# THE WESTERN COASTAL PLAIN OF BELGIUM

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## General Introduction

The lowlying coastal plain was formed and shaped during the Holocene. However, the present day surface is the record of the very last step of its development and evolution. The sequence of events that built the plain, are found in the subsurface and are to be acquired by means of boreholes.

Lowland excursions seldom can offer splendid outcrops and are therefore very often unappreciated or misjudged. Indeed a single borehole shows the record of just one single spot in a complex mosaic. That mosaic, bearing the sequence of events and the coastal evolution of the area, is to be unravelled by means of establishing the geometry of the various facies in the depositional body of the coastal plain, so that every single borehole is put into a larger context. Such a 3-dimensional approach forms a firm basis for the interpretation of the individual core which then can be rate at its true value. The 3-dimensional approach also yield the framework in which all relevant factors and processes of coastal development can be integrated.

The western part of the coastal plain is characterized by a southward extension crossed by the sole river in the plain (fig.1) This landward extension used to be called the *IJzer Embayment*, although the present-day position of the river has little relevance to it, as will be discussed at the different excursion stops. Moreover the river is canalized over the major parts of its course as the entire plain has been reclaimed since about the 11$^{th}$ century AD, resulting in a polder with a completely controlled drainage.

The elevation of the plain is ranging between +2m to +5m. Ordnance datum (T.A.W.) refers to LLWS what explains that the Dutch NAP (Normaal Amsterdams Peil) is 2.33m higher.

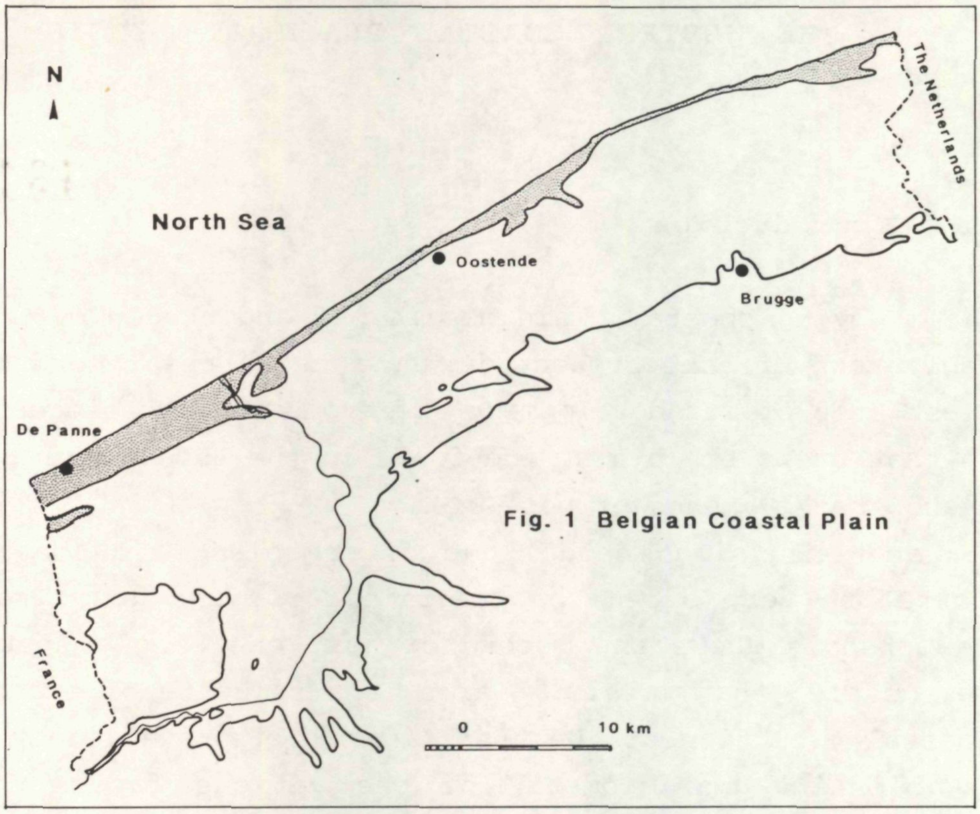


Fig. 1 Belgian Coastal Plain

## Geological Setting

The western part of the coastal plain differs significantly from the eastern part and this in several aspects.

The main difference, however, is the well developed Holocene sequence in the western part which is to be explained by the topography of the subsoil.

### *Eocene deposits*

The Quaternary sequence lies unconformably upon Eocene deposits consisting of a ca 100m thick stiff compact clay, the Ieper Clay (Yc). The top of it, an erosional surface, ranges between +1m in the south and -30m in the very seaward area. The top exhibits a significant relief (fig.2) with a rather deep incised valley in the central part of the landward area. Just outside the plain in that landward part, the Eocene deposits are characterized by a very steep slope in the eastern direction and reach a level of +30m. In the very west of the plain, the Eocene surface shows a more gentle and regular slope. Seawards, the valley shape is not pronounced any longer.

## Topography of Eocene deposits

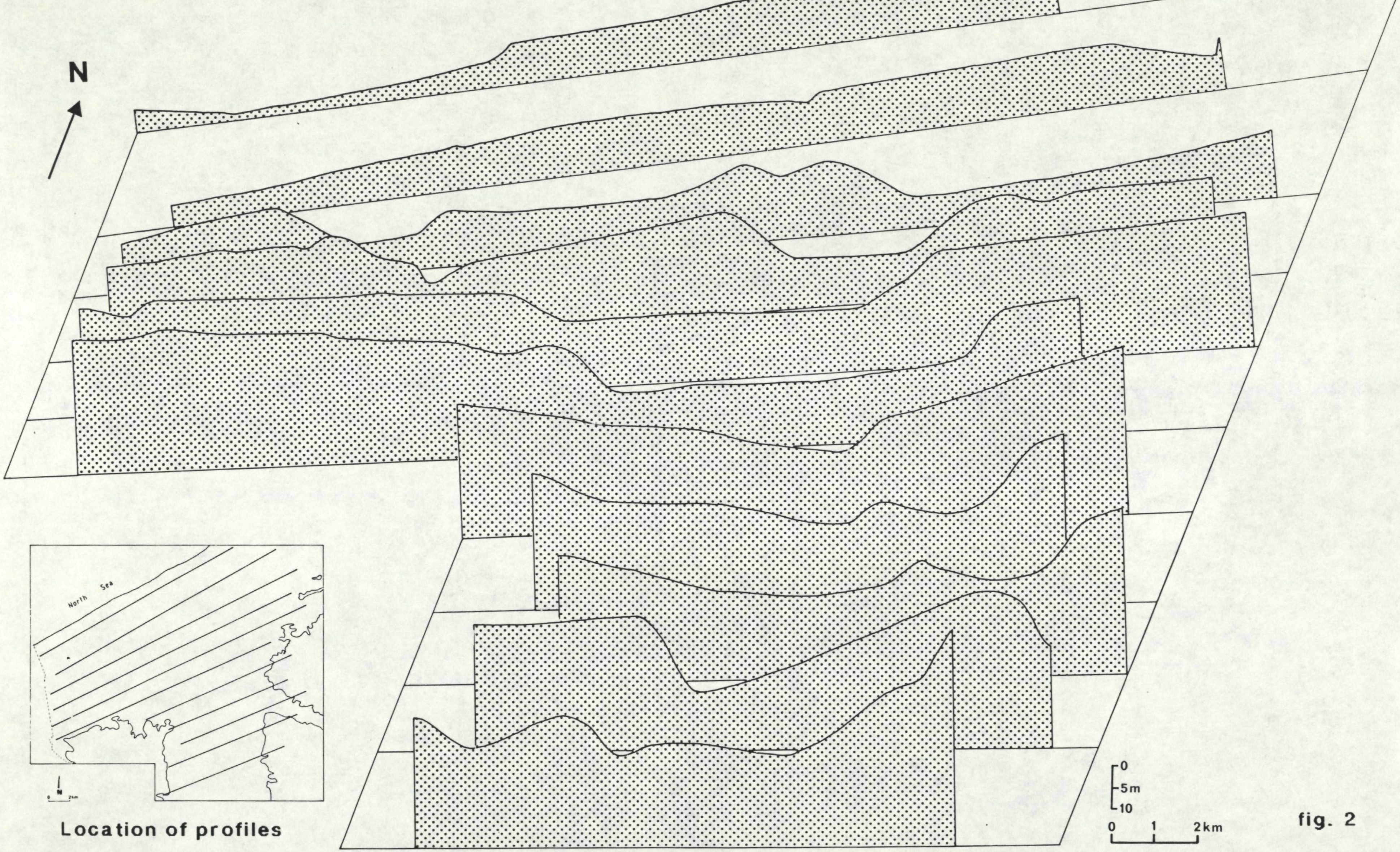



fig. 2

***Pleistocene deposits***

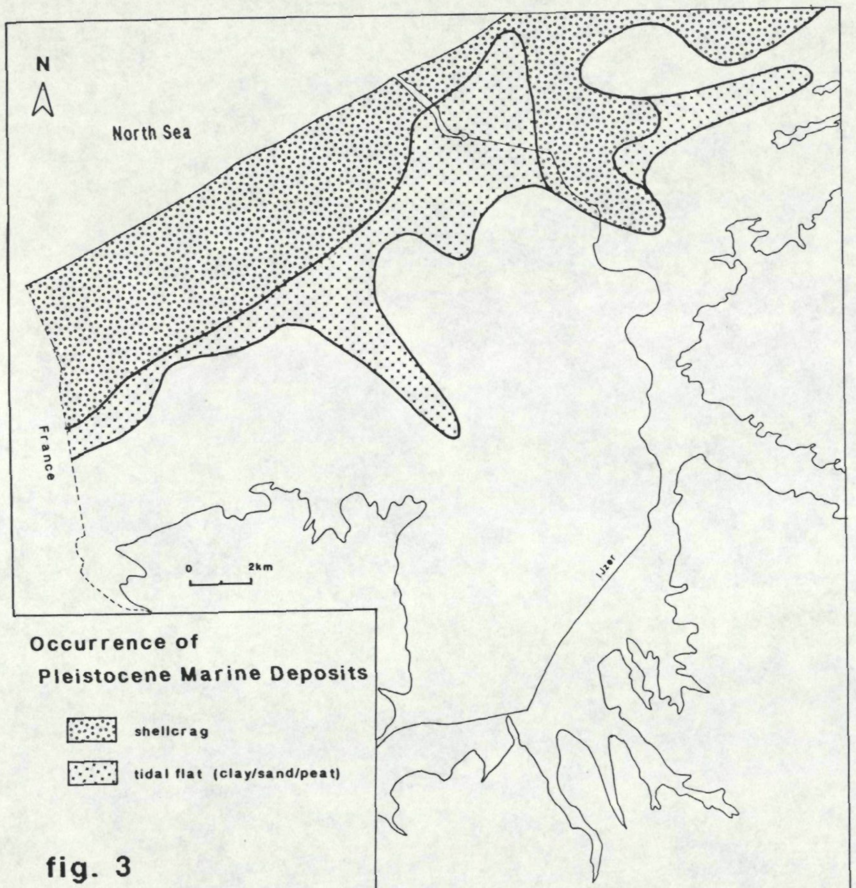
The Eocene clay is covered by Pleistocene deposits with a maximum thickness of 12m.

Marine Pleistocene deposits were found restricted in the seaward area (fig.3). They consist mainly of a shellcrag with a thickness up to nearly 10m, occurring between -15m to -30m. However, slightly more landward, less energetic deposits are found (between -11m to -16m) such as fine sand and clay with occasionally peat, reflecting a coastal plain/tidal flat environment. According to a pollenanalysis, these deposits belong to a later phase of the Eemian (E6).

The typical facies of the shellcrag will be demonstrated in the boreholes of the Seaward Area; the tidal flat facies in borehole Leeuwenhof (L, fig.9).

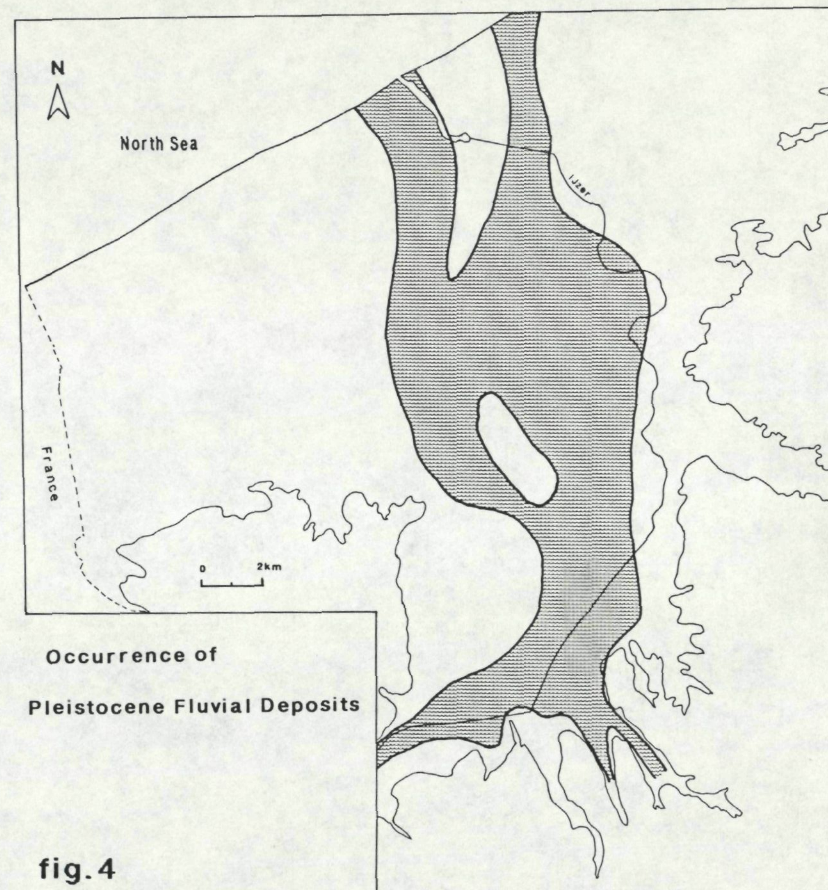
In a limited N-S area, well developed Weichselian fluvial deposits were found (fig.4), mainly fine grained channel fill sediments. Most of the time, in the channellag, they contain reworked Holsteinian marine deposits, characterized by the presence of *Cerastoderma edule* shells, most probably belonging to the "Izenberge Crag" (Herzeele Formation, Middle Pleistocene, Sommé *et al.*,1978).

In the very southern part of the plain (fig.5), a Holsteinian peatlayer was encountered in only few localities south of the river IJzer (Baeteman, 1978). That interglacial peat is also occurring in the neighbourhood of Lo (Vanhoorne, 1962) and has recently been found (at -3m to -4m) in a core at Woumen, overlying a sequence starting (at -8.70m) with coastal deposits covered by floodplain sediments, and underlying coastal deposits covered by finally Weichselian fluvial sediments (until +1m). From the available data, it is evident that the plain was influenced by a marine transgresssion in the Middle Pleistocene, but the data are still too scarce to be conclusive about any palaeogeographical reconstruction.




Occurrence of
Pleistocene Marine Deposits

fig. 3




Occurrence of
Pleistocene Fluvial Deposits

fig. 4

In the very western part of the plain, the Pleistocene deposits consist of a thin cover (ca 0.5m) of mainly reworked Eocene deposits. On the other hand, Weichselian Coversands are very well developed in the east.

The topography of the Pleistocene subsoil (fig.6) shows a rather good similarity to that of the Eocene. It is dominated by a deep narrow depression going far south where it is bifurcating into small valleys outside the coastal plain. The present-day location of the river IJzer is south and east of this depression.

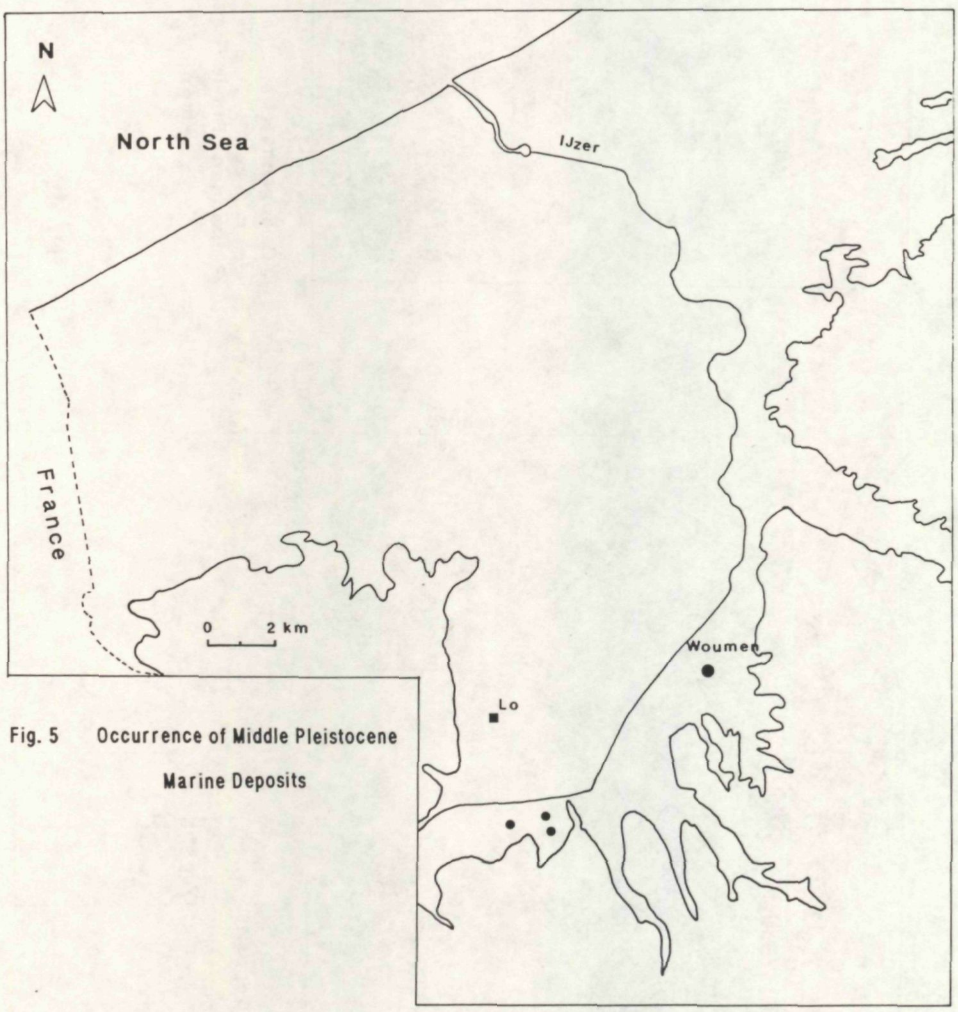



Fig. 5 Occurrence of Middle Pleistocene Marine Deposits

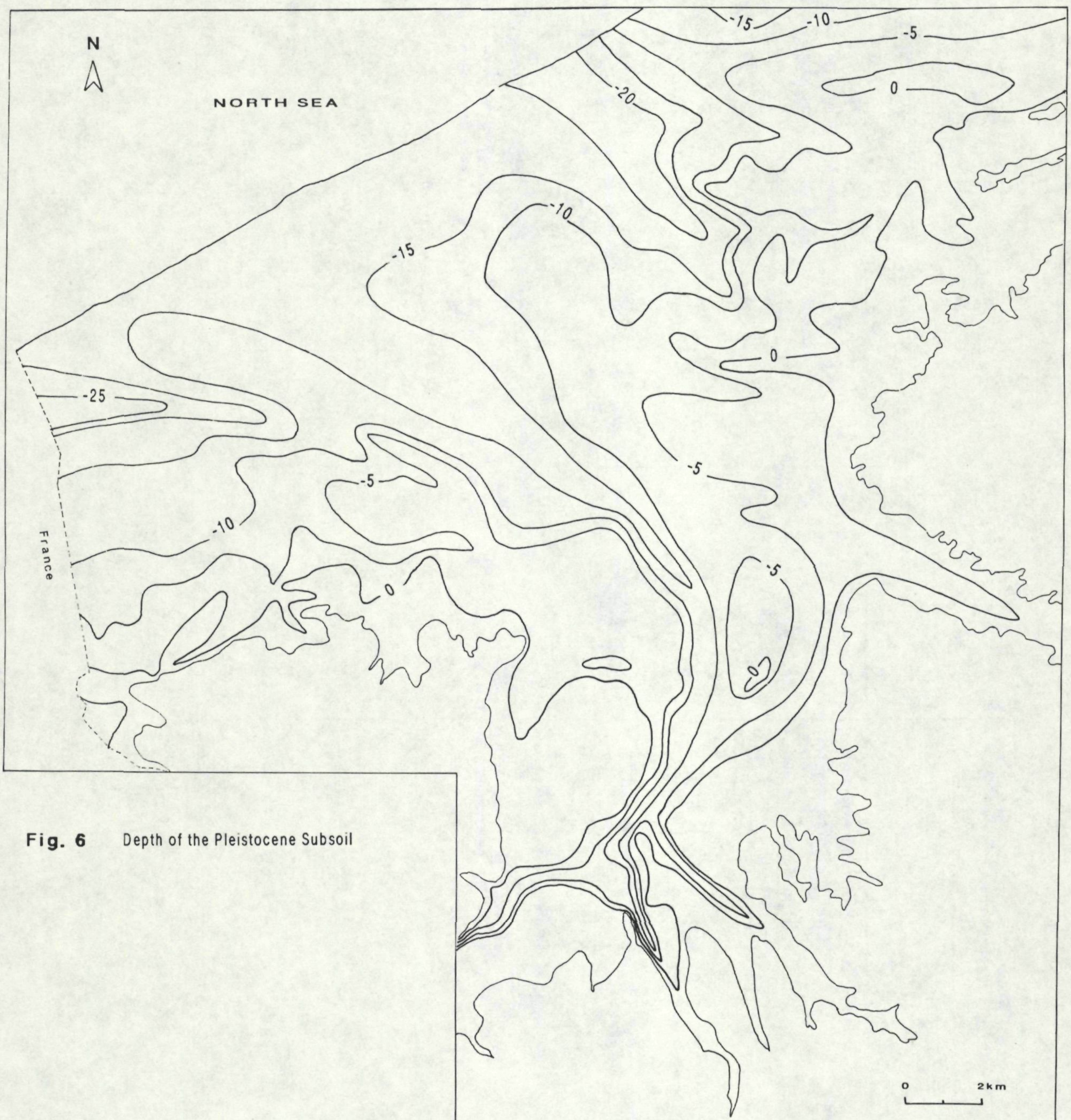



**Fig. 6** Depth of the Pleistocene Subsoil

### *Stratigraphy of the Holocene coastal deposits*

The Holocene coastal deposits are mainly formed under tidal and semi-terrestrial conditions. The Holocene infill is also known as *Flandrian* deposits or as being accumulated by the *Flandrian Transgression.* The deposits reach their greatest thickness of ca 30m in the seaward region and wegde out toward the Pleistocene hinterland.

These unconsolidated coastal deposits are characterized by lateral zonation. In the seaward region, only marine and brackish clastic sediments are present overlying a basal peat in some places. In the central part of the plain, the deposits consist in general of an alternation of brackish-marine sediments and peatlayers. Toward the Pleistocene hinterland, the deposits are formed by only a basal peat overlain by a cover of clastic brackish-marine sediments, while at the border of the outcropping Pleistocene area, the cover of brackish-marine sediments forms the entire Holocene sequence.

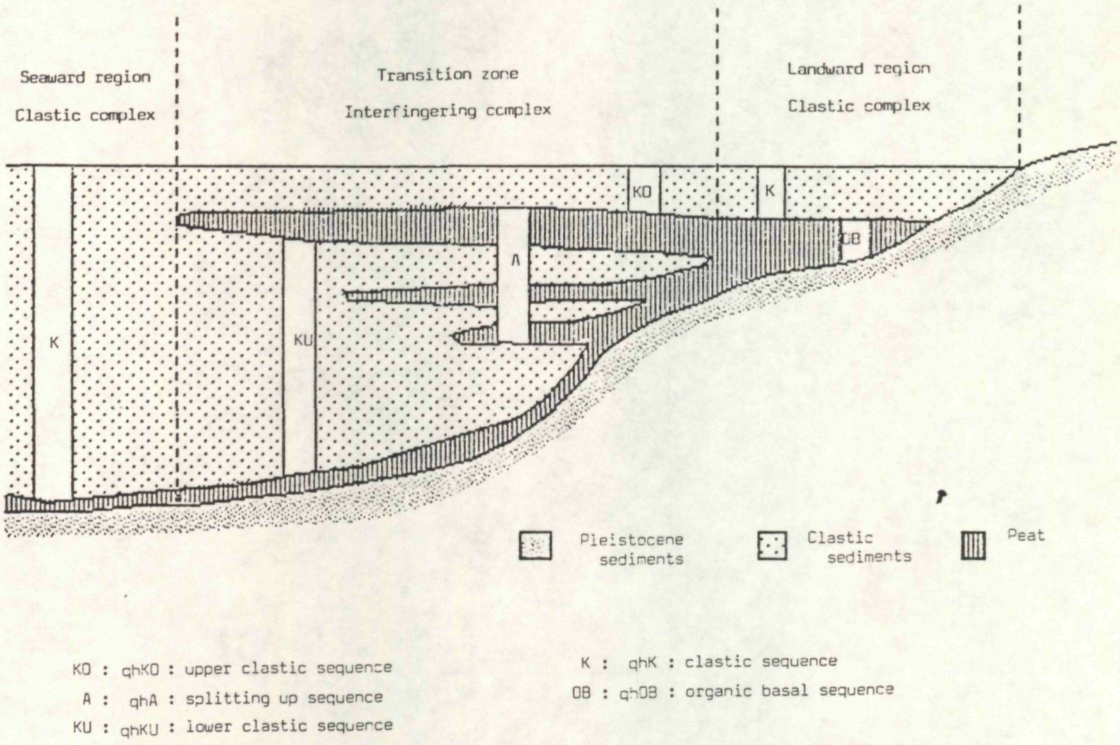



**Fig. 7 Lithological Classification**

Such lateral zonation, which is typical for the coastal plains of the southern North Sea, led to the development of a lithological classification of coastal deposits based on the vertical succession and lateral interfingering of clastic sediments and peat (Barckhausen *et al.*,1977, Streif,1978, Baeteman, 1981, Mostaert,1985, Baeteman,1987, Baeteman & Van Strijdonck, 1989). The traditional subdivision of the Holocene into Calais and Dunkerque deposits (transgressions?) indeed belongs definitely to the geological history, at least for this part of the excursion.

The lithological classification consists of complexes and sequences (fig.7). In the seaward and very landward regions, the deposits belong to the *clastic complex* bearing one sequence, *viz.* the clastic sequence, possibly underlain by the basal peat, represented as organic basal sequence. In the central part of the plain, labelled as transition zone, the deposits, characterized by clastic sediments and intercalated peatlayers, are grouped into the *interfingering complex*.

The organic basal sequence on the one hand and the splitting up sequence, bearing one or more peatlayers, on the other hand offer the possibility for the development of a geochronology, linking the lithological classification. 14-C dates from the peatlayers are given in the description of the Central Area.

The lithological classification also forms the basis for relevant mapping units. The complexes are represented by means of main profile types; X-type for the clastic complex, Y-type for the interfingering complex and Z-type for the peat complex, where the Holocene sequence mainly consists of peat.

Using the main profile types, a general profile type map can be established (fig.8) revealing a very clear overview of the Holocene geological setting. On the general profile type map (fig. 8) the occurrence of the organic basal sequence (basal peat) was only indicated in the landward regions for the X-type ($X_2$) as many boreholes are uncomplete as soon as the Pleistocene subsoil is beyond handauger reach.

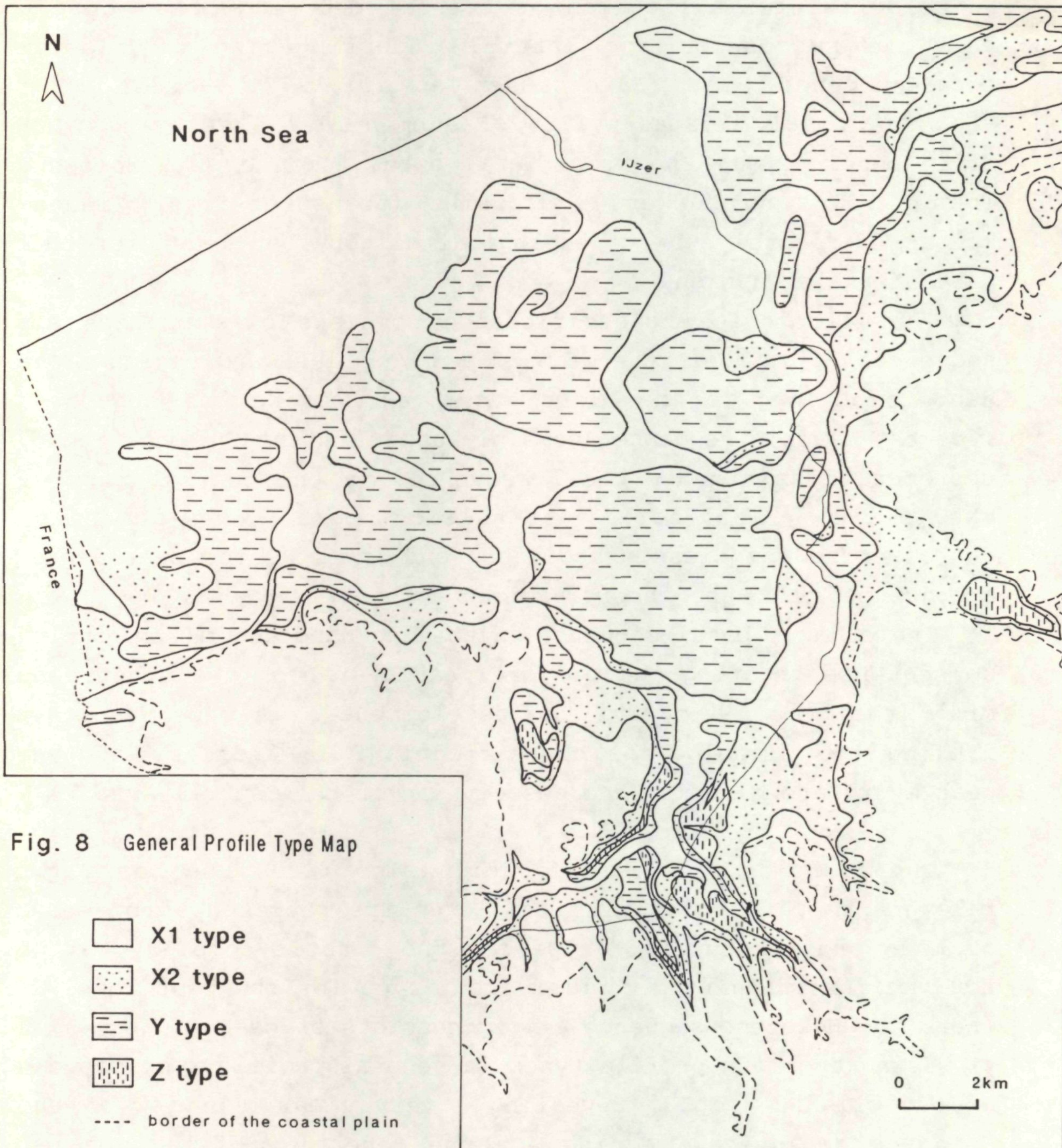



Fig. 8 General Profile Type Map

During the excursion several boreholes of 3 selected areas labelled as seaward, central and landward area (fig.9) will be demonstrated. The particular facies of the Holocene and Pleistocene sediments will be discussed, as well as the coastal evolution, which is the result of the geological mapping of the plain based on sedimentological investigation, however, without palynological nor micropalaeontological analyses (except for diatomanalysis for few selected boreholes).

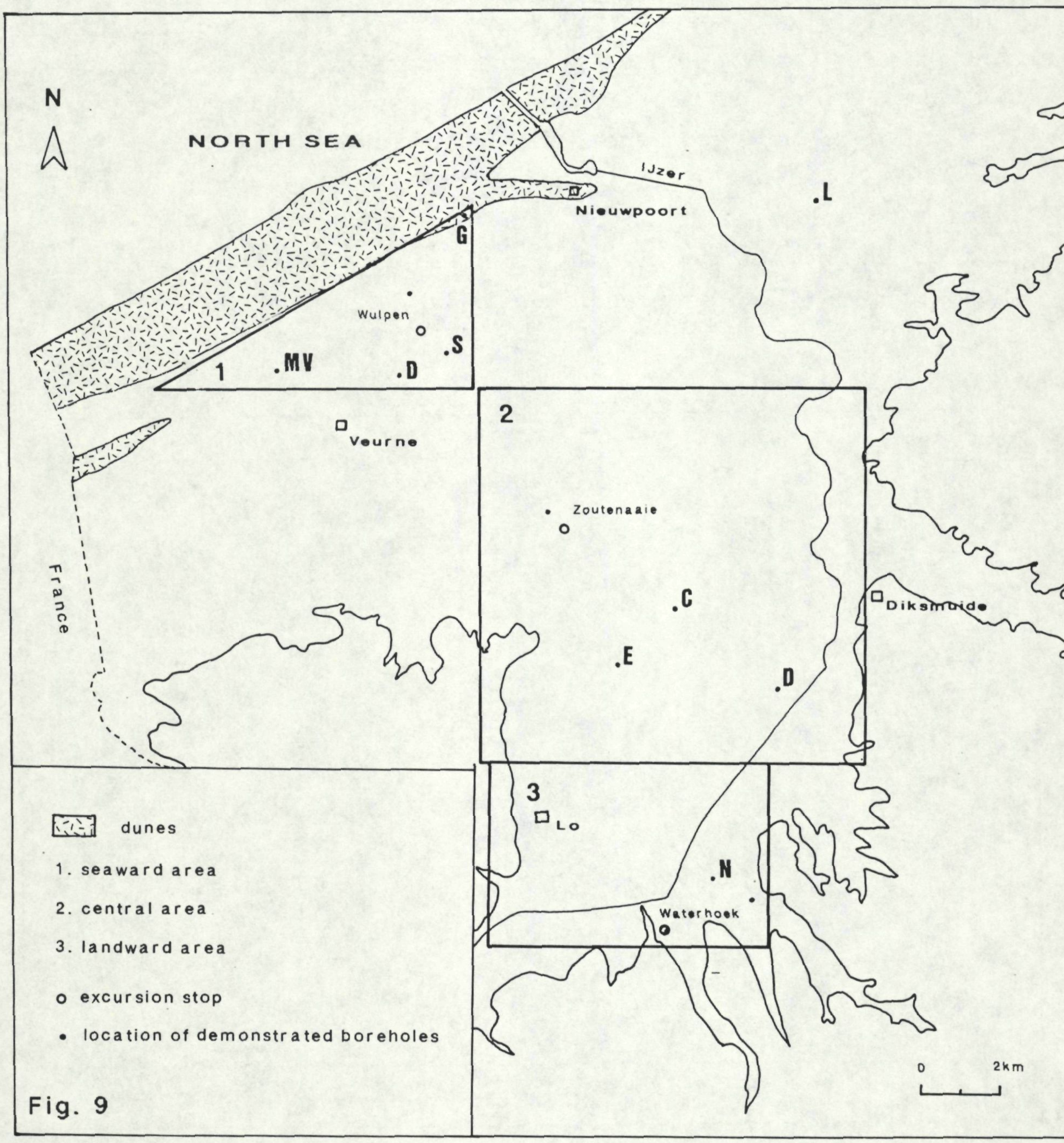


Fig. 9

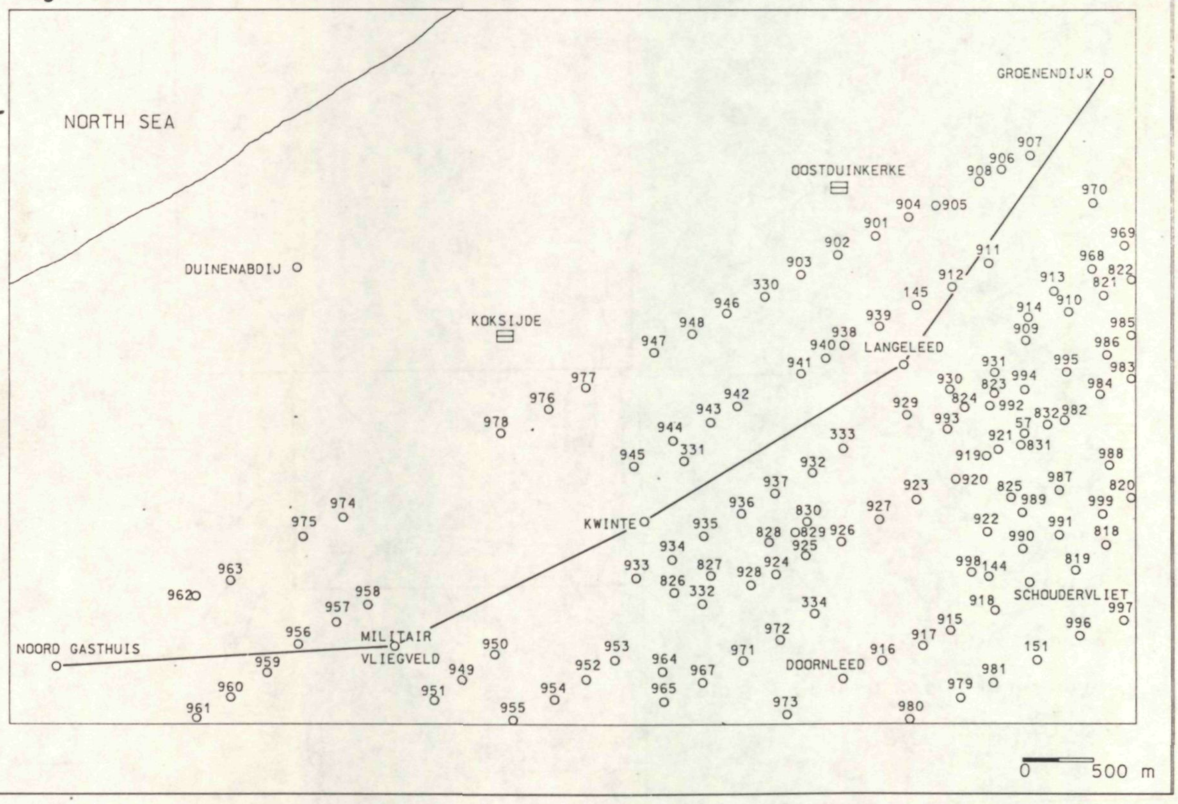
## SEAWARD AREA

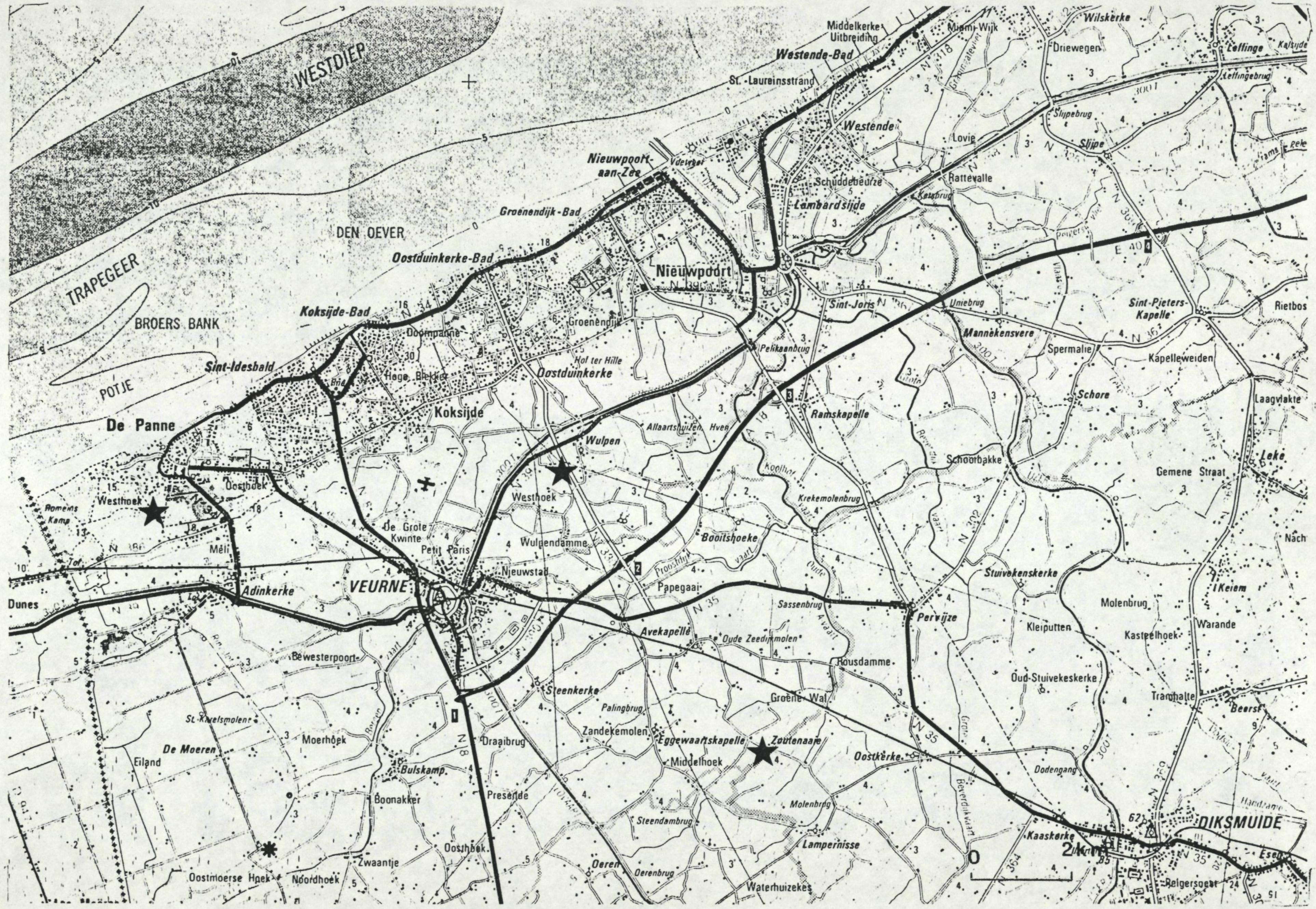
### *Excursion point: Wulpen*

The seaward area (fig.10), located landward from the broad coastal dune barrier, is characterized by a dominance of clastic sediments (fig.11, profile types #1,2,& 3). Peat intercalations are occurring in restricted areas. It should be mentioned that the profile type map is only representative until a depth of -2m as handaugering was hampered by the water-saturated sand.

In the clastic sequence, different facies can be recognized. A SW-NE cross-section parallel to the coast with boreholes until the Eocene deposits, reveals different events and a different evolution in the infill of the plain (fig.12). Boreholes M.V. and Groenendijk will be demonstrated.

**Fig. 10** LOCATION OF BOREHOLES IN THE OOSTDUINKERKE AREA





WESTDIEP
TRAPEGEER
BROERS BANK
POTJE
DEN OEVER
De Panne
Sint-Idesbald
Koksijde-Bad
Oostduinkerke-Bad
Groenendijk-Bad
Nieuwpoort-aan-Zee
Nieuwpoort
Westende-Bad
Westende
Middelkerke Uitbreiding
Miami-Wijk
St.-Laureinsstrand
Lombardsijde
Schuddebeurze
Rattevalle
Lovie
Driewegen
Wilskerke
Leffinge
Leffingebrug
Slijpebrug
Slijpe
Sint-Joris
Pelikaanbrug
Uniebrug
Mannekensvere
Spermalie
Sint-Pieters-Kapelle
Kapelleweiden
Rietbos
Laagvlakte
Schore
Leke
Gemene Straat
Schoorbakke
Ramskapelle
Koksijde
Oostduinkerke
Hof ter Hille
Groenendijk
Doornpanne
Hoge Blekker
Wulpen
Westhoek
Oosthoek
Romeins Kamp
Méli
Adinkerke
Dunes
De Grote Kwinte
Petit Paris
Wulpendamme
Nieuwstad
VEURNE
Booitshoeke
Krekemolenbrug
Allaartshuizen
Hven
Papegaai
Avekapelle
Sassenbrug
Oude Zeedijkmolen
Rousdamme
Pervijze
Stuivekenskerke
Kleiputten
Molenbrug
Kasteelhoek
Warande
Keiem
Oud-Stuivekeskerke
Tranhalte
Beerst
Groene Wal
Zoutenaare
Oostkerke
Eggewaartskapelle
Middelhoek
Zandekemolen
Palingbrug
Steenkerke
Dodengang
Kaaskerke
DIKSMUIDE
Esen
Belgersoest
Molenbrug
Lampernisse
Steendambrug
Oeren
Oerenbrug
Waterhuizekes
Bewesterpoort
St. Karelsmolene
De Moeren
Moerhoek
Eiland
Bulskamp
Draaibrug
Boonakker
Presefide
Oosthoek
Zwaantje
Noordhoek
Oostmoerse Hoek
E 40
N 35
N 8
0
2 km

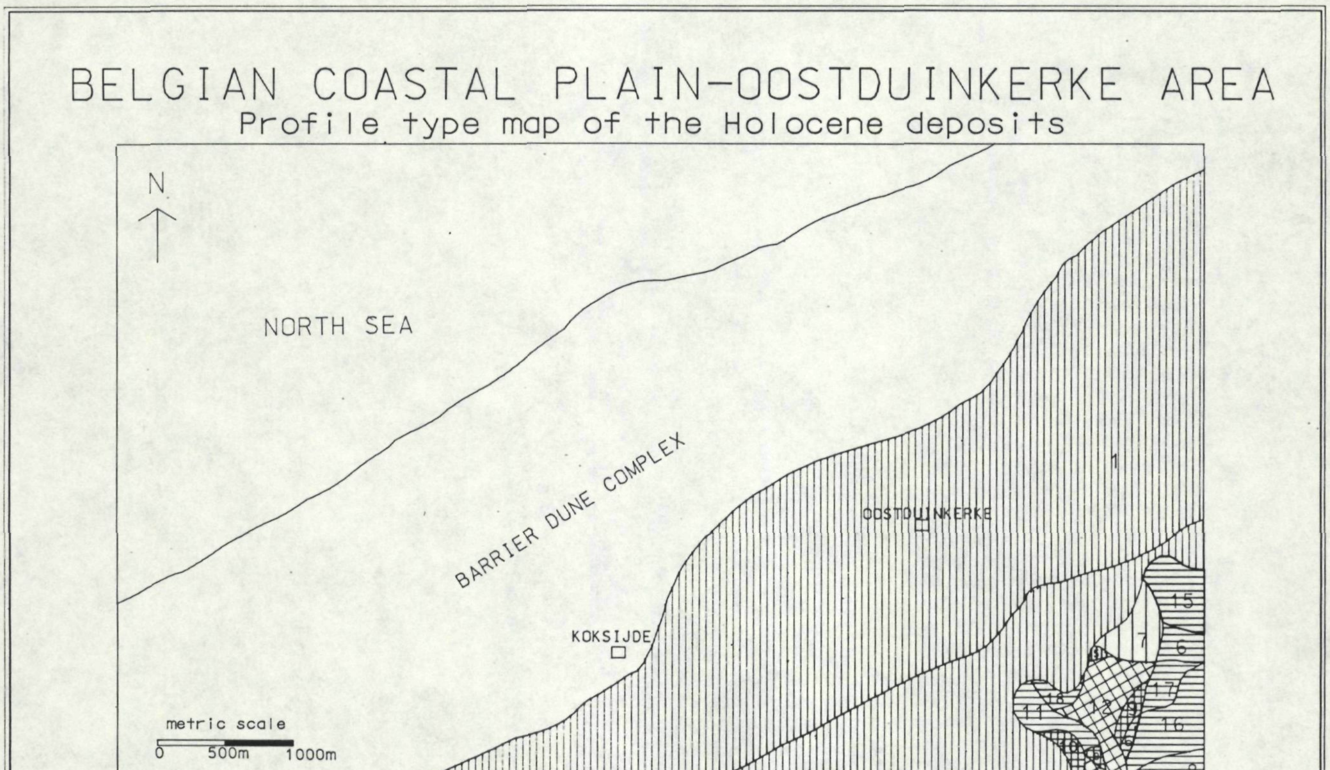
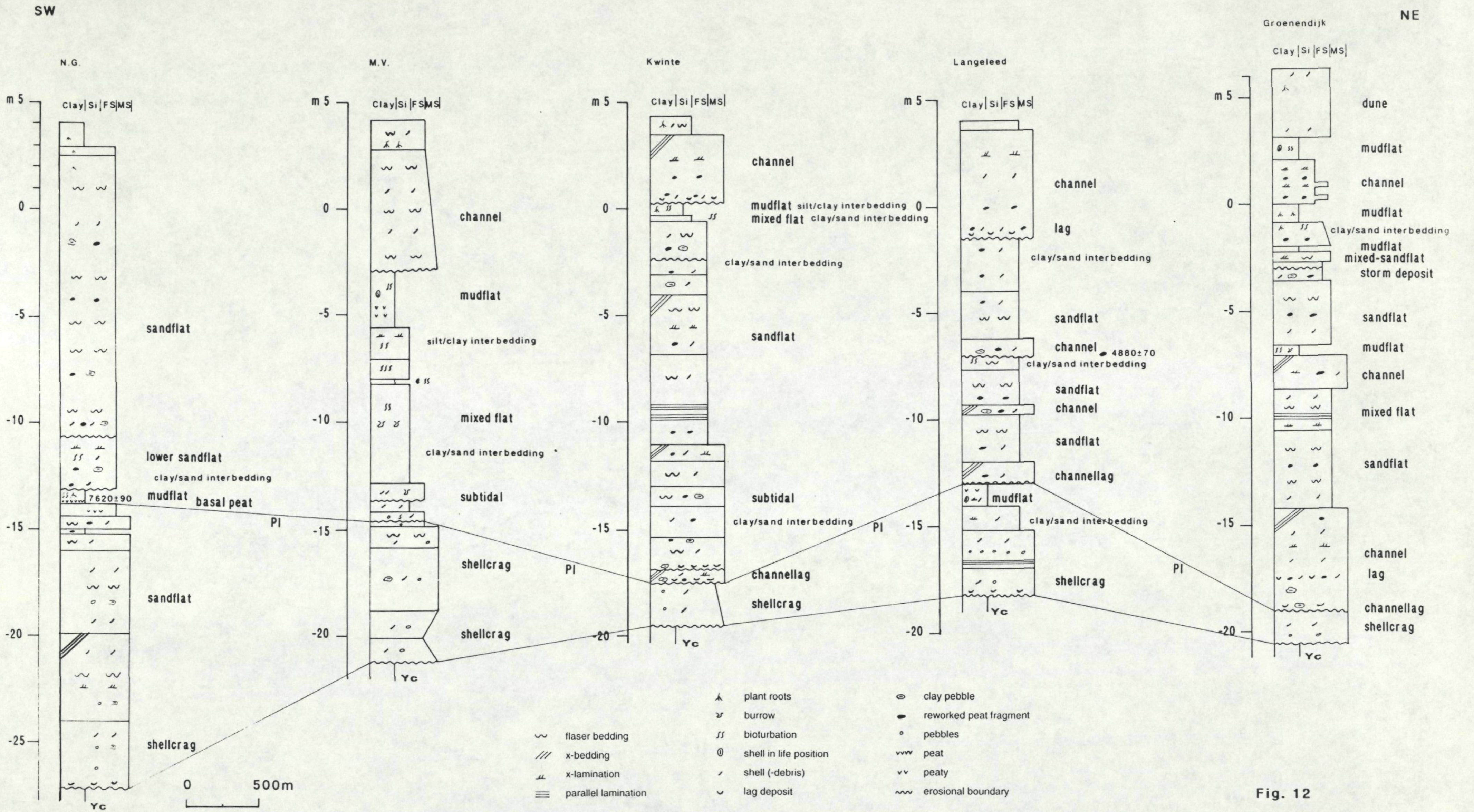

BELGIAN COASTAL PLAIN-OOSTDUINKERKE AREA
Profile type map of the Holocene deposits
N
NORTH SEA
BARRIER DUNE COMPLEX
OOSTDUINKERKE
KOKSIJDE
metric scale
0 500m 1000m
SCHEMATIC SECTION
Explanation of the profile types
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
LEGEND OF SCHEMATIC SECTION
Tidal flat deposits (undifferentiated)
peat
Mud flat deposits
Sand flat deposits
Tidal channel/gully deposits

Fig. 11



SW
NE
N.G.
M.V.
Kwinte
Langeleed
Groenendijk
Clay | Si | FS | MS
m 5
0
-5
-10
-15
-20
-25
sandflat
lower sandflat
clay/sand interbedding
mudflat
7620±90
basal peat
Pl
shellcrag
channel
mudflat
silt/clay interbedding
mixed flat
clay/sand interbedding
subtidal
mudflat silt/clay interbedding
mixed flat clay/sand interbedding
channellag
lag
4880±70
dune
channel lag
mixed-sandflat
storm deposit
Yc
0 500m
flaser bedding
x-bedding
x-lamination
parallel lamination
plant roots
burrow
bioturbation
shell in life position
shell (-debris)
lag deposit
clay pebble
reworked peat fragment
pebbles
peat
peaty
erosional boundary


Fig. 12

Only in the west (borehole N.G.), the Holocene begins with a basal peat (7620±90 BP at -13.75m) which is covered by mudflat clay. However, a sandflat eroded the mudflat and dominated the environment most probably during the rest of the Holocene. In borehole M.V. a subtidal environment initially developed, evolving to a well developed mixed and mud flat. In the Kwinte borehole, however, clear evidence of erosion are found at the base in the form of channellag and erosional boundary. It can be assumed that several meters of Pleistocene deposits were eroded. A subtidal environment accumulated sand and clay for about 5m and was replaced by a sandflat which, in view of its thick accumulation, persists for a long time. It finally evolved into a mixed and mud flat, representing a regressive sequence. In both M.V. and Kwinte boreholes the top of the mudflat is eroded by a tidal channel.

Borehole Langeleed shows a quite different picture as it consists of two minor, regressive sequences (although not completely developed: from sandflat to mixed flat), each time truncated by an erosional tidal channel. Reworked peat fragments from the channel sediments were dated at 4880±70 BP (fig.12), revealing that the uppermost peatlayer has been eroded.

Borehole Groenendijk is characterized in its lower part by a nearly complete regressive sequence, but the mixed flat is truncated by a tidal channel at about -9m. It is quite probable that this channel is to be correlated with the slightly higher situated channel in Langeleed.

It is very remarkable that a thin mudflat deposit is occurring between the channel and the sandflat, but it is not inconceivable that this half a meter of bioturbated clay is just an erosive part of a mudflat redeposited in its entirety. The lower and upper boundaries are indeed very sharp. Such a phenomenon will be demonstrated in borehole Doornleed where about 2 meter of clay and peat were redeposited as a whole in the channel fill.

The second regressive sequence (as from -9m onward) in borehole Groenendijk is interrupted by half a meter of badly sorted sand and clay with numerous shells and peat fragments and which has been interpreted as storm deposit. Also at this

COMPOSITE CROSS SECTION

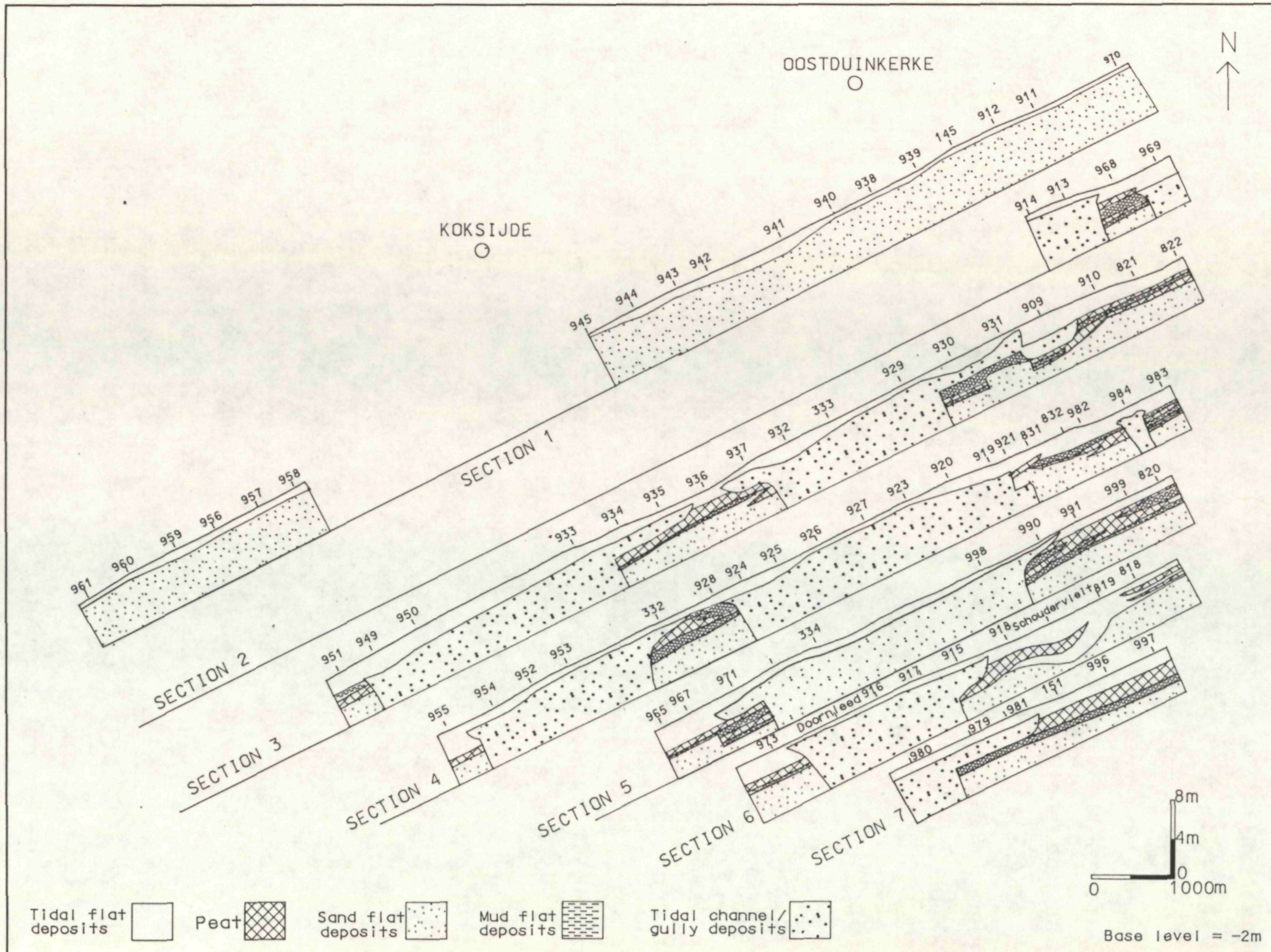



Fig. 13

location the top of the regressive sequence is truncated by a tidal channel which here is less developed. Moreover it consists mainly of clay and reworked peat and shows a clear silting up sequence evolving to mudflat.

The borehole data from the seaward region clearly demonstrate that in the upper Holocene, more particularly in the sequence which developed after the last peatgrowth, two distinct erosional phases happened. In between the phases of erosion, the area quietly developed as sand, mixed and mudflat.

It is quite probable that the first erosional phase is to be correlated with the transgressive overlap which is occurring in the uppermost peatlayer in this seaward area (fig.13) and which is dated between 3580±60 BP and 3490±60 BP. 14-C dates of this transgressive overlap from 3 locations are shown on fig. 14. The age of the second erosional phase remains questionable (see Landward Area).

The fact that in this particular area as shown on fig. 12, no peatbogs developed, only faint peat initiations in borehole M.V., indicates that it was continuous under full tidal influence. Most probably a major tidal inlet is to be situated there in which a tidal channel or several ones were migrating laterally in a sandflat with mixed and mudflats at its borders. Only beyond the reach of the direct tidal influence, peatbogs could develop.

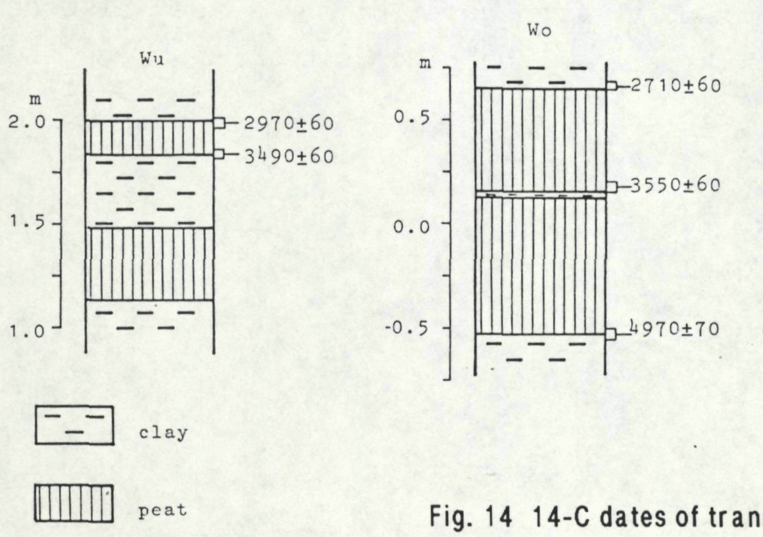



Fig. 14 14-C dates of transgressive overlap in y BP

The tidal inlet most probably existed as from the beginning of the Holocene infill as basal peat covered by mudflat deposits, like in borehole N.G. and Schoudervliet, are lacking.

The typical facies of the basal peat evolving to freshwater marsh and finally mudflat, will be shown in borehole Schoudervliet (fig.15), located slightly landwards from the SW-NE cross-section (fig.12). The mudflat in the lower part of borehole Schoudervliet is truncated by a channellag. The channel fill deposits evolve to a sandflat which in turn is replaced by a tidal channel as from -8.30m with fragments of reworked peat at its base. The channel deposit evolves to a sandflat until -1.4m and displays a very sharp upper boundary. The overlying silty clay, sandy at the base and with numerous rounded peatfragments, is characterized by a.o. cross-laminations and unconformaties. The boundary with the overlying peat is formed by a thin truncating sand layer. Also the peat layer shows sharp erosional upper and lower boundaries.

Although the peat is found at the level the uppermost peat layer is occurring here, (which generally is situated between +0.5 and +2m, fig. 13), and the 14-C date of 4540±65 BP for the base is in accordance with the age of the base of the uppermost peat layer in that area, the presence of it is problematic.

The tidal channel occurring as from -8.30m is most probably the same as the one displayed in the SW-NE cross-section (fig. 12) and from which the incision is to be dated around 3500 BP.

That means that the clay and peat covering the sandflat as from -1.40m is to be interpreted as channel fill from the tidal channel formed during the second erosional phase. Also here, the whole peat layer was eroded and redeposited in its entirety.

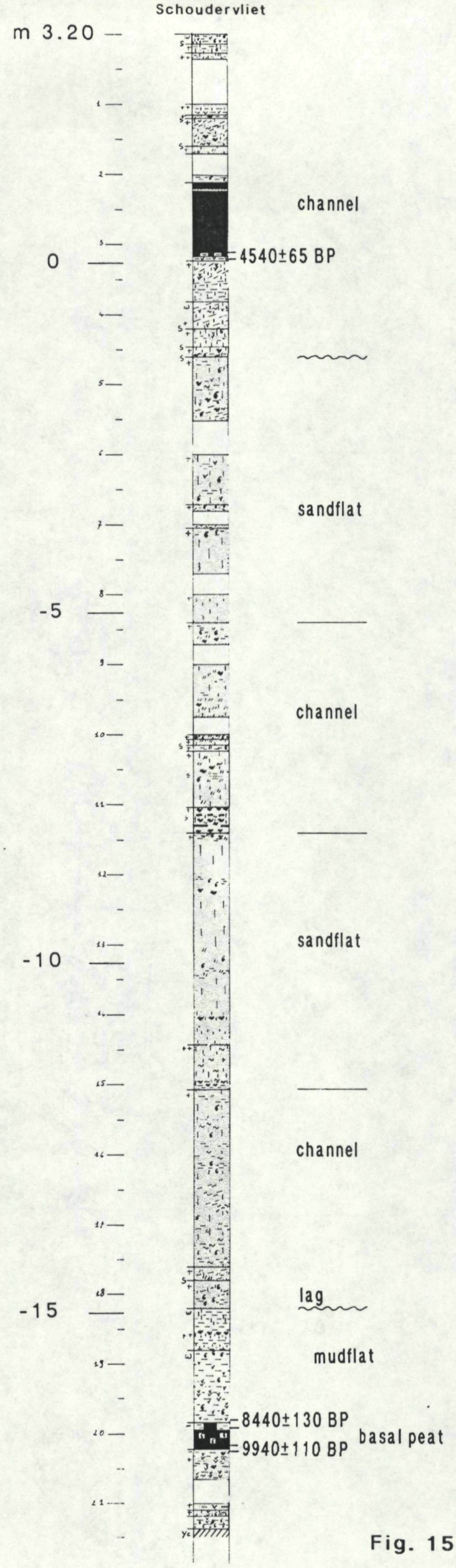
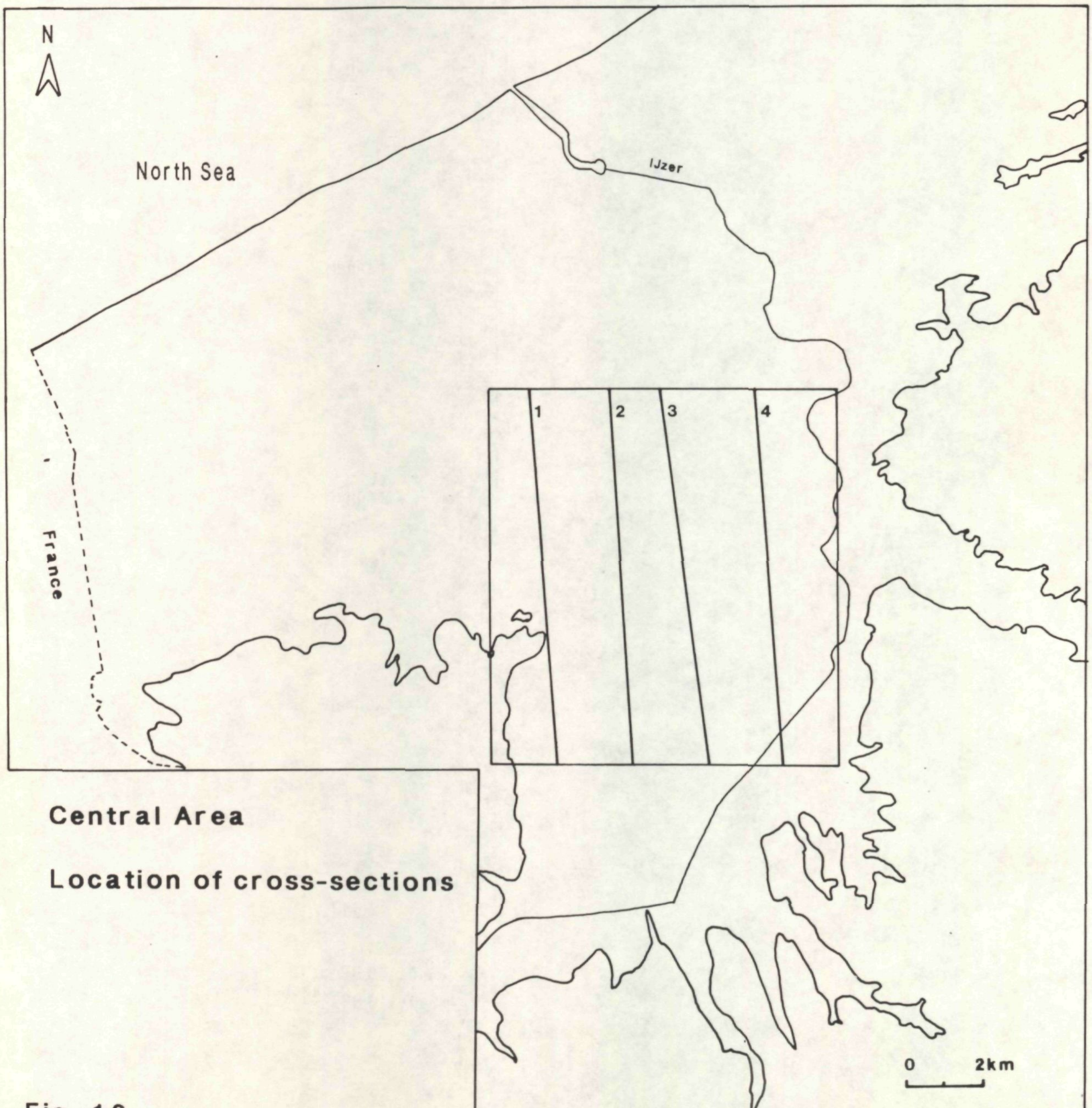

Schoudervliet
m 3.20
0
-5
-10
-15
4540±65 BP
8440±130 BP
9940±110 BP
channel
sandflat
channel
sandflat
channel
lag
mudflat
basal peat

Fig. 15

## CENTRAL AREA

*Excursion point: Zoutenaaie*

The central area (fig. 16) pre-eminently exhibits that the Holocene infilling of the plain is dominated by its subsoil. The 4 cross-sections (fig. 17, 18, 19 & 20) covering this entire area, demonstrate that the topography of the Pleistocene subsoil is very similar to that of the Eocene Ieper clay.




**Central Area**

**Location of cross-sections**

Fig. 16

The Pleistocene consists of Weichselian fluvial deposits which reach a maximum thickness of 11m. Only in the very NW part of this area, coastal deposits were encountered as from a depth of -11m, evidently eroded at the top, consisting of fine sand and clay with numerous bivalves of *Corbicula fluminales* and organic deposits. These deposits most probably represent the landward extent of an Eemian coastal/estuarine embayment (fig.3).

The central area also forms one of the particular regions where the typical cyclic formation of coastal deposits where peat is alternating with tidal flat deposits (Y-type on fig.8).

The oldest known Holocene infill in this area was found in the pre-existing Pleistocene valley (fig. 19) where a basal peat developed at 8170±90 BP years (at -15.60m). In the valley a mud flat developed, however quickly replaced by a sand flat and tidal channel which filled the valley for about 8m with only clastic sediments.

Sea level reached the altitude of -7.5m at about 7000 BP. As from that period on, mud flats in the lower parts, and peatgrowth (basal peat) on the more elevated parts, dominated the entire area. Between about 7000 BP and about 5300 BP, the basal peat transgressed over the Pleistocene subsoil, while mud flat sediments continue to accumulate, however, with several periods of peatgrowth. The peats are not always occurring regularly at the same altitude or with the same extension and thickness. The best developed peat is situated between -2m and -3m and dated in the period between 5800 BP and 6400 BP.

As from 5300 - 5000 BP on, the plain was silted up and the marine influence was very much reduced. A very extensive peatbog developed which forms the uppermost peatlayer of the series of intercalated peats. It merges with the basal peat where the Pleistocene subsoil is at higher elevations.

The uppermost intercalated peat is mostly 1m to 2m thick and is generally situated between the altitudes of ca -0.5m and +1m. In the Belgian literature it is usually referred to as *surface peat*. Such a classical alternation of peat and mudflat clay is well displayed at borehole Cayenne (C, fig. 19) which will be demonstrated.

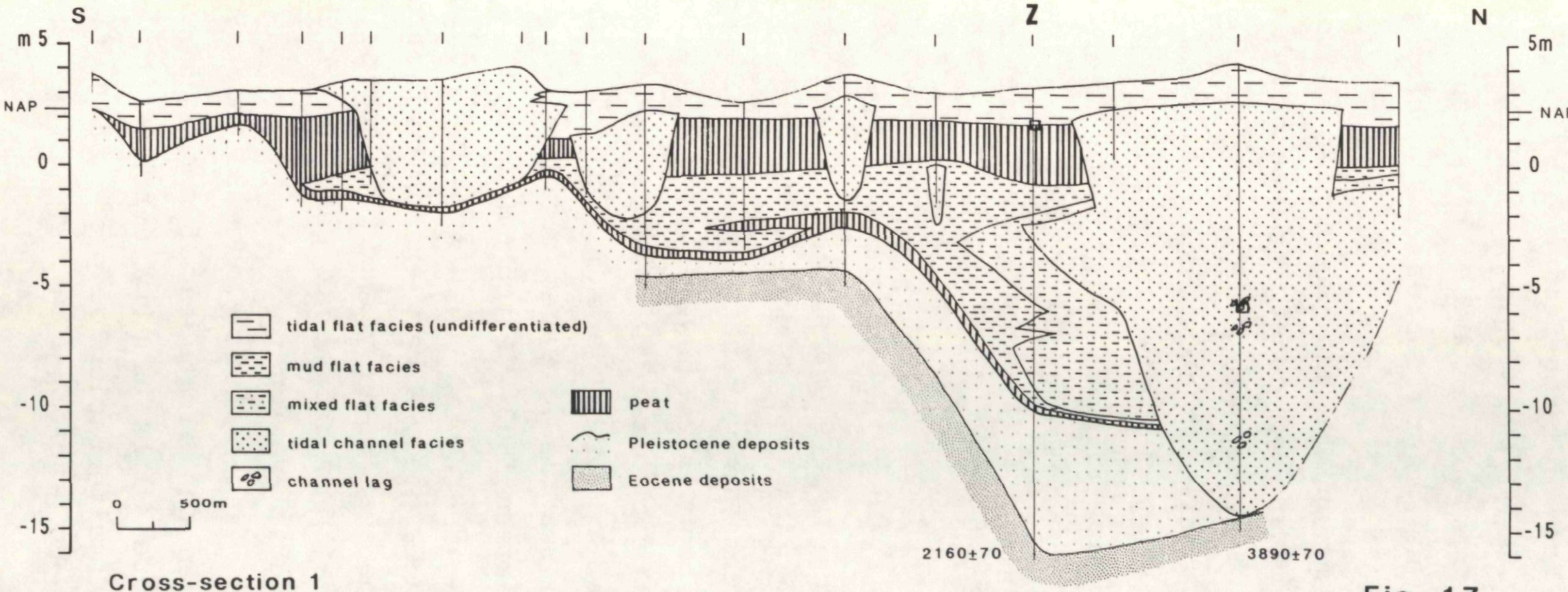

S
Z
N
m 5
NAP
0
-5
-10
-15
5m
NAP
0
-5
-10
-15
tidal flat facies (undifferentiated)
mud flat facies
mixed flat facies
tidal channel facies
channel lag
peat
Pleistocene deposits
Eocene deposits
0
500m
2160±70
3890±70
Cross-section 1

Fig. 17

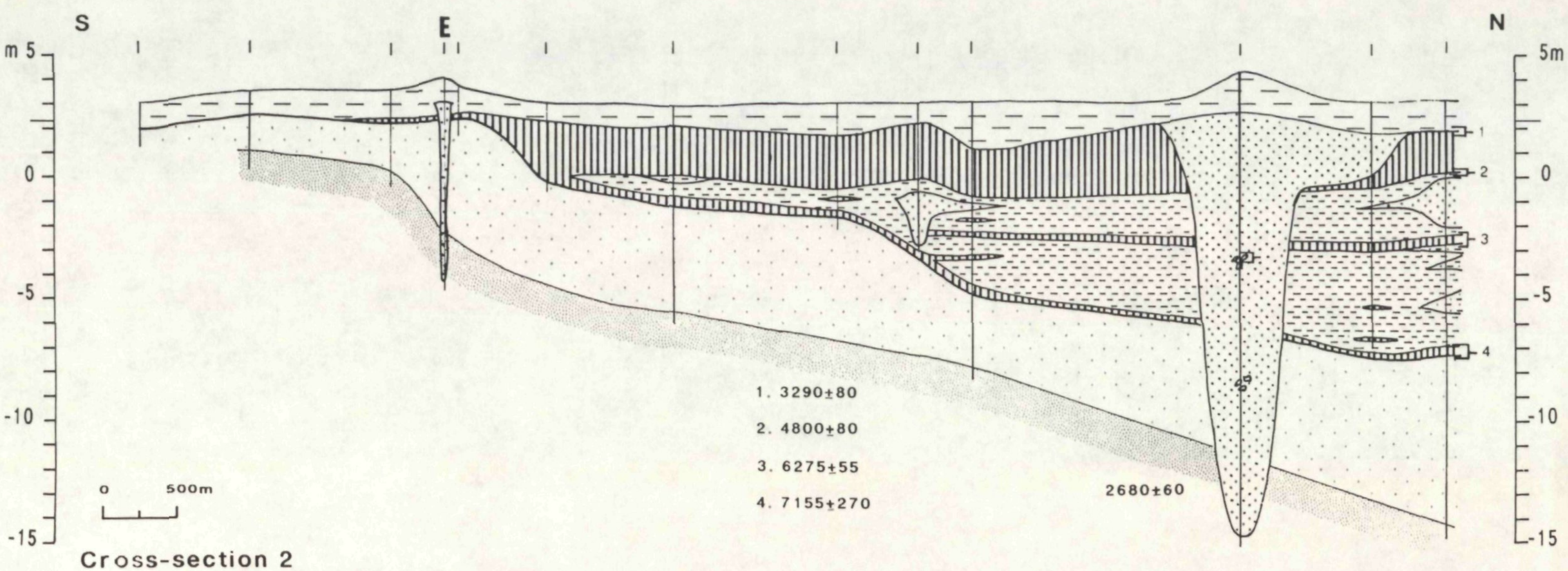

S
E
N
m 5
0
-5
-10
-15
5m
0
-5
-10
-15
1
2
3
4
1. 3290±80
2. 4800±80
3. 6275±55
4. 7155±270
2680±60
0
500m
Cross-section 2

Fig. 18

The radiocarbon dates from the base of this uppermost intercalated peat from the entire coastal plain show an age range of 5360±70 BP to 4220±65 BP (Baeteman & Van Strijdonck, 1989). However, the greatest number of dates reveals an age in a much smaller range, i.e. 4700 BP - 5220 BP in which moreover a concentration of dates is observed between resp. 4700 BP - 4970 BP and 5130 BP - 5160 BP. The two youngest dates happen to come from locations in the seaward area. On the other hand, the oldest dates were obtained from the peat occurring in the very landward part of the plain, rather close to the outcropping Pleistocene deposits.

The radiocarbon dates from the top show an age range of 1610±55 BP to 3290±80 BP. The very young age of 1185±40 BP (fig. 19) forms a striking exception.

Mudflats and peatbogs were not the only environment, however. The area was crossed by tidal channels, some of them were located where the pre-existing Pleistocene valleys are situated. Most of these channels have been active during the entire Holocene infill, however not always with the same intensity. Although it is not always obvious to recognize phases of renewed activity or incision in the sequence of channels in boreholes, the evidence that they were continuously active, is seen in the sequence of their adjacent areas (fig. 17 & fig. 19) where the typical mud flat deposits are replaced by mixed flat and channel deposits. The evidence is well displayed in borehole Zoutenaaie (Z, fig. 17) which will be demonstrated.

However, at excactly the same location, these tidal channels also produced significant erosion of the Holocene sequence in the period after the last peatgrowth. During which incision phase is not known. Indeed, reworked peat fragments from channellags at a depth of -5.70m and -3.40m were dated 3890±70 BP and 2680±60 BP, respectively (fig. 17 and fig. 18). The explanation of the very deep scouring of the channels remains questionable too.

On the other hand, it is quite probable that many other tidal channels came into existence only in the period after the end of the peatgrowth and are the result of but one erosional phase. Most remarkable examples of peat erosion and tidal channel fill will be demonstrated in boreholes Eendekot and Devisch (E & D, fig. 18 & fig. 20).

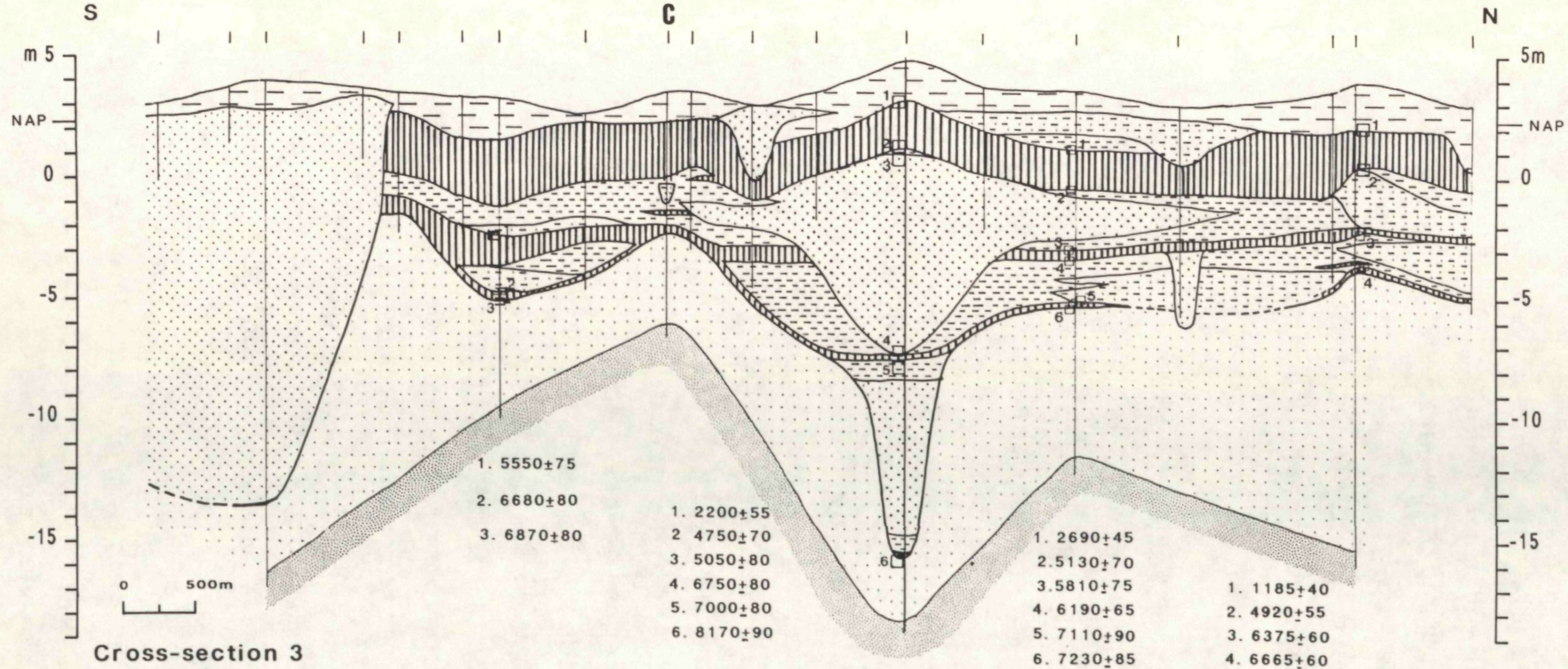

S
C
N
m 5
NAP
0
-5
-10
-15
5m
NAP
0
-5
-10
-15
0 500m
Cross-section 3
1. 5550±75
2. 6680±80
3. 6870±80
1. 2200±55
2 4750±70
3. 5050±80
4. 6750±80
5. 7000±80
6. 8170±90
1. 2690±45
2.5130±70
3.5810±75
4. 6190±65
5. 7110±90
6. 7230±85
1. 1185±40
2. 4920±55
3. 6375±60
4. 6665±60

Fig. 19

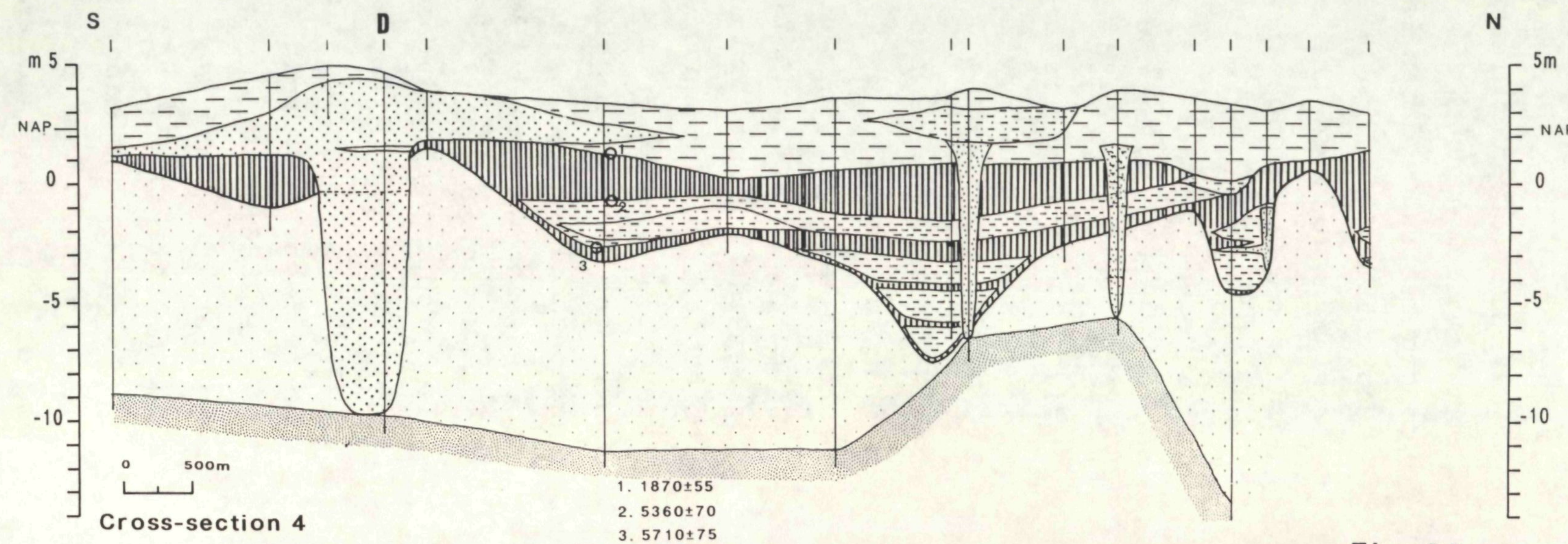

S
D
N
m 5
NAP
0
-5
-10
5m
NAP
0
-5
-10
0 500m
Cross-section 4
1. 1870±55
2. 5360±70
3. 5710±75

Fig. 20