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# Late Valanginian calcareous nannofossils from central Europe and their biogeographic significance

By  
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With 7 Text-Figures and 1 Plate

## KURZFASSUNG

Aus dem tiefen Ober-Valangin (Zone des *Prodichotomites hollwedensis*) von Zentralpolen wird kalkiges Nannoplankton beschrieben. Die Nannofloren zeigen deutliche Beziehungen zu Assoziationen aus NW Deutschland und der Nordsee und haben somit ein boreales Gepräge. Bemerkenswert ist das Fehlen tethyalen Arten, da es bei den gleichzeitig auftretenden Ammoniten starke Einflüsse von Gattungen tethyalen Herkunfts gibt. Das Vorkommen borealer Nannofloren in Polen belegt eindrucksvoll die von verschiedenen Autoren (KEMPER,

RAWSON & THIEULOY 1982; MUTTERLOSE 1992a) beschriebene weiträumige Transgression im tiefen Ober-Valangin. Im Rahmen dieser Transgression gelangten einerseits tethyale Elemente in das boreale Reich, andererseits konnten boreale Nannofloren zumindest bis Polen vorstoßen. *Micrantholithus speetonensis*, eine Nannofossilart, die bisher nur aus dem Unter-Valangin bekannt war, wird erstmalig aus dem Ober-Valangin abgebildet.

## ABSTRACT

Calcareous nannofossils are described from the lower Upper Valanginian (*Prodichotomites hollwedensis* ammonite zone) of Central Poland. The flora shows close similarities to associations found throughout NW Europe and the North Sea, and is thus thought to have Boreal affinities. The absence of Tethyan nannofossils is remarkable, though the ammonites show strong influxes of Tethyan genera. The presence of

Boreal nannofloras in Poland clearly indicates that the widespread early Late Valanginian transgression of various authors (KEMPER, RAWSON & THIEULOY 1982; MUTTERLOSE 1992a) was evident here. *Micrantholithus speetonensis*, a nannofossil species, hitherto only known from the Early Valanginian, is documented for the first time from the Late Valanginian.

## 1. INTRODUCTION AND OBJECTIVES

The marine Lower Cretaceous sediments of central Europe occur at a boundary between two different floral and faunal realms: the Tethys in the south and the Boreal Realm in the north. Within the Boreal Realm continuous Valanginian sections are known from NW Germany only. In NE England (Speeton, Lincolnshire, Norfolk) strata of Valanginian age are extremely condensed and are characterised by several hiatuses (RAWSON et al. 1978).

In Valanginian and Hauterivian times the Carpathian seaway linked the Tethyan and the Boreal Realms via Poland. This marine passage enabled an exchange of marine floras and faunas (MUTTERLOSE 1992a). The migration patterns were mainly controlled by biologic, climatic and palaeoceanographic factors. Valanginian sediments of central Poland thus play a major role in the understanding of migration patterns/directions. Furthermore this area is important for biostratigraphic correlation between Tethyan and Boreal sediments.

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In Central Poland, strata of Valanginian age are exposed in the Wawal section which has been studied in detail recently by KUTEK et al. (1989). The Wawal section was measured and sampled by the author in August 1991. Subsequently, the calcareous nannofossil assemblages of this section have been compared to assemblages of the same age from NW Germany. One objective of this study was to observe the nannofloral similarities and differences between Poland and the Tethyan/Boreal Realms. A second objective was to assess the control of migration patterns by climatic variations and/or sea level changes. Finally, the distribution patterns of ammonites and calcareous nannofossils were compared: this clearly has implications for the use of each group in delimiting faunal/floral realms and in inter-realm biostratigraphic correlation.

Samples from the Wawal section in Poland were compared to Valanginian material from NW Germany. The Hollwede and Twiehausen sections described by MUTTERLOSE (1992b) are thought to contain sediments of similar age to those sampled in Poland.

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## 2. METHODS

Simple smear-slide preparations were examined under a Zeiss polarising microscope. The abundance of calcareous nannofossils in the material is variable, but in general low: comprising anywhere from 0% to 10% of the rock. For each sample at least 300 specimens or all specimens in at least 200 fields of view were counted, using a magnification of 1250x. The abundances of each coccolith species were tabulated on the range chart by giving counts for each species/sample.

Preservation is indicated as follows: G (good), M (moderate), P (poor). Taxa considered in this study are listed in the appendix. Most bibliographic references for these taxa are given in PERCH-NIELSEN (1985); any not included therein are given in the references. In the captions LM, POL and TL denote light photomicrograph, cross-polarized light and plain transmitted light.

## 3. SECTIONS STUDIED

Material from three sections of early Late Valanginian age have been examined for their calcareous nannofossil content (Fig. 1).

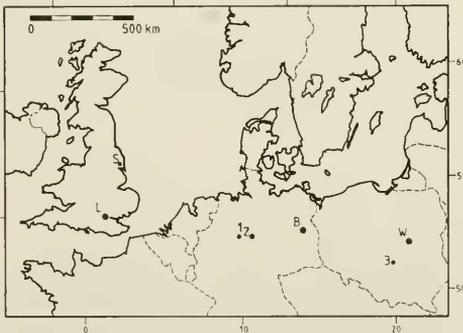


Fig. 1: Location of studied sections. 1 = Hollwede, 2 = Twiehausen, 3 = Wawal. B = Berlin, L = London, S = Speeton, W = Warszawa.

### Wawal (Central Poland)

This clay pit, which is still mined, is located east of Wawal, about 10 kilometres southeast of Tomaszow Mazowiecki (Central Poland). Strata dip slightly towards the south and southwest, mining progresses towards the southwest. The old

STAGES	Belemnite zones NW Europe	Biostratigraphic units	Ammonite zones NW-Europe	Ammonite zones Tethys	
VALANGINIAN	UPPER	Asnerien beds	<i>Elenicerus paucinodum</i>	<i>Neocomites (T) cutlifficus</i>	
		Arnoldien beds	<i>Dicostella tuberculata</i>		
		Acroteuthis acret	Dichotomites beds	<i>Prodichotomoides ivanovi</i>	<i>Humantoceras trinodosum</i>
				<i>Dichotomites bidichotomoides</i>	
				<i>Dichotomites triptychoides</i>	<i>Sauvoniceras verrucosum</i>
	LOWER	Acroteuthis kemperi	Polyptychites beds	<i>Prodichotomites hollwedensis</i>	
				<i>Polyptychites sphaeroidalis</i>	<i>Thurmannicerus campyloctonus</i>
		Platylenticeras beds	<i>Polyptychites clarkes</i>		
			<i>Polyptychites multicostatus</i>		
			<i>Polyptychites pavlowi</i>	<i>Thurmannicerus petronisicus</i>	
		<i>Platylenticeras involutum</i>	<i>Platylenticeras heteropleurum</i>		
		<i>Platylenticeras robustum</i>	<i>Th. atopeta</i>		

Fig. 2: Correlation chart of the Tethyan and NW German zonation of the Valanginian. Stippled field shows the interval studied. The zonation has been compiled from numerous sources (see text).

part of the pit, where strata of Early Valanginian age were exposed, has been filled in with gravel. In August 1991 about 6-8 m of clay and siltstone of early Late Valanginian age (*Prodichotomites hollwedensis* ammonite zone; KUTEK et al. 1989) were exposed. The lithology, the biostratigraphy and the position of the samples are shown in Fig. 3. Twelve samples were examined through the section: an additional four samples were supplied by KUTEK and MARCINOWSKI.

Hollwede (NW Germany; TK 25 Lemförde, Nr. 3516, R: 34 65 950, H: 58 07 500)

Mining in this pit, which is located about 80 km west of Hannover, was abandoned some twenty years ago. The section was measured in 1990 by the author. The sediments consist of about 7 m of silty clays, which are of early Late Valanginian age (*Prodichotomites hollwedensis* ammonite zone). Seven samples were studied. MUTTERLOSE (1992b) gives a detailed description of the lithology, the position of the the samples and a list of the macrofauna.

Twiehausen (NW Germany; TK 25 Rahden, Nr. 3517, R: 34 67 080, H: 58 07 400)

Situated about 75 km west of Hannover this pit, which is still mined, exposes about 16 m of rhythmically bedded dark clays and sideritic nodules. The rich ammonite fauna (which includes Tethyan and Boreal genera) shows that the succession belongs to the *Prodichotomites hollwedensis* zone (early Late Valanginian). Only eight samples out of 21 yielded calcareous nannofossils. These samples are derived from the lower part of the section (beds 81–85). For further details see MUTTERLOSE (1992b).

## 4. BIO- AND LITHOSTRATIGRAPHY

The Valanginian stage in NW Germany comprises 200 m of dark clays. No significant biostratigraphic hiatus has been resolved and the succession is thought to be complete. A detailed zonation exists for ammonites (e. g. KEMPER 1978, RAWSON 1983), belemnites (MUTTERLOSE 1990), foraminifera (BARTENSTEIN & BETTENSTAEDT 1962) and nannofossils (MUTTERLOSE 1992c). A comprehensive overview has been given recently by MUTTERLOSE (1992a). Based on the ammonite genera *Platylenticeras* and *Polyptychites* the Lower Valanginian can be subdivided into the lower *Platylenticeras* beds and the upper *Polyptychites* beds. The Late Valanginian is characterized by the onset of the boreal ammonite genera *Prodichotomites* and *Dichotomites*. The early Late Valanginian *Prodichotomites hollwedensis* ammonite zone shows strong influxes of Tethyan ammonites (KEMPER et al. 1981).

The Lower Valanginian in Central Poland is represented by the *Platylenticeras* beds and the *Polyptychites* beds. The presence of these ammonite genera indicate strong links with NW Europe. The Late Valanginian comprises 30–50 m of clays and siltstones (MAREK & RACZYNSKA 1979, RACZYNSKA 1979, MAREK 1983). Whilst boreal ammonite genera (*Dichotomites*, *Prodichotomites*) are common, Tethyan genera (*Saynoceras*, *Leopoldia*, *Astieria*, *Neocomites*, *Bochianites*) occur at certain levels. KUTEK et al. (1989), who described the ammonite sequence of the Wawal section, clearly demonstrated the mass occurrence of Tethyan ammonite genera (*Saynoceras*, *Valanginites*, *Olcostephanus*, *Sarasinella*, *Neocomites*, *Neoboploceras*, *Karakaschiceras*, *Bochianites*) in the *Prodichotomites hollwedensis* ammonite zone. These ammonite genera are associated with boreal *Prodichotomites*.

## 5. DISTRIBUTION OF FLORAS

### 5.1 WAWAL (POLAND)

Twelve samples from the early Late Valanginian of the Wawal section of Central Poland have been examined. Fig. 4 gives the ranges of the species encountered. Both diversity and abundance of calcareous nannofossils are low, though the calcium carbonate contents varies between 5–15%. The majority of samples showed only moderate preservation, this being especially true for the central part of the section. In addition, poor preservation was found to correspond to impoverished assemblages. Apart from samples 99/4 and 99/5 more than 200 fields of view have been examined without counting more 200 specimens. A higher diversity, which correlates with a higher abundance, has been observed in samples 99/4 and 99/5 only. It is remarkable that the calcium carbonate content (8.5%) of these samples is only average. Shells of bivalves, which are scattered throughout the section, mainly contribute to the calcium carbonate content.

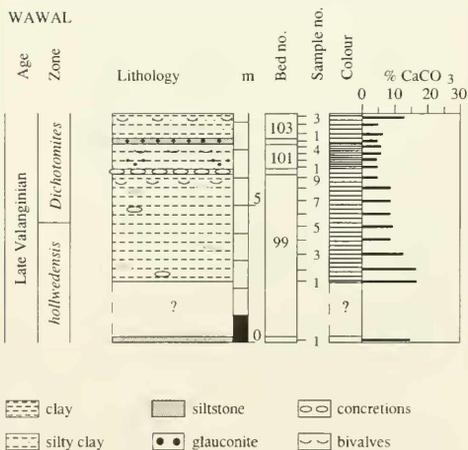


Fig. 3: Bio- and lithostratigraphy of the Wawal section (Central Poland). Biozonation after KUTEK et al. (1989). The question mark indicates an interval of about two metres which was not exposed in 1991.

Late Valanginian		Age	WAWAL
<i>hollwedensis</i>	<i>Dichotomites</i>	Ammonite Zone	
98/1	99/5	103/3	Sample no.
200	200	200	Fields of view
4	24	11	Number of species
30	303	54	Individuals
M	G	M	Preservation
1	26	2	<i>Biscutum constans</i>
1	6	1	<i>Cyclagelospaera margerelii</i>
1	180	3	<i>Watznaueria barnesae</i>
27	40	37	<i>Watznaueria ovata</i>
1	4	1	<i>Axopodorhabdus dietzmannii</i>
1	1	1	<i>Crucibiscutum salebrosum</i>
1	20	1	<i>Diazomatolithus lehmannii</i>
1	16	4	<i>Lithraphidites carniolensis</i>
1	2	1	<i>Micrantholithus obtusus</i>
1	2	4	<i>Micrantholithus speetonensis</i>
1	7	1	<i>Rotelapillus laffitei</i>
1	33	6	<i>Vekshinella stradneri</i> ssp. 1
1	17	1	<i>Zygodiscus diplogranmus</i>
1	1	1	<i>Discorhabdus rotatorius</i>
1	4	1	<i>Cretarhabdus crenulatus</i>
1	1	1	<i>Cretarhabdus striatus</i>
1	3	1	<i>Cretarhabdus</i> sp.
1	1	1	<i>Diadorhombus rectus</i>
1	2	1	<i>Grantarhabdus meddii</i>
1	1	1	<i>Microstaurus chistiatus</i>
1	1	1	<i>Maniviella pennatoidea</i>
1	1	1	<i>Nannoconus</i> sp.
1	12	1	<i>Rhagodiscus asper</i>
1	15	1	<i>Sollasites horticus</i>
1	1	1	<i>Speetonia colligata</i>
1	1	1	<i>Tegumentum striatum</i>
1	2	1	<i>Vekshinella quadriarculla</i>
1	2	1	<i>Vekshinella stradneri</i> ssp. 2
1	7	1	<i>Zygodiscus erectus</i>
1	22	1	<i>Cretarhabdus conicus</i>
1	2	1	<i>Nannoconus elongatus</i>
1	11	4	<i>Vekshinella stradneri</i> ssp. 3
1	4	1	<i>Vekshinella stradneri</i> ssp. 4
1	1	1	<i>Cretarhabdus angustiforatus</i>
1	1	1	<i>Watznaueria britannica</i>
98/1	99/5	103/3	Sample no.
14.2	8.5	13	% CaCO <sub>3</sub>
			Lithology
			Age

Fig. 4: Distribution of nannofossils in the Wawal section, Central Poland. Preservation: G = good, M = moderate, P = poor. For the exact position of the samples and the explanation of the lithology compare Fig. 3.

Late Valanginian		Age	HOLLWEDE
<i>hollwedensis</i>		Ammonite Zone	
98/1	103/1	103/1	Sample no.
200	200	200	Fields of view
17	8	8	Number of species
133	35	35	Individuals
M	M	M	Preservation
1	1	1	<i>Assipetra infracretacea</i>
1	1	1	<i>Axopodorhabdus dietzmannii</i>
1	49	1	<i>Biscutum constans</i>
1	1	1	<i>Cretarhabdus striatus</i>
1	1	1	<i>Cretarhabdus</i> sp.
1	1	1	<i>Crucibiscutum salebrosum</i>
1	6	6	<i>Cyclagelospaera margerelii</i>
1	20	20	<i>Diazomatolithus lehmannii</i>
1	1	1	<i>Grantarhabdus meddii</i>
1	1	1	<i>Lithraphidites carniolensis</i>
1	1	1	<i>Micrantholithus obtusus</i>
1	4	4	<i>Rhagodiscus asper</i>
1	5	1	<i>Rotelapillus laffitei</i>
1	1	1	<i>Vekshinella stradneri</i> ssp. 3
1	23	23	<i>Watznaueria barnesae</i>
1	126	1	<i>Watznaueria ovata</i>
1	5	5	<i>Zygodiscus erectus</i>
1	5	5	<i>Cretarhabdus crenulatus</i>
1	15	6	<i>Vekshinella stradneri</i> ssp. 1
1	6	6	<i>Watznaueria britannica</i>
1	1	1	<i>Discorhabdus rotatorius</i>
1	1	1	<i>Cretarhabdus conicus</i>
1	2	2	<i>Corollithion geometricum</i>
1	1	1	<i>Hemipodorhabdus gorkae</i>
1	1	1	<i>Micrantholithus</i> sp.
1	1	1	<i>Nannoconus</i> sp.
1	5	5	<i>Sollasites horticus</i>
1	10	10	<i>Tegumentum striatum</i>
1	14	14	<i>Vekshinella quadriarculla</i>
1	5	5	<i>Zygodiscus diplogranmus</i>
1	1	1	<i>Micrantholithus hoschulzii</i>
1	1	1	<i>Microstaurus chistiatus</i>
1	1	1	<i>Nannoconus globulus</i>
1	1	1	<i>Nannoconus kamptneri</i>
1	1	1	<i>Scapholithus fossilis</i>
1	1	1	<i>Tranolithus gabalus</i>
98/1	103/1	103/1	Sample no.
2.5	3.5	3.5	% CaCO <sub>3</sub>
			Lithology
			Age

Fig. 5: Distribution of nannofossils in the Hollwede section, NW Germany. Preservation: G = good, M = moderate. For the explanation of the lithology compare Fig. 3. The exact position of the samples and the lithology are given in MUTTERLOSE (1992b).

The species listed in Fig. 4 are typical Valanginian to earliest Hauterivian assemblages. Most common is *Watznaueria barnesae*, an environmentally tolerant and cosmopolitan species. In samples with more than 100 specimens the relative abundance of *W. barnesae* varies from 39% (sample 99/4) to 93% (sample 99/5). Other common species include *Biscutum constans*, *Cyclagelosphaera margerelii*, *Zygodiscus diplogrammus*, *Zygodiscus erectus*, *Diazomatolithus lehmani*, *Lithraphidites carniolensis*, *Vekshinella stradneri* and *Rhagodiscus asper*. All these are cosmopolitan species, which are present throughout the Early Cretaceous.

Biostratigraphic important index species include *Speetonia colligata*, *Tegumentum striatum* and *Crucicellipsis cwilliceri*. *S. colligata* ranges from the Berriasian to the Hauterivian, *T. striatum* from the Late Valanginian to the Early Hauterivian. Rare specimens of *C. cwilliceri* (Berriasian to Late Hauterivian) have been observed in an additional sample (above bed 103), not listed in the range chart. All three species have been described from the Boreal Realm, the Tethys and the Indian Ocean.

Strictly Tethyan species are rare or absent: *Calicalathina oblongata*, *Conusphaera mexicana* and *Tubodiscus* spp. have not been observed. The genus *Nannoconus*, abundant in coeval strata of the Tethyan Realm, is extremely rare. Species of Boreal affinities, however, do occur. *Crucibiscutum salebrosum* and *Micrantholithus speetonensis* are present in sample 99/1. *C. salebrosum*, abundant in the Late Valanginian to Early Hauterivian, is restricted to two high latitude belts; this species has not been described from the Tethys so far (MUTTERLOSE 1992c). It seems likely, that this species is a cold water morphotype. *M. speetonensis* has been documented only from the Valanginian of the North Sea and Speeton, NE England (PERCH-NIELSEN 1979). More precise biostratigraphic data are not available for the North Sea. In Speeton *M. speetonensis* is

restricted to beds D4A and D4B, which are of Early Valanginian age (CRUX 1989). However, at Speeton only 5.5 m of Lower Valanginian clays are present and the Upper Valanginian is missing. According to the present data the range of *M. speetonensis* has to be extended at least into the early Late Valanginian. In conclusion, the nannofloras of the early Late Valanginian of the Wawal section have a Boreal character, Tethyan elements being largely absent.

5.2 HOLLWEDE (NW GERMANY)

All seven samples studied, yield a nannoflora of low diversity and low abundance (Fig. 5). The preservation is moderate, the calcium carbonate content varies from 1% to 8%. *Watznaueria barnesae* is again the dominant species. In samples with more than 100 specimens the relative abundance of *W. barnesae* varies from 60% (sample 97/2) to 82% (sample 95/2). *Cyclagelosphaera margerelii*, *Biscutum constans*, *Diazomatolithus lehmani*, *Zygodiscus erectus*, *Micrantholithus obtusus*, *Crucibiscutum salebrosum*, *Watznaueria britannica*, *Tegumentum striatum* and *Vekshinella stradneri* are present throughout the sequence. Tethyan species are once again missing, a few specimens of *Nannoconus* spp. have been observed. Though *M. speetonensis* is missing, the assemblages show Boreal affinities.

5.3 TWIEHAUSEN (NW GERMANY)

About twenty samples from this section were studied, eight of these yield an extremely impoverished nannoflora (Fig. 6). The assemblages are of low abundance and low diversity, only seven species were observed. These assemblages correspond to a low calcium carbonate content of 1%. No Tethyan elements were observed.

TWIEHAUSEN																			
Age	Ammonite Zone	Sample no.	Fields of view	Number of species	Individuals	Preservation	<i>Rhagodiscus asper</i>	<i>Tegumentum striatum</i>	<i>Watznaueria barnesae</i>	<i>Watznaueria ovata</i>	<i>Diazomatolithus lehmani</i>	<i>Crucibiscutum conicus</i>	<i>Lithraphidites carniolensis</i>	<i>Vekshinella stradneri</i>	Sample no.	% CaCO <sub>3</sub>	Lithology	Age	
Late Valanginian	<i>hollwedensis</i>	89/2	200	.	.	.	.	.	.	.	.	.	.	.	89/2	0.7	-----	Late Valanginian	
		89/1	200	.	.	.	.	.	.	.	.	.	.	.	89/1	0.7	-----		
		85/4	200	5	43	M	15	.	25	.	.	.	1	1	1	85/4	0.8		-----
		85/3	200	.	.	.	.	.	.	.	.	.	.	.	.	85/3	0.8		-----
		85/2	53	2	2	P	.	.	1	.	1	.	.	.	.	85/2	0.7		-----
		85/1	200	.	.	.	.	.	.	.	.	.	.	.	.	85/1	0.8		-----
		83/1	200	1	5	M	.	.	5	.	.	.	.	.	.	83/1	0.8		-----
		81/1	200	4	5	M	1	1	2	1	.	.	.	.	.	81/1	1		-----

Fig. 6: Distribution of nannofossils in the Twiehausen section, NW Germany. Preservation: M = moderate, P = poor. For the explanation of the lithology compare figure 3. The exact position of the samples and the lithology are given in MUTTERLOSE (1992b).

## 6. PALAEOBIOGEOGRAPHY AND PROVINCIALISM

Calcareous nannofossils show a provincialism during the Berriasian-Barremian interval of the Early Cretaceous, similar to that exhibited by micro- and macrofaunas (foraminifera, ammonites, belemnites, bivalves, brachiopods). Based on calcareous nannofossils two different floral realms, the Tethys and the Boreal Realm can be recognized. Each of these realms is characterized by different species (MUTTERLOSE 1992c). Tethyan and cosmopolitan species are present in the Tethys, while the Boreal Realm is marked by Boreal, cosmopolitan and Tethyan taxa.

Tethyan species include *Diadorbomus rectus*, *Rucinolithus wisei*, *Conusphaera* spp., *Nannoconus* spp. (except for *N. abundans* and *N. borealis*), *Lithraphidites bollii*, *Calcialathina oblongata*, *Crucellipsis cuvillieri*, *Tubodiscus* spp. These spread out only under suitable ecological conditions into other areas. It seems likely that temperature, sea level changes and the presence of suitable seaways were the main factors controlling the palaeobiogeographic distribution of this group.

Conversely, boreal species include *Sollasites horticus*, *Corolithion silvaradion*, *Kokia* spp., *Sollasites arcuatus*, *Eprolithus antiquus*, *Perissocyclus fletcheri*, *Tegalolithus septentrionalis* and *Micrantholithus speetonensis*. These species are restricted to the Boreal Realm.

Berriasian sediments throughout NW Europe are characterized by a dominance of non-marine strata, reflecting widespread regression. Faunas and floras preserved in rare marine incursions are of purely Boreal provenance, showing close links to those of the Russian Platform (MUTTERLOSE 1992a).

The subsequent Valanginian stage is marked by major palaeoceanographic changes. The earliest Valanginian is characterized by a major transgression and the return of marine conditions over wide areas of NW Europe. In the course of this transgression the Carpathian seaway opened via Poland, allowing an exchange of Boreal and Tethyan floras and faunas. This marine seaway between the Tethyan and Boreal Realms existed throughout the Valanginian (Fig. 7). A further transgression in the early Late Valanginian (*Prodichotomites hollwedensis* zone) expanded this seaway further. Possible shifts in the provenance of the marine floras and faunas in Poland should thus reflect sea level changes. Palaeoclimatic variation may also have influenced provenance: this has yet to be documented in the same detail as sea level changes.

The ammonite fauna of the Wawal section has been described recently in detail by KUTEK et al. (1989). The Lower Valanginian yields rich Tethyan assemblages (*Karakaschicerias* spp.), associated with Boreal (?) *Platylenticeras*. In the basal part of the subsequent Upper Valanginian (the *Prodichotomites hollwedensis* zone) Tethyan ammonites (*Saynoceras*, *Valanginites*, *Olcostephanus*, *Neocomites*, *Karakaschicerias*, *Bochianites*) are found in the same strata as the Boreal ammonite genus *Prodichotomites*. This horizon corresponds to the early Late Valanginian transgression, which is evident over much of Europe: in NW Germany the transgression caused expansion of the Lower Saxony Basin. The early Late Valanginian *Prodichotomites hollwedensis* ammonite zone shows strong influxes of Tethyan ammonites: a first immigration wave of

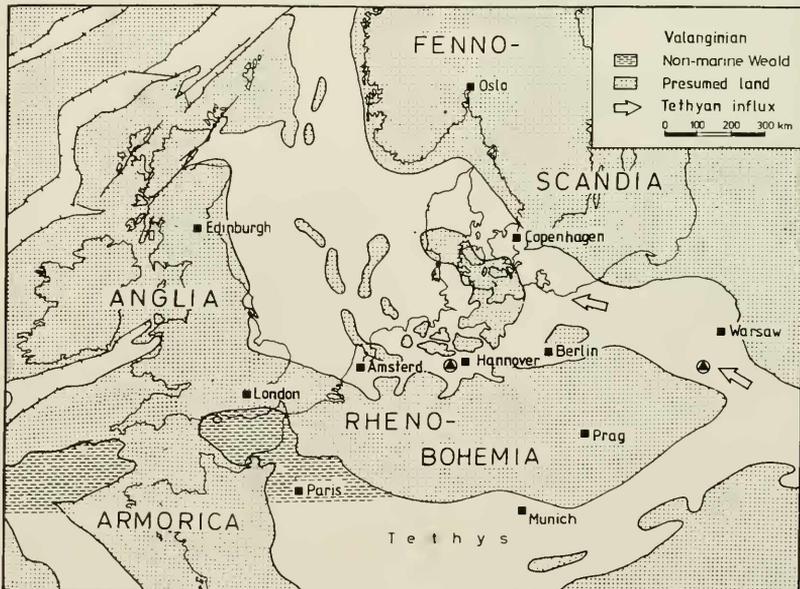


Fig. 7: Palaeogeographic map for the Valanginian of NW Europe. After MUTTERLOSE (1992a).

large sized *Oleostephanus* is followed by a main influx of *Valanginites*, *Bochianites*, *Saynoceras*, *Neohoplaceras* and *Karakaschiceras* (KEMPER et al. 1981, MUTTERLOSE 1992a). The subsequent *Dichotomites* beds are dominated in the Wawal section and in NW Germany by the Boreal ammonite genera *Prodichotomites* and *Dichotomites*.

The nannofossil assemblages of both the *P. hollwedensis* zone and the subsequent *Dichotomites* beds in the Wawal section are of clearly Boreal affinities. Tethyan genera are extremely rare or absent in the *P. hollwedensis* zone. The absence of Tethyan nannofloras in beds with strong influxes of Tethyan ammonites may be explained by the following possibilities:

1. Poor preservation causing the absence of Tethyan nannofossils.
2. Water depth restricting the Tethyan elements to shallow or deep-water settings.
3. Facies control excluding Tethyan nannofossils from the Boreal siliciclastic facies.
4. Nannofossils are ecologically more sensitive than ammonites, restricting the spread of warm-water Tethyan species into the Boreal Realm.

Preservational factors can be excluded for two reasons. Though preservation in general is moderate, the samples with Boreal assemblages do not show evidence of dissolution. Furthermore Tethyan nannoconids, *Conusphaera* spp. and *C. oblongata* are more prone to solution or are solution resistant, due to their wall structure (e. g. THIERSTEIN 1976). Water depth may control the distribution of nannofossils, limiting Tethyan species to shallow or deep water settings. However, *Nannoconus*-rich assemblages have been described from Early Cretaceous sediments of Central Italy, also in sections of palaeodepth up to 1000–2000 m (ARTHUR & PREMOLI-SILVA 1982).

BUSSON & NOEL (1991) suggested that nannoconids preferred clean, clear water, being abundant in limestone and absent or rare in siliclastic layers. This facies control could explain the absence of nannoconids in the siliclastic facies of Poland and NW Germany. This fails to explain the absence of the other Tethyan taxa, which are typical in siliclastic facies.

Furthermore, no nannoconids have been observed in the Early Hauterivian „reef facies“ of the eastern part of NW Germany. This facies consists of shallow water limestones with strong influxes of stenothermal benthic warm water faunas (foraminifera, algae, sponges, corals, bryozoans; MUTTERLOSE 1992a).

A further possibility is that the distribution of calcareous nannofossils is more strongly controlled by climatic factors than in other groups. The evidence for this is outlined below. Strong geological and palaeontological evidence suggest a major transgression for the early Late Valanginian *Prodichotomites hollwedensis* zone. This transgression obviously enabled Boreal nannofossils (*M. speetonensis*, *C. salebrosus*) and ammonites to spread south. Both species have been mentioned from the Valanginian of the southern Carpathians (Romania), where they are associated with Boreal ammonites (MELINTE 1991). Despite the presence of suitable seaways, Tethyan species were not able to make their way to Poland and NW Germany, suggesting these nannofloras to be sensitive to climatic variation.

In the Tethys extremely common in limestones, nannoconids show a slightly different distribution to that of coccoliths. In the Valanginian of the Boreal Realm they are generally rare. They have only been described from the early Late Valanginian (*Prodichotomites hollwedensis* zone) of NW Germany. This short influx of Tethyan nannoconids which is coeval with the influx of Tethyan ammonites in the earliest Late Valanginian, marks a particular immigration horizon (*Nannoconus* spp. A horizon, MUTTERLOSE 1991, 1992c). The rarity of nannoconids in the early Late Valanginian of the Wawal section, which is intermittent in between the Tethys and the Boreal Realm, is surprising. However, nannoconids are always rare in the NW German sections making up to 2% of the assemblage. The rarity of nannoconids in Poland may be explained by the factors quoted above (restricted to deep or shallow settings; facies control; climatic control). Alternatively nannoconids might have used a different migration route (e. g. a shallow sea-way via the Proto Atlantik) to invade the North Sea basin. Presently there are not enough data available to come to final conclusions.

## 7. CONCLUSIONS

The provenance of marine floras and faunas observed in the early Late Valanginian of Central Poland are somehow contradictory. Boreal ammonite populations remained stable even during strong Tethyan influxes. The calcareous nannofossils are, however, of purely Boreal affinities; Tethyan elements being largely absent. The nannofossil assemblages clearly support the idea of a widespread transgression in the

*Prodichotomites hollwedensis* ammonite zone, allowing Boreal species to migrate towards the south. The absence of Tethyan species making their way north via the Polish basins suggests that calcareous nannofossils are extremely sensitive to climatic variations that presumably existed between the Boreal and Tethyan Realms.

## 8. APPENDIX

List of calcareous nanofossils in alphabetical order of generic epithets:

*Asipetra infracretacea* (THIERSTEIN, 1973) ROTH, 1973  
*Axopodorhabdus dietzmanni* (REINHARDT, 1965) WIND & WISE, 1977  
*Biscutum constans* (GORKA, 1957) BLACK, 1967  
*Calicalathina oblongata* (WORSLEY, 1971) THIERSTEIN, 1971  
*Conusphaera* TREJO, 1969  
*Conusphaera mexicana* TREJO, 1969  
*Corollithion geometricum* (GORKA, 1957) MANIVIT, 1971  
*Corollithion silvaradion* FILEWICZ et al. in WISE & WIND, 1977  
*Cretarhabdus* BRAMLETTE & MARTINI, 1964  
*Cretarhabdus angustiforatus* (BLACK, 1971) BUKRY, 1973  
*Cretarhabdus conicus* BRAMLETTE & MARTINI, 1964  
*Cretarhabdus crenulatus* BRAMLETTE & MARTINI, 1964  
*Cretarhabdus striatus* (STRADNER, 1963) BLACK, 1973  
*Crucibiscutum salebrosum* (BLACK, 1971) JAKUBOWSKI, 1986  
*Cruciclipis cuvillieri* (MANIVIT, 1966) THIERSTEIN, 1971  
*Cyclagelosphaera margerelii* NOEL, 1965  
*Diadorhombus rectus* WORSLEY, 1971  
*Diazomatolithus lehmanni* NOEL, 1965  
*Discorhabdus rotatorius* (BUKRY, 1969) THIERSTEIN, 1973  
*Eprolithus antiquus* PERCH-NIELSEN, 1979  
*Grantarhabdus meddii* BLACK, 1971  
*Hemipodorhabdus gorkae* (REINHARDT, 1969) GRUN in GRUN & ALLEMANN, 1975  
*Kokia* PERCH-NIELSEN, 1988  
*Lithraphidites bollii* (THIERSTEIN, 1971) THIERSTEIN, 1973  
*Lithraphidites carniolensis* DEFLANDRE, 1963  
*Manivitella pemmatoidea* (DEFLANDRE in MANIVIT, 1965) THIERSTEIN, 1971  
*Micrantholithus boschulzii* (REINHARDT, 1966) THIERSTEIN, 1971  
*Micrantholithus obtusus* STRADNER, 1963  
*Micrantholithus speetonensis* PERCH-NIELSEN, 1979  
*Microstaurus chiastius* (WORSLEY, 1971) GRUN in GRUN & ALLEMANN, 1975  
*Nannoconus* KAMPTNER, 1931  
*Nannoconus abundans* STRADNER & GRUN, 1973  
*Nannoconus borealis* PERCH-NIELSEN, 1979  
*Nannoconus elongatus* BRÖNNIMANN, 1955

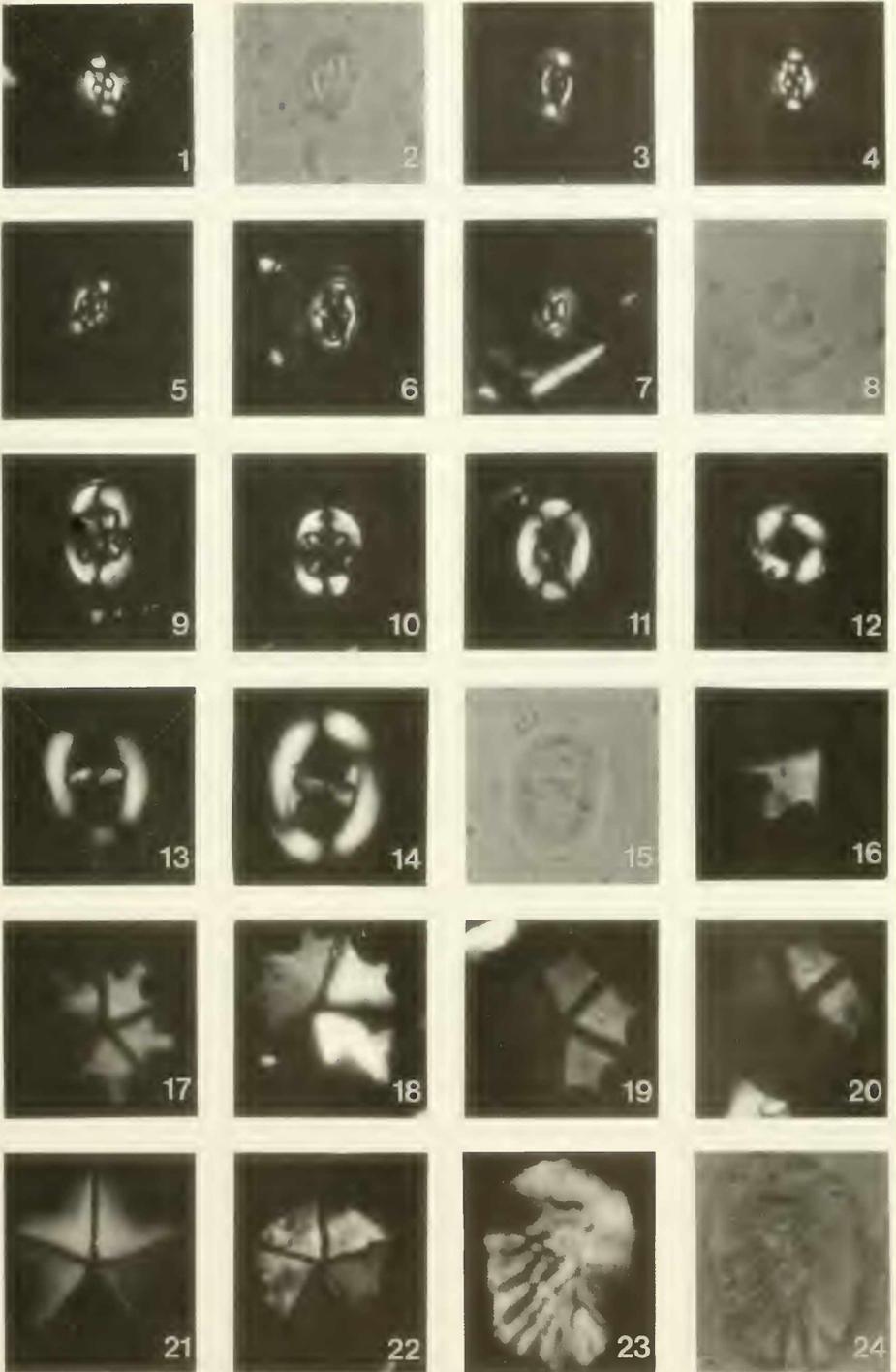
*Nannoconus globulus* BRÖNNIMANN, 1955  
*Nannoconus kamptneri* BRÖNNIMANN, 1955  
*Perisocyclus fletcheri* BLACK, 1971  
*Rhagodiscus asper* (STRADNER, 1963) REINHARDT, 1967  
*Rotellapillus laffittei* (NOEL, 1957) NOEL, 1973  
*Rucinolithus wizei* THIERSTEIN, 1971  
*Scapholithus fossilis* DEFLANDRE in DEFLANDRE & FERT, 1954  
*Sollasites arcuatus* BLACK, 1971  
*Sollasites horticus* (STRADNER et al. in STRADNER & ADAMIKER, 1966) CEPEK & HAY, 1969  
*Speetonia colligata* BLACK, 1971  
*Tegulalithus septentrionalis* (STRADNER, 1963) CRUX, 1986  
*Tegumentum striatum* (BLACK, 1971) TAYLOR, 1978  
*Tranolithus gabalus* STOVER, 1966  
*Tubodiscus* THIERSTEIN, 1973  
*Vekshinella quadricarulla* (NOEL, 1965) ROOD et al., 1971  
*Vekshinella stradneri* ROOD et al., 1971  
*Watznaueria barnesae* (BLACK in BLACK & BARNES, 1959) PERCH-NIELSEN, 1968  
*Watznaueria britannica* (STRADNER, 1963) REINHARDT, 1964  
*Watznaueria ovata* BUKRY, 1969  
*Zygodiscus diplogrammus* (DEFLANDRE in DEFLANDRE & FERT, 1954) BRAMLETTE & MARTINI, 1964  
*Zygodiscus erectus* (DEFLANDRE in DEFLANDRE & FERT, 1954) REINHARDT, 1965

List of ammonites in alphabetical order of generic epithets:

*Bochiantes* LORY, 1898  
*Dichotomites* KOENEN, 1909  
*Karakaschiceras* THIEULOX, 1971  
*Neocomites* UHLIG, 1905  
*Neohoploceras* SPATH, 1939  
*Olcostephanus* NEUMAYR, 1875  
*Platylenticeras* HYATT, 1900  
*Polyptychites* PAVLOW, 1892  
*Prodichotomites* KEMPER, 1971  
*Saynoceras* MUNIER-CHALMAS, 1893  
*Valanginites* KILIAN, 1910

**Plate 1** Photomicrographs from the early Late Valanginian *Prodichotomites hollwedensis* ammonite zone. All figures 3080x. The slides are deposited with the Bayerische Staatssammlung für Paläontologie und historische Geologie, München

- Fig. 1–6 *Crucibiscutum salebrosum* (BLACK, 1971) JAKUBOWSKI, 1986. – (1, 3, 4, 5, 6) POL; (2) TL; (1, 2) Sample Hollwede 101/1/90; (3) Sample Hollwede 99/2/90; (4, 5) Sample Hollwede 103/1/90; (6) Sample Hollwede 99/1/90. Boreal species.
- Fig. 7, 8 *Biscutum constans* (GORKA, 1957) BLACK, 1967. – (7) POL; (8) TL; Sample Hollwede 101/1/90.
- Fig. 9–11 *Tegumentum striatum* (BLACK, 1971) TAYLOR, 1978. – POL; Sample Hollwede 97/2/90.
- Fig. 12 *Diazomatolithus lehmanni* NOEL, 1965. – POL; Sample Hollwede 101/1/90.
- Fig. 13–15 *Speetonia colligata* BLACK, 1971. – (13, 14) POL; (15) TL; Sample Wawal 99/1/91.
- Fig. 16–20 *Micrantholithus speetonensis* PERCH-NIELSEN, 1979. – POL; Sample Wawal 99/1/91. Boreal species.
- Fig. 21 *Micrantholithus obtusus* STRADNER, 1963. – POL; Sample Hollwede 97/2/90.
- Fig. 22 *Micrantholithus boschulzii* (REINHARDT, 1966) THIERSTEIN, 1971. – POL; Sample Wawal 99/1/91.
- Fig. 23, 24 *Nannoconus kamptneri* BRÖNNIMANN, 1955. – (23) POL; (24) TL; Sample Hollwede 101/1/90.



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