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DIACHRONISM OF THE *DEFLANDREA OEBISFELDENSIS* ACME TOWARDS THE SOUTHERN MARGIN OF THE BELGIAN BASIN

by

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ABSTRACT

The biostratigraphic significance of the *Deflandrea oebisfeldensis* acme is lost near the southern margin of the North Sea Basin where it is recorded in higher dinoflagellate zones within the lowermost Ypresian deposits. A tentative explanation of the diachronism of the *D. oebisfeldensis* acme is based on certain changes of palaeogeography and palaeohydrography of the North Sea Basin during the Early Ypresian.

RESUME

La signification biostratigraphique de l'acme de *D. oebisfeldensis* se perd vers les limites méridionales du Bassin de la Mer du Nord, où on l'observe plus haut dans les zones à dinoflagellés des dépôts de base de l'Yprésien. Nous tentons d'expliquer le diachronisme de l'acme de *D. oebisfeldensis* par certains changements paléogéographiques et paléohydrographiques du Bassin de la Mer du Nord au cours de l'Yprésien inférieur.

KEY WORDS

Ypresian, Dinoflagellates, biostratigraphy, Belgium.

MOTS CLE

Yprésien, dinoflagellates, biostratigraphie, Belgique.

1. THE POSITION OF THE *DEFLANDREA OEBISFELDENIS* ACME IN THE WETZELIELLACEAE ZONES

The biostratigraphical significance of the relatively high frequencies of *Deflandrea oebisfeldensis* and related forms observed in the Late Paleocene deposits in the North Sea Basin indicated as the *D. oebisfeldensis* acme Zone, has to be restricted.

The position of the *D. oebisfeldensis* acme in the Wetzeliellaceae Zones (figure 2) can be deduced from information found in Knox and Harland (1979), Heilmann-Clausen (1985), Nielsen *et al.* (1986), Heilmann-Clausen and Costa (1989) and my own published work ; information about the presence of *D. oebisfeldensis* in Lessines, St. Omer and Château de la Bruyère is not yet published. In the central North Sea Basin (Forties field, Well 39/2-1) in East Anglia (Harwich), in Denmark (Store Baelt borehole), and in North Germany (Wursterheide borehole), one encounters the *D. oebisfeldensis* acme in the upper part of the *Apectodinium hyperacanthum* Zone. The species attains a frequency between 5 and 7 % in Knokke from -288 m up to -284 m (Member X) and of about 3 % in Kallo at -377 m ; this occurs a few meters below the level in

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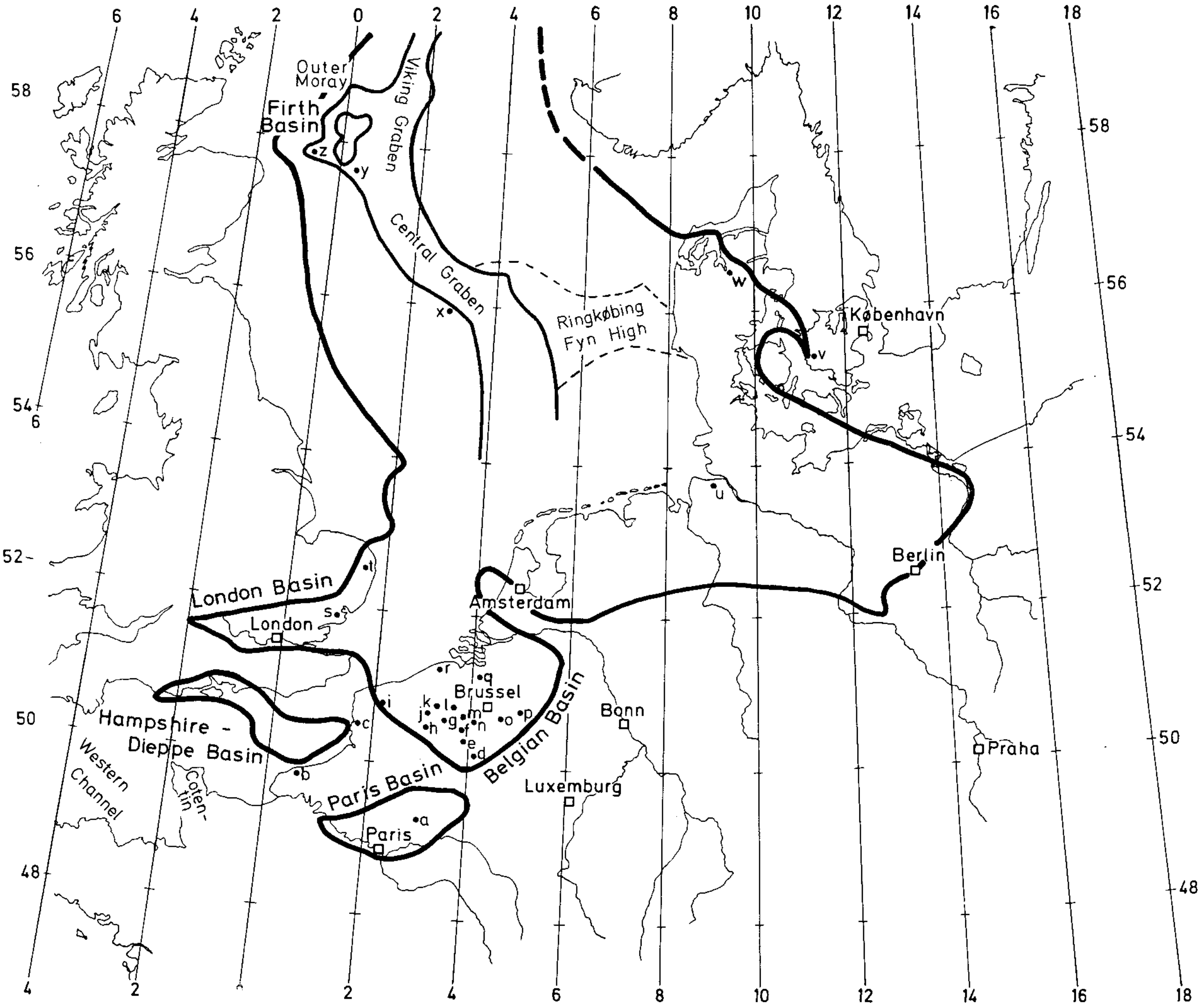

Figure 1. Location of the commented boreholes and outcrops.
bold line : approximate limit of areas with Early Eocene deposits.

Localities in alphabetical order

Château de la Bruyère	c	Marke	j	Saint Maur	g
Cuise-la-motte	a	Mons-Ghlin	f	Saint Omer	i
Erquelinnes	d	Mont Héribu	e	Steenhuize-Wijnhuize	l
Forties Field	y	Orchies	d	Store Baelt	v
Harwich	s	Ormesby	t	Varengeville	b
Kallo	q	Outer Moray-Firth Basin	z	Viborg	w
Knokke	r	Overijse	o	Well 39/2-1	x
Lessines	m	Quenast	n	Wursterheide	u
Linter	p	Ronse-Waaienberghe	k		

which *Wetzeliella lobisca* appears for the first time (at - 282.26 m in Knokke where it was recorded as *W. meckelfeldensis* in Dupuis *et al.* (1990, table 1 and p. 40) and at -374.5 m in Kallo recorded as *W.* aff. *symmetrica* and *W.* aff. *symmetrica* ? in De Coninck (1969, pp. 8, 9 and 21, Pl. IV, figs. 1-8). According to Jolley and Spinner (1989, fig. 3), *W. lobisca* appears already at the base of the *Wetzeliella astra* Zone but its frequency is higher in the upper part of that zone. At Lessines, *D. oebisfeldensis* is relatively frequent in the lowermost level of the deposits resting upon the microdioritic intrusion. Among the accompanying species we regularly note several *Apectodinium* spp. and a few *Phthanoperidinium crenulatum*. One *Wetzeliella astra* was found, indicating that the deposits can be situated in the *W. astra* zone. *P. crenulatum* is probably not as significant for biostratigraphy of the Lower Ypresian as was suggested in De Coninck (1991, fig. 2, p. 291). At St. Omer, northwestern France, *D. oebisfeldensis* attains its highest frequency in company of *W. astra* and *W. lobisca*, thus possibly a little higher in the dinoflagellate zonation. At Que

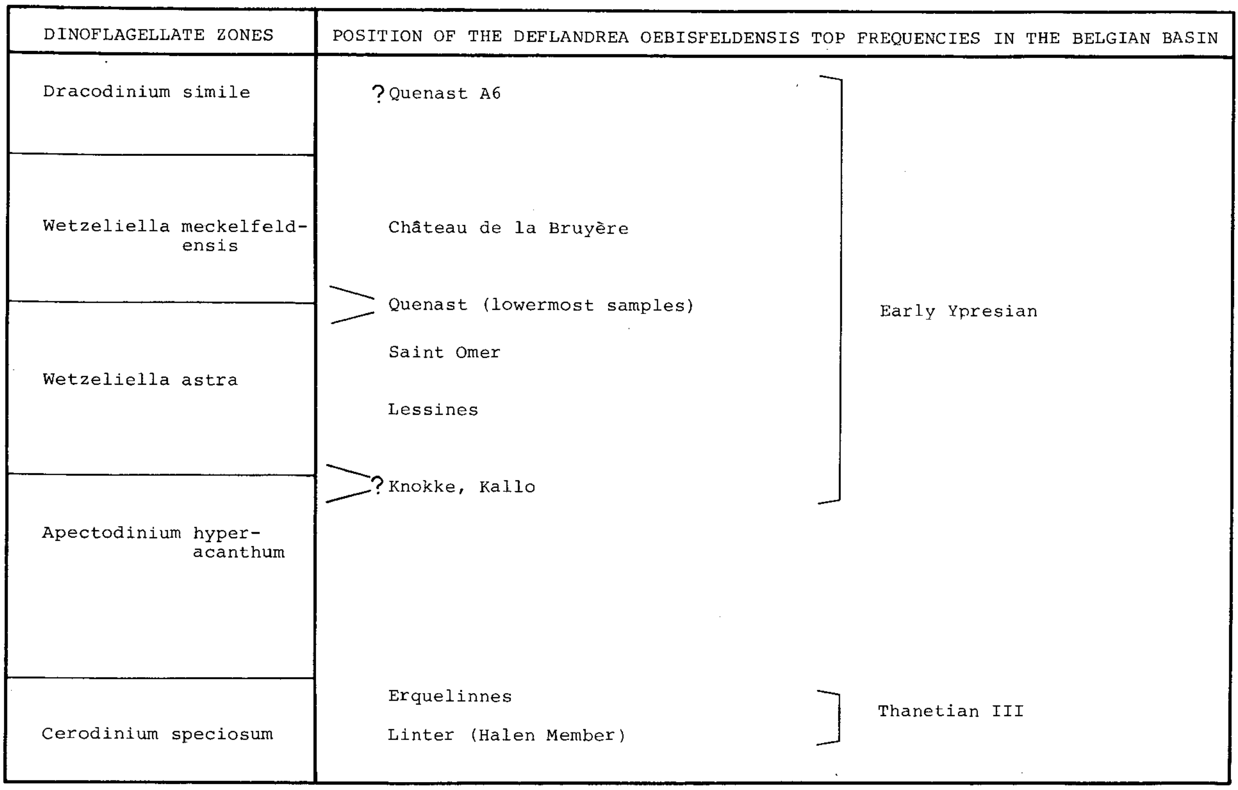

Figure 2. Position of the *Deflandrea oebisfeldensis* top frequencies in the Belgian Basin.

nast, Belgium, relatively high frequencies (up to 6 %) of *D. oebisfeldensis* are observed in the clay matrix from the conglomerate (Quenast A_1 in De Coninck, 1986) found in a cleft in the microdiorite and also in the base of the Ypresian deposits overlying the intrusive rocks. Among the accompanying species, we encounter *W. lobisca* (recorded as *W.* sp. A in De Coninck 1986, pp. 10, 21 and 44), *W. meckelfeldensis* and again *Phthanoperidinium crenulatum*. As the presence of *P. crenulatum* is probably not very relevant, the other species suggest that the acme is situated in the top of the *W. astra* Zone (Quenast A_1) and in the *W. meckelfeldensis* Zone for the deposits directly overlying the microdiorite. Higher in the deposits (Quenast A_6 in De Coninck, 1986) just below the level with some gravel, the species makes up 5% of the assemblage which contains only one specimen of Wetzeliellaceae (*W.* sp. cf. *D. varielongitudum*). The biostratigraphic position of A_6 remains uncertain : it cannot be younger than our *Dracodinium simile* Zone because several significant species from higher zones are missing. Elsewhere, near the border of the Belgian Basin *D. oebisfeldensis* has also been recorded in the *W. meckelfeldensis* Zone, namely in the lowermost Ypresian in the Overijse boring (0.1 %) (De Coninck 1981, table 1), at Mont-Héribu (1%) and at Mons-Glin (1%) (De Coninck *et al.* 1983, table 3), and at Orchies (less than 1%) (De Coninck 1976, p. 18). These percentages are not really acme frequencies and it remains uncertain whether laterally at the same levels higher frequencies occur. Finally, beyond the Belgian Basin, near the northeastern border of the Hampshire-Dieppe Basin, at Château de la Bruyère up to 35 % of *D. oebisfeldensis* are found together wit *W. lunaris* an *W. meckelfeldensis*, i.e. in the *W. meckelfeldensis* Zone. *D. oebisfeldensis* has not been recorded in Ypresian deposits from further in the Hampshire-Dieppe Basin or from the Paris Basin.

2. QUESTIONS ARISING FROM THESE OBSERVATIONS

1. How can we explain the appearance of the acme of *D. oebisfeldensis* and related forms in higher zones within the southern Ypresian deposits of the Belgian Basin and in the adjacent northeastern part of the Hampshire-Dieppe Basin, while in the northern part of the Belgian Basin and further north in the North Sea Basin the acme was already over ?
2. Why is the species never recorded in corresponding deposits in the Paris Basin or in the Hampshire-Dieppe Basin ?
3. Why does *D. oebisfeldensis* disappear ultimately above the *Dracodinium simile* Zone ?

3. TENTATIVE EXPLANATION

At the meeting of the R.C.N.P.S. in September 1991, R. Knox and C. King made some remarks about the conditions in the North Sea Basin during the Early Ypresian. The hypothesis that follows puts forward that certain environmental conditions may have been necessary for the flourishing of *D. oebisfeldensis* and very related forms, and takes into account the remarks and suggestions.

During the time corresponding to the uppermost part of the *Apectodinium hyperacanthum* Zone up to the final *Dracodinium simile* Zone, relatively anoxic water was probably stagnating in the deeper parts of the North Sea Basin. Towards the border of the basin, and also during some regressive phases the sea became shallower and the interface between the anoxic, stagnating bottom water and the surface water gradually was more often disturbed probably by increased tidecurrents reaching the interface. At such depths the phytoplankton (and among them the dinoflagellates) must have suffered repeatedly very stressing conditions of a different kind than those near the watersurface. Certain dinoflagellate species such as the one which generated the cyst *Deflandrea oebisfeldensis*, may have reacted by massive cyst production, when anoxic bottom water was contaminating their environment.

Maybe that such an environmental situation existed already within the Paris Basin and the Belgian Basin earlier in the Late Paleocene. Indeed, *D. oebisfeldensis* was recorded by Gruas-Cavagnetto (1976, p. 14 & 20, pl. 1, fig. 13) in the boring at Cuise-la-Motte, in Thanetian III deposits only. These correspond to the upper part of the *Cerodinium speciosum* Zone. At the time of sedimentation of the Thanetian III deposits, the northern sea had invaded the adjacent part of the Paris Basin and the eastern part of the London Basin (Cavelier, 1987, pp. 263 & 265; Siesser *et al.*, 1987, p. 86 & fig. 6; Gramann & Kochel, 1988, p. 429). In the Belgian Basin, the species and related forms are encountered in a corresponding stratigraphic position. In the uppermost level of the Bois Gilles Formation (top of the *C. speciosum* Zone) at Erquelinnes, the frequency of '*Deflandrea* sp. cf. *D. speciosa* - *D. oebisfeldensis*' attains 3 % (De Coninck *et al.*, 1981, Table 2). In the Halen Member (*C. speciosa* Zone) at Linter, 1.3 % was recorded in the boring at -21.50 m, where *C. speciosum* becomes very frequent (12.5 %) (Vlerick, 1987, table 1). No information is available about an eventual presence of *D. oebisfeldensis* in the same stratigraphic position in the southeast of England. After the Thanetian III episode, a regressive phase took place in the North Sea Basin. According to Knox (1989, p. 26), the lowering of the sea level (top-Lista event) left only a restricted marine area and sedimentation became limited to the Central Graben in which the Forties Sands were deposited. These Forties Sands correspond to the lower part of the *Apectodinium hyperacanthum* Zone (Knox & Harland, 1979, pp. 464 & 465). Apparently fully marine conditions remained confined to the central North Sea Basin (Viking Graben, Outer Moray Firth Basin and Central Graben) (Knox *et al.*, 1981, p. 276; Gramann & Kochel, 1988, p. 430) during most of the time of the *A. hyperacanthum* Zone. In this central part, the tide or convection currents were probably only rarely able to reach stagnating lower watermasses, while in the very shallow remaining parts of the North Sea Basin such a waterstratification could not develop. Therefore, the particular conditions which we suppose to be required for the production of *D. oebisfeldensis*, were generally lacking during that time in the whole North Sea Basin. This can explain the low frequencies of *D. oebisfeldensis* in the central deposits and its absence in the Woolwich Beds and equivalent deposits in the border region of the North Sea Basin. A hiatus probably coinciding with the NP9/NP10 Zones boundary separates the Woolwich Beds from the oldest representative of the London Clay transgression, the Hales Clay Member (Knox, 1990, pp. 59-62 ; Knox, this volume). This member is well developed in the area of Norfolk (Ormesby boring) and corresponds to the Knudeklint Member which forms the lower part of the Danish Fur Formation and which corresponds to the negative ash-series-deposits in that area. It is in the upper levels of this oldest representative of the London Clay transgression that *D. oebisfeldensis* reappears, becoming sometimes frequent again in the assemblages. The species was indeed recorded in the upper part of the negative series in the Viborg 1 borehole by Heilmann-Clausen (1985, p. 28) and also in the upper part of the equivalent subunit E2 in the Outer Moray-Firth Basin in the central North Sea (Knox *et al.,* 1981, p. 278). Its increase in frequency possibly indicates that, already during the earliest phase of the London Clay transgression, water stratification had developed again and that some shallowing of the sea towards the end of this first transgressive-regressive phase can be held responsible for the increased disturbance of the interface between anoxic, stagnant bottom waters and surface waters. Acme frequencies are further observed in the succeeding ash bearing Harwich Member in the north-eastern London Basin, in the positive series in Denmark (Viborg 1 borehole and Store Baelt borehole) and in northern Germany (Wursterheide borehole), and also in the lowermost Member X in the Knokke borehole (Belgium) between -288 and -284 m. Later occurrences have already been given (see introduction).

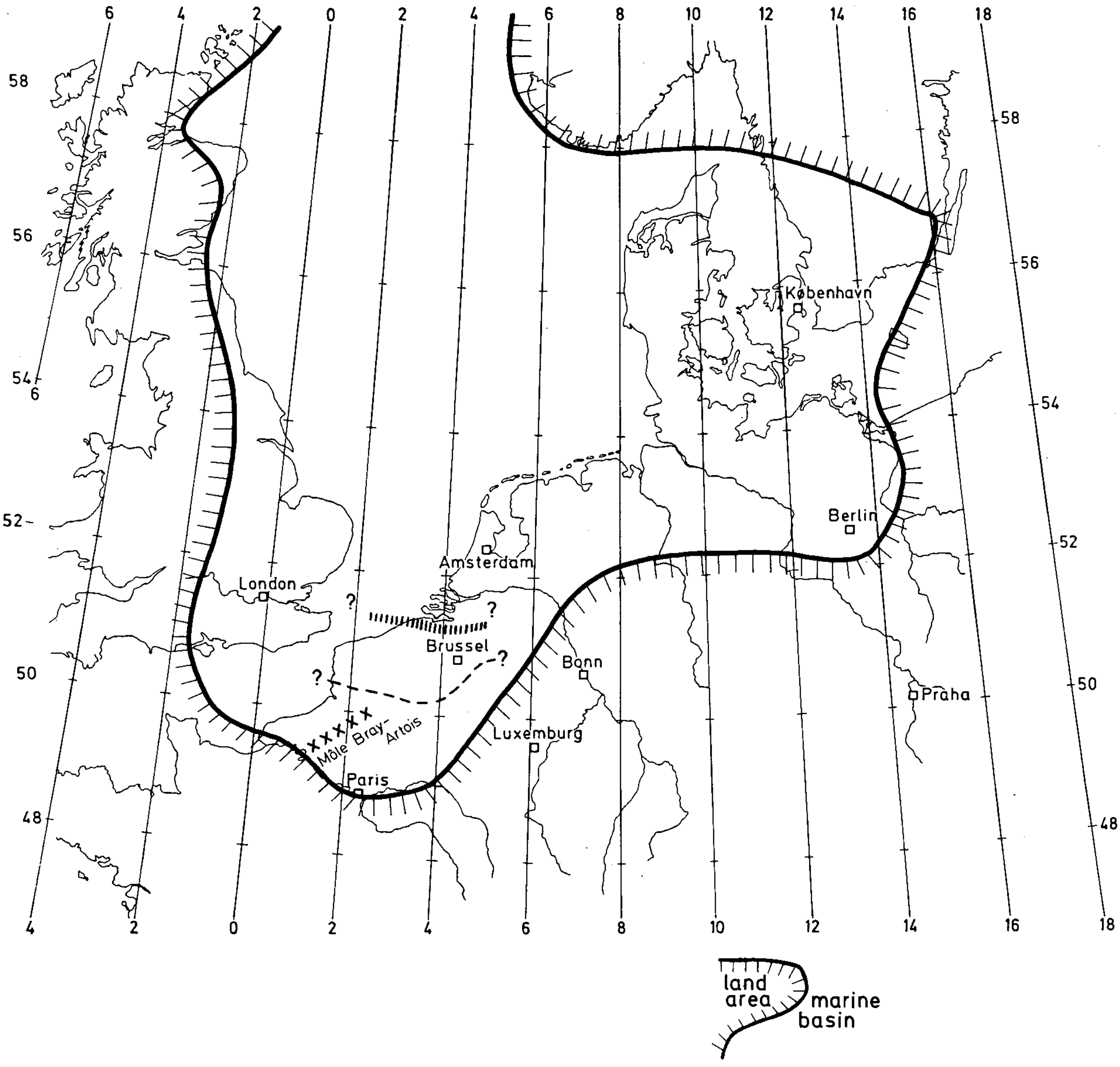

Figure 3. Southern limit of stagnant, anoxic bottom waters during sedimentation of :

1. The uppermost part of the *Apectodinium hyperacanthum* Zone. IIIIIII
2. *Wetzeliella meckelfedensis* Zone. Up to the *Dracodinium simile* Zone. - - - -

The Ypresian transgression was a major one as was the Late Paleocene one during which the Thanet Beds (London Basin) and the Sables de Bracheux (Paris Basin) etc. were deposited. During sedimentation of the *W. astra* up to the *D. simile* Zone, the transgression was certainly important enough to allow water stratification to progress further south in the Belgian Basin where near the margin it was frequently disturbed leading to *D. oebisfeldensis* production (figure 3). The anoxic bottom water could probably not advance further into the Paris Basin because of the Bray-Artois Môle (Dupuis *et al.* 1984, pp. 53-56), behind which very shallow sea and several areas with brackish conditions occurred. Apart from its extreme northeastern region, the Hampshire-Dieppe Basin too became very shallow in its eastern part preventing a further penetration of anoxic waters. Indeed, extremely shallow conditions are suggested there by increased frequencies of *A. homomorphum* and *A. parvum* in the levels above the deposits containing *W. meckelfeldensis* (Chateauneuf & Gruas-Cavagnetto, 1978, p. 75). Locally in the Varengeville Formation, *W. meckelfeldensis* itself is very frequent (up to 22 %) (Gruas & Bignot, 1985, p. 120). Such high percentages too are indicative of shallow, near-shore conditions. The absence of anoxic waters in the areas discussed would hence explain why *D. oebisfeldensis* is never recorded in the Lower Ypresian from the Paris and Hampshire-Dieppe Basin.

Why does *D. oebisfeldensis* become very rare near the end of sedimentation of our *Dracodinium simile* Zone in the shallow areas near the margin of Belgian Basin, where the species was still more or less flourishing ? The answer is probably to be found in a major hydrographic change affecting especially the southern North Sea Basin. The Ypresian transgression attained then its maximal extension in the Paris Basin and in the Hampshire-Dieppe Basin. Already near the beginning of the sedimentation of our *Eatonicysta ursulae* Zone, when calcareous benthonic and planktonic foraminiferids appear in the Belgian Basin, a connection was created between the Anglo-Paris-Belgian Basin and the Western Channel. Boillot and Le Calvez (1961, p. 29) indicate that such a connection must already have existed for a certain time in the Ypresian. A regular water flow from the Western Channel, the Loire atlantique and the Aquitaine Basin may have penetrated the Anglo-Paris-Belgian Basin by the Cotentin region. Indeed, Bignot, Hommeril and Larsonneur (1968, p. 411) think that parts of the old surface of the Col du Cotentin, which is situated at an altitude of 35 to 40 m, may have been formed by marine abrasion during Cretaceous and Eocene times. The steady flow of oceanic waters into the southern, extended North Sea Basin started probably together with the sedimentation of our *E. ursulae* Zone, at the base of which the sudden arrival of many calcareous benthonic and also planctonic foraminiferids (= base of BF IV association zone in Willems & Moorkens, 1991, p. 238, pl. 3; Event I1 in King, 1991, p. 352, fig. 4) reveals a major change in the hydrography of the basin. Other arguments in favour of a supply of oceanic water from the Western Channel are found higher in the *D. varielongitudum* Zone *sensu* Costa and Downie (1976). In this zone corresponding with the transition between our *E. ursulae* Zone and *D. varielongitudum* Zone *sensu* De Coninck (1981, p. 292), accumulations of *Nummulites planulatus* are found in the Sands of Mons-en-Pévèle or in their lateral equivalents, the Roubaix Clay and the Sands of Forest from the southwestern and southeastern Belgian Basin, for instance at Steenhuize-Wijnhuize and Ronse-Waaienberghe (Vanhove & De Coninck, 1992, pp. 356-357) and at Marke (Steurbaut, 1988, p. 343). This species arrived a first time in the Paris-Belgium Basin through the penetration of southern oceanic water into the basin (Gramann, 1988, pp. 413-414). In the Hampshire Basin, it appears only from the time of deposition of Fisher Bed IV of the Bracklesham Group, i.e. significantly later than in the Paris and Belgian Basin. The counter clockwise hydrographic system of the southwards enlarged North Sea Basin certainly caused this difference and was also responsible for the contrast between the "boreal" sharks found in the London Clay division B up to E and the "Tethyan" species in the partly equivalent Roubaix Clay and Mons-en-Pévèle Sands from the Belgian Basin (Ward, 1990, unpublished information). *Turritella* beds are also observed in the Roubaix Clay and lateral equivalents. These concentrations result from rather strong currents near the bottom. Reworked species of organic walled phytoplancton from the *W. meckelfeldensis - Charlesdowniea crassoramosa* Zone have been recorded in the nummulite and *Turritella* bearing Mons-en-Pévèle Sands at Steenhuize-Wijnhuize and at Ronse-Waaienberghe (Vanhove & De Coninck, 1992, pp. 358 and 359). Very probably they indicate local erosion of the seabottom in the eastern shallow area of the Hampshire-Dieppe Basin and further in the direction of the Belgian Basin. Together with the flow of southern oceanic water northeast, sediment particles and among them microfossils brought in suspension again, could very well have settled after arriving in the southern Belgian Basin.

The connection of the North Sea Basin with the Western Channel changed the whole hydrography in the Belgian Basin, where the particular conditions favouring the production of *D. oebisfeldensis* cysts disappeared. Maybe in the western part of the London Basin, the change was less pronounced and did not yet affect the water stratification. *D. oebisfeldensis* is indeed recorded at Enborne in the upper part of the Stiff Clays (= London Clay Division B) (Davey *et al.*, 1966, p. 233 and Table I) corresponding to our *E. ursulae* Zone (De Coninck 1991, fig. 4).

As a conclusion, we can say that the *D. oebisfeldensis* acme Zone lost some of its biostratigraphic importance in the southern marginal areas of the North Sea Basin. Instead, it may have acquired more significance for the environmental history of the Early Ypresian in the southern North Sea Basin.

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PLATE 1

All figures : *Deflandrea oebisfeldensis* Alberti 1959.

magnification : 500 X

Figure 1. Linter boring 105W345, - 21.5 m, slide 2.

Figure 2. Linter boring 105W345, - 21.5 m, slide 2.

Figure 3. Linter boring 105W345, - 21.5 m, slide 2.

Figure 4. Erquelinnes Sablière du Bois-Gilles, M7, slide 2.

Figure 5. Knokke boring 11E138, - 284.1 à - 284.2 m, slide 1.

Figure 6. Knokke boring 11E138, - 284.1 à - 284.2 m, slide 1.

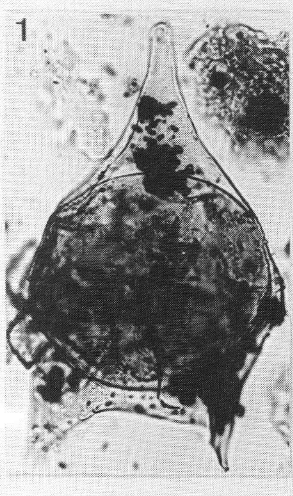
Figure 7. Erquelinnes Sablière du Bois-Gilles, M7, slide 5.

Figure 8. Erquelinnes Sablière du Bois-Gilles, M7, slide 1.

Figure 9. Knokke boring 11E138, - 284.1 à - 284.2m, slide 1.

Figure 10. Knokke boring 11E138, -284.1 à -284.2m, slide 1.

Figure 11. Kallo boring 27E148, -377m, slide 9.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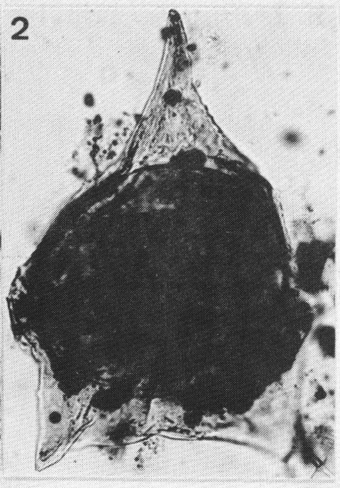
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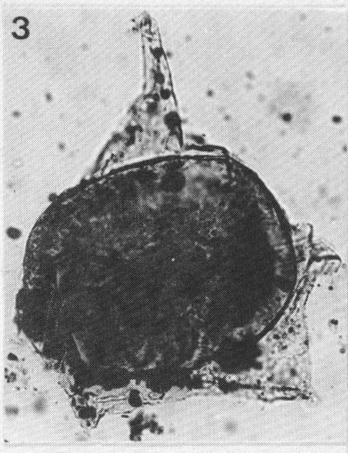
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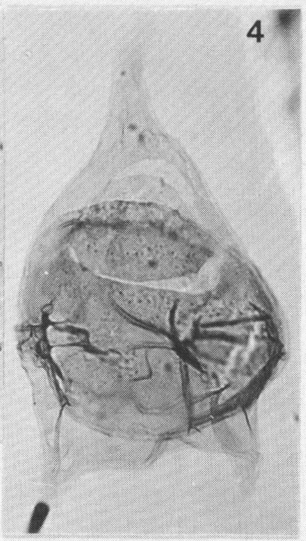
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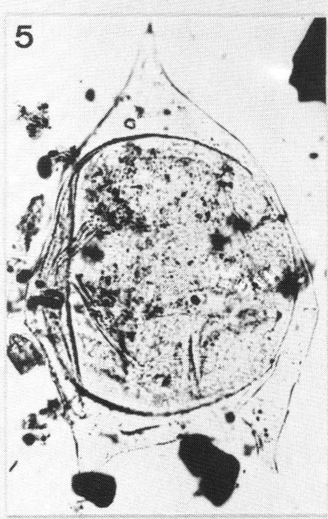
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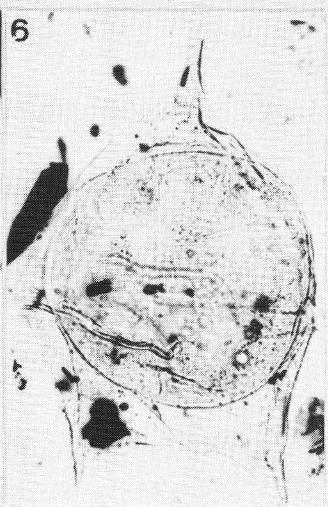
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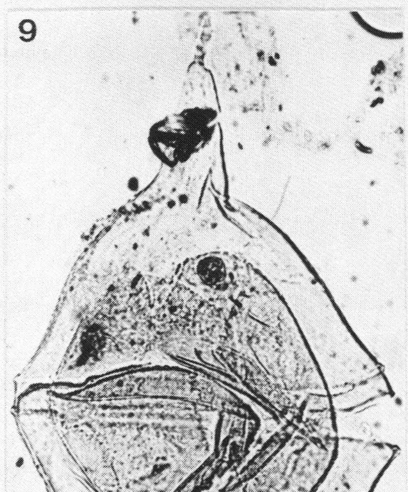
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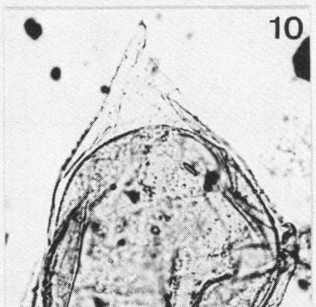
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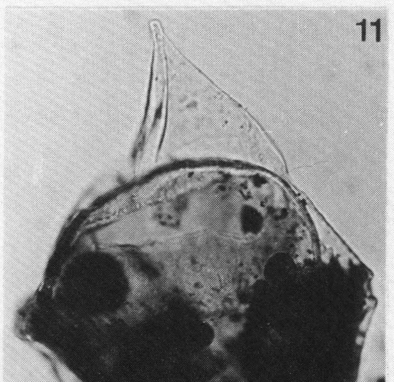
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PLATE 2

Figures 1, 2, 5, 6, 7, 8, 9 and 10. *Deflandrea oebisfeldensis* Alberti 1959.

Figures 3 and 4. *Wetzeliella lobisca* (Williams and Downie 1966) Jolley and Spinner 1989.

Figures 11 and 12. *Wetzeliella lunaris* Gocht 1969.

magnification : 500 X

Figure 1. Kallo boring 27E148, -377m, slide 1.
Figure 2. Kallo boring 27E148, -376.5m, slide 8.
Figure 3. St. Omer - Helfaut, 12, slide B.
Figure 4. St. Omer - Helfaut, 12, slide A.
Figure 5. St. Omer - Helfaut, 14, slide A.
Figure 6. St. Omer - Helfaut, 12, slide A.
Figure 7. Château de la Bruyère boring SA 62, about -12m, slide 3.
Figure 8. Quenast Carrière CGCP, A1b, slide 4.
Figure 9. Château de la Bruyère boring SA 62, about -12m, slide 1.
Figure 10. Overijse boring 103W145; -70.9m, slide 3.
Figure 11. Château de la Bruyère boring SA 62, about -12m, slide 3.
Figure 12. Château de la Bruyère boring SA 62, about -12m, slide 1.


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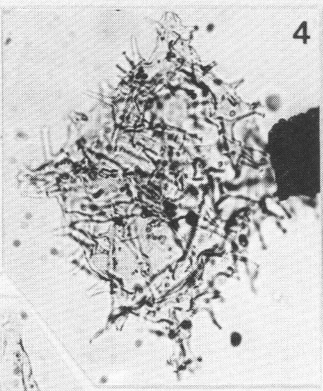
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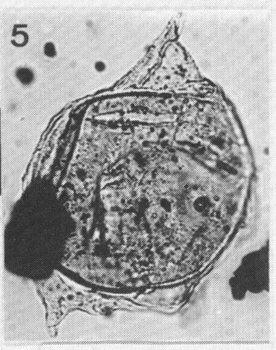
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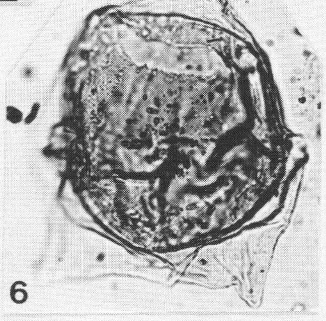
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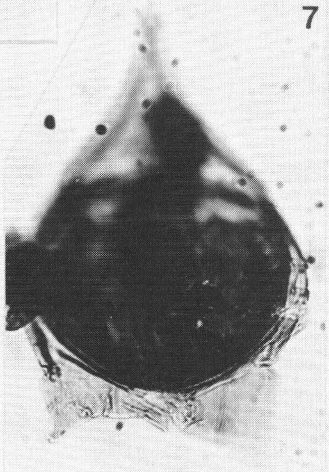
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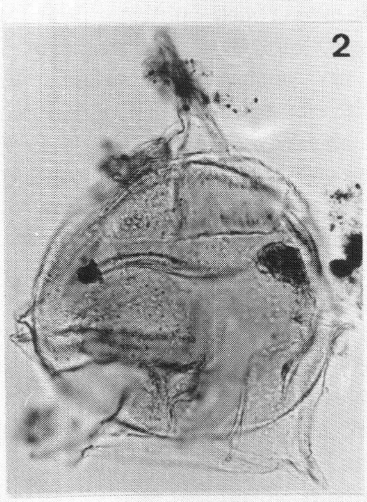
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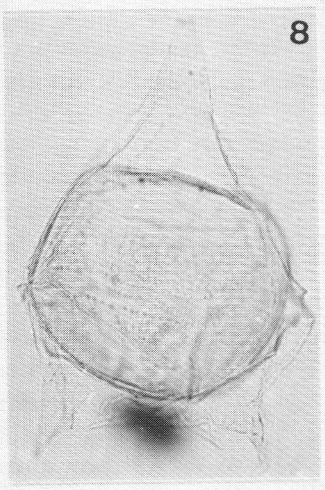
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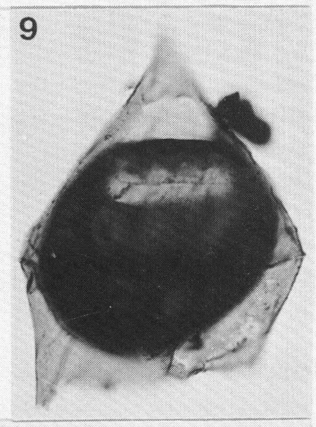
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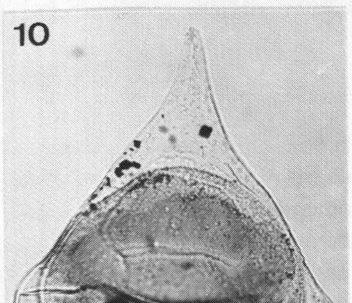
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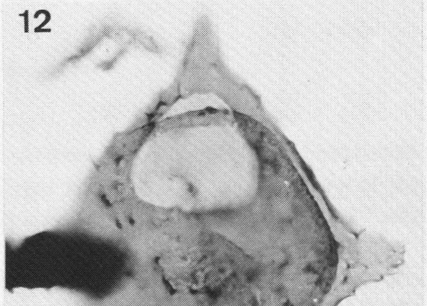
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