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AN ALTERNATIVE CLASSIFICATION AND PROFILE TYPE MAP APPLIED TO THE HOLOCENE DEPOSITS OF THE BELGIAN COASTAL PLAIN (*)

by Cecile BAETEMAN (**)

ABSTRACT. - The renewed mapping of the Belgian coastal plain met with difficulties concerning mapping units. The objections against the classical tripartition Calais-surface peat-Dunkerque are explained and proved by means of analysis of literature. The new lithological classification (BARCKHAUSEN *et al.*) and its advantages are described. Application of the new method is shown in 2 different Holocene profile type maps of the western part of the Belgian coastal plain.

1. INTRODUCTION.

Until now Holocene geology of the Belgian coastal plain never has gone through a thorough research. The Holocene or "Système Quaternaire supérieur ou Moderne" on the most recent geological map of Belgium, made by Mourlon and dated from 1895 is divided into :

alp 2	Argile des polders supérieure
alq	Sable meuble, jaune à *Cardium*
alp 1	Argile des polders inférieure
alr 2	Argile sableuse grise passant au sable, dit sable mou supérieur
t	Tourbe
alr 1	Sable fin, plus ou moins argileux grisâtre, dit sable mou inférieur.

About 1950 soilmapping started to investigate the geology of the coastal plain in a more detailed way. The soilmaps clearly give an exact picture of the spreading of the upper and most recent sediments.

The deeper Holocene sediments were hardly considered. Only some vague ideas were supposed because of lack of exact information. The only existing data about the deeper sediments were coming from a series of drill holes carried out during the years 1930 and accurately described by HALET. However it never was taken into account that these borings were all located along the coastline, an

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area with its own specific characteristics. Yet the data were considered representative for the entire coastal plain.

2. PROBLEMS WITH REGARD TO MAPPING UNITS.

Since 1975 a boring campaign started in the western part of the Belgian coastal plain to investigate the complete sequence of the Holocene sediments and to draw up a new geological map. The choise of the stratigraphy and the mapping units however led to serious problems.

Normally a legend is based on the existing stratigraphy of the area. In Belgium the Holocene sequence is divided into 3 units, *viz.* Calais afzetting, oppervlakte veen, Dunkerque afzetting (transgressie). This tripartition is also used in northern France and in the legend of the Dutch geological map. Although it may appear self-evident that this classification and terminology could be applied here as well, further inquiries showed important problems concerning that tripartition.

As a basic principle it was admitted that the mapping units should be clearly recognizable in the field. They must not be units which can only be distinguished by means of "laboratory-limits" like e.g. 14-C data (HAGEMAN, 1963).

The mapping units must be representative for the entire coastal plain and besides they should give as much lithological information as possible. Moreover one should consider that mapping a coastal plain is nearly exclusively done by borings; in fact isolated points which have to be correlated.

When taking into account these principles, it was obvious that the existing stratigraphical classification based on Calais and Dunkerque could not longer be considered for several reasons.

One of these reasons is the indistinct stratigraphical meaning of the names Calais and Dunkerque. They have been used by various authors with apparently different meanings in different stratigraphical systems. This led to serious confusion. This confusion will appear from the following historical review. The different classifications in which Calais and Dunkerque appear are illustrated in table 1, 2 and 3.

3. THE STRATIGRAPHICAL MEANING OF THE NAMES CALAIS AND DUNKERQUE THROUGHOUT THE LITTERATURE.

3.1. THE ORIGINAL MEANING OF THE NAMES CALAIS AND DUNKERQUE IN THE STRATIGRAPHY.

In his work "Recherches sur les terrains Quaternaires du nord de la France" from 1924 DUBOIS subdivided the *Flandrien* in 3 deposits : Assise d'Ostende, Assise de Calais, Assise de Dunkerque. DUBOIS described the deposits on a pure lithological base, but defined them according to the molluscs. The *Assise de Calais* is defined as a bluegrey sand from the coastal plain occurring between -15m and 0m and characterised by *Zirphaea crispata* and *Ostrea edulis* but without *Mya arenaria*. The *Assise de Dunkerque* is defined as sand with *Cardium* and polderclay with *Scrobicularia* and *Mya arenaria*, historically dated (III - XIII century). In that lithostratigraphical classification DUBOIS has a great interest in the content of molluscs.

In that way he identified sometimes the *Assise de Dunkerque* as "zone paléontologique à *Mya arenaria*".

In reality this zone corresponds to a very recent deposit as *Mya arenaria* invaded the European coasts during the 16th and 17th centuries (HESSLAND, 1945).

DUBOIS did not consider the peatlayer occuring between the *Assise de Calais* and the *Assise de Dunkerque* as a separate unit, but joined it to the *Assise de Calais*. Moreover he described the peatlayer as a theoretical boundary, difficult to recognize.

3.2. CALAIS AND DUNKERQUE IN THE BELGIAN STRATIGRAPHY.

CORNET (1927) is the first author two introduced Calais and Dunkerque in the Belgian stratigraphy in a pure lithostratigraphical sense, followed by HACQUAERT who already made some changes in the original classification by adding the peatlayer to the *Assise van Duinkerke*, without any comment.

The first important change in the stratigraphical meaning of the names was brought by BRIQUET (1930) who used *flandrien* and *dunkerquien* to indicate transgressions, sea-level rises and the period of sedimentation. BRIQUET did not pay attention to the sediments themselves, because he considered that the coastal plain was build up by two consecutive transgressions : the *transgression marine flandrienne* and the *transgression marine dunkerquienne*. The name Calais was not mentioned in his work.

HALET (1931) was the only Belgian author who could not agree with DUBOIS' stratigraphical system. He pretended that it was impossible to subdivide the sediments of the coastal plain in deposits, because of the lack of sharp boundaries. According to him the peatlayer could not be considered as reference-level for the limitation of the deposits.

Although HALET was one of the few geologists who disposed of accurate information with exact observations, his statement never was taken into consideration in future research.

The investigation in the coastal plain however attests the influence of BRIQUET, like for instance the numerous works of TAVERNIER (1938, 1943, 1946, 1947, 1948a, 1948b and 1954), who took most of BRIQUET's ideas, at least in the beginning.

TAVERNIER neither did not look very close to the meaning of a stratigraphical classification and its terminology. In 1938 and 1943 he used *Flandriaansche transgressie* and *Duinkerkiaansche transgressie* whereby he paid great importance to the chronological position of especially the *Duinkerkiaansche* transgression. The name Calais is not mentioned here as well, but TAVERNIER prefered the terminology *sables pissards* introduced by GOSSELET (1893) and used by BLANCHARD (1906) and BRIQUET (1930). Only in the article of 1946 the *Assise de Calais* appears. However the meaning of it is not very clear, because in his classification, called *Chronologie du Quaternaire* the *Assise de Calais* is described as a lithological unit belonging to a transgression. The accompanying table (cf. table 1) representing a chronological classification with a depth-scale and based on lithostratigraphical units gives evidence of the problems about setting up a stratigraphical system for the Holocene and the confusion that exists about the meaning of the terminology. In the same article the *Assise de Dunkerque* is not mentioned, but in the table TAVERNIER

Subdivisions du Flandrien en Flandre

Assise de Dunkerque	Dépôts actuels. Sables marins (XIIIe siècle). Sol médiéval. Sables marins (du IIIe au VIIIe siècle) Sol gallo-romain.			Mya arenaria	Zirphaea crispata, Mya truncata	
Assise de Calais	Dépôts poldériens et marécageux (sable gris bleu, argiles de polder, tourbes néolithiques).		Cordon littoral des Pierrettes	?		
Assise d'Ostende	Sables de Leffinghe à Corbicula	Limon d'Ostende Sable d'Ostende à Corbicula	Tourbe profonde de Coquelles Argile d'estuaire de Coquelles (à E. primigenius)		?	Corbicula fluminalis.

DUBOIS 1924

Nr uit Tabel II	Beschrijving der lagen	Assise van :
4 3	Polderklei en Jong Cardium-zand . . . . . Turf	Duinkerke
2	Fijnkorrelige afzettingen (leem en zand) . .	Kales.
1	Grove afzettingen met *Corbicula fluminalis.*	Oostende.

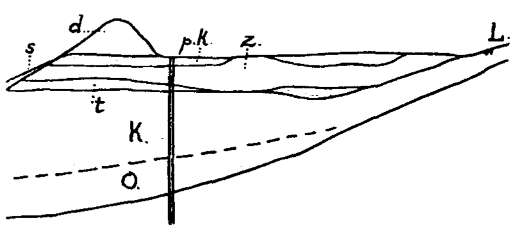


Fig. 3.

Schematisch dwarsprofiel door de Vlaamsche Zeevlakte.

O = Lagen der Assise van Oostende ; *K* = Lagen der Assise van Kales. Deze gaan over tot Leemen *L* naar het binnenland toe. *t* = Turf ; *z* = Zand met *Cardium edule* ; *p. k.* = Polderklei ; *d* = Duinen ; *s* = strandafzettingen.

HACQUAERT 1930

Système Holocène (*Ho*).

Plaine maritime.	*Intérieur du pays.*
Ho. Sables éoliens (dunes V), argile des polders (*alp*), sables marins (*alq*) et tourbe (*t*).	*Ho.* Sables éoliens (V), dépôts des pentes (*alc*), travertins (*tf*), limon de crue (*alm*), alluvions, parfois tourbeuses, du fond des vallées (*alt*), tourbe (*t*) et limonite (*af*).

Système Pléistocène (*Q*).

PLEISTOCENE SUPÉRIEUR (*Q2*).

Plaine maritime.	*Intérieur du pays.*
Q2. Sables à faune marine et limons.	*Q2.* Limons divers et sables fluviatiles. A la base, gravier et cailloutis. Faune froide : *Elephas primigenius, Rangifer tarandus.*

PLEISTOCENE INFÉRIEUR (*Q1*).

Q1. Graviers, cailloux, sables et glaises fluviatiles, limons.

Faune chaude : *Elephas Trogontheri, Rhinoceros Merckii, Corbicula fluminalis.*

LEGENDE GEOLOGISCHE KAART BELGIE 1929
HALET 1931

INDEELING VAN HET HOLOCEEN

BOVEN-HOLOCEEN	+ 1000 — 0	SUBATLANTISCH	*Duinkerkiaansche transgressie*	Vorming van jong-duinlandschap ; Afzetting van jonge zeeklei (Polderklei) en jong alluvium ; Verdrinken van het oppervlakte-veen.
	— 1000	SUBBOREAAL	*Vermoedelijke Stilstand van de zeespiegelrijzing*	Grenshorizon van WEBER (?) ; Veenvorming ; Stuifzandvorming (?) in binnenland.
	— 2000 — 3000 — 4000 — 5000	ATLANTISCH	*Flandriaansche transgressie*	Aanvang van de vorming van oppervlakte-veen in zeevlakte en valleien. Afzetting van de «sables pissards» ; Vorming van oud-duinlandschap ; Opvulling der valleien ; Mariene doorbraak van het Nauw van Kales.
ONDER-HOLOCEEN	— 6000 — 7000 — 8000 — 9000	BOREAAL	*Lagere stand van de zeespiegel*	Veenvorming (pro parte veen op groote diepte); stuifzandvorming in het binnenland. Engeland met continent verbonden

Doorloopende hoogveenvorming op sommige plaatsen, zooals op de Hooge Venen.

TAVERNIER 1943

Holocène.

Holocène supérieur	+ 1000	Subatlantique.	*Transgression dunkerquienne*	Argile et Sables supérieurs des Polders, alluvions récentes.
	0 — 1000	Subboréal	*Arrêt du mouvement positif*	Horizon de Weber (?). Formation de la tourbe de surface.
	— 2000 — 3000 — 4000	Atlantique.	*Transgression flandrienne*	Début de la formation de la tourbe de surface. Argile et sable infér. des Polders (sables pissards). Alluvions anciennes.
	— 5000			(Formation du Pas-de-Calais).
Holocène inférieur	— 6000 — 7000 — 8000	Boréal	*Niveau de la mer très bas*	Tourbe de grande profondeur *(pro parte)*. Sable éolien sur le tardiglaciaire. Creusement des vallées holocènes.
	— 9000			*(Angleterre reliée au continent).*

Plaine maritime belge.

	G. Dollfus, 1884	A. Rutot, 1897	G. Dubois, 1924	F. Halet, 1931	R. Tavernier, 1946
0	Remblai	« Moderne »	« Flandrien sup. » (Assise de Dunkerque) (Post-gallo romaine)	« Moderne » Argile supérieure et Tourbe	Argile supérieure de Polders
- 5	« Moderne »	Argile supérieure et Tourbe	« Flandrien moyen » (Assise de Calais) Tourbe		Tourbe de surface
- 10	« Quaternaire supérieur »	« Flandrien » marin avec *Corbicula fluminalis* à la base	Sables pissards	« Flandrien » Assise de Calais (sables pissards)	Assise de Calais (Holocène)
- 15 - 20			« Flandrien inférieur » (Assise d'Ostende) A. Sable de Leffingue (niveau de la Tourbe de Coquelles)	Couches de passages sablo-limoneuses avec zones tourbeuses ou graveleuses	Zone sablo-limoneuse et niveau de tourbe profonde (Tardiglaciaire)
- 25 - 30	« Quaternaire inférieur » Sable marin avec *Corbicula fluminalis*		B. Sable d'Ostende	Assise d'Ostende	Assise d'Ostende à *Corbicula fluminalis* (Interstadiaire Würm)

TAVERNIER 1946

HOLOCÈNE

ANNÉES	PÉRIODES	VÉGÉTATION	PLAINE MARIT.
+1.000	RÉCENT ET SUBATLANT.que (HUMIDE)	DÉBOISEMENT INTENSE	ASSISE DE DUNKERQUE (PLUSIEURS PHASES DE TRANSGRESSION) DUNES RÉCENTES
0 -1.000	SUBBORÉAL (RELATIVEMENT SEC ET CHAUD)	CHÊNAIE MIXTE AVEC HÊTRE	FORMATION DE TOURBE DE SURFACE
-2.000 -3.000 -4.000 -5.000	ATLANTIQUE (RELATIVEMENT CHAUD ET HUMIDE)	CHÊNAIE MIXTE CHÊNE, TILLEUL, ORME, FRÊNE, COUDRIER ET AULNE SURTOUT DANS LES PLAINES HÊTRE SPORADIQUE	ASSISE DE CALAIS (SABLES PISSARDS) DUNES INTERNES DE GHYVELDE RUPTURE DU PAS-DE-CALAIS / LOCALEMENT FORMATION DE TOURBE PROFONDE (PRO PARTE)
-6.000 -7.000	BORÉAL (CHAUD ET SEC)	FORÊTS DE PIN, COUDRIER, AULNE, TILLEUL, ORME ET CHÊNE	
-8.000	PRÉBORÉAL	PIN ET BOULEAU	
-10.000 -15.000	SUBARCTIQUE	BOULEAU ET PIN PARC MARÉCAGEUX (SOUS-SOL GELÉ)	ASSISE D'OSTENDE (ZONE DE LEFFINGE)
-20.000	ARCTIQUE	TOUNDRA	

TAVERNIER 1948

HOLOCENE

Années	Périodes	Végétation	Plaine maritime
+1.000	Récent et Subatlantique (Humide)	Déboisement intense	Assise de Dunkerque (plusieurs phases de transgression) Dunes récentes
0	Subboréal (Relativement sec et chaud)	Chênaie mixte avec Hêtre	Formation de tourbe de surface
—2.000 —2.000 —3.000 —4.000	Atlantique (Relativement chaud et humide)	Chênaie mixte Chêne, Tilleul, Orme, Frêne, Coudrier et Aulne surtout dans les plaines Hêtre sporadique	Assise de Calais (Sables pissards) Dunes internes de Ghyvelde Rupture du Pas-de-Calais
—5.000 —6.000 —7.000	Boréal (chaud et sec)	Forêts de pin, coudrier, aulne, tilleul, orme et chêne	Localement formation de tourbe profonde (pro parte)
—8.000	Préboréal	Pin et bouleau	
—10.000	Tardiglaciaire	Parc-toundra	

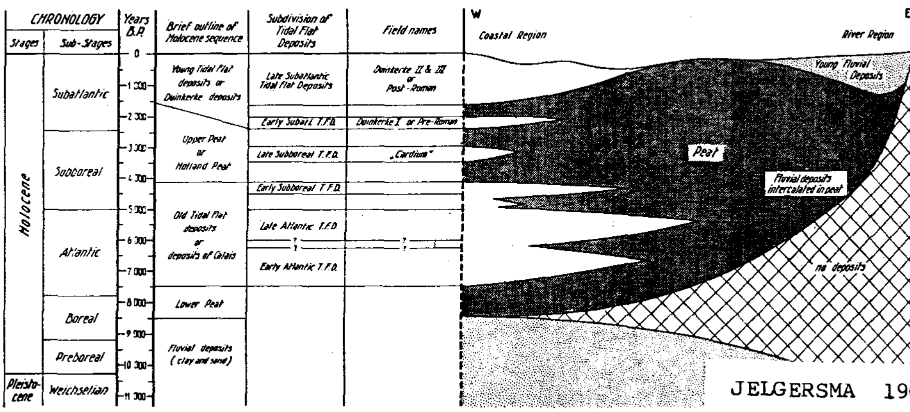
TAVERNIER 1954

Boven Holoceen	Duinkerkiaanse transgressie Duinkerke III transgressie Duinkerke II transgressie Duinkerke I transgressie
Midden Holoceen	Oppervlakte veen Zanden van het Oud Duinlandschap Sedimenten van de assise van Kales
Onder Holoceen	Veen op grotere diepte

Moormann 1954

Lithostratigrafische classificatie		
Formatie	**Laagpakket**	**Laag**
Formatie van Holland	Afzettingen van Duinkerke	Duinkerke IIIb Duinkerke IIIa Duinkerke II Duinkerke I Duinkerke 0
	Afzettingen van Tiel	Tiel IIIb Tiel IIIa Tiel II Tiel I Tiel 0
	Jongere duin- en strandzanden	
	Oudere duin- en strandzanden	
	Hollandveen	
	Afzettingen van Calais	Calais IVb Calais IVa Calais III Calais II Calais I
	Afzettingen van Gorcum	Gorcum IVb Gorcum IVa Gorcum III Gorcum II Gorcum I
	Basisveen	

HAGEMAN 1963

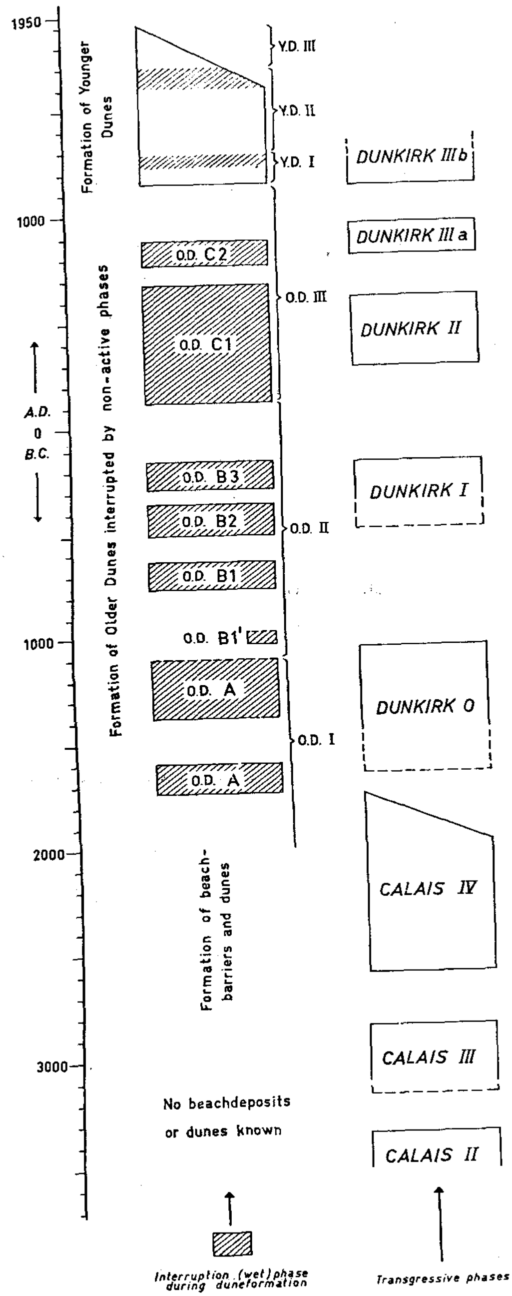


JELGERSMA 1961

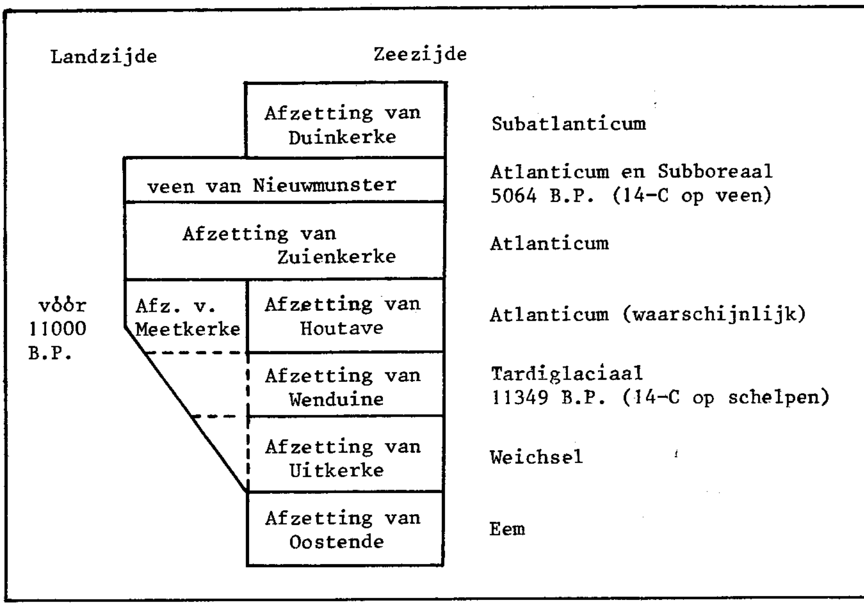
Lithostratigraphische Parallelisierung des Küsten-Holozäns (Grenzwerte gemittelte [14]C-Daten)

Niederlande	Niedersachsen	Schleswig-Holstein	Schicht	Schichten	Unterformation	Formation
	o_4 1400 n.					
D IIIb 1100 n.	o_3 1100 n.	J_2	Wyk	Pewsum		
D IIIa 800 n.	o_2 750 n.	J_1	Tönning			
D II 250 n.						
0	o_1 0	0			Dünkirchen	Holozäne Nordsee-Formation
D I 500 v.	200 v.	V 600 v.	Schwabstedt			
1000 v.	u_2 1000 v.	1000 v.		Midlum		
D 0 1600 v.	u_1 1700 v.	IV 1900 v.	Meldorf			
2200 v.			Husum			
C IV	m_{3B}	III B		Dornum		
2800 v.	m_{3A} 2900 v.		Fiel			
C III 3200		III A 3500 v.			Calais	
	m_{2B}	II B	Eesch			
C II 4300 v.	m_{2A} 4200 v.	II A 5000 v.		Baltrum		
C I 5400	m_1 ?5800 v.	I ?	Barlt			

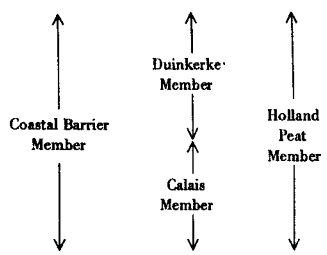
BRAND, HAGEMAN, JELGERSMA & SINDOWSKI 1965



JELGERSMA, DE JONG, ZAGWIJN & VAN REGTEREN ALTENA 1970



DE BREUCK, DE MOOR & MARECHAL 1970



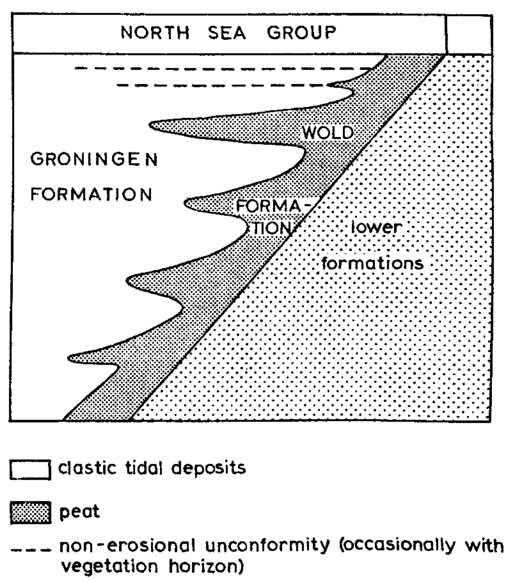
In the Calais Member four beds are distinguished : Calais I, II, III and IV; the Duinkerke Member is differentiated as Duinkerke 0, I, II and III. The fluviatile equivalents in the perimarine area are the Gorkum and Tiel members, respectively.

The following correlation is accepted (B. P. Hageman, 1969; A. Verbraeck, 1970) :

Duinkerke III	1150 years B.P. and later			Tiel III
Duinkerke II	1700	—	1350 years B.P.	Tiel II
Duinkerke I	2550	—	2050	Tiel I
Duinkerke 0	3450	—	2950	Tiel 0
Calais IV	4550	—	3750	Gorkum IV
Calais III	5250	—	4750	Gorkum III
Calais II	6250	—	5250	Gorkum II
Calais I	7950	—	6450	Gorkum I

DE JONG 1971

The main lithostratigraphical subdivision applied to the sedimentary sequence in the Groningen coastal area



ROELEVELD 1974

TABLE 2 The chronology of the Holocene

Conv. ^{14}C time scale	EPOCH	A G E+	TIME INTERVALS transgressive / regressive	years++ BP	AD/BC
y. B.P.	HOLOCENE	SUBATLANTIC	↑ Dunkerque III-B	750	1250
1000			Holland IX	950	1000
			Dunkerque III-A	1150	800
			Holland VIII	1350	600
			Dunkerque II	1650	300 AD
2000			Holland VII	2000	50 BC
			Dunkerque I-B	2475	525
			Holland VI	2600	650
3000		SUBBOREAL	Dunkerque I-A	2975	1025
			Holland V	3225	1275
			Dunkerque 0	3500	1550
			Holland IV-B	3675	1725
4000			Calais IV-B	3950	2000
			Holland IV-A	4200	2250
			Calais IV-A	4500	2550
			Holland III	4700	2750
5000			Calais III	5000	3050
		ATLANTIC	Holland II	5225	3275
			Calais II		
6000			Holland I	6250	4300
			Calais I ↑	6450	4500
7000					
8000		BOREAL			
9000		PREBOREAL			
10.000					

ROELEVELD 1974

Lithostratigrafie		Ouderdom	
Formatie	Laagpakket		
WESTLAND FORMATIE	Afzettingen van Duinkerke		HOLOCEEN
	Holland veen	1500 B.C. 2000 B.C.	
	Afzettingen van Calais	6000 B.C.	
	Elbow Afzettingen		

ZAGWIJN & VAN STAALDUINEN 1975

<u>La tourbe de "Grande Profondeur"</u>

Boréal - début Atlantique

<u>La transgression Flandrienne</u>

5500 à 2300 av. J.C.
Assise de Calais (sables pissards)

<u>La régression Pré-Dunkerquienne</u>

fin de la période atlantique
- les dunes d'Adinkerke - Ghyvelde
- la tourbe

<u>La transgression Pré-Romaine</u>

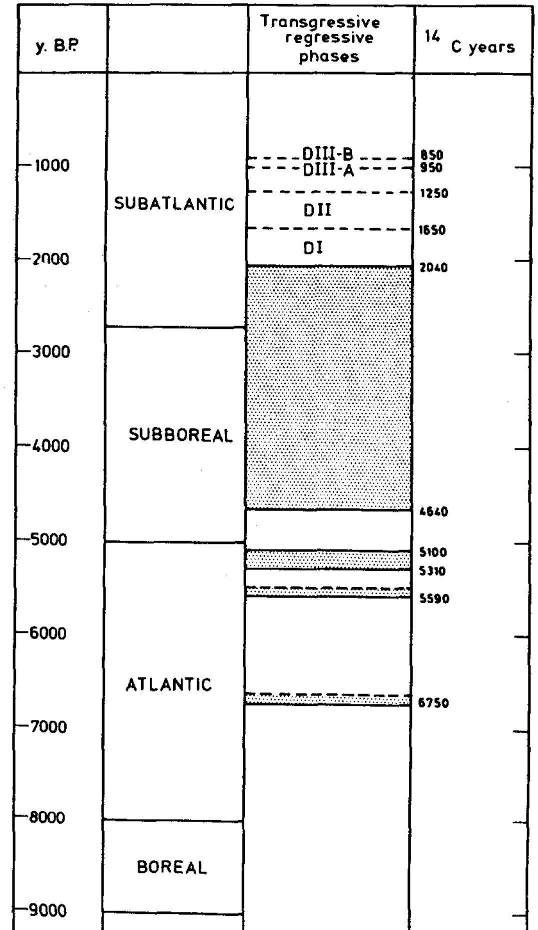
fin de l'Holocène moyen

<u>Les transgressions Dunkerquiennes</u>

1. La transgression du Dunkerquien 1
   IIe s. av. J.C. - Ier siècle
2. La régression Romaine
   Ier - IVe siècle
3. La transgression du Dunkerquien 2
   IVe - VIIIe siècle
4. La régression Carolingienne
   VIIIe - XIe siècle
5. La transgression du Dunkerquien 3
   - Transgression du D 3a : XIe siècle
   - Transgression du D 3b : XIIe siècle

<u>Les polders historiques</u>

OZER 1976



Chronological timescale.

BAETEMAN 1978

replaced it by *Argile supérieure des Polders*. The surface peat is only described as representing a stand still in the sea-level rise between the *transgression flandrienne* and the *transgression dunkerquienne*.

In 1947 on the contrary, TAVERNIER considered the surface peat as an apart unit, but the *Assise de Calais* and the *Assise d'Ostende* are brought together in one chronologically determined unit. The *Assise de Dunkerque* is described as "invasion marine du 4e siècle".

In the following articles of TAVERNIER (1948a, 1948b, 1954) no changes worth mentioning are occuring.

This analysis of TAVERNIER's work shows that no logical consistency in the stratigraphical classification exists and that the names Calais and Dunkerque have been used with several meanings. But the further research on the Holocene was influenced precisely by these publications.

This was the case with the new classification presented by MOORMANN in 1954 (cf. table 2) where lithostratigraphy, chronostratigraphy, transgression and geomorphological units are occurring in the same chronostratigraphical classification.

In the publication of TAVERNIER & MOORMAN (1954) the Holocene is subdivided in a chronological system :

- l'Holocène inférieur
- l'Assise de Calais
- l'Assise de Dunkerque, subdivided in chronologically determined transgressive phases.

The surface peat is not mentioned anymore.

In the Belgian literature, the subdivision of the Holocene is not very clear and inaccurate up till now, whereby no distinction is made between chronostratigraphy, lithostratigraphy and transgression. The only constant in the classifications is the occurrence of the names Calais and Dunkerque, however without any accurate definition.

3.3. THE INTRODUCTION OF CALAIS AND DUNKERQUE IN THE STRATIGRAPHY OF THE NETHERLANDS.

In 1960 DE JONG & HAGEMAN proposed a new legend for the geological map of the Netherlands. The principle of *profile types* is here introduced for the first time. The components of the profile types are lithostratigraphical units, *viz. Afzetting van Duinkerke, Afzetting van Holland, Afzetting van Calais*. The *Afzetting van Duinkerke* and *Afzetting van Calais* were taken from the Belgian literature, while the *Afzetting van Holland* replaces the former term *oppervlakte veen*. These units were divided into (non formal) formations defined as lithostratigraphical units, which in turn were subdivided into landscape types.

In 1963 HAGEMAN completed that proposition by introducing several *levels* allowing to make a clear distinction between lithological units on the one hand and transgressions on the other hand. In the new lithological classification the *Formatie van Holland* is subdivided in (formal) Members (to which the *Afzettingen van Duinkerke* and the *Afzettingen van Calais* belong) which in turn are subdivided into Beds and in which all the transgressive phases are placed.

3.4. THE APPLICATION OF CHRONOLOGICAL CRITERIA IN THE LITHOSTRATIGRAPHY.

In reality however this lithostratigraphical classification of HAGEMAN is based on the succession of transgressions and regressions. To compare and correlate the several transgressions on a regional scale, the interfingering peatlayers have to be dated.

An eloquent evidence of this new tendency is the article of BRAND, HAGEMAN, JELGERSMA & SINDOWSKI (1965) on the subdivision of the marine Holocene along the North Sea coast. *Dünkirk* and *Calais* were considered as lithostratigraphical units, but the regional correlation was based on 14-C data. The several transgressive phases, determined by 14-C data however, were also named Calais and Dünkirk.

This new trend, whereby a lithostratigraphical classification is set up on base of only age determination, is followed by e.g. SINDOWSKI (1968) and HOFFMANN (1969). SINDOWSKI took the geochronologically determined boundaries from the system of BRAND *et al.* and used them to establish a lithostratigraphical classification in another area. HOFFMANN also used 14-C data to subdivide the Holocene of Sylt into *Calais* and *Dünkirk* which here got the meaning of deposits of a transgression.

By using transgressions the Holocene is not subdivided anylonger on a pure lithostratigraphical base and the names Calais and Dunkerque get a chronostratigraphical meaning. The identification of lithostratigraphical units with transgressive and regressive phases resulted in the application of chronological criteria for the determination of the lithostratigraphical identity of sedimentary units.

The use of 14-C data will gain more and more importance and will be considered as one of the main elements in the lithostratigraphical classifications.

The publication of HAGEMAN in 1969 proves this tendency. The lithostratigraphical units *Calais deposits* and *Dunkirk deposits*, separated by the *main peatlayer of the Holland peat* are subdivided on base of transgressions which are dated and nominated as Calais I, II, III,... and Dunkirk I, II, III,... . It is true Hageman points out that the 14-C data should be considered locally.

Taking into account the stratigraphical principles, DE JONG introduced in 1971 the formal terms *Calais Member* and *Duinkerke Member* which he subdivided into Beds, but which were defined on a pure geochronological base. He took exactly the same timescale HAGEMAN published in 1969 (to define the transgressions) as a generally accepted subdivision for the marine Holocene without any comment on the local character of the 14-C data.

In a new classification proposed by ZAGWIJN & van STAALDUINEN (1975) again some changes in the stratigraphical terminology appear : *Afzettingen van Calais, Afzettingen van Duinkerke, Hollandveen.* The latest is described as the main separation between the older and younger deposits. The use of a peatlayer as a correlationmethod in a lithostratigraphical system is highly undesirable and leads to the intermixing of chrono- and lithostratigraphy.

3.5. THE ACTUAL SITUATION IN BELGIUM.

The ambiguity about the stratigraphical systems and about the meaning of the names Calais-Dunkerque also remained in Belgium.

In 1971 PAEPE subdivided the Holocene in *Calais formatie* and *Duinkerke formatie* while he still used the *Afzetting van Calais* and *Afzetting van Duinkerke* in the description of the profile.

The confusion is clearly shown in the article of GULLENTOPS (1974) which even needs no further comment. The author devided the Holocene sediments into :

- transgressive Atlantic Calais-lagoons
- Subboreal Holland-peat
- Subatlantic Dunkerque transgressions.

In the article of Paepe *et al.* (1976) on the new definition of Flandrian it became impossible to find out what Calais and Dunkerque stand for. The authors wrote in one and the same article : *Substages of the Flandrian, as Calais and Dunkerque, Calais deposits, Calais and Dunkerque series.*

Other evidence of the confused situation is shown in the article of OZER (1976) who used nearly all the existing stratigraphical terminology and systems pell-mell.

BAETEMAN (1978) mixed up the chrono- and lithostratigraphy when writing "the Flandrian stage comprises the Calais member, the Dunkerque member, ...".

3.6. FINAL CONSIDERATIONS ON THE STRATIGRAPHICAL MEANING OF CALAIS-DUNKERQUE.

This preceding analysis of the literature shows very clearly that the names Dunkerque-Calais always are defined as lithostratigraphical units, but they are used to nominate transgressions based on chronological criteria. These transgressions in turn serve to set up a chronostratigraphical subdivision with units named Dunkerque and Calais.

The intermixing of transgressions and regressions on one hand and a stratigraphical system on the other is an inaccurate and undesirable method in the Holocene geology. Moreover the assimilation of the succession peat-clastic sediments as a succession of regression-transgression is not always valid and should never be generalised uncritically for the entire coastal plain.

The honour is due to STREIF (1971, 1972, BARCKHAUSEN, PREUSS & STREIF, 1977) and ROELEVELD (1974, 1980) who thoroughly criticized the classical tripartitioned stratigraphical system. They introduced a new lithological resp. lithostratigraphical system in which the confusion about the Dunkerque-Calais terminology definitely was ended.

4. THE OTHER DEFICIENCIES OF THE CLASSICAL TRIPARTITION.

Besides the unclear stratigraphical meaning of the terminology, there are other objections why the classical succession of the Calais Deposits - surface peat - Dunkerque deposits can not be considered as basis for the legend.

In that system the surface peat is regarded as the dividing unit between the Calais and Dunkerque Deposits. But the use of a peatlayer as a reference-level in a mapping system is very inaccurate and unreliable. The marine Holocene sediments lend themselves very well for the setting up of a chronostratigraphy based on 14-C data of the several peatlayers. However problems may arise about the significance of the peatlayers.

Indeed neither the top not the base of a peatlayer are necessary of the same age over the entire plain. Moreover the presence of the sizeable surface peat demonstrates that some transgressive intervals have not been recorded while in other parts of the coastal plain these transgressive intervals have been recorded (ROELEVELD, 1974).

The long distance correlation of peatlayers is only possible by means of age determination (STREIF 1972). This concerns also the difference between regional and local peatlayers. However this method leads to the chronostratigraphy which is unpracticle and not useful in our mapping system as the boundaries are not recognizable in the field. Moreover a chronostratigraphical system must not be generalised for an entire coastal plain and therefore does not fit for the use as a basis for a legend.

Another objection why the classical tripartition can not be used is a very practicle one. The surface peat is lacking in a great part of the coastal plain. Until now it was believed that in this area the peat was completely eroded by the Dunkerque-II transgression, so that the Holocene sequence over there consists of sandy creek-sediments from the Dunkerque-II transgression. However in a great part of those areas peatgrowth never could occur as the environment was not suitable for it. That means that those areas are characterised by sediments deposited since the very beginning that the plain was influenced by the Holocene sea-level rise. In most of these areas it is very difficult to carry through any lithological or other classification as they always have been characterised by the same depositional sedimentary environment since the beginning of the filling up of the coastal plain.

As final objection it should be mentioned that Dunkerque or Calais do not reveal anything about the lithology.

5. THE NEW LITHOLOGICAL SYSTEM.

In view of the objections put forward above it seems unreasonable to base the legend for the Holocene map on the classical tripartition. We prefer to apply the lithological system recently introduced by BARCKHAUSEN, PREUSS & STREIF in 1977. These authors developed a new method for the representation of sedimentary sequences in coastal regions in the form of profile types. The application of the system covers tidal flat areas, marshes and coastal peatbogs.

In the new method a hierachic system of lithological classification has been developed, based on the vertical succession and the lateral interfingering of clastic sediments on the one hand and peat on the other hand.

In the lithological classification system three different hierarchic levels can be distinguished (STREIF, 1978a) :

1. THE COMPLEXES
   - a clastic complex (clastic sediments without intercalated peatlayers)
   - an interfingering complex (clastic sediments are intercalated by peatlayers)
   - a peat complex (sedentary organic deposits are dominant).

   The complexes can be represented in the form of main profile types, respectively the X, Y and Z-type.

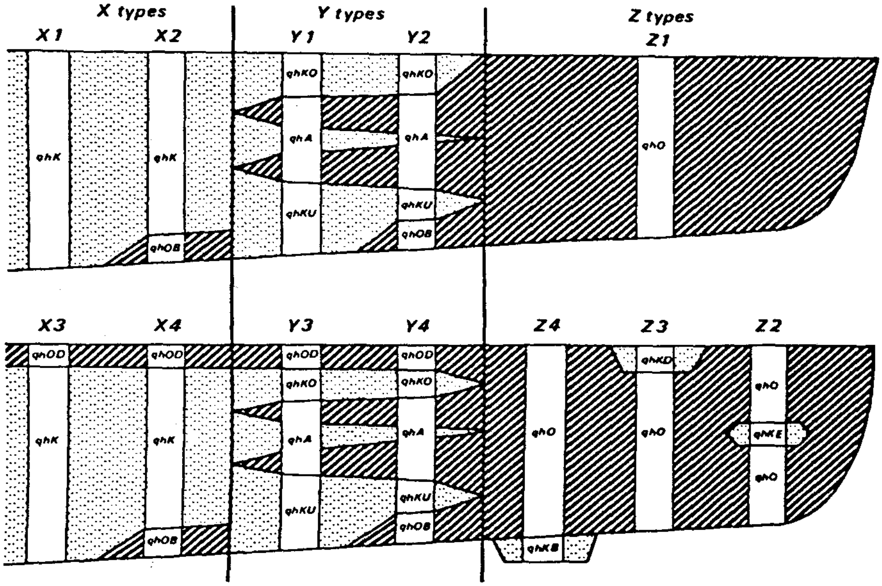
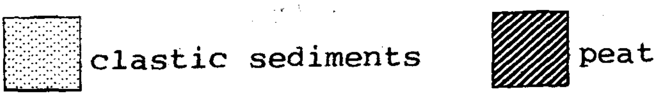
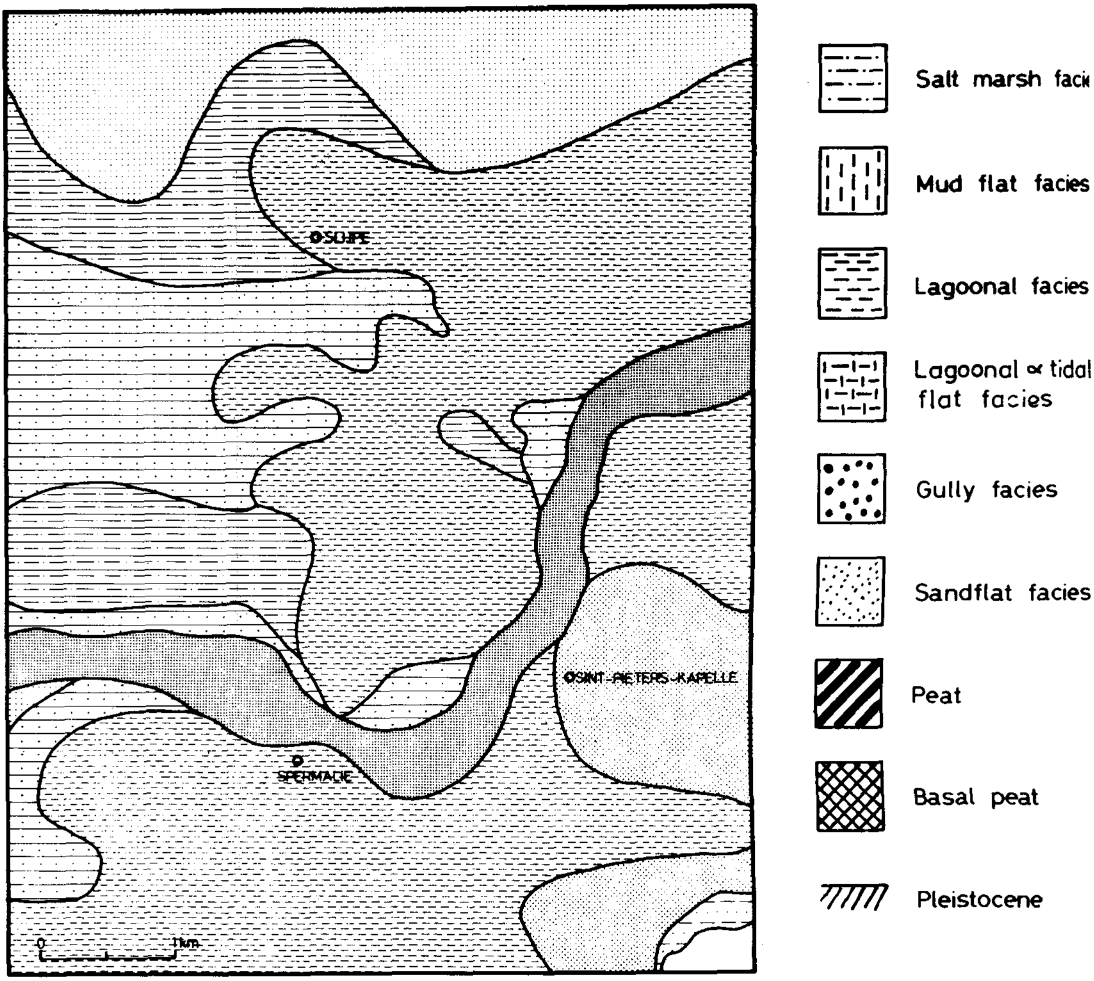


*Fig. 1: Schematic cross section through the coastal deposits with the lables for the principal profile types (X_1, X_2, X_3, X_4, Y_1,... etc. Z4). The sequences are labeled with stratigraphic symbols according to BARCKHAUSEN, LOOK, VINKEN & VOSS (1975). qhK = clastic sequence, qhOB = organic basal sequence, qhOD = organic cover sequence, qhKU = lower clastic sequence, qhA = splitting up sequence, qhKO = upper clastic sequence, qhO = organic sequence, qhKB = clastic basal sequence, qhKE = clastic interbedded sequence, and qhKO = clastic cover sequence.



*with the permission of H. STREIF

PROFILE TYPE MAP OF THE HOLOCENE



Schematic Section-Legend of the special profile types

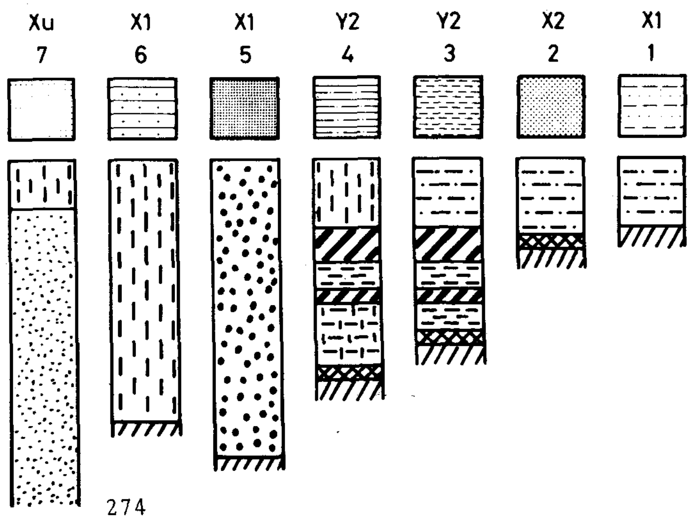


Fig. 2

LEGEND.

MAIN PROFILE TYPE	SUBORDINATE PROFILE TYPE	SPECIAL PROFILE TYPE			
			SEQUENCE	PETROGRAPHY	GENESIS
X	X1	1	qhK	clay with thin sandlayers	salt marsh facies
	X2	2	qhK qhOB	clay with thin sandlayers peat	salt marsh facies peat
Y	Y2	3	qhKO qhA qhKU qhOB	clay with thin sandlayers alternation of peat and mud mud peat	salt marsh facies peat-lagoonal facies lagoonal facies peat
	Y2	4	qhKO qhA qhKU qhOB	clay alternation of peat and mud alternation of mud and fine sand, clayey peat	mudflat facies peat-lagoonal facies lagoonal-tidal flat facies peat
X	X1	5	qhK	sand and clayey silt	gully facies
	X1	6	qhK	alternation of thin layers sand and mud	mud and mixed flat facies
	Xu	7	qhK	alternation of thin layers sand and mud silty sand	mud and mixed flat facies sandflat facies

2. THE SEQUENCES are subdivisions of the complexes and consist of one or more facies units. Some interrelationships between o nic ans clastic deposits can be deduced from the vertical su cession and the lateral interfingering of the sequences. Th variety of possible interrelation is represented in form of schematic section (fig. 1).

3. THE FACIES UNITS give a more detailed subdivision of the seq ces and are at the base of "special profile types". The fac units are variable in number and in range, so that genetic, trographic, structural and other criteria can be taken into count and represented in an unlimited number of special prof types. The facies units and the special profile types have be selected with respect to the specific objectives and the vailing local conditions.

6. APPLICATION OF THE NEW SYSTEM.

According to the new system two kinds of profile type were drawn for the western part of the coastal plain.

A general map on a small scale, based on the main prof types, X, Y and Z, clearly shows a general picture of the Holoce sequence (fig. coloured map : spreading of the lithological com xes).

The map based on the main profile types can be easily c without a thourough and detailed study of the boring-descriptior and yet gives a distinct idea of the Holocene geology of the are

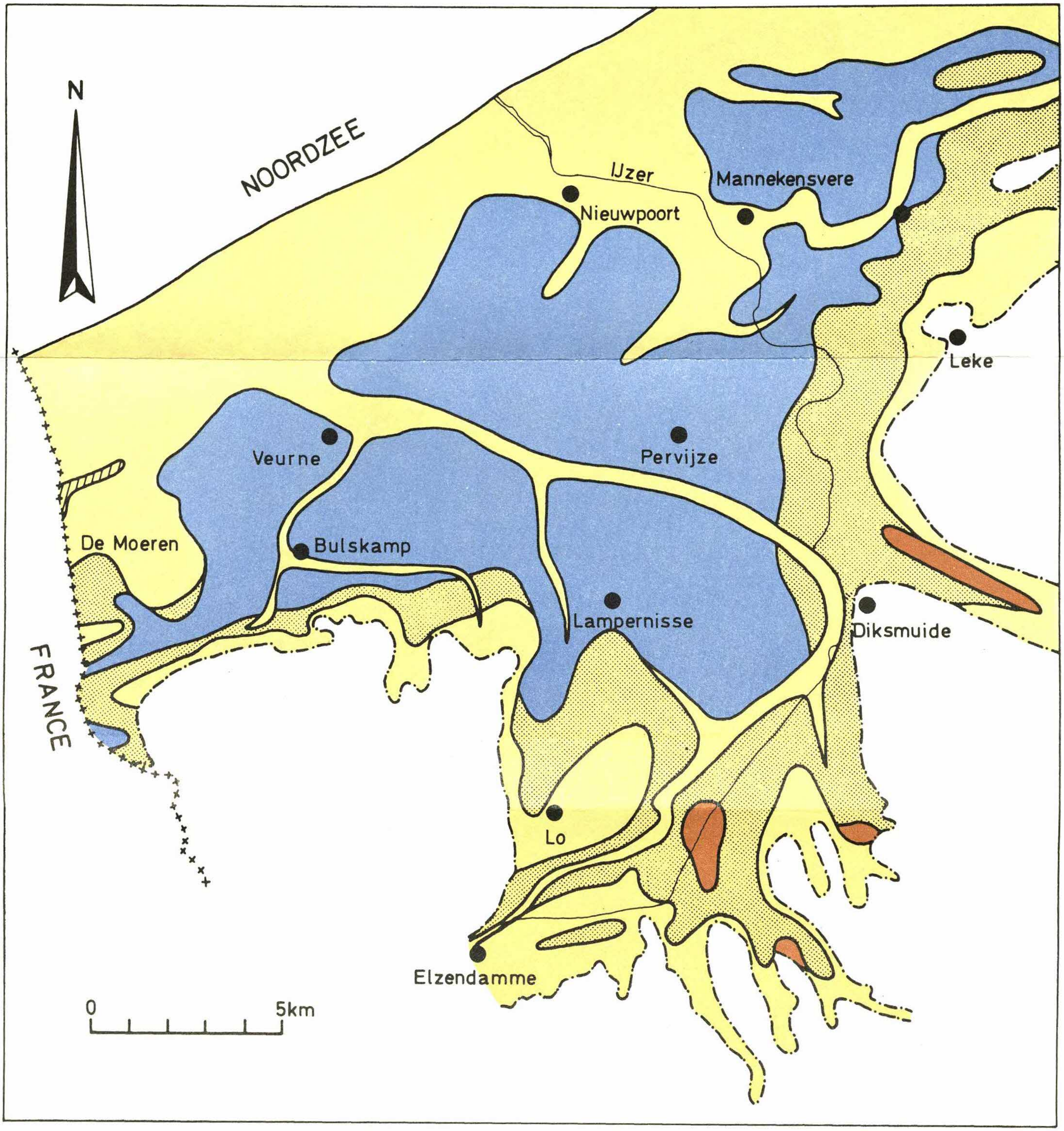
The general map shows that the X-type is occurring in t main areas, *viz.* in the seaward part of the plain, with importan landward extentions (SE of Nieuwpoort and in the area of De Moer and along the outcropping Pleistocene. In the latest area the X type was distinguished (clastic sediments with basal peat). The tidal channels, which are of great importance for the developmen of a coastal plain, also figure clearly on that kind of map. Th Y-type is occurring between those two areas. The Z-type (exclus vely peat covered by a thin packet of clastic sediments) is rest ted to the southern and eastern part of the plain.

The components of the detailed profile type map are the special profile types based on the facies units. As criteria fc the facies units the following depositional sedimentary environ- ments were chosen : the reedmarsh or lagoon, the tidal flat, wit its subdivision into salt marshes, mudflat, mixed flat and sandf the tidal channels and the coastal peatbogs.

These depositional sedimentary environments are charact rized by their specific facies which will be considered as mappi unit. Thus the mapping units chosen are lithogenetic units whic can be described lithologically and which give a distinct pictur of the genesis, the filling up and, at the same time, of the evo lution of the coastal plain during the Holocene.

A fragment of the profile type map of Nieuwpoort is shc as an example of a more detailed map (fig. 2). It is build up b 7 special profile types.

Profile type 1 and 2 occur nearby the outcropping Pleis cene and consist of salt marsh sediments reaching a thickness o to c. 2.5 m, underlain by basal peat in profile type 2.



verspreiding van de lithologische complexen

X1 — profieltype	Y — profieltype
X2 — profieltype	Z — profieltype
X3 — profieltype	

C. Baeteman

Profile type 3, belonging to the Y-type, takes up a great part of the map. Its splitting up sequence consists of one or more peatlayers intercalated by mud from the lagoonal facies. In this example no distinction was made between areas where only one peat-layer on the one hand and two or more peatlayers on the other hand, are occurring. But special profile types could be selected to point out that difference. In profile type 4, also belonging to the Y-type, the direct marine influence is already present in the under clastic sequence, where tidal flat deposits are alternating with lagoonal deposits.

Profile type 7 pre-eminently shows the direct marine influence occurring in seaward areas. Its clastic sequence comprises sandflat sediments reaching a thickness of up to c. 20 m, overlain by a cover of mud- and mixed flat sediments.

The mapped area is intersected by a tidal channel represented by profile type 5. The influence of the tidal channel in the building up of a coastal plain is demonstrated by the extension of the tidal flat in landward direction. This is shown on the map by profile type 6, consisting of exclusively the tidal flat facies.

7. FINAL CONSIDERATIONS.

The advantage of the new lithological classification and its application in the form of profile types is that by means of the basis data a general map can be drawn very easyly and quickly, showing already the general picture of the Holocene of a coastal area.

Besides, the system can be used for showing not only pure geological information, but thanks to the liberty in choosing the criteria for the facies units, useful information and more economic interesting data can figure on the map (like e.g. raw materials or pure lithological data like the quality and granulometric composition of sand).

These data can be easily read from the map without the need of raveling out a classical stratigraphical system.

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