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Sea-level changes during Late Cenomanian and Early Turonian in the Saxonian Cretaceous Basin

by

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With figures 1–9

Summary

The Saxonian Upper Cenomanian is characterised by a shallow marine environment and rapid changes in sedimentation. Preserved basin margins and complete sections from coast to shelf give the opportunity of reconstructing sea level changes during the global Cenomanian-Turonian Boundary Event. Comparison of vertical sections of different sedimentary environments permits the recognition of three major transgressive sequences. The first transgression occurred during the *Calycoceras naviculare* Zone and produced the first marine deposits in the southern part of the Saxonian Cretaceous Basin. The sedimentary environment and areal distribution of the overlying unit (*Metoicoceras geslinianum / Actinocamax plenus* Zone) indicate a relative sea level fall of at least 20 m in the latest *naviculare* Zone. The regression exposed basement elevations which had been inundated previously. The boundary surface between the two Upper Cenomanian units therefore shows erosion and reworking in most sections except those within the rapidly subsiding basin axis. The transgression during the *Actinocamax plenus* Zone reached a much greater amplitude than the preceding sea level rise, since deposits are preserved on the top of swells that are 20 to 50 m higher than the average top of the *naviculare* Zone deposits. A second but minor obvious hiatus marks the top of the *plenus* sequence. Widespread marl sedimentation and the flooding of the last intrabasinal swells during the earliest Turonian demonstrate a rapid and conspicuous sea level rise during the *Mytiloides hattini* Zone. The results of these investigations compare favourably with sequence-stratigraphical interpretations of the Cenomanian-Turonian boundary interval of western Europe.

1. Introduction

The Cenomanian-Turonian boundary acquired particular interest when a short-term anoxic event was discovered in cores drilled in the Northern Atlantic. This time interval is characterised by major changes in the biostratigraphical, lithological as well as geochemical record in marine deposits in many parts of the world (Arthur et al., 1987).

The depositional environment in the Cretaceous chalk basins of Europe provides evidence for important eustatic changes during the Late Cenomanian and Early Turonian which were superimposed on a general rise in sea-level. While transgressions had only minor influence on the deposition of the hemipe-

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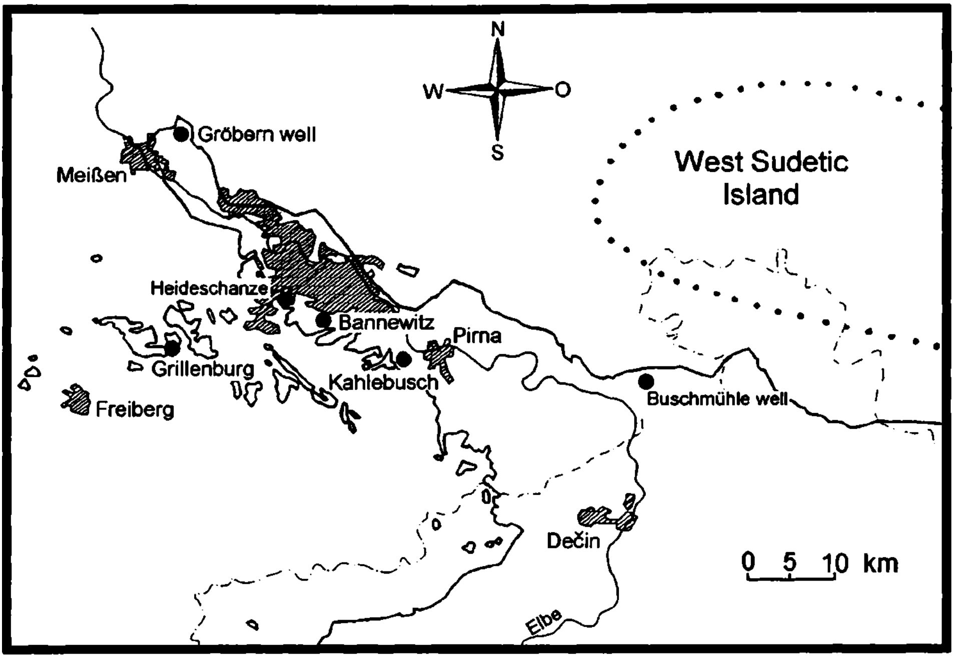

Figure 1: Localities for the Cenomanian-Turonian Boundary Interval mentioned in the text.

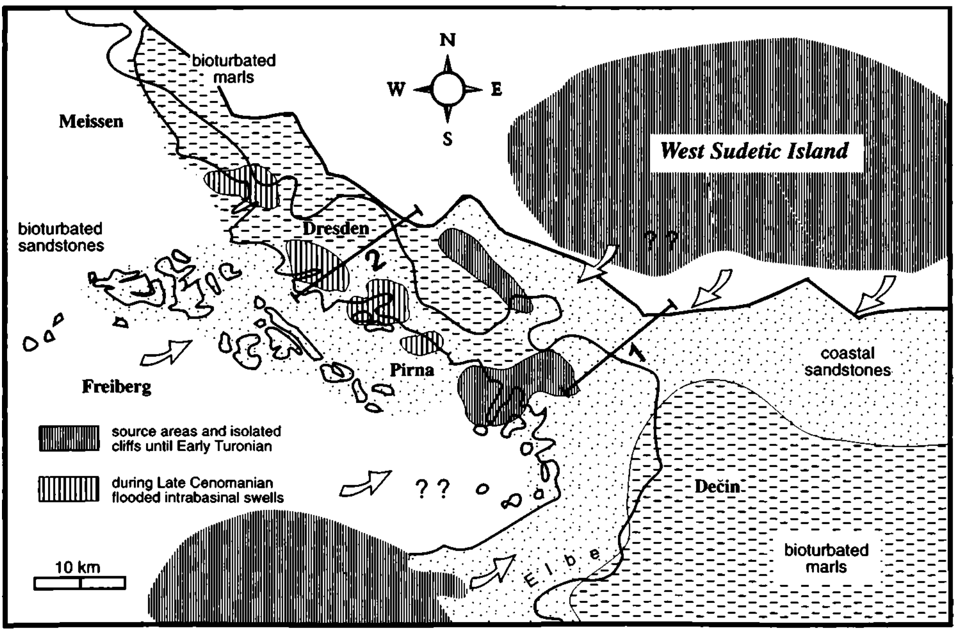

Figure 2: The palaeogeographic map shows the existence of a narrow sea-strait between two source areas. The coastal sandstones of the Upper Cenomanian pass basinward into bioturbated siltstones and marls. The distribution of facies-belts is complicated by intrabasinal swells, which continued to influence sedimentation and the thickness of deposits until the Early Turonian.

lagic chalk, regressions were expressed by changing thickness of units, horizons of reworking or the formation of hardgrounds and are consequently easier to recognise.

Regressions during the latest naviculare Zone and the *Neocardioceras juddii* Zone were described by JEFFERIES (1963), HANCOCK (1987), POMEROL & MORTIMORE (1993) for the British region and the eastern Paris Basin. ERNST, SCHMID and SEIBERTZ (1983) found indications for a regression in north-western Germany some metres below the 'Plenus-Bank'. The first sequence stratigraphical interpretations of the Cenomanian-Turonian Boundary Event in northern Germany were given by HILBRECHT & DAHMER (1994).

The Cretaceous deposits of the Bohemian Cretaceous Basin document relative sea level changes more clearly than those of other areas in Europe because of their marginal setting. It is probable that the coastal to offshore sections of the Saxonian Cretaceous will provide new insights into the unsolved problem of what happened during the Cenomanian-Turonian anoxic event, in particular, the extent to which pronounced short-term sea level changes controlled the depositional history.

The Late Cenomanian sediments of the Saxonian Cretaceous Basin (*Metoicoceras geslinianum/Actinocamax plenus* Zone) gained special interest due to the diversity of environments represented and the well preserved fauna (SCHANDER, 1923; HÄNTZSCHEL, 1933, 1938; UHLIG, 1941; TRÖGER, 1956, 1969); these sediments were initially studied in the context of palaeontology and biostratigraphy.

The first sedimentological investigations were focused on the rocky coast deposits exposed near Dresden-Plauen (TRÖGER, 1956). The transgressive nature of the Plenus succession was demonstrated by SEIFERT (1955) and TRÖGER (1956) and the transgression was linked to the global sea level rise during the Late Cenomanian and Early Turonian.

2. Stratigraphy of the Upper Cenomanian and Lower Turonian deposits in Saxony

The first Cretaceous transgression that reached the Bohemian-Saxonian Basin occurred during the late Early Cenomanian (*Mantelliceras saxbii* and/or *Mantelliceras dixoni* zones). The sediments deposited during this transgression are restricted to the northern part of the basin near Meissen (Meissen Formation: TRÖGER & PRESCHER, 1989). No Middle Cenomanian marine deposits are known in Saxony or in Bohemia. The first important sea-level rise occurred during the early Late Cenomanian *Calycoceras naviculare* Zone and flooded a deeply weathered peneplain with incised river valleys. The fluvial to estuarine valley-fills are believed to be of Mid- to Late Cenomanian age (KRUTZSCH, 1962, PACLTOVA, 1989).

Late Cenomanian and Early Turonian marine deposits have a wide areal distribution in the Bohemian-Saxonian Cretaceous Basin and consist mainly of clastic sediments (figure 2). The deposits are divided into formal lithostratigraphic units (PRESCHER, 1981). The Oberhäslich Formation and the overlying Dölzschen Formation in Saxony represent the Upper Cenomanian and correspond to the Korycany Formation of northern Bohemia.

In Saxony the Lower Turonian rests with sharp contact on the Cenomanian and is represented by the Schmilka Formation (sandstones near basin margins)

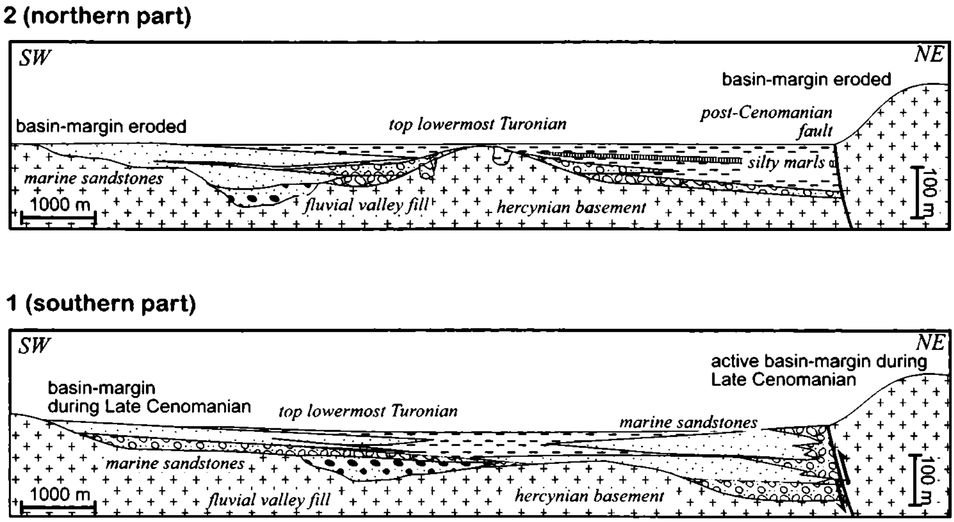

Figure 3: Cross-sections of the Saxonian Cretaceous Basin. For the positions of the cross-sections refer to the palaeogeographic map. The north-eastern basin margin is bounded by a fault, which corresponds in the southern part to the ancient basin margin. In the northern part of the basin the fault cuts through offshore deposits. Coastal sandstones pinch out at the swell margins. Distribution of thickness of different stratigraphic units reflects compensation of bed rock topography.

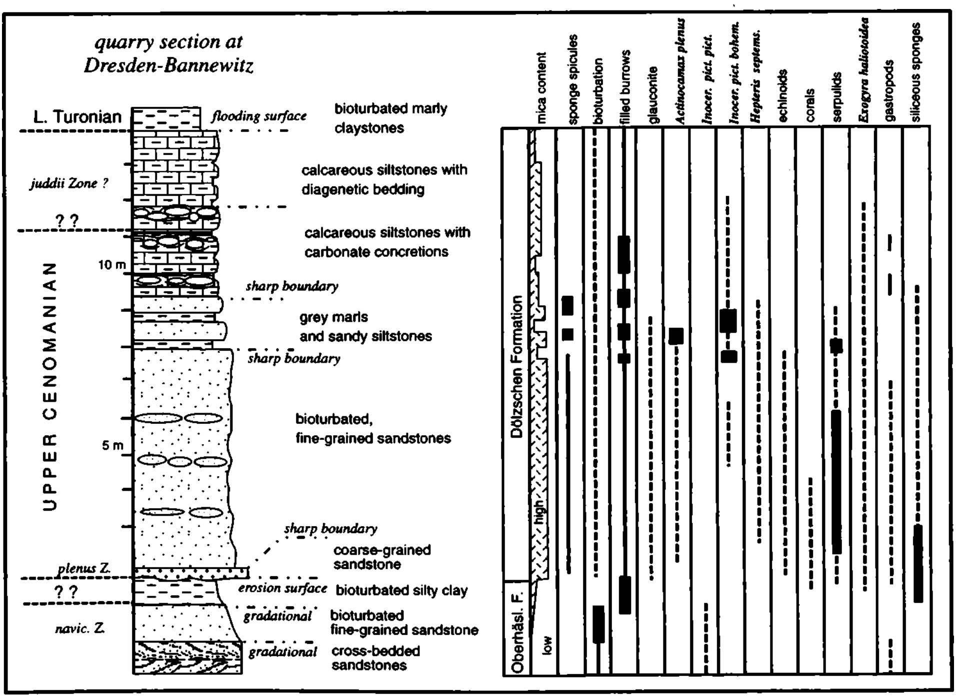

Figure 4: Typical sections near the western basin margin are characterized by bioturbated fine-grained sandstones. Evidence for pronounced relative sea-level fluctuations is given by facies changes to bioturbated offshore deposits and erosion surfaces. They refer to periods of falling sea-level.

and the Briessnitz Formation (silty marls in a more basinal situation). These two formations equate with the Bila Hora Formation of northern Bohemia.

2.1. Deposits of the Oberhäslich Formation

The deposits of the lowermost Upper Cenomanian unit (Oberhäslich Formation) yield *Inoceramus pictus pictus* and *Inoceramus pictus bannewitzensis* in addition to the zonal ammonite *Calycoceras naviculare*.

This predominantly transgressive succession consists mainly of tidally transported sandstones which pass into micaceous siltstones at the top. The thickness of the retrogradational succession varies strongly from 0 to 30 m, depending on the distribution of highs and lows of the submarine topography. The greatest thicknesses occur within the drowned river-valleys and at the margin of the main source area, the West Sudetic Island to the north-east (figures 2 and 3). The sedimentological patterns e.g. the distribution of conglomerates, current-directions and the position of facies-belts reflect the influence of a major fault-zone on the north-eastern edge of the basin. The wedge-shaped basin fill appears to express downwarping along the Elbe Lineament (MALKOVSKY, 1987). Sections in the axis of the resulting half-graben are more complete due to higher subsidence rates.

Towards the south-western border of the half-graben, deposition was influenced by the residual islands. Intercalated conglomerates and the absence of *naviculare* Zone deposits around the highs demonstrate shallow water covering during early Late Cenomanian. The distribution of sandstones and analysis of the source areas provides evidence of terrigenous input from the western basin-margin (figure 2). The flanks of swells are surrounded by a narrow belt of coarse-grained or conglomeratic sandstones. These pass over short distances into fine-grained clays and marls or interfinger with the coastal sandstones of the two major source areas. The swells themselves provided only a limited proportion of clastics to the sediment budget of the basin.

The transition to fine-grained, carbonate-rich siltstones and marls in the higher parts of the Oberhäslich Formation is accompanied by low sedimentation rates (high degree of bioturbation) and decreasing water dynamics.

2.2. Deposits of the Dölzschen Formation

The succeeding depositional unit is sharply differentiated from the underlying sequence in both the fossil record and sedimentary features. It documents the most pronounced vertical and lateral changes in depositional environments of any of the Cretaceous formations in Saxony. The Dölzschen Formation comprises the *Metoicoceras geslinianum* Zone and probably also the *Neocardioceras juddii* Zone. Although the index fossil of the latest Cenomanian *juddii* Zone has never been found in Saxony, two features of the succession allow us to infer nearly complete preservation of the highest Upper Cenomanian in basinal sections. Firstly, the extinction-level of *Rotalipora cushmani* lies in the lower part of the Dölzschen Formation, which is overlain by about 20 m of undated silty marlstones, before the first occurrence of *Mytiloides hattini* marks the basal Turonian. Secondly, the continuous stable carbon isotope curve (TRÖGER & VOIGT, 1995) is comparable with that for the expanded Beachy Head section of southern England, which spans a relatively complete succession of the Upper Cenomanian and Lower Turonian (WOOD & MORTIMORE, 1995 and references therein).

The Dölzschen Formation is typically represented by shallow marine sandstones or conglomerates at the base, which pass upwards into silty marls. The

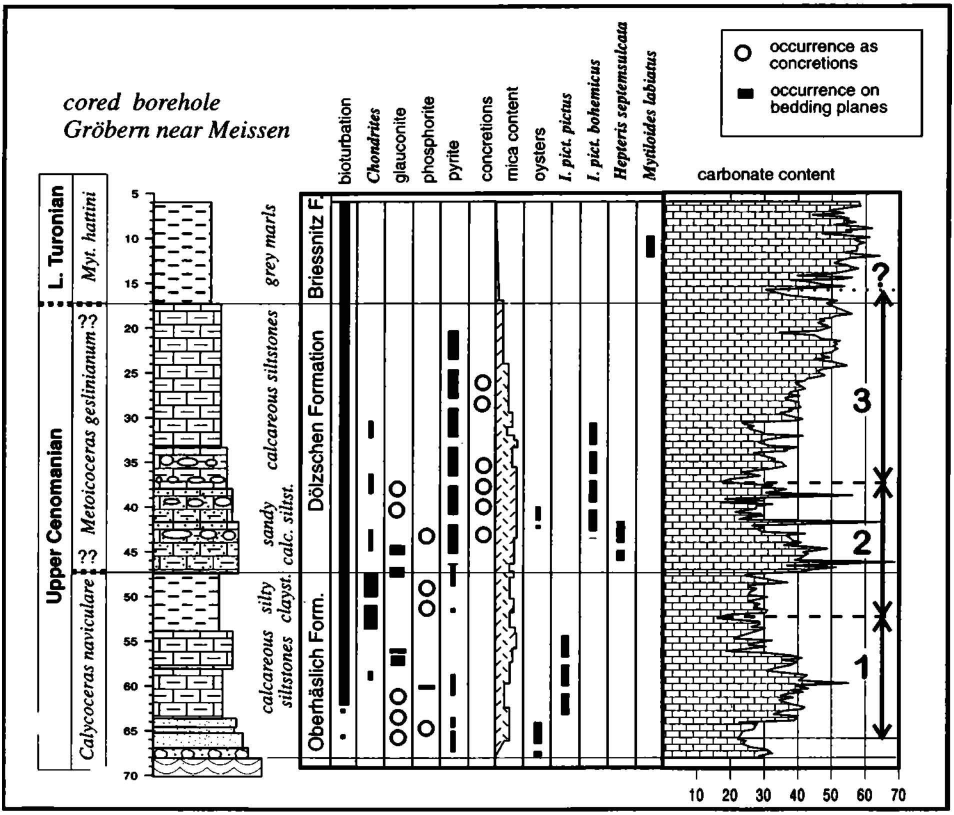

Figure 5: Basinal sections consist of thoroughly bioturbated homogeneous siltstones. The carbonate content varies in a cyclic pattern. Synchronous changes of the grain size suggest fluctuations of terrigeneous input. The faunal record is normally sparse. Biostratigraphic boundaries are defined by inoceramids and foraminifera.

facies succession is variable, depending on local topography. Basinal sections of the Dölzschen Formation are characterised by calcareous siltstones with numerous carbonate concretions, passing upwards into siliceous marlstones.

At the north-eastern basin margin, conglomerates and coarse sandstones predominate. Although the index fossils have not been found, the occurrence of the serpulid *Hepteris septemsulcata* and the bivalve *Neithea notabilis* (two species restricted to the uppermost Cenomanian in the Saxonian Cretaceous Basin), is indicative of the *Actinocamax plenus* Zone. The higher parts contain no fossils and the base of the Lower Turonian is consequently difficult to recognise on a biostratigraphical basis.

2.3. Deposits of the Briessnitz Formation and the Schmilka Formation

The lower boundary of the Briessnitz Formation is marked by a marl horizon. The unit displays a clear coarsening upward pattern to light grey, calcareous siltstones in central parts of the basin. At the basin margins, the Schmilka Formation starts typically with fine-grained sandstones or marls. These are suc-

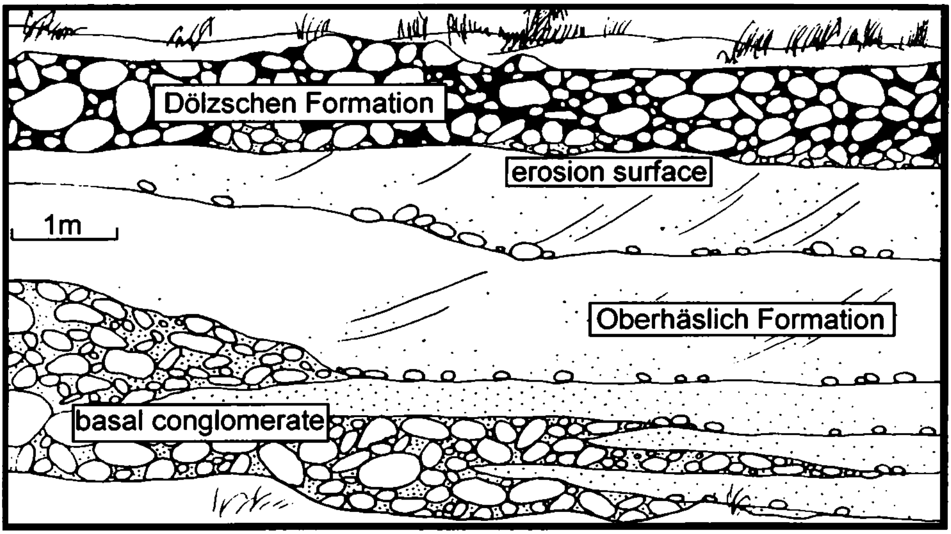

Figure 6: The old Heidenschanze quarry near Dresden Coschütz shows the most important erosion surface within the Upper Cenomanian. The deposits below the conglomerate belong to the Oberhäslich Formation and comprise cross-bedded sandstones interfingering with a conglomerate-channel. Above the truncation surface follows a surf conglomerate (Dölzschen Formation). The matrix was later infilled by micritic limestone containing bioclastic-debris of bivalves, echinoids, corals and radiolitids. *Actinocamax plenus* and *Metoicoceras geslinianum* prove a very late Cenomanian age.

ceeded upwards by bioturbated sandstones followed by cross-bedded sandstones.

The macrofossil assemblage of the Briessnitz Formation includes *Mammites nodosoides* and common inoceramids of the *Mytiloides*-group. Although *Watinoceras coloradoense* has never been found, the presence of earliest Turonian deposits is established by the appearance of *Mytiloides hattini* in the marl horizon of the basal Briessnitz Formation.

No determinable ammonites have been found in the Schmilka Formation. Biostratigraphical correlation with the Briessnitz Formation is based on the occurrence of *Mytiloides* ssp. The basal clay-member of the Schmilka Formation (Lohmgrund marl) is not precisely dated. The first *Mytiloides mytiloides* have been found 2 metres above the marl.

3. Facies of the Upper Cenomanian and basal Lower Turonian in Saxony

3. 1. Nearshore facies at the active basin margin

At the north-eastern edge, the Saxonian Cretaceous Basin is bounded by a major fault, which separated an uplifting basement block (West Sudetic Island) from a subsiding half-graben in the southwest during the Late Cretaceous. The Upper Cenomanian sediments are up to 110 m thick in the immediate vicinity of the West Sudetic Island (figure 3) and consist of coarse, mature sands and conglomerates, poor in fossils and sedimentary structures (Decker, 1963). These deposits are only known from boreholes, so that the following description refers to single cores and general reconstructions of sedimentary development are more or less speculative.

Although some inoceramids of the *pictus*-group have been found, the scarcity of organic remains does not allow definition of biostratigraphic boundaries in this unit. The Upper Cenomanian comprises two major coarsening upward sequences, separated by a marine flooding surface (Buschmühle well). Clear indications for a break in facies conditions are missing (DECKER, 1963). On top of the basal Cenomanian transgressive conglomerate rest cross-bedded sandstones passing up into bioturbated sandstones. The overlying sandstone succession shows a clear coarsening upward pattern and terminates in a conglomeratic sandstone up to 4 m thick. This succession equates with the Oberhäslich Formation developed elsewhere in the basin. The second coarsening upward unit (Dölzschen Formation) is richer in fossils and fine-grained sandstones predominate, especially in the lower parts of the succession. In more basinal sections, the median of grainsize-distribution decreases from 0.5 mm to 0.1 mm (MIBUS, 1975). Coarse quartz sandstones predominate up to the top of the Upper Cenomanian.

The boundary with the overlying Lower Turonian Schmilka Formation is commonly marked by a sharp lithological contact, with fine-grained bioturbated sandstones or grey marls resting on top of coarser sandstones or conglomerates. Mytiloides labiatus is relatively abundant, with the first appearance reported a few metres above the marls.

3.2. Slope sections at the passive western basin margin

The south-western, passive margin of the half-graben was eroded during the Cenozoic. Only the distal part of an extended sandstone belt pinching out into bioturbated offshore marls is preserved (figure 3).

The Upper Cenomanian deposits display a distinct subdivision reflecting the formation of the asymmetric basin and a penecontemporaneous regional rise in sea-level. While the lower Oberhäslich Formation is characterized by tidally- and storm-influenced coarse-grained clastics, deepening of the basin caused the transition from bioturbated fine-grained sandstone to thoroughly bioturbated silty clays (figure 4). The lack of stormbeds and the retreat of the current-influenced facies belt towards the coastline suggest deepening below storm-wave base in the western parts of the basin. The tracefossil community is dominated by *Thalassinoides, Chondrites, Teichichnus* and *Zoophycos*. The clays contain no fossils other than siliceous sponges and consequently cannot be exactly dated.

Above the conspicuous, up to 3 m thick, pelitic bed lies a fine-grained, micaceous sandstone which is well exposed in a few quarries south of Dresden (figure 4). A thin horizon of coarse sand rests with erosive contact on top of the bioturbated mud of the Oberhäslich Formation. *Thalassinoides* traces penetrating the fine-grained sediment are filled with this sand. Large erosion marks and loadcasts prove rapid spilling of the clastics over unconsolidated mud and erosion of an unknown part of the underlying sequence.

The boundary layer is mostly very thin (1–3 cm) and grades upward into homogeneous massive, fossil-rich sandstones. In the lowermost part of the overlying sandstone, glauconite and sponge spicules are abundant. The micaceous quartz sandstones are well sorted and strongly silicified. Primary calcite cement known from borehole cores of this stratigraphic horizon is completely dissolved in outcrops. The shells of oysters and serpulid tubes are commonly replaced by chalcedony.

The fine-grained sandstone member is about 10 m thick and yields a diverse parauthochthonous fossil assemblage consisting predominantly of serpulids, bivalves and brachiopods. The belemnite *Actinocamax plenus* occurs from directly above the base to the second third of the member. Together with abundant *Inoceramus pictus bohemicus,* it proves the *geslinianum* Zone of the Upper Cenomanian. The abundance of serpulids, the good preservation of thin bivalve shells and the high degree of bioturbation indicate starved sedimentation and the absence of strong currents.

The sandstone of the basal Dölzschen Formation is overlain with a sharp basal contact by grey silty marlstones. These are strongly bioturbated, rich in mica and yield, apart from sponge spicules and sparse inoceramids (*Inoceramus pictus bohemicus*), only some small oysters (*Exogyra haliotoidea*).

The lower part of this unit is characterised by some beds with large carbonate concretions, which form an important marker horizon traceable into the very uniform hemipelagic deposits.

The upper part of the Dölzschen Formation consists of uniform bioturbated siltstones without concretions. Rapid changes in thickness and a sharp contact with the overlying Briessnitz Formation suggest an erosion surface. The basal Briessnitz Formation is characterised by claystones with low carbonate content and only sparse fossils.

3.3. Basinal sections of Upper Cenomanian and lowermost Lower Turonian

Towards the north-western edge of the present distribution of Cretaceous deposits the sandstone belts from the two different source areas are replaced by homogeneous bioturbated mudstones (figure 5).

Biostratigraphical subdivision of these well sections is possible by means of abundant inoceramids, some ammonites (*Calycoceras naviculare, Metoicoceras geslinianum*) and foraminifera (*Rotalipora, Praeglobotruncana, Whiteinella*).

The lithostratigraphical boundary coincides with the biostratigraphical boundary, which is defined by the first occurrence of *Inoceramus pictus bohemicus* and *Hepteris septemsulcata* (as a substitute for the rare *Actinocamax plenus*, which accompanies the serpulid in cliff-margin sections).

The average carbonate content is of the order of 40 %, but fluctuates between 18 and 72 % in a cyclic pattern. The carbonate content is represented by partly dissolved coccoliths and foraminifers as well as inoceramid shell fragments. The sand content varies with respect to the progradation of the sandstone bodies. Glauconite is abundant only at the base of the Oberhäslich Formation and in the lower part of the Dölzschen Formation.

The carbonate content shows three slightly asymmetrical cycles, each starting with low carbonate values followed by a gradual increase to the middle part and a continuous decline to the top (figure 5). In the second cycle, which starts slightly below the base of the Dölzschen Formation, a conspicuous break is developed, probably caused by submarine erosion (indicated by higher amounts of quartz-grains and a sharp base to the following unit).

Approximately 7 m below the Dölzschen Formation, a significant decrease in the carbonate content to below 25 % takes place. In addition to the increasing input of terrigenous material, the content of plant debris becomes higher. The high diversity trace fossil assemblage of the *naviculare* Zone (*Thalassinoides, Teichichnus, Zoophycos, Chondrites*) is replaced by a monospecific bioturbation pattern which is dominated by *Chondrites*. These small traces are commonly pyritized. It seems likely that this horizon can be correlated with the widely distributed *Chondrites* Event of northern Germany and England (TRÖGER & VOIGT, 1995).

A rapid rise in carbonate content slightly above the base of the Dölzschen Formation is caused by the formation of large concretions. Given a constant level of bioproductivity, the relative decline of fine terrigenous detritus indicates greater distances from the source areas and/or flooded drainage-networks. The base of the Lower Turonian is not marked by a significant shift of the carbonate signal. The constantly rising carbonate content is accompanied by the gradual transition from silt- to clay-dominated sedimentation.

3.4. Upper Cenomanian to Lower Turonian deposits related to cliffs and swells

The Saxonian Upper Cenomanian is distinguished by the occurrence of a number of small, isolated islands which were situated within the basin. Most of these swells were inundated by the Late Cenomanian *plenus* transgression and are covered with sediments deposited during the late Late Cenomanian. Only two larger islands, situated to the east and north-east of Pirna (figure 2), remained above water at this time and were consequently not overlain by Upper Cenomanian sediments. Here, the granite or granodiorite basement is directly overlain by Lower Turonian sandstones and marls (dated by the occurrence of *Mytiloides labiatus* and *Mytiloides mytiloides)*, which were deposited when the

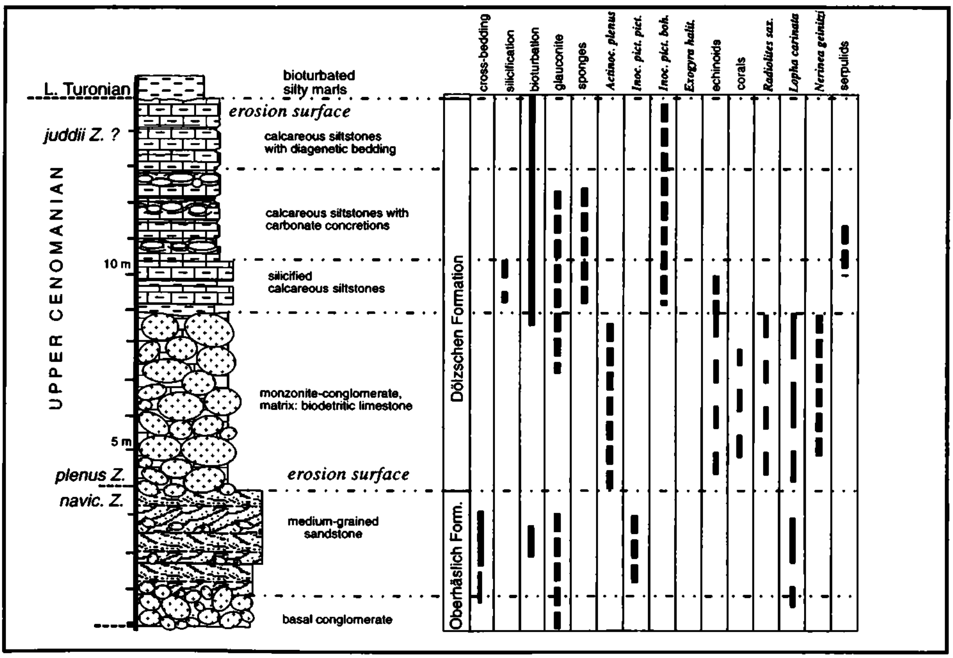

Figure 7: The section of a prominent swell-margin is situated near the Heidenschanze quarry (Gittersee borehole). The conglomerate above the erosion surface is succeeded by sponge-rich siltstones passing up into bioturbated siltstones. The reduced thickness of these siltstones in comparison to sections away from the swells and the sharp boundary with the Lower Turonian Briessnitz Formation suggest that the top of the succession has been eroded.

islands were first inundated during the Early Turonian transgression. This date must mark the point when the continuing sea-level rise resulted in the depositional environment being no longer current dominated, thereby allowing the accumulation of sediment on the top of the swells. All the intrabasinal swells must have already lost their influence on sedimentation during the Late Cenomanian, because deposits of this age consist of fine-grained sediments only, with no conglomerate or sandstone intercalations indicative of derivation from swells. The situation around the buried Cenomanian cliffs is ideally suited for the recognition of facies development and sequence stratigraphical interpretation because of the precision of biostratigraphic dating and the abrupt changes of individual units in both thickness and facies (figures 6 and 7).

The flat eroded surfaces of swells are normally covered with deposits containing *Metoicoceras geslinianum* and *Actinocamax plenus*. The Dölzschen Formation is represented by fine-grained marls and silty marlstones showing features of condensation. All high energy deposits are missing, and bioturbated marls with *Rotalipora cushmani* were deposited directly on the bedrock surface (figure 9).Older beach deposits of the Dölzschen Formation are preserved only in depressions. They consist of well rounded cobbles of the underlying bedrock and are cemented by micritic limestones with bioclastic debris of a high-diversity fauna. TRÖGER (1956) counted 295 different species. LÖSER (1989) estimated the number of species would exceed 400. The faunal assemblage is mainly composed of bivalves, echinoids, gastropods, bryozoans, calcareous algae, small rudists and corals, indicating warm, oxygen-rich surface water. The infilling of the spaces between the cobbles by marls probably occurred after leaving the surf zone as a result of to further deepening during continuous transgression.

The conglomerates are overlain by thoroughly bioturbated marls and calcareous siltstones, with a low-diversity fauna. Sponges and small oysters predominate, inoceramids (*Inoceramus pictus bohemicus*) are comparatively rare. The diagenetic dissolution of disintegrated sponge spicules led to the development of small siliceous concretions, diffuse siliceous cement or total replacement of calcitic shells.

In areas beyond the swells, deposits of the Dölzschen Formation lie with erosive contact on the Oberhäslich Formation (figure 7). At the flanks of the swells, rocky coast deposits reach the greatest thickness. Deep truncation and development of channels with conglomerate fill indicate strong reworking and erosion of sandstones and marls deposited during the *naviculare* Zone highstand. Depending upon the distance from the cliffs and local current conditions, the deposits of the basal Dölzschen Formation are represented by packages of well rounded beach-cobbles up to one metre diameter (figure 6), thin conglomerates or coarse sandstones. The first *Metoicoceras geslinianum* Zone fossils are found above the erosion surface or in the later marl and limestone infillings in the interstices of the cobble packages.

The stacking pattern of sequences around the intrabasinal swells allows the reconstruction of a complex depositional history (VOIGT et al., 1994):

After the first (*naviculare* Zone) transgression, when river-valleys and the peneplain were progressively inundated, the cliffs were surrounded by beach conglomerates and current-dominated sandstones. After complete inundation during the highstand, most of the swells lost their influence on sedimentation. They were reactivated by the subsequent sea-level fall at the end of the *naviculare* Zone. Any fine-grained deposits were eroded from the swells at this time by the downward migration of the dynamic water-layer.

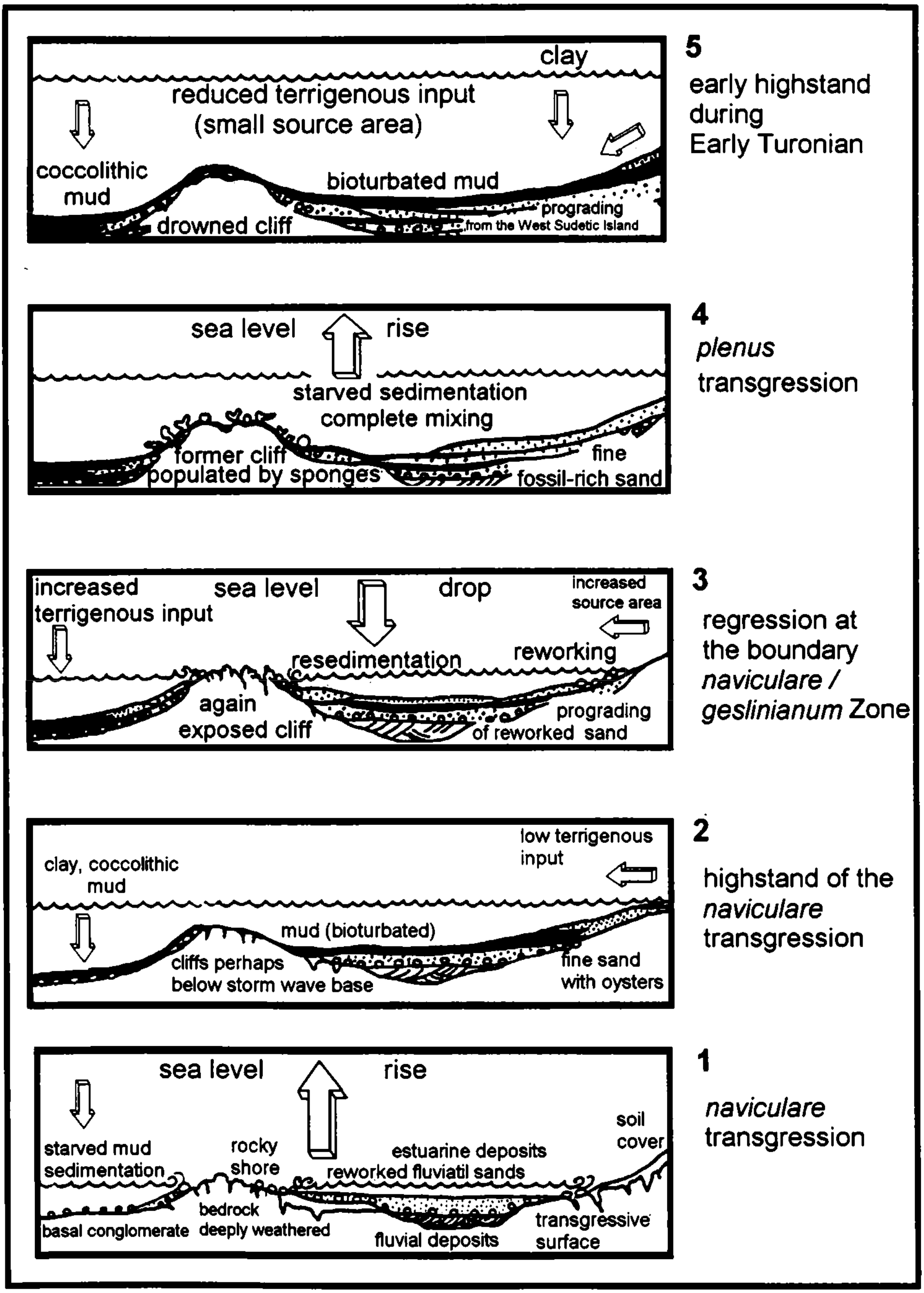

Figure 8: Development of a typical cliff area of the Saxonian Cretaceous Basin during the Late Cenomanian and Early Turonian.

Thick packages of beach conglomerates reflect the sea-level lowstand and cover older nearshore deposits at the former cliff edges (figure 8). However, redeposited sandstones are rare in deeper parts of the basin. The increasing portion of terrigenous material in the basinal sections is probably derived from reworked *naviculare* Zone deposits, but consists mainly of silt-grade grains and clay. Our interpretation is that the small islands were not sufficiently extensive to serve as a source for large amounts of coarser clastics.

The renewed rise of sea-level during the *plenus* transgression allowed short-term colonisation of the exposed hardgrounds by corals, sponges and rudists. Deposition of marls and siltstones on top of these faunal communities is the expression of progradation during the subsequent sea-level highstand. The reduced thickness on the swells (condensation with formation of phosphorites) indicate persistent elevation above the adjacent sea-floor accompanied by starved sedimentation below storm wave base. Water depths were sufficient to allow accumulation of fine-grained sediments on the swells since this transgression occurred. The absence of the thick fossil-rich sandstone member which was simultaneously deposited around the swells is interpreted as the result of fast drowning and elevation above the normal bedload transport.

4. Sequence stratigraphic interpretation and biostratigraphic dating

The Upper Cenomanian to Lower Turonian succession of Saxony documents an overall transgression, which is expressed by a retrogradational stacking pattern of clastic sequences and a significant increase in coastal onlap

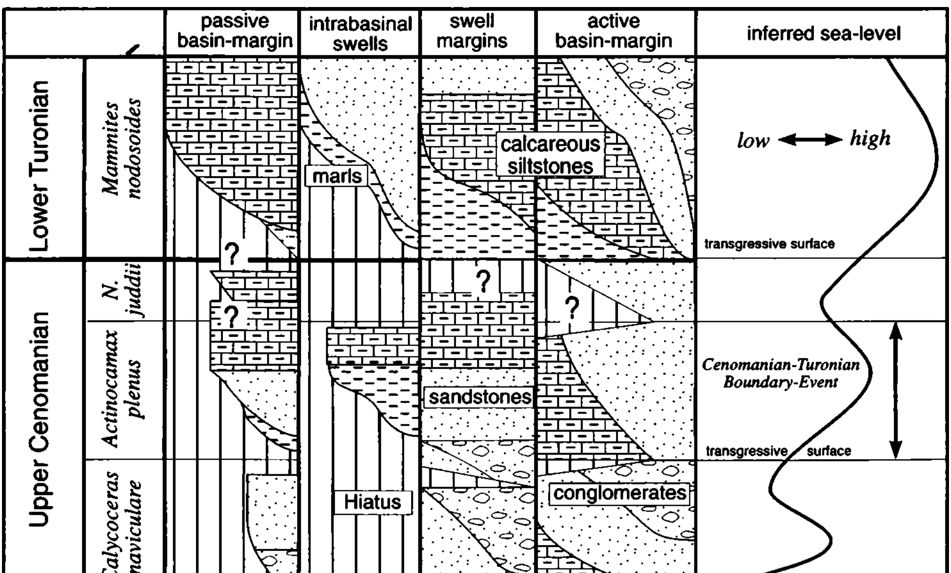

Figure 9: Summary of the different section types of the Cenomanian-Turonian Boundary interval of the Saxonian Cretaceous. Truncation at the sequence boundaries cuts down to different levels. The increasing coastal onlap during transgressions shows that the fluctuations of sea-level were of the order of 20–50 m.

(figure 9). Superimposed on this development, two minor (third order) regressions produced shallowing-upward sequences.

It is important to note that the comparison of sections in different positions of the Saxonian Cretaceous Basin provides evidence for the coincidence of sequence boundaries in all depositional environments. We conclude that tectonic movements within the fault zone had less influence on sedimentation than eustatic sea level changes.

In particular, the transition from the *naviculare* Zone to the *geslinianum* Zone is characterised by a significant sequence boundary, reflected by deep erosion, transition to a sediment regime with enhanced reworking and high terrigenous input in more basinal sections.

The development of homogeneously bioturbated sandstones and mudstones without coarse intercalations in the vicinity of the younger *plenus*-cliff areas provides evidence for the first complete drowning of the Cenomanian landscape. The regression occurred before the first appearance of *Metoicoceras geslinianum, Actinocamax plenus* and *Inoceramus pictus bohemicus,* which are found in the transgressive systems tract of the next sequence. While *A. plenus* and *M. geslinianum* are proven to occur only in the lower third of the whole sequence, the homogeneous silty marlstones which represent the predominant facies in the highest Upper Cenomanian yield *Inoceramus pictus bohemicus* up to the base of the basal Lower Turonian. The sharp boundary and significant thickness variations of the silty marlstones suggest erosion at this level. We interpret this contact as a marine erosion surface followed by the next sequence, which starts with a new transgressive systems tract and a synchronous shift of coastal onlap onto the western source area during the zone of *Mytiloides hattini.* The basal Lower Turonian marls (Briessnitz Formation) reach the greatest areal extent of all the Cretaceous sediments deposited below storm wave base. They reflect the maximum transgression.

The up to 150 m thick tidally distributed sandstone fan prograding during the Early Turonian from the West Sudetic Island covered the hill- and valley surface. The compensation of the sea bottom relief ended the strong differentiation of depositional environment within the Bohemian-Saxonian Cretaceous Basin (TRÖGER, 1969).

5. Discussion and Conclusions

The global Cenomanian-Turonian Boundary event was interpreted as the result of enhanced burial of organic carbon during a major transgression of the sea over wide shelf areas (ARTHUR et al., 1987). The excursion of the stable carbon isotope curve exactly spans the time of the *Metoicoceras geslinianum* Zone and a minor part of the of *Neocardioceras juddii* Zone. According to the proposed model, it is to be expected that changes in the eustatic sea level during the Late Cenomanian followed a distinct pattern. The transgression during the *Metoicoceras geslinianum* Zone should have been of more importance than the preceding *naviculare* Zone transgression, which already led to a significant extension of sea-covered shelf areas. The return to reduced amounts of the heavy carbon isotope in the global cycle is explicable only if a large amount of buried organic carbon is recycled by reworking during a sea level fall. If the model is correct, a regression in latest Cenomanian time is responsible for the return to nearly normal isotope proportions.

The inferred sea level curve of the Saxonian Cretaceous Basin compares very well with the predicted fluctuation pattern. The amount of regression is difficult to assess in Saxony because of the widespread erosional surfaces and the unknown amount of erosion in the swell areas. The close proximity of transgressive *geslinianum* Zone swell deposits and older offshore naviculare Zone sediments allow us to estimate the pre-*geslinianum* Zone sea-level fall to have been about 20 to 50 m. The regression during the *Neocardioceras juddii* Zone was less important in the Saxonian Cretaceous Basin. Deposits of the *Metoicoceras geslinianum* Zone were not eroded from intrabasinal swells. However, a major unconformity is developed at this time on the western basin margin of the Bohemian Cretaceous Basin. Here, the terminal Late Cenomanian regression caused reworking of younger sediments and led to a significant hiatus between Upper Cenomanian and Lower Turonian units (ULICHNÝ et al., 1993). The same hiatus is recognisable in most sections of northern Germany (HILBRECHT & DAHMER, 1994) and England (HANCOCK, 1987).

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