

# Cenomanian through Lower Coniacian events in the Upper Cretaceous of Saxony, Germany

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## ABSTRACT :

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The event sequence recognised in the Cenomanian through basal Coniacian (Late Cretaceous) of the Elbe Valley is compared with the event stratigraphic scheme worked out in NW Germany. The following events, recognised originally in Lower Saxony, and subsequently in other Cretaceous areas of north-western Europe, were found in Saxony: *Schloenbachia / virgatus* eustatocent (Lower Cenomanian); *Chondrites* ecoevent, *Puzosia* eustatocent and *plenus* eustatocent (Upper Cenomanian); *hattini* ecoevent, *Mytiloides* ecoevents, *hercynicus* ecoevent, *Hyphantoceras* ecoevent, *Didymotis* ecoevents and *waltersdorfensis* ecoevent (Turonian); *erectus* ecoevent, *hannoversis* ecoevent, and *incostans* ecoevent (Lower Coniacian). Both the oxic/anoxic Cenomanian/Turonian boundary event and the facies change at the base of the *Metoicoceras geslinianum* Zone are recognisable. With the exception of the *Mytiloides* ecoevents, recorded in all facies types, all the events are well developed only in the marly-silty facies. Local events, specific to the Cretaceous of Saxony are: the Late Cenomanian Pennrich event, known from the Sudetic area, and the Middle Turonian rhynchonellid events, occurring in sandy and transitional facies between Pirna and Bad Schandau.

**Key words:** Upper Cretaceous, Saxony, Elbe Valley, Cenomanian, Turonian, Coniacian, Event stratigraphy, Global and local events, Eustatocent, Ecoevent, Tectocent, Inoceramids.

## INTRODUCTION

The first integrated stratigraphic investigations were carried out by ERNST, SCHMID, KELLER, KLISCHIES and SEIBERTZ (see ERNST & al. 1979a, b) in the region of Braunschweig and Hannover, Lower Saxony. An event stratigraphic concept for the Cenomanian and Turonian successions in NW Germany (Lower Saxony, Münsterland Basin) was introduced a few years later by ERNST & al. (1983 – in cooperation with S. KELLER and C.J. WOOD). They distinguished and described eustatocents, ecoevents, tephroevents (tuffite layers), tectocents, lithoevents and phyloevents, in addition to the global organic carbon burial event in late Cenomanian

and early Turonian successions, which was termed Oceanic Anoxic Event by SCHLANGER & JENKYN (1976). Eleven eustatocents are particularly important for detailed correlation in NW Germany. They are marked by rapid transgressions or regressions, glauconitic horizons, hardgrounds, concretionary horizons, hiatuses, fossiliferous horizons and facies changes. Other events are developed more locally, for example in areas of rising salt structures. Additional investigations concerning the events and their global and local importance were carried out by KAPLAN & SCHMID (1983), KAPLAN (1998a, 1998b) – Münsterland Basin, HILBRECHT & al. (1986 – Lower Saxony), HILBRECHT & DAHMER (1994 – Lower Saxony, Münsterland Basin),

DIEDRICH (2000 – Münsterland Basin), LEHMANN (1999 – Münsterland Basin), NIEBUHR & al. (1999 – Lower Saxony), HORNA (1996 – Subhercynian Cretaceous Basin), WOOD & ERNST (1998 – Lower Saxony). Event stratigraphic and sequence stratigraphic investigations in the Cretaceous of the Elbe Valley were first undertaken by TRÖGER & VOIGT (1995). The Cenomanian through Turonian events of Germany, with particular reference to the Middle Cenomanian *primus* event, the Mid-Cenomanian event and the Late Turonian *Hyphantoceras* event, were reviewed by DAHMER & ERNST (1986). The terminal Turonian *Didymotis* events in the Czech Republic were detailed by ČECH (1989). Summarized representations of the Cenomanian through basal Coniacian events in Germany are given recent publications (HISS & al. 2000 and MUTTERLOSE & al. 1998).

The main objectives of this paper are: (1) Comparison of the Cenomanian, Turonian and basal Coniacian events of NW Germany with those in Saxony; (2) Investigation of the local events in the Elbe Valley Cretaceous; and (3) Presentation of the influence of facies changes on the distribution of events in Saxony.

#### PALAEOGEOGRAPHY OF THE ELBE VALLEY IN THE CRETACEOUS

The Upper Cretaceous of Saxony (Cenomanian through basal Coniacian) is situated mainly in the linea-

mental zone of the Elbe Valley, between Meißen, Dresden, Pirna and Bad Schandau. This was one of the main connections between the Cretaceous basins of NW Germany and the Cretaceous North Bohemian Basin (Czech Republic) (Text-fig. 1) and, in a more general context, between the Tethyan Realm in the south and the North Temperate Realm in the north. Due to subsequent erosion no Cretaceous strata are preserved in the Elbe valley NW of Meißen.

Faunal migrations took place both from the NW to the SE and from the SE to the NW. Isolated, mainly Cenomanian, erosional outliers are situated south of the Elbe Valley Cretaceous (Text-fig. 2A), for example, the Tharandter Wald (Cenomanian, lowermost Turonian), the Dippoldiswalder Heide (Cenomanian), the Paulsdorfer and Höckendorfer Heide (Cenomanian) and the Reinhardtsgrimmer Heide (Cenomanian). The Elbe Valley Cretaceous basin was bounded by the West Sudetic Island to the north and the Mid European Island to the southwest. Small tectonic movements influenced sedimentation. This is shown by the existence of small Cenomanian NW-SE and NE-SW striking island chains and by the formation of a boundary trough (sensu VOIGT 1963) south of the West Sudetic Island and immediately south of the Lausitz Fault (overthrust).

To the Upper Cretaceous of Saxony also belongs the Upper Cretaceous of the Zittau Mountains (Upper Cenomanian – Lower Coniacian) (Text-fig. 2), which forms part of the North Bohemian Cretaceous (Cenomanian

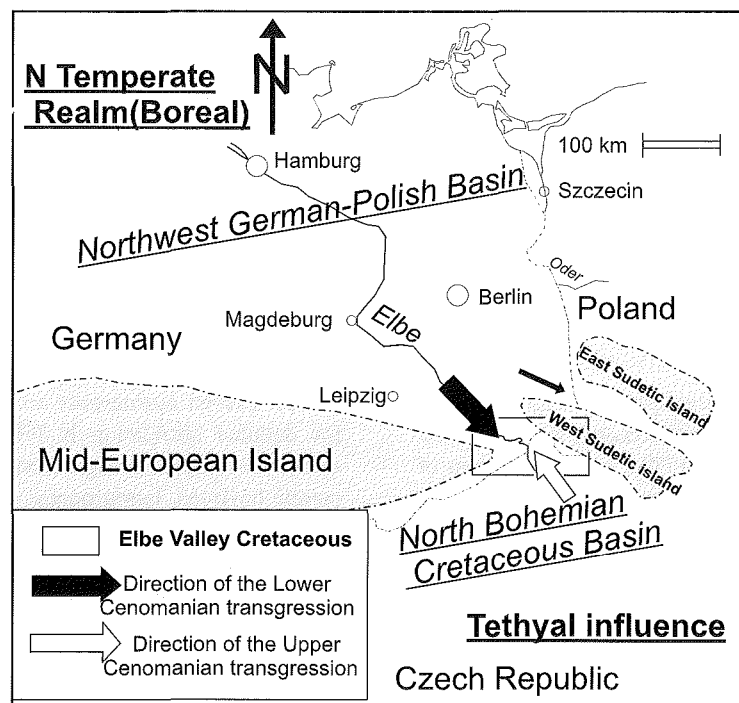


Fig. 1. Palaeogeographical situation of the Cretaceous of the Elbe Valley in central Europe

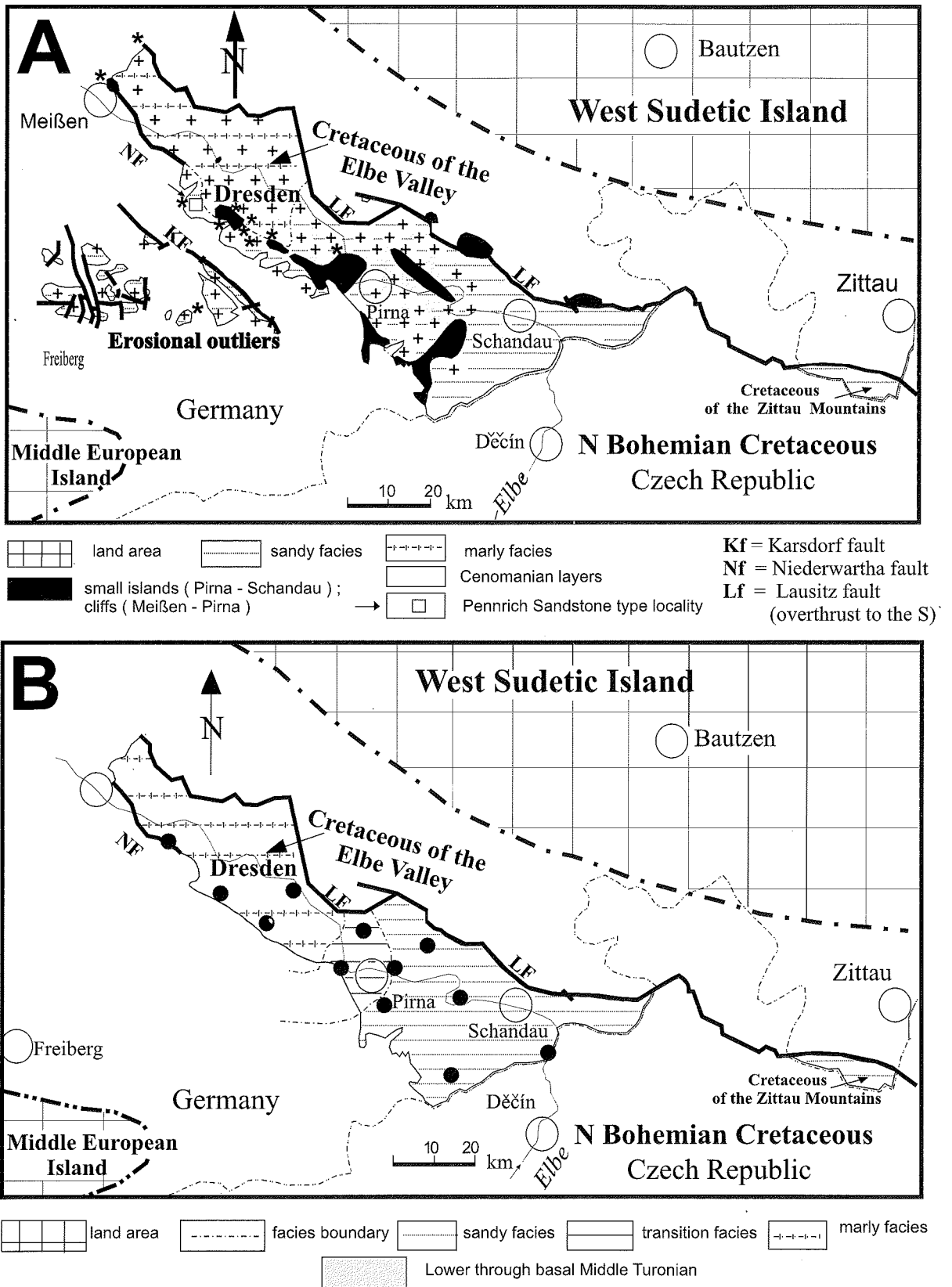


Fig. 2. A. Distribution of the Pennrich Sandstone (+) and of the plenus event (\*) (Upper Cenomanian) in the Elbe Valley Cretaceous including the Zittau Mountains; B. Distribution of the *Mytiloides* events (●) (Lower Turonian) in the Elbe Valley Cretaceous including the Zittau Mountains

Fig. 3. Comparison of the Cenomanian events of Saxony and Lower Saxony including the Münsterland Basin

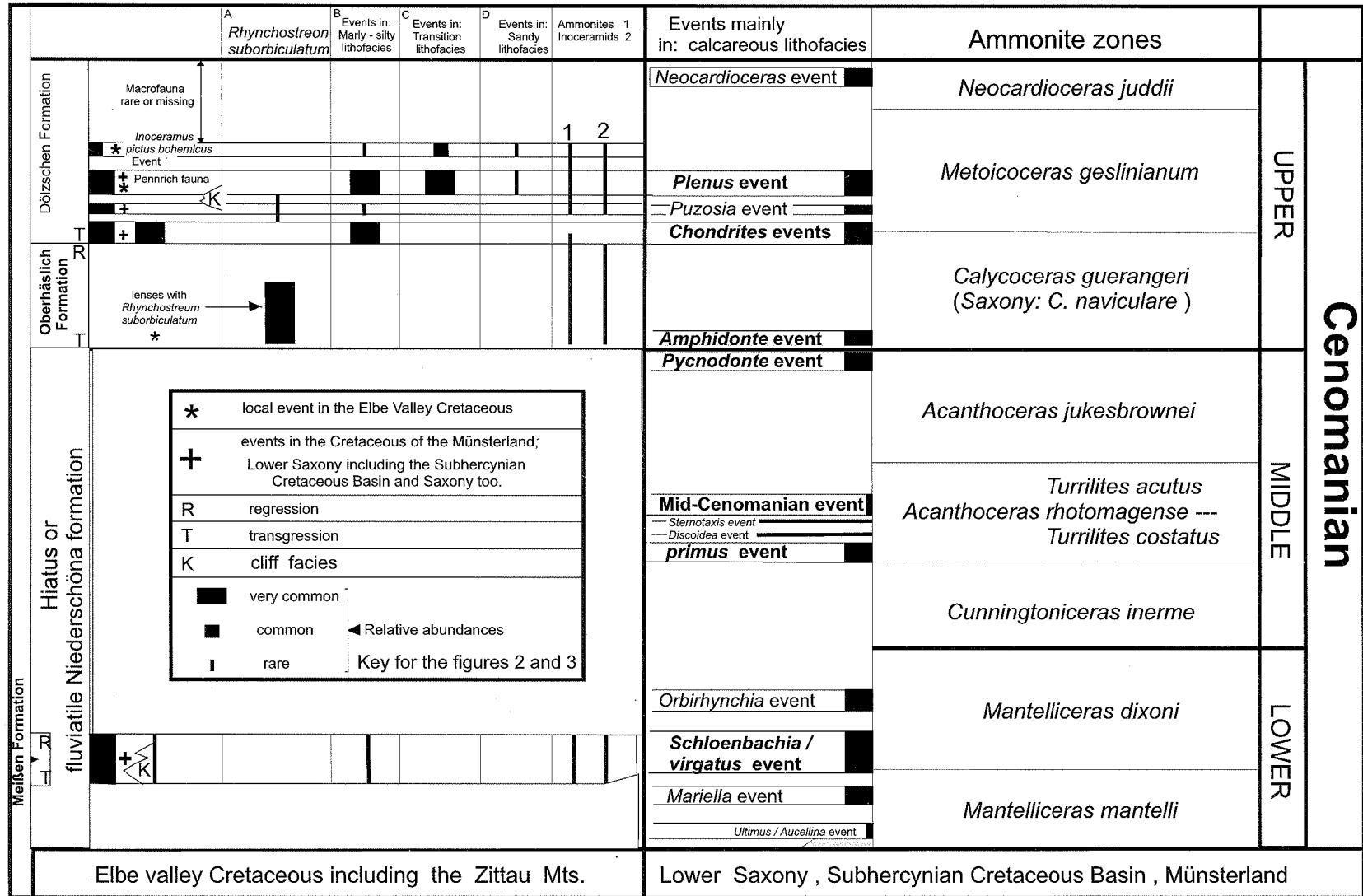


Fig. 4. Comparison of the Turonian and of the Early Coniacian events of Saxony and Lower Saxony including the Münsterland Basin

Events	Marly lithofacies.	Transition lithofacies	Sandy lithofacies.	Rhynchostreon suborbiculatum	ammon.	Inoceramid zonation in Saxony	Events in: calcareous lithofacies	ammonite zones		
eroded							<i>Koeneni</i> event	<i>Peroniceras tricarinatum</i>	LOWER	<b>Coniac.</b>
+						<i>Cremnoceramus crassus</i> (= <i>I. schloenbachi</i> )	<i>Inconstans</i> event <i>Isomicraster</i> event <i>Hannovrensis</i> event	<i>Forresteria petrocoriensis</i>		
+	+					<i>Cremnoceramus deformis erectus</i> (= <i>rotundatus</i> sensu TRÖGER)	<i>Erectus</i> (= <i>rotundatus</i> ) ev. <i>Cremnoceramus waitersdorfensis</i> ev.	<i>Prionocyclus germari</i>		
+						<i>Mytiloides scupini</i>	<i>Didymotis</i> events			
						<i>M. labiatoidiformis</i> <i>Mytiloides incertus</i> <i>Inoceramus costellatus</i> (= ? <i>Inoceramus perplexus</i> )	<i>Mytiloides incertus</i> event <i>Hyphantoceras</i> event	<i>Subprionocyclus neptuni</i>	UPPER	
+						<i>Inoceramus costellatus pietzschii</i> <i>I. lamarcki stuemckei</i> <i>I. inaequivalvis</i>	<i>Costellatus/plana</i> ev.			
*	Rhynchonellid event 2					<i>Inoceramus lamarcki</i>	<i>Lamarcki</i> events <i>Lamarcki cuvierii</i> event	<i>Collignoniceramus woolgari</i>	MIDDLE	
*	Rhynchonellid event 1					<i>Inoceramus apicalis</i> <i>Inoceramus cuvierii</i>	<i>Hercynicus</i> event (L)			
+						<i>Mytiloides hercynicus</i> <i>Mytiloides subhercynicus</i>		<i>Mammites nodosoides</i>	LOWER	
+						<i>Mytiloides labiatus</i> <i>Mytiloides mytiloides</i>	<i>Mytiloides</i> events			
						<i>Mytiloides kosmatti</i> <i>Mytiloides mytiloides</i>				
+						<i>Mytiloides hattini</i>	<i>Hattini</i> event (L)	<i>Watinoceras coloradoense</i>		
Elbe Valley Cretaceous (Saxony) including the Zittau Montains							Lower Saxony , Subhercynian Basin ,Münsterland			

through Santonian). These sediments represent nearshore Cretaceous deposits at the southern margin of the West Sudetic Island. North of the West Sudetic Island, NW of Görlitz, there is a westward prolongation of the North Sudetic Upper Cretaceous (Cenomanian through Santonian of Silesia, Poland). These Upper Cretaceous strata are not discussed in this paper.

All these Upper Cretaceous strata are nearshore sequences which show marked facies changes from coarse-grained sandstones, to siltstones and calcareous siltstones (so-called Pläner), and then to marls and limestones. These facies changes were caused mainly by sea-level changes (TRÖGER & VOIGT 1995).

#### UPPER CRETACEOUS EVENTS IN SAXONY

Eustato-events, ecoevents, tectoevents, major facies changes and the Cenomanian/Turonian Boundary event were all observed in the Upper Cretaceous of Saxony (Cenomanian through Lower Coniacian). The tephro-events are missing.

##### Cenomanian Events (Text-figs 2, 3A)

The comparison presented herein between the events of NW Germany and those of Saxony is based particularly on papers by ERNST & *al.* (1983), KAPLAN & SCHMID (1983), KAPLAN (1998a), LEHMANN (1999) and NIEBUHR & *al.* (1999) (Text-fig. 3). The Lower and Middle Cenomanian substages are characterized mainly by hiatuses or by the fluvial Niederschöna Formation. The presence of ichnofossils in the uppermost parts (possibly basal Upper Cenomanian) of the Niederschöna Formation show the influence of marine incursions. The first transgression, from the NW, took place in the Early Cenomanian *Mantelliceras dixonii* Zone. The transgression reached the region of Meißen in the NW part of the Elbe Valley lineamental zone. Early Cenomanian marine strata are missing in other parts of the Elbe Valley. The Lower Cenomanian Meißen Formation consists mainly of red coloured fossiliferous conglomerates (so-called Red Conglomerates of Meißen Zscheila), fossiliferous glauconitic limestones and green sandstones. The rich cliff facies fauna, especially in Meißen Zscheila, yields corals, sponges, brachiopods, bivalves (oysters, rudists, spondylids, pectenids) and echinoids (see PRESCHER & TRÖGER 1989). Inoceramid bivalves (groups of *Inoceramus crippsi* MANTELL and *Inoceramus virgatus* SCHLÜTER) and ammonites are rare. The latter are represented by *Scaphites obliquus* J. SOWERBY, *Schloenbachia costata* SHARPE, *Schloenbachia subtuberculata* SHARPE and *Turritites scheuchzerianus* BOSC. The transgression was followed by a regression. The Meißen

Formation correlates with the *Schloenbachia/virgatus* eustatoevent of NW Germany

Uplifting and tilting of fault-blocks in the Palaeozoic and partly Proterozoic basement interrupted the Early Cenomanian transgression. Consequently no marine influences are seen in the uppermost Lower and Middle Cenomanian strata in the Elbe Valley. This tectoevent can partly be correlated with the mid-Cenomanian eustatoevent of NW Germany.

The main transgression connecting the Cenomanian of NW Germany and Bohemia through the Elbe Valley lineamental zone took place in the early Late Cenomanian. The basal Upper Cenomanian Oberhäslich Formation contains lenses and layers with the large exogyrine oyster *Rhynchostreon suborbiculatum* (LAMARCK). This species is very common in the Upper Cenomanian of the Tethyan Realm, northern Bohemia and the Elbe Valley. This ecoevent was caused by warm currents flowing from the SE. The event is restricted to the Upper Cenomanian of the Elbe Valley lineamental zone and northern Bohemia. The oyster events of NW Germany, which are characterised by concentrations of small oysters (*Pycnodonte*, *Amphidonte*), are absent from Saxony.

The majority of the NW German latest Cenomanian events can be recognised in the Dölzschen Formation of the Elbe Valley and its erosional outliers. A regression that is particularly well documented around the island chains (see Text-fig. 2 A) took place early in the *Metoicoceras gestlinianum* Zone in Saxony. It was followed by another transgression. This corresponds well to the event series known from NW Germany. The sea-level changes were accompanied by distinct facies changes. A marly to silty facies characterises the NW part of the Elbe Valley, between Meißen and Heidenau (SE of Dresden). This facies is surrounded by a transitional facies, consisting of alternations of calcareous siltstones and fine-grained sandstones. A sandy facies is found in the erosional outliers and SE of Pirna. All the islands between Meißen, Dresden and Pirna were submerged. There are numerous cliffs and small islands with a typical bio- and lithofacies in the lowest parts of the *Metoicoceras gestlinianum* Zone. Events that are well known from NW Germany, such as the *Chondrites*, *Puzosia* and *plenus* events, are clearly recorded in the marly to silty facies in the NW part of the Elbe Valley. *Praeactinocamax plenus* (BLAINVILLE) is very rare and occurs mainly in the vicinity of cliffs and small islands (Text-fig. 2A).

*Praeactinocamax plenus* also occurs rarely in a cold water fauna, called the 'Pennrich Fauna' (HÄNTZSCHEL 1933; UHLIG 1941). The type locality of the 'Pennrich Fauna' is an abandoned quarry at Dresden-Pennrich (Text-fig. 2). This fauna is composed mainly of serpulids,

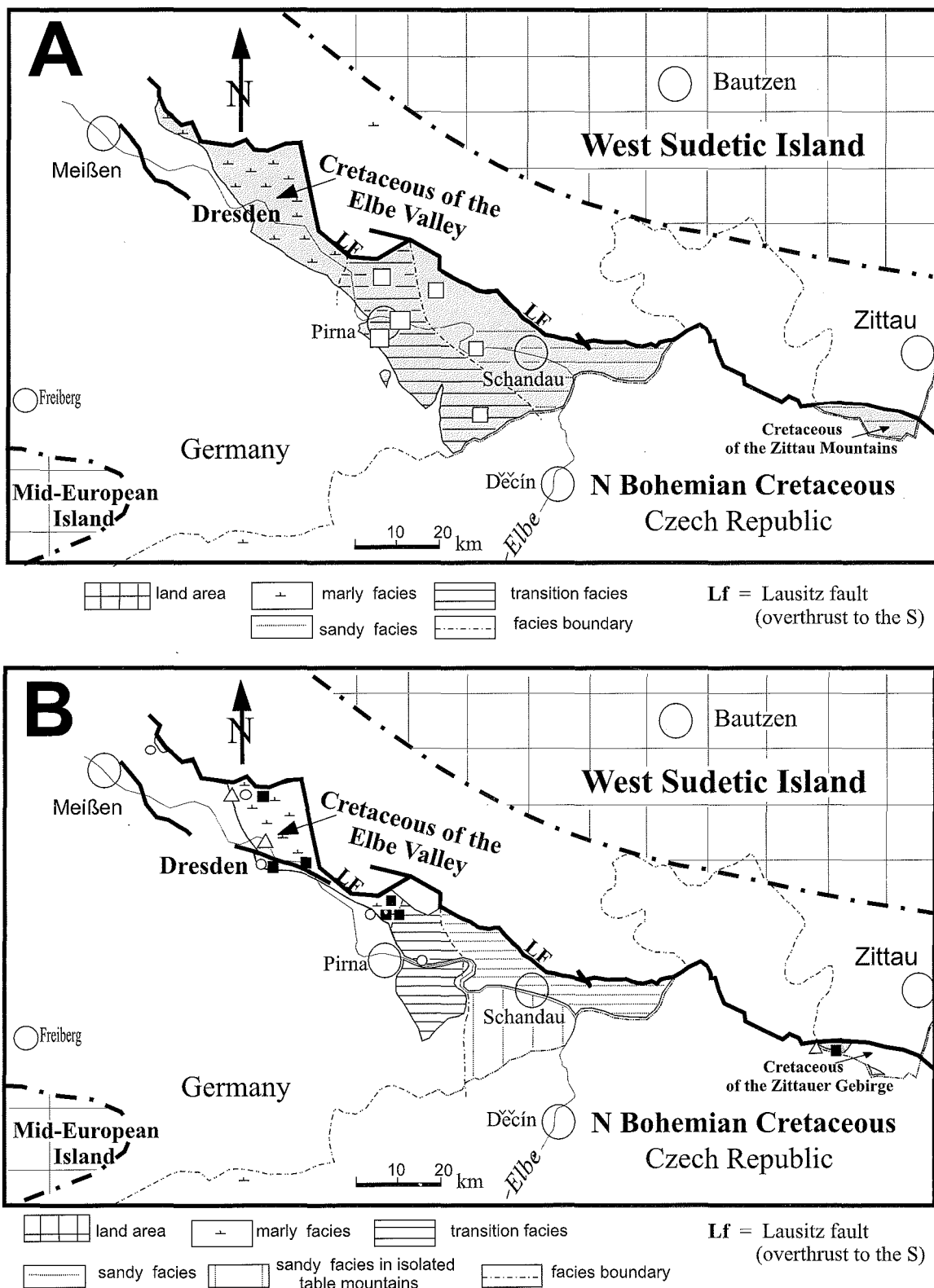


Fig. 5. A. Distribution of the local rhychonellid event (□) (Middle Turonian) in the Elbe Valley Cretaceous including the Zittau Mountains; B. Distribution of the *Didymotis* event (Δ), *Hyphantoceras* event (○) (Upper Turonian) and of the *Waltersdorfensis* through *erectus* events (■) in the Elbe Valley Cretaceous including the Zittau Mountains

brachiopods and bivalves, the dominant species being *Glomerula gordialis* (SCHLOTHEIM), *Hepteria septemsulcata* (RÖMER), *Entolium membranaceum* (NILSSON), *Lima (Limea) granulata* (NILSSON), *Neitheia (Neithella) notabilis* (MÜNSTER), and small oysters belonging to the genera *Pycnodonte* and *Amphidonte*. With the exception of the cliff facies the 'Pennrich Fauna' is widely distributed in the Elbe Valley (see Text-fig. 2A), but it is also known, from the same stratigraphical and facies position, from the Regensburg area, Czech Republic and Poland (Sudetic Cretaceous Area according to HÄNTZSCHEL 1933). It is similar to the Late Cenomanian fauna described by JEFFERIES (1962) from the higher part of the Plenus Marls of southern England.

The local *Inoceramus bohemicus* event is located above the Pennrich event. This event is seen mainly in the marly/silty and transitional facies and only rarely in the sandy facies. Its type locality is a quarry near Hartha (Tharandter Wald erosional outlier).

The latest Cenomanian *Neocardioceras juddii* event has not been recognised in Saxony. The extreme rarity of fossils in the uppermost Cenomanian and lowermost Turonian strata in the Elbe Valley, and the higher content of pyrite in the marls and calcareous siltstones (in the so-called *plenus* Pläner) beneath the first occurrence of *Mytiloides hattini* (ELDER), suggest a correspondence of this part of the succession to the anoxic event at the Cenomanian/Turonian boundary.

#### Turonian events (Text-figs 2B, 4 and 5C, D)

In Text-fig. 4 the most important Turonian events of NW Germany (ERNST & al. 1983; KAPLAN & SCHMID 1983; LEHMANN 1999; NIEBUHR & al. 1999) are compared with all the Turonian events observed in the Elbe Valley, including the Upper Cretaceous of the Zittau Mountains.

Three main facies types can be distinguished in the Turonian of the Elbe Valley (SEIFERT 1955; TRÖGER 1969). The marly-silty facies is situated in the NW part of the Elbe Valley between Meißen, Dresden and Pirna. The Elbsandsteingebirge in the SE are characterised mainly by blocky sandstones. The transitional facies, with horizontal and vertical facies changes, is developed between the marly-silty and sandy facies. The facies belts were displaced to the south during the Early and Middle Turonian (compare Text-figs 2B and 5C). The connection between the marly-silty facies and the NW German-Polish Basin was situated NW of Meißen, but subsequently eroded. All the Early and Late Turonian events of NW Germany are represented in the Elbe Valley, but some of the events are largely restricted to the marly-silty lithofacies, e.g. the Early Turonian *Mytiloides hattini* event, the Late Turonian

*Hyphantoceras* event (including the *M. incertus* event) and the terminal Turonian *Didymotis* events (Text-fig. 5D). In contrast, the Early Turonian *Mytiloides labiatus* events are of widespread occurrence and are well represented in all the facies types (see Text-fig. 2B), with the exception of the sandy facies in the Zittau Mountains. Four horizons with common *Rhynchostreon suborbiculatum* (LAMARCK) testify to the presence of warm currents flowing from the SE to the NW in the latest Early Turonian, as well as in the Middle and Late Turonian (see Text-fig. 4).

Rare specimens of *Inoceramus cuvieri* SOWERBY, *Inoceramus apicalis* WOODS, *Inoceramus lamarcki* PARKINSON and *Inoceramus lamarcki stuemcke* HEINZ were found in the Middle Turonian. A precise correlation with the series of four *lamarcki/cuvieri* events of ERNST & al. (1983) is not possible. Two horizons with very common rhynchonellid brachiopods were observed in the Middle Turonian transitional and sandy facies (Text-figs 4, 5C), in the area between Pirna and Bad Schandau. The type locality of the rhynchonellid event 1 is situated in the former clay pit Pirna Zehista, in the basal part of the Lower Green Sandstone. The rhynchonellids are accompanied by rare *Inoceramus apicalis* WOODS. Rhynchonellid event 2 is restricted to Sandstone b with *Inoceramus lamarcki stuemcke* HEINZ and was observed in boreholes between Königstein, Wehlen and Lohmen.

#### Basal Coniacian events (Text-figs 4 and 5D)

The youngest preserved Cretaceous strata in the Elbe Valley and the Zittau Mountains are of early Early Coniacian age. Middle Coniacian through Santonian strata are preserved in northern Bohemia.

The topmost Turonian *Cremnoceramus waltersdorfensis* event and the basal Coniacian *C. deformis erectus* event characterize the Turonian/Coniacian boundary interval in the marly-silty facies (see TRÖGER & WEJDA 1997, 1998). The *C. waltersdorfensis* event is also known from the sandy facies of the Sonnenberg quarry in the village of Waltersdorf, in the Zittau Mountains.

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