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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 Murlon 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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(\*) This article is part of a PhD thesis entitled "De Holocene ontwikkeling van de westelijke kustvlakte (België)".

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 choice 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 LITERATURE.

### 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 occurring 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 who 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 built 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 *Duinkerkiensche transgressie* whereby he paid great importance to the chronological position of especially the *Duinkerkiensche transgression*. The name Calais is not mentioned here as well, but TAVERNIER preferred 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<br>de<br>Dunkerque | Dépôts actuels.  |  |  | Mya arenaria<br>Zirphaea crispata, Mya truncata |
|                           | Sables marins (XIII <sup>e</sup> siècle).<br>Sol médiéval.<br>Sables marins (du III <sup>e</sup> au VIII <sup>e</sup> siècle)<br>Sol gallo-romain. |  |  |   |
| Assise<br>de<br>Calais    | Dépôts poldériens et marécageux<br>(sable gris bleu, argiles de polder,<br>tourbes néolithiques).  |  | Cordon littoral<br>des<br>Pierrettes   |   |
| Assise<br>d'Ostende       | Sables<br>de<br>Leffinghe<br>à<br>Corbicula  | Limon<br>d'Ostende<br>à<br>Sable d'Ostende<br>à<br>Corbicula | Tourbe profonde<br>de Coquelles<br>à<br>Argile d'estuaire de<br>Coquelles (à E. primigenius) | Corbicula fluminalis.                           |

DUBOIS 1924

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

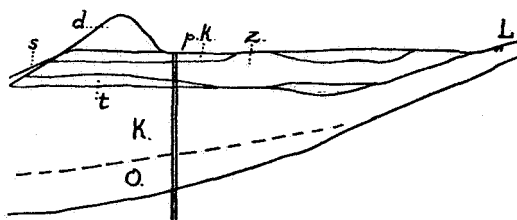


Fig. 3.

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.*

Ho. Sables éoliens (dunes V), argile des polders (*alp*), sables marins (*alq*) et tourbe (*t*).

*Intérieur du pays.*

Ho. Sables éoliens (V), dépôts des pentes (*alc*), travertins (*lf*), limon de crue (*alm*), alluvions, parfois tourbeuses, du fond des vallées (*all*), tourbe (*t*) et limonite (*af*).

**Système Pléistocène (Q).**

**PLEISTOCENE SUPERIEUR (Q<sub>2</sub>).**

*Plaine maritime.*

Q<sub>2</sub>. Sables à faune marine et limons.

*Intérieur du pays.*

Q<sub>2</sub>. Limons divers et sables fluviatiles. A la base, gravier et cailloutis.

Faune froide: *Elephas primigenius*, *Rangifer tarandus*.

**PLEISTOCENE INFERIEUR (Q<sub>1</sub>).**

Q<sub>1</sub>. Gravier, 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 | SUBATLANTISCH | <i>Duinkerkaansche transgressie</i>                     | Vorming van jong-duinlandschap; Afzetting van jonge zeekei (Polderkei) en jong alluvium; Verdrinken van het oppervlakte-veen.  |
|                | 0      | SUBBORBAAL    | <i>Vermoedelijke Stilstand van de zeespiegelrijzing</i> | Grenshorizon van WEBBER (?); Veenvorming; Stuitzandvorming(?) in binnenland.   |
|                | - 1000 | ATLANTISCH    | <i>Flandriaansche transgressie</i>                      | 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 | - 2000 |               |   |  |
|                | - 3000 | BORBAAL       | <i>Lagere stand van de zeespiegel</i>                   | Veenvorming (pro parte veen op groote diepte); stuitzandvorming in het binnenland.   |
|                | - 4000 |               |   |  |
|                | - 5000 |               |   |  |
|                | - 6000 |               |   |  |
|                | - 7000 |               |   |  |
|                | - 8000 |               |   |  |
|                | - 9000 |               |   | Engeland met continent verbonden   |

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

TAVERNIER 1943

Holocène.

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

Plaine maritime belge.

|      | G. DOLLFUS,<br>1884                          | A. RUTOT,<br>1897                | G. DUBOIS,<br>1924  | F. HALET,<br>1931   | R. TAVERNIER,<br>1946  |
|------|--|----------------------------------|---|---|--|
| 0    | Remblai                                      | " Moderne "                      | " Flandrien sup. "<br>(Assise de Dunkerque)<br>(Post-4 <sup>e</sup> allé romaine) | " Moderne "   | Argile supérieure de Polders   |
|      |  | Argile supérieure                |   | Argile supérieure et Tourbe   |  |
| - 5  | " Moderne "                                  | et Tourbe                        | " Flandrien moyen "<br>(Assise de Calais)   |   | Tourbe de surface  |
|      |  |                                  | Tourbe  | " Flandrien "   |  |
| - 10 | " Quaternaire supérieur "                    | " Flandrien " marin              | Sables pissards   | Assise de Calais (sables pissards)  | Assise de Calais (Holocène)  |
|      |  | avec <i>Corbicula fluminatis</i> | " Flandrien inférieur "<br>(Assise d'Ostende)                                     | } Couches de passages sablo-limoneuses avec zones tourbeuses ou graveleuses | } Zone sablo-limoneuse et niveau de tourbe profonde (Tardiglaciaire) |
| - 15 |  |                                  | A. Sable de Leflingue (niveau de la Tourbe de Coquelles)                          |   |  |
| - 20 |  | à la base                        |   |   | Assise d'Ostende   |
|      | " Quaternaire inférieur "                    |                                  |   |   | à <i>Corbicula fluminatis</i>  |
| - 25 | Sable marin avec <i>Corbicula fluminatis</i> |                                  | B. Sable d'Ostende  | Assise d'Ostende  | <i>fluminatis</i>  |
|      |  |                                  |   |   | (Interstadiaire Würm)  |
| - 30 |  |                                  |   |   |  |
|      |  |                                  |   | TAVERNIER   | 1946   |

# HOLOCÈNE

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

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  | Atlantique                            | 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 |
| -3.000  | (Relativement chaud et humide)        |  |  |
| -4.000  |                                       |  |  |
| -5.000  |                                       |  |  |
| -6.000  | Boréal (chaud et sec)                 | Forêts de pin, coudrier, aulne, tilleul, orme et chêne   | Localement formation de tourbe profonde (pro parte)                                    |
| -7.000  |                                       |  |  |
| -8.000  | Préboréal                             | Pin et bouleau   |  |
| -10.000 | Tardiglaciaire                        | Parc-toundra   |  |

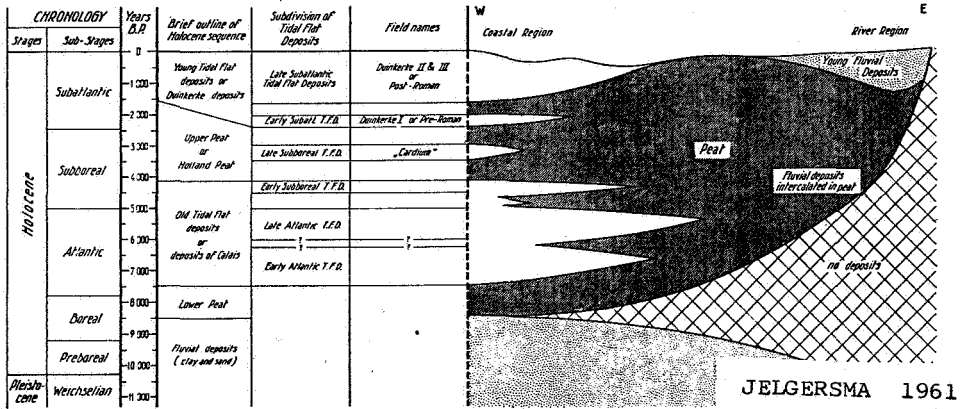
TAVERNIER 1954

|                    |   |
|--------------------|---|
| Boven<br>Holocene  | Duinkerkiense transgressie<br>Duinkerke III transgressie<br>Duinkerke II transgressie<br>Duinkerke I transgressie |
| Midden<br>Holocene | Oppervlakte veen<br>Zanden van het Oud Duinlandschap<br>Sedimenten van de assise van Kales                        |
| Onder<br>Holocene  | Veen op grotere diepte  |

Moormann 1954

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

HAGEMAN 1963

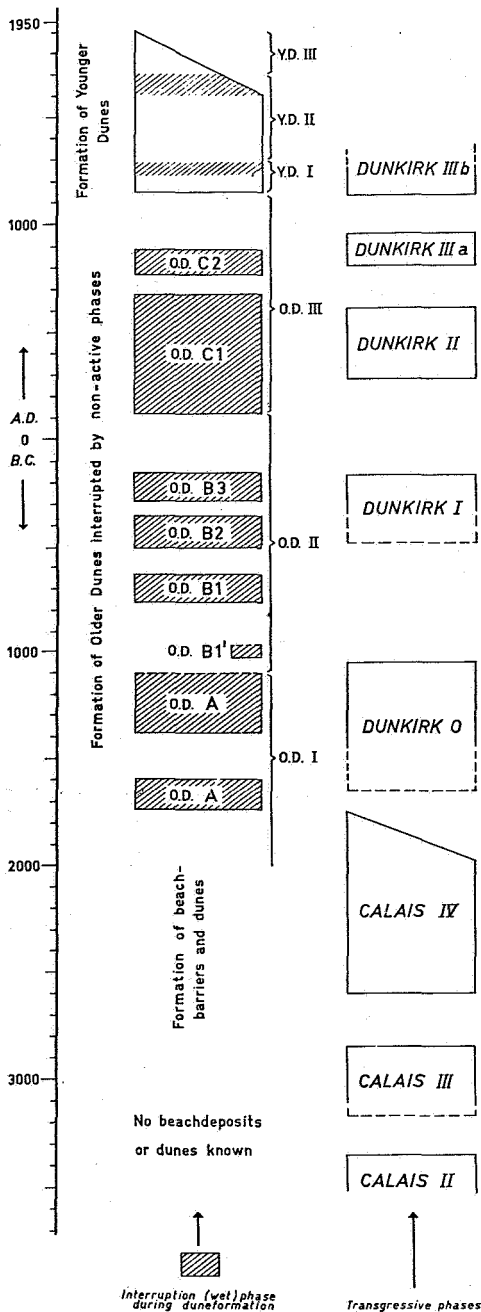


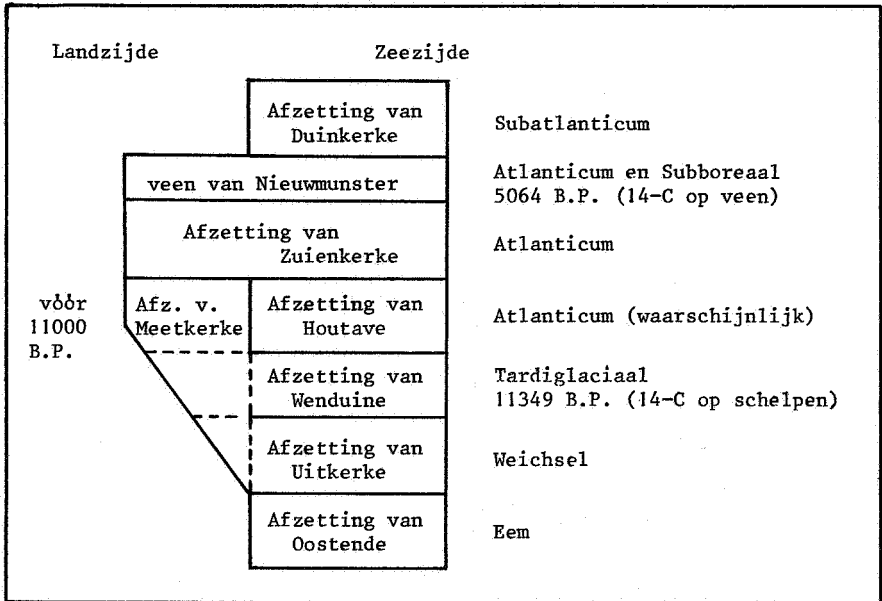
Lithostratigraphische Parallelisierung des Küsten-Holozäns (Grenzwerte gemittelte <sup>14</sup>C-Daten)

| Niederlande            | Niedersachsen                                    | Schleswig-Holstein | Schicht     | Schichten | Unterformation | Formation                  |
|------------------------|--|--------------------|-------------|-----------|----------------|----------------------------|
| D III b 1100 n.        | o <sub>4</sub> 1400 n.<br>o <sub>3</sub> 1100 n. | J <sub>2</sub>     | Wyk         | Pewsum    |                | Holozäne Nordsee-Formation |
| D III a 800 n.         | o <sub>2</sub> 750 n.                            | J <sub>1</sub>     | Tönning     |           |                |                            |
| D II 250 n.<br>0       | o <sub>1</sub> 0                                 | 0                  |             |           | Düнкirchen     |                            |
| D I 500 v.<br>1000 v.  | u <sub>2</sub> 200 v.<br>1000 v.                 | V                  | Schwabstedt |           |                |                            |
| D 0 1600 v.<br>2200 v. | u <sub>1</sub> 1700 v.                           | IV                 | Meldorf     | Midlum    |                |                            |
| G IV 2800 v.           | m <sub>3</sub> B 2900 v.                         | III B              | Husum       |           | Dornum         |                            |
| G III 3200             | m <sub>3</sub> A                                 | III A              | Fiel        |           |                |                            |
| C II 4300 v.           | m <sub>2</sub> B 4200 v.                         | II B               | Eesch       |           | Calais         |                            |
| C I 5400               | m <sub>2</sub> A                                 | II A               | Baltrum     |           |                |                            |
|                        | m <sub>1</sub> 25800 v.                          | I                  | Barlt       |           |                |                            |

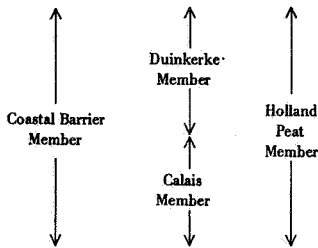
BRAND, HAGEMAN, JELGERSMA & SINDOWSKI 1965







DE BREUCK, DE MOOR & MARECHAL 1970

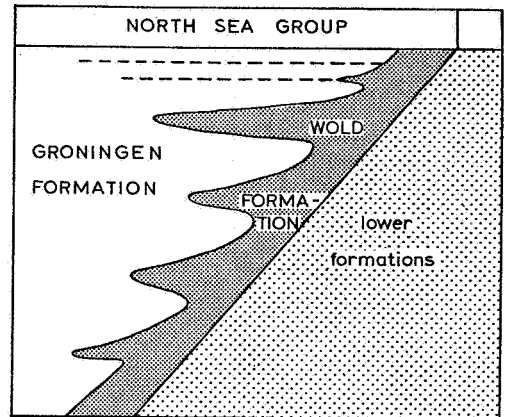


In the Calais Member four beds are distinguished: Calais I, II, III and IV; the Duinkerke Member is differentiated as Duinkerke 0, I, II and III. The fluvial equivalents in the perimarine area are the Gorkum and Tiel members, respectively.

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   |

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



clastic tidal deposits

peat

--- non-erosional unconformity (occasionally with vegetation horizon)

DE JONG 1971

ROELEVELD 1974

TABLE 2 The chronology of the Holocene

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

ROELEVELD 1974

| Lithostratigrafie    |                                 | Ouderdom               |         |
|----------------------|---------------------------------|------------------------|---------|
| Formatie             | Laagpakket                      |                        | HOLOCEN |
| WESTLAND<br>FORMATIE | Afzettingen<br>van<br>Duinkerke | 1500 B.C.<br>2000 B.C. |         |
|                      | Holland veen                    |                        |         |
|                      | Afzettingen<br>van<br>Calais    | 6000 B.C.              |         |
|                      | Elbow<br>Afzettingen            |                        |         |

ZAGWIJN & VAN STAALDUINEN 1975

La tourbe de "Grande Profondeur"

Boréal - début Atlantique

La transgression Flandrienne

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

La régression Pré-Dunkerquienne

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

La transgression Pré-Romaine

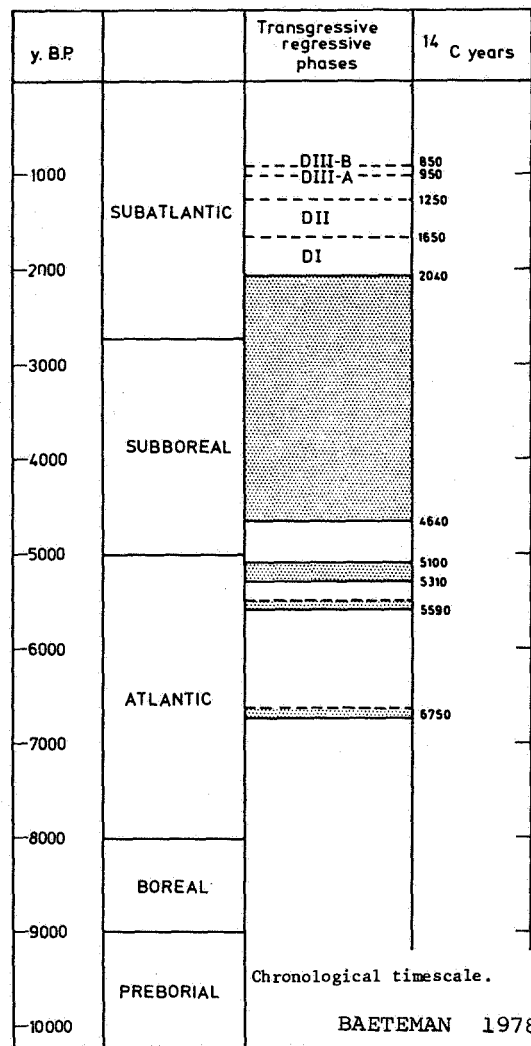
fin de l'Holocène moyen

Les transgressions Dunkerquiennes

1. La transgression du Dunkerquien 1  
III<sup>e</sup> s. av. J.C. - I<sup>er</sup> siècle
2. La régression Romaine  
I<sup>er</sup> - IV<sup>e</sup> siècle
3. La transgression du Dunkerquien 2  
IV<sup>e</sup> - VIII<sup>e</sup> siècle
4. La régression Carolingienne  
VIII<sup>e</sup> - XI<sup>e</sup> siècle
5. La transgression du Dunkerquien 3  
- Transgression du D 3a : XI<sup>e</sup> siècle  
- Transgression du D 3b : XII<sup>e</sup> siècle

Les polders historiques

OZER 1976



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 occurring.

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 divided 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 nor 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 unpractical 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 practical 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 hierarchic 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.

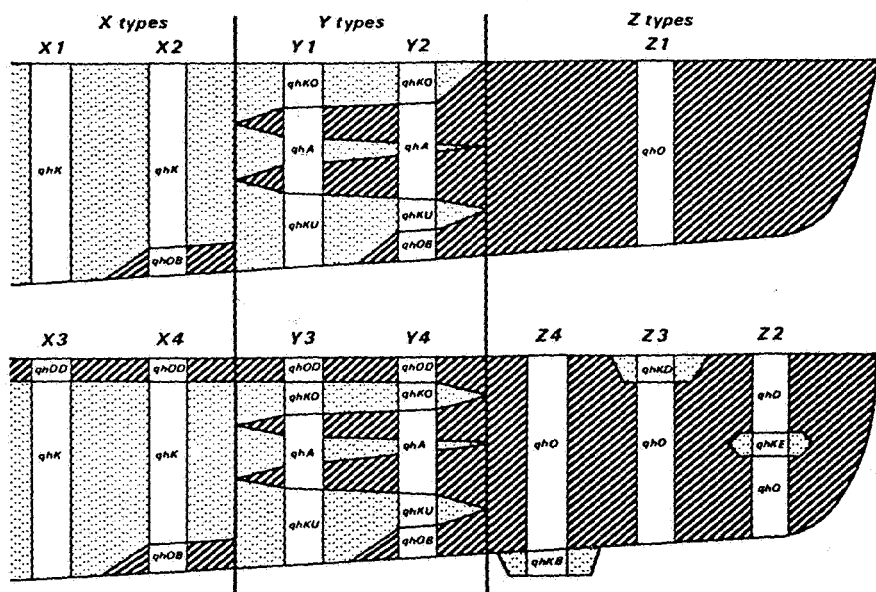
In the lithological classification system three different hierarchic levels can be distinguished (STREIF, 1978a) :

### 1. THE COMPLEXES

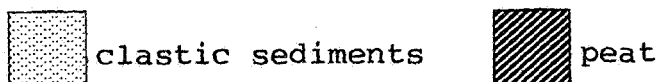
- a clastic complex (clastic sediments without intercalated peatlayers)
  - an interfingering complex (clastic sediments are intercalated by peatlayers)
  - a peat complex (sedimentary organic deposits are dominant).
- The complexes can be represented in the form of main profile types, respectively the X, Y and Z-type.



# REPRESENTATION OF SEQUENCES

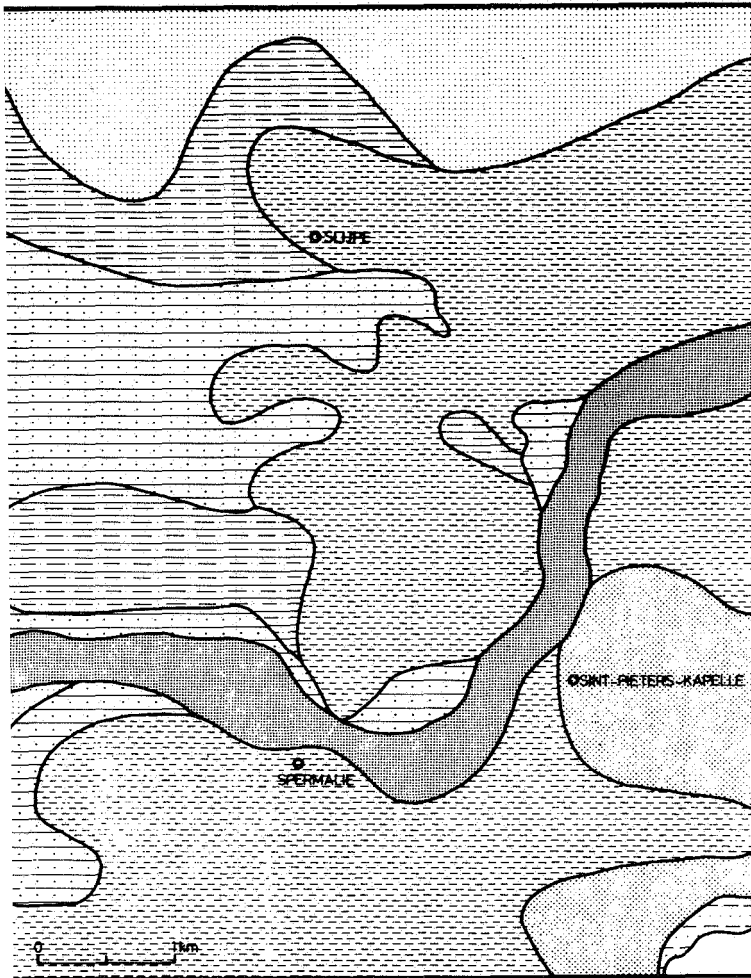











\*Fig. 1: Schematic cross section through the coastal deposits with the labels for the principal profile types ( $X_1$ ,  $X_2$ ,  $X_3$ ,  $X_4$ ,  $Y_1$ , ... etc.  $Z_4$ ). The sequences are labeled with stratigraphic symbols according to BARCKHAUSEN, LOOK, VINKEN & VOSS (1975). qhK = clastic sequence, 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



-  Salt marsh facies
-  Mud flat facies
-  Lagoonal facies
-  Lagoonal or tidal flat facies
-  Gully facies
-  Sandflat facies
-  Peat
-  Basal peat
-  Pleistocene

Schematic Section- Legend of the special profile types

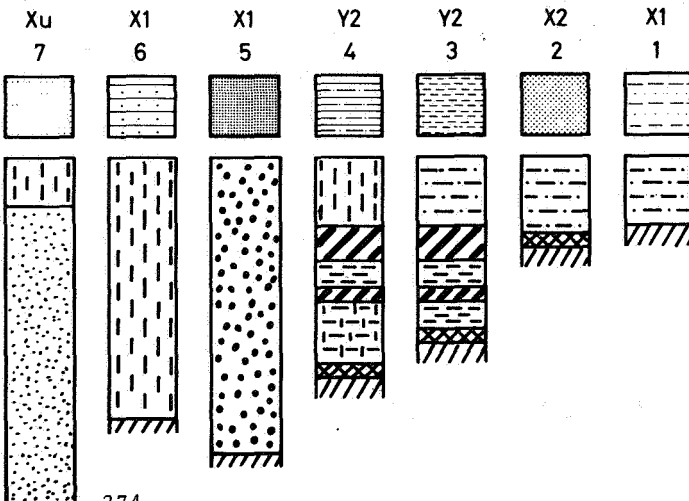


Fig. 2

LEGEND.

| MAIN PROFILE TYPE | SUBORDINATE PROFILE TYPE | SPECIAL SEQUENCE              | PROFILE PETROGRAPHY   | TYPE GENESIS   |
|-------------------|--------------------------|-------------------------------|---|--|
| X                 | X1                       | 1 qhK                         | clay with thin sandlayers   | salt marsh facies  |
|                   | X2                       | 2 qhK<br>qhOB                 | clay with thin sandlayers<br>peat   | salt marsh facies<br>peat  |
| Y                 | Y2                       | 3 qhKO<br>qhA<br>qhKU<br>qhOB | clay with thin sandlayers<br>alternation of peat and mud<br>mud<br>peat                 | salt marsh facies<br>peat-lagoonal facies<br>lagoonal facies<br>peat         |
|                   |                          | 4 qhKO<br>qhA<br>qhKU<br>qhOB | clay<br>alternation of peat and mud<br>alternation of mud and fine sand, clayey<br>peat | mudflat facies<br>peat-lagoonal facies<br>lagoonal-tidal flat facies<br>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<br>sandflat facies                                 |

2. THE SEQUENCES are subdivisions of the complexes and consist of one or more facies units. Some interrelationships between organic and clastic deposits can be deduced from the vertical succession and the lateral interfingering of the sequences. The variety of possible interrelation is represented in form of a schematic section (fig. 1).
  3. THE FACIES UNITS give a more detailed subdivision of the sequences and are at the base of "special profile types". The facies units are variable in number and in range, so that genetic, petrographic, structural and other criteria can be taken into account and represented in an unlimited number of special profile types. The facies units and the special profile types have to be selected with respect to the specific objectives and the prevailing local conditions.
6. APPLICATION OF THE NEW SYSTEM.

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

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

The map based on the main profile types can be easily drawn without a thorough and detailed study of the boring-descriptions and yet gives a distinct idea of the Holocene geology of the area.

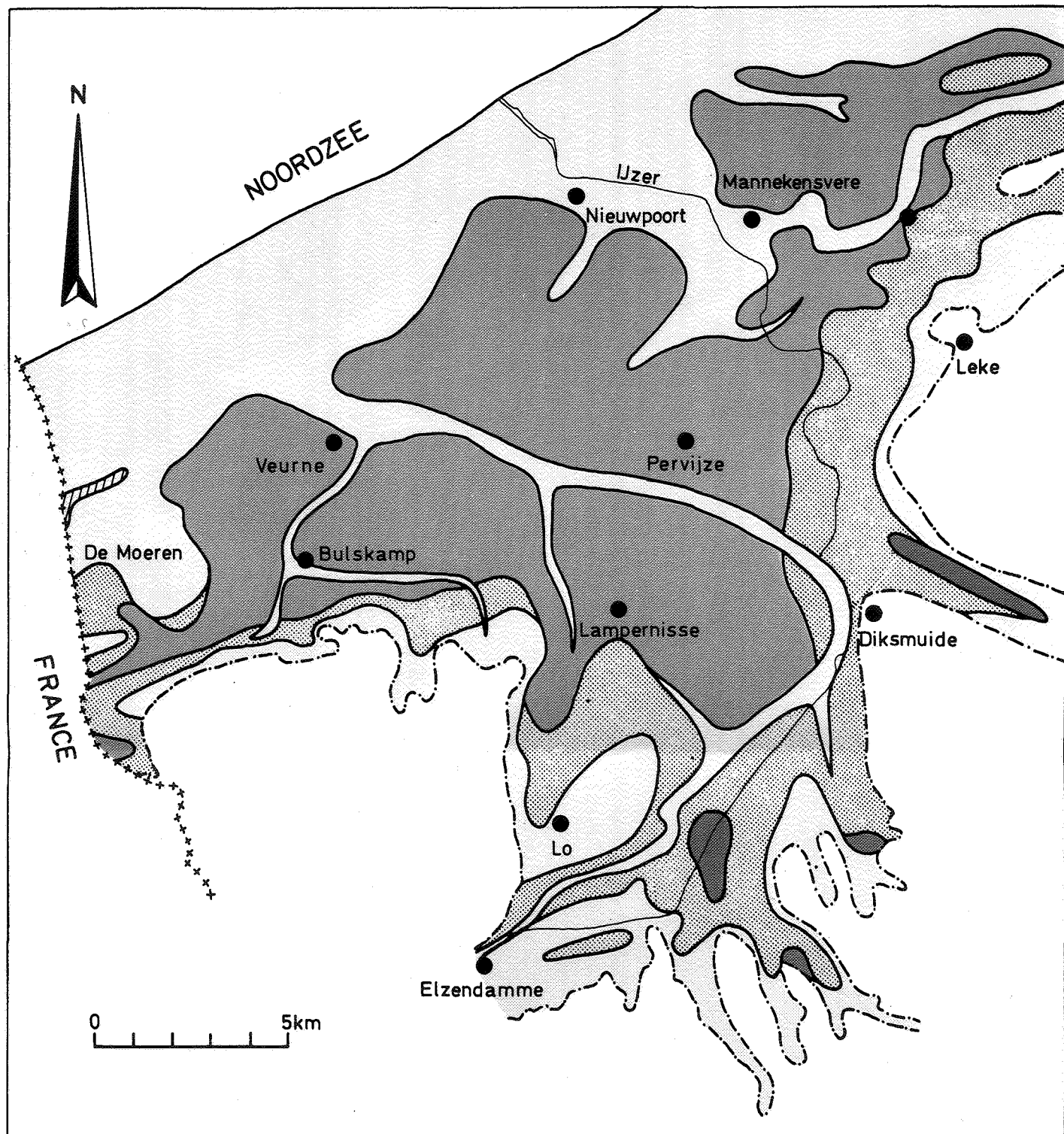
The general map shows that the X-type is occurring in two main areas, *viz.* in the seaward part of the plain, with important landward extensions (SE of Nieuwpoort and in the area of De Moeren) and along the outcropping Pleistocene. In the latest area the X2-type was distinguished (clastic sediments with basal peat). The tidal channels, which are of great importance for the development of a coastal plain, also figure clearly on that kind of map. The Y-type is occurring between those two areas. The Z-type (exclusively peat covered by a thin packet of clastic sediments) is restricted 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 for the facies units the following depositional sedimentary environments were chosen : the reedmarsh or lagoon, the tidal flat, with its subdivision into salt marshes, mudflat, mixed flat and sandflat, the tidal channels and the coastal peatbogs.

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

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

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



### verspreiding van de lithologische complexen



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 easily 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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