fossils in the oolitic sandstones
- Correlation with the marginal (sandy) Lower Buntsandstein to the southeast
- Timing of dolomitisation
- Cycles and sequences in the Lower Buntsandstein
- Facies sequence (simple transition from marine to terrestrial deposition or basin reorganisation)
- Seismic features in clastic sequences – evidence for basin development
- Facies of the basal Volpriehausen Formation (sandplain with salt crusts, eolian deposition or terminal sandy fan)

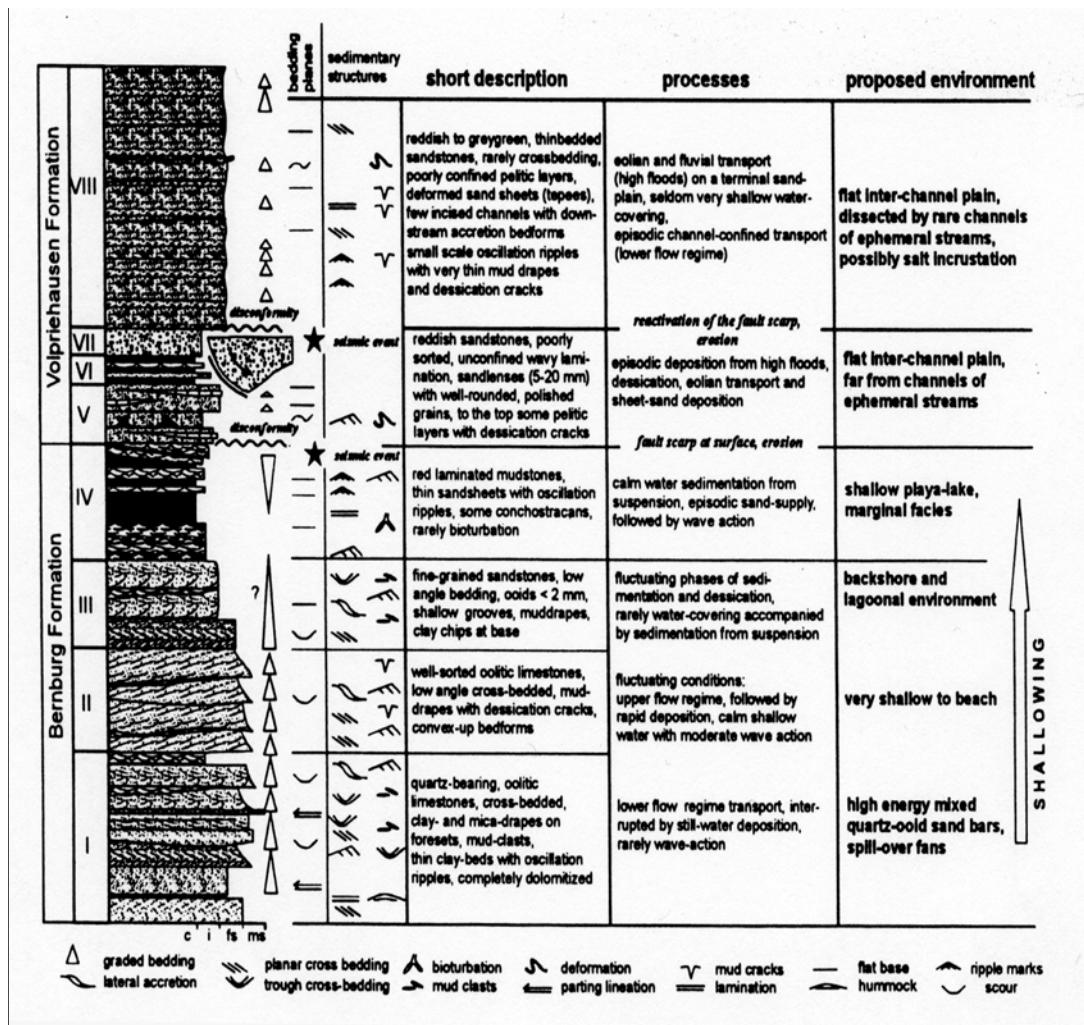


Fig. 16: The Wangen section exposes the boundary of the Lower and Middle Buntsandstein. In general, the section marks the transition from a marginal marine (lacustrine?) depositional system with oolite shoals to a sandy plain with fluvial and eolian deposition.

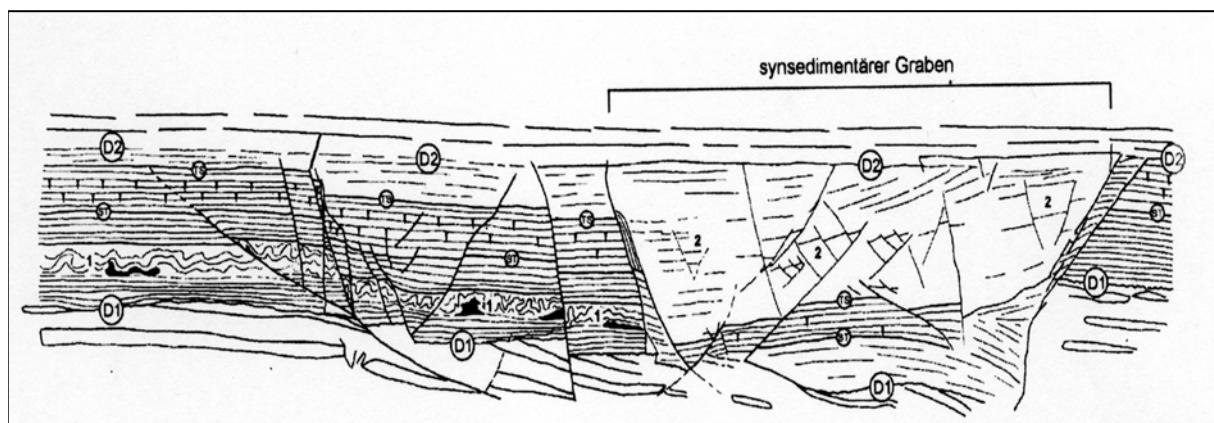


Fig. 17: Sketch showing quarry wall of Großwangen section.
Figs. 16 and 17 after VOIGT & GAUPP (2000)

- Conchostracan-biostratigraphy (facies dependence or evolutionary trend)
- Reasons for lake level shifts, climate, tectonics or global sea-level?

Key literature:

RADZINSKI (1967, 1995), HEINZELMANN (1967), KOZUR & SEIDEL (1983), SCHÜLER et al. (1989), GAUPP et al. (1998), VOIGT & GAUPP (2000), VOIGT et al. (2002), ROMAN (2003, 2005), BACHMANN & KOZUR (2004), KOZUR & WEEMS (2007)

Stop 8: Middle Buntsandstein of the quarries west of Nebra (optional)
(Fig. 18)

Locality:

Large quarry walls and cliffs 0.4 km west of Nebra

Stratigraphy:

Uppermost part of Hardegsen Formation and Solling Formation

Main features to be observed:

- Upper part of the Hardegsen Formation: thin bedded floodplain or terminal fan deposits with various sedimentary structures (bioturbation, caliche, mudcracks), conchostracans
- Base of the Solling Formation: coarse-grained, pebbly sandstones with cross-bedding at the base of large scale channels, cutting into floodplain deposits
- Reworked calcretes and carbonates cementation at the base of channels
- Soil formation in the floodplain deposits of the upper parts of the Solling Formation (columnar, nodular and platy calcretes), redeposition of reworked calcretes in overlying fluvial sandstones
- Bioturbation, plant remnants and conchostracans

Sedimentology:

- Carbonate cementation in the channel sandstones of the Solling Formation
- Lateral accretionary bedding and trough cross-beds (downstream accretion) within the channel fills

Facies sequence and stacking patterns:

- Top Hardegsen floodplain deposits are eroded to different levels by the overlying Solling sandstone channels

Points of discussion:

- Timing and factors controlling the formation of the Solling Unconformity
- Trends in sedimentary structures and channel architecture, changes in accommodation potential (reorganisation of the basin tectonics, relief enhancement or climatic change)

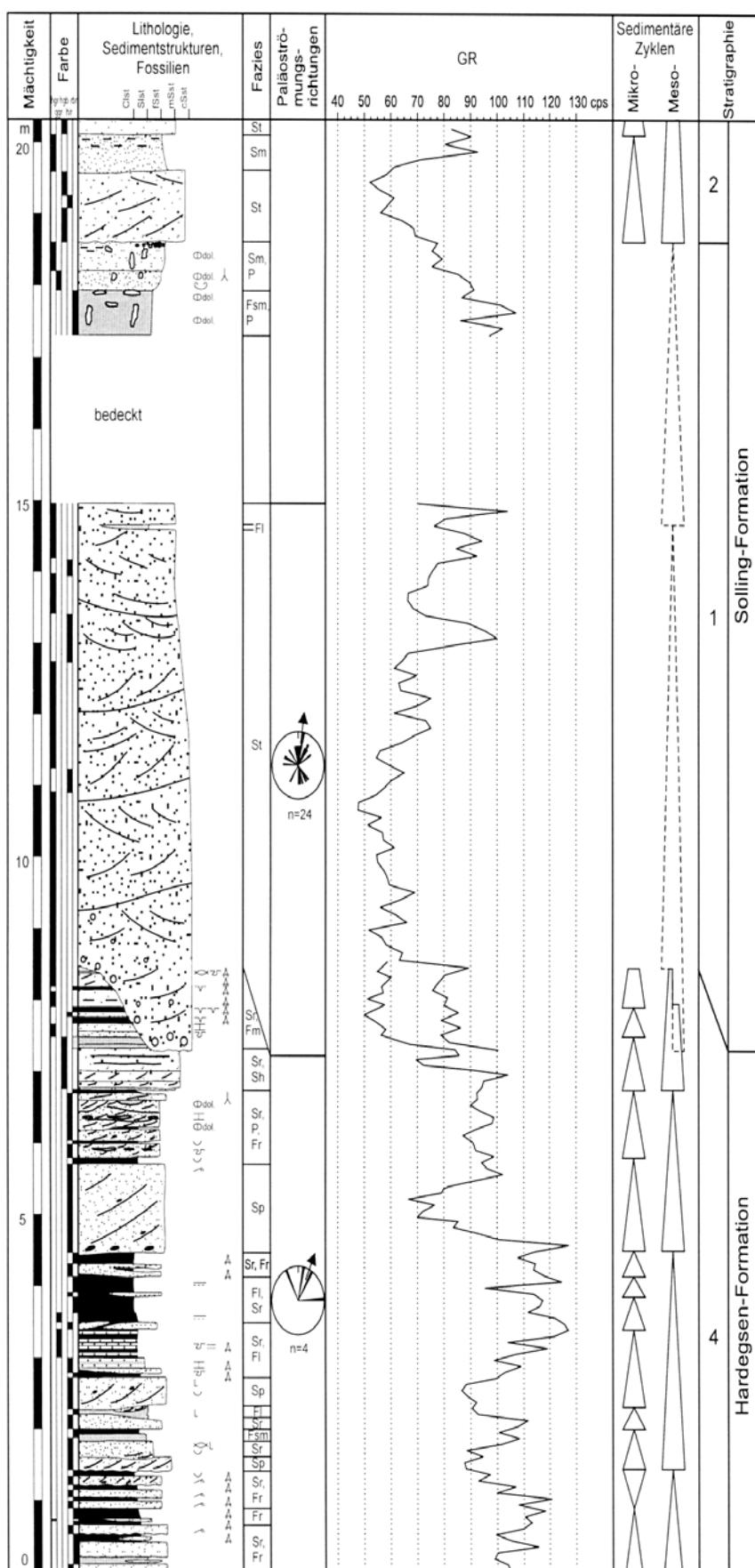


Fig. 18: Nebra section, after ROMAN (2003, 2005).

Key literature:

RADZINSKI (1967, 1995), HEINZELMANN (1967), KOZUR & SEIDEL (1983), SCHÜLER et al. (1989), GAUPP et al. (1998), VOIGT & GAUPP (2000), VOIGT et al. (2002), ROMAN (2003, 2005), BACHMANN & KOZUR (2004), KOZUR & WEEMS (2007)

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