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## The Evolution of the Coastal Dunes in the Western Belgian Coastal Plain

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Evolution, coastal dunes, correlation, C14 dating, Holocene pollen diagram.  
Belgium (Western Coastal Plain)

**A b s t r a c t :** Two main dune systems exist in the area west of Nieuwpoort: the Younger Dunes along the present coastline, and the Older Dunes isolated within the coastal plain near the French border and also running parallel to the coast. Both systems have recently been subjected to geological and palynological investigations. The Older dune system is believed to be older than 4300 B. P. The Younger Dune-area appears to have a complex history. A stretch of older dune-sediments (however not as old as these of the Older dunesystem) was found underneath the Younger Dunes, also near the French border. The age of these sediments is ranging from 2800 B. P. to 900 B. P. Furthermore two subphases of Younger Dune-formation are distinguished. Prior to the 14th century A. D. the dune area consisted of a relatively level plain. The completion of this plain marked the end of an active eolian phase. This phase started in the 11th century A. D., probably as the result of an increased incidence of storm-floods at that time (the Dunkerque-3 transgression). From the end of the 14th century on, large parabolic dunes partially buried the former landsurface. Some of them are still moving nowadays.

Here the evolution of the Younger Dunearea near De Panne is described in more detail including aspects of the vegetational history of the dune area and adjacent coastal plain. Some attention is also drawn on the position of former coastlines.

### [Die Entwicklung der Küstendünen in der westlichen Küstenebene von Belgien]

**K u r z f a s s u n g :** Zwei Hauptdünengebiete kommen im Gebiet westlich von Nieuwpoort vor: die Jüngeren Dünen entlang der heutigen Küstenlinie sowie die Älteren Dünen, die in der Nähe der französischen Grenze isoliert in der Küstenebene auftreten und ebenfalls küstenparallel verlaufen. Beide Systeme wurden geologisch und paläontologisch untersucht. Es wird vermutet, daß das Ältere Dünensystem in der Zeit vor 4300 v. h. entstanden ist. Ein Streifen weiterer älterer Dünensedimente (der jedoch nicht so alt wie das Ältere Dünensystem ist) wurde, ebenfalls nahe der französischen Grenze, unter den Jüngeren Dünen gefunden. Das Alter dieser Sedimente liegt zwischen 2800 und 900 v. h. Bei der Entstehung der Jüngeren Dünen wurden zwei Subphasen unterschieden. Vor dem 14. Jahrhundert bildete das Dünengebiet eine relativ ebene Fläche. Ihre Entstehung markiert das Ende einer aktiven äolischen Phase, die im 11. Jahrhundert n. Chr. wahrscheinlich als Folge damals verstärkt auftretender Sturmfluten einsetzte

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(Dunkerque-3 Transgression). Mit dem Ende des 14. Jahrhunderts begannen sich große Sicheldünen zu bilden, die Teile der früheren Landoberfläche begruben. Einige von ihnen bewegen sich noch heute.

Die Entwicklung des Jüngeren Dünengebietes bei De Panne wird eingehend beschrieben, einschließlich der Vegetationsgeschichte des Dünengebietes und der anschließenden Küstenebene. Einige Aufmerksamkeit wird auch der Lage früherer Küstenlinien gewidmet.

## 1. Introduction

In the last few years geological and pollenanalytical investigations have been carried out in the dunes of the western Belgian coastal plain, mainly in the area west of Nieuwpoort (LEBBE & DE CEUNYNCK 1980, DE CEUNYNCK & THOEN 1981). Two distinct dune systems exist in that area:

a) The "Older Dunes" of Adinkerke, a dune ridge with less pronounced topography running parallel to the coast. The present day location of the Older Dunes suggests that at one time the coast was situated more to the south of the actual one. Two radiocarbon dates of the base of an important peat layer situated at the landwards side of the Older Dunes yielded  $4270 \pm 65$  B. P. (IRPA 590) and  $4300 \pm 65$  B. P. (IRPA 589)<sup>1</sup>. The fact that the peat layer associated with it is absent north of these dunes where instead beach deposits are found indicates that the coastline was at that time situated just north of the Older Dunes, 2,8 km inland of the present coastline (fig. 1). It also follows that the Older Dunes are older than 4300 B. P.

b) The "Younger Dunes" along the present coast, generally showing high parabolic dune forms and usually considered not to be older than the 9th century A. D. (DEPUYDT 1967).

The following summarizes the results of geological and palynological investigations carried out in the area covered with the Younger Dunes, mainly west and south of De Panne.

## 2. The Period between 800 B. C. and 1000 A. D.

Already in 1951, MOORMANN indicated the presence of older dune sediments beneath the sediments of the Younger Dunes of De Panne. The extension of these sediments was studied by LEBBE & DE CEUNYNCK (1981) (fig. 1). To avoid confusion with the Older Dunes of Adinkerke these sediments will be designated informally as „older dunes of De Panne“. Radiocarbon dating of a peaty layer within these sediments yielded  $1965 \pm 110$  B. P. (Hv 9136) for the top and  $2660 \pm 100$  B. P. (Hv 9137) for the base (fig. 2). Earthenware of the Iron Age is associated with this peaty layer. Until now, no older peaty layers or humic former land surfaces have been found in the area. However dune formation probably started earlier, since the earliest date — 2660 B. P. — reflects only the beginning of a stabilisation phase of the dunes. A reconstruction of the Iron Age dune surface, partly hypothetical, is represented in fig. 2. It is based on

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1) All radiocarbon dates are listed in table 1 with their calibrated ages and some of them also with an estimated age based on additional archaeological and/or historical evidence.

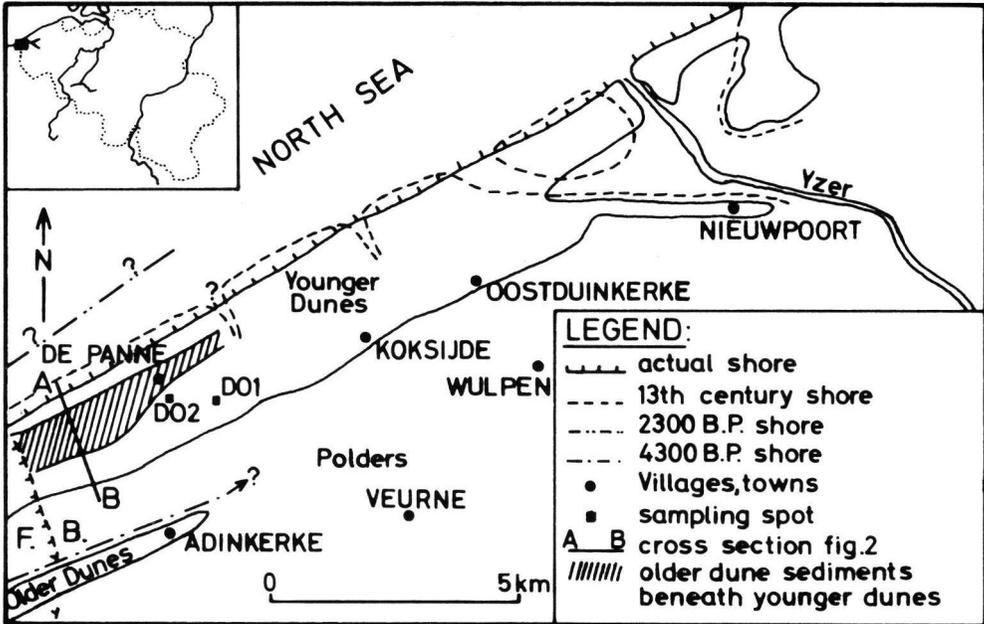


Fig. 1: Map showing the studied area.

stratigraphical and archaeological evidence. Pollen analysis of the peaty layer revealed that most of the time the area was covered with shrub vegetation consisting mainly of *Juniperus*. No *Hippophae* — the dominant shrub of present-day dune vegetation — was found (DE CEUNYNCK & THOEN 1981). The relative importance of *Quercus* (13 to 22 %) points to woody patches in the vicinity. Together with the stratigraphical evidence this suggests that the coastline at the time was situated at least 1 km north of the actual one (fig. 2; 2300 B. P.: climax of shrub and wood vegetation in the dune area). The Romans settled on the same dune area and Roman earthenware occurs very frequently on top or within the "older dune sediments of de Panne". Most of the previous mentioned shrub and wood vegetation was destroyed as a result of renewed eolian activity during The Roman period (DE CEUNYNCK & THOEN 1981). However this activity did not result in the deposition of large amounts of dune sands. Only within the northern part of the dune sediments a layer of sterile sands clearly separates the Iron Age and Roman archaeological layers. Repeated analyses of the buried Roman dune surface did unfortunately not yield any pollen.

Just before the beginning of our era the sandy tidal flat area south of the "older dunes of De Panne" progressively changed in a salt marsh. Then a reed peat comparable with the northern German "Darg" (cfr. OVERBECK 1975) developed on most of the salt marshes just south of the dunes. This demonstrates a declining marine influence in that particular area. The base of the reed peat was dated  $2080 \pm 55$  B. P. (IRPA 582; DO 2 fig. 1 & 3). About 270 A. D. the Romans left the area because of the pressure by German tribes and above all because of the increasing marine influence in the area (THOEN 1978). Most of the present-day Belgian coastal plain was then flooded by the sea; this event is traditionally called the Dunkerque 2-transgression (TAVERNIER et al. 1970).

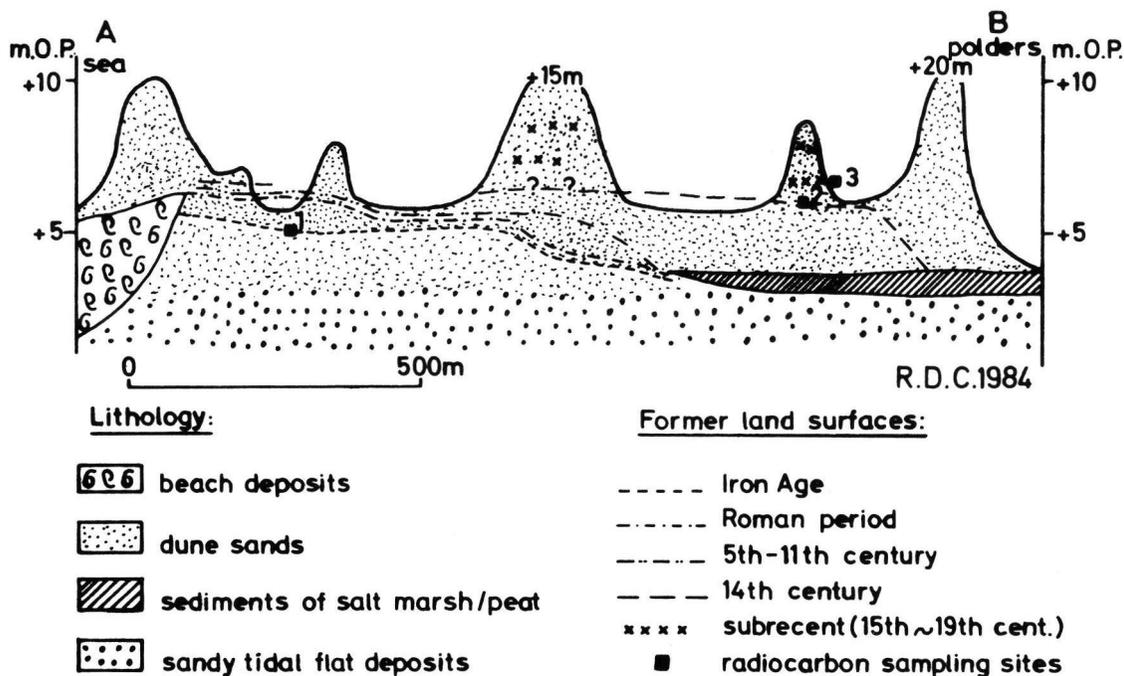


Fig. 2: Cross-section of the dune area west of De Panne; localisation indicated on the map of fig. 1; radiocarbon dates:

- 1) base  $2660 \pm 100$  B. P. (Hv 9136), top  $1965 \pm 110$  B. P. (Hv 9137);
- 2)  $550 \pm 75$  B. P. (DEPUYDT, 1967a); 3)  $430 \pm 75$  B. P. (DEPUYDT, 1967b).

Consequently the area south of the "older dunes of De Panne" changed again in a tidal flat-salt marsh area. The Dunkerque 2-transgression destroyed most of the "older dunes" except the ones near De Panne and the "Older Dunes" of Adinkerke. The pollendiagram DO 2 (fig. 3) clearly demonstrates the events described above. The clayey part ( $-5,47$  to  $-5,66$  m below surface) represents sediments of the Dunkerque 2-transgression and is characterized by a high content of tree pollen (max. 45 %) and in a lesser degree by Chenopodiaceae (15—19 %). Dinoflagellates, foraminifers and reworked Tertiary and Cretaceous pollen are frequent but not indicated in the diagram. Within the basal peat layer mainly pollen of Gramineae and Cyperaceae are found. The presence of Chenopodiaceae suggests that part of the area still was a salt marsh. The small quantities of *Juniperus* and *Hippophae* and possibly *Myrica* and *Calluna* could have originated from the dune area. During the 5th century A. D. marine influence decreased and a reed peat started to grow again on parts of the salt marsh area (radiocarbon date  $1630 \pm 55$  B. P.; IRPA 581; also  $1470 \pm 50$  B. P., IRPA 580). At about the same time a Merovingian commercial post was probably established in the "older dunes of De Panne" as is indicated by the discovery of Merovingian coins and fibulae. Karolingian fibulae have been found as well (TERMOTE 1984). We believe that this period marks the onset of a stabilisation phase of the remnants of the older dunes of De Panne lasting at least until the 11th century. The dune surface of that period is

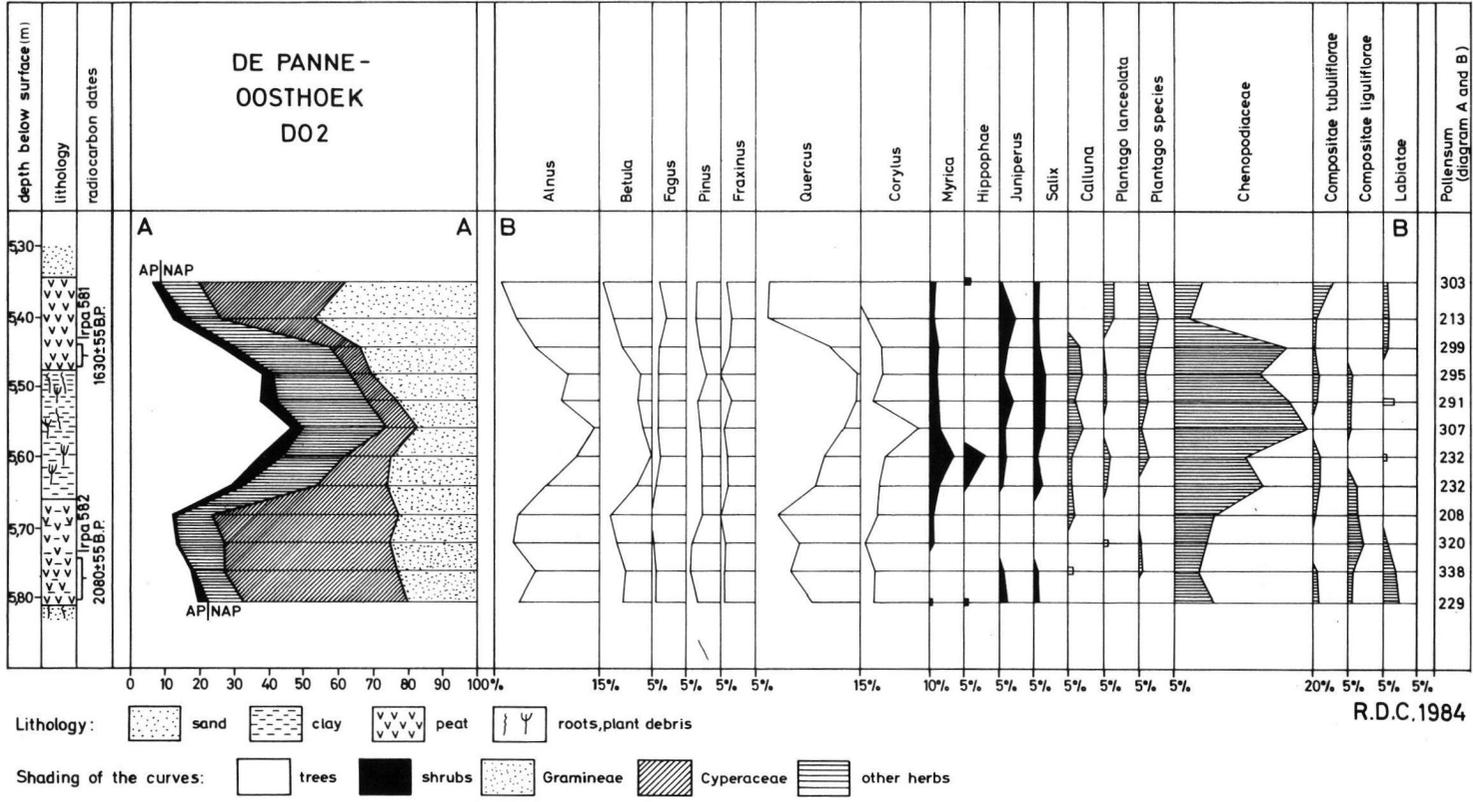


Fig. 3: Pollendiagram DO 2 of the salt marsh sediments and peat layers just south of the older dunes of De Panne and now covered with the Younger Dunes (localisation on fig. 1); absolute height of the surface + 8.5 m O. P., pollensum does not include spores and aquatic pollen.

Tab. 1: Radiocarbon dates with calibrated age according to KLEIN et al. (1982) and for the samples younger than 2100 B. P. also with an estimated age based on additional historical or archeological evidence; DEPUYDT = DEPUYDT, 1967

Lab. number	Date B.P.	Calibrated age	Estimated age
IRPA 590	4300 $\pm$ 65	3340-2860 B.C.	
IRPA 589	4270 $\pm$ 65	3155-2670 B.C.	
HV 9137	2660 $\pm$ 100	1045-600 B.C.	
HV 9136	1965 $\pm$ 110	175 BC-230 A.D.	1th century B.C.
IRPA 582	2080 $\pm$ 55	375 B.C.-30A.D.	1th century B.C.
IRPA 581	1630 $\pm$ 55	235-580 A.D.	5th-6th cent. A.D.
IRPA 580	1470 $\pm$ 50	435-630 A.D.	5th-6th cent. A.D.
IRPA 579	590 $\pm$ 50	1280-1410 A.D.	14th century A.D.
DEPUYDT, A.	550 $\pm$ 75	1320-1420 A.D.	14th century A.D.
DEPUYDT, B.	430 $\pm$ 75	1400-1515 A.D.	15th century A.D.

essentially the same as the Roman surface, but local eolian disturbances are not excluded. Pollenanalytical evidence indicates that in part of the dune area an Ericaceae-heathland had developed.

The growth of the upper peat layer in the former salt marsh area (fig. 3) stopped at about the same time when man started to use the polders for grazing sheep and cattle. The polders were then no more than high salt marshes with restricted peat areas near the dunes. This "first" landuse of the polders has been historically and archeologically dated as of the 9th and 10th centuries A. D. (VERHULST 1967). At DO 2 a small bone of a cow (!) was found on top of the peat surface which in turn was covered with dune sediments of the Younger Dunes.

### 3. The younger dunes west and south of de Panne (1000 A. D. onwards)

The so-called Dunkerque 3-transgression (11th century A. D.; TAVERNIER et al. 1970) most probably caused further erosion of the dunes of that time. But on this occasion large amounts of sands were blown inland in the shape of moving dunes. This process means that sites situated inland could have been buried underneath a moving dune for instance 100 years or even more after the original formation of that particular dune, depending on the velocity of movement and the distance of the site from the point of origin of that dune (the beach of that time). So it is not surprising that part of the polders became progressively buried underneath a few meters of dune sands most probably during the 12th and 13th century A. D. i. e. almost two centuries after the Dunkerque 3-transgression seeing that the moving dunes first had to cross the dune

area (fig. 2). Afterwards, the dunelandscape consisted of an almost level plain with an absolute height of about 6 to 7 m O. P.<sup>2</sup> (area west and south of De Panne) most likely bound by a dune ridge to the sea. A reconstructed coastline of the 13th century is indicated on fig. 1. It is based on archeological, historical and geological evidence (modified after TERMOTE 1984). The previously mentioned level plain has been encountered on different occasions in corings or in exposures and is marked by a buried soil. This former dune surface is indicated on fig. 2 (14th century surface). Pollenanalyses of this former landsurface reveals that at first vegetation was predominantly herbaceous. Very rapidly a shrub developed with *Hippophae rhamnoides* as predominant species in the drier areas and *Salix arenaria* as the dominant species in the humid areas. The surface has been dated on two occasions:  $550 \pm 75$  B. P. (DEPUYDT 1967a; localisation on fig. 2) and  $590 \pm 50$  B. P. (IRPA 579, localisation = DO 1 on fig. 1). Both dates suggest that the sites were buried underneath dune sands at about the same time during the transition of the 14th to the 15th century A. D. Since these sites are situated at some distance of the sea, it is inferable that the moving dunes that caused the burying of these sites were formed earlier. We tentatively link these events with a new important eolian phase related with the present day parabolic dunes. During this phase more of the polders became covered with dune sands (fig. 2). Furthermore the sea eroded the dune area west of De Panne until the present northern border of the "older dune sediments" was reached.

Historical, archeological and radiometric evidence suggest that since then the parabolic dunes never totally ceased moving. Even today some of the parabolic dunes are still progressing at a rate of a few meters a year. Furthermore the natural vegetation was disturbed by the intensive grazing with sheep and cattle and by the burrowing activities of rabbits and many blow-outs were formed obliterating the original topography. To complicate things even more, the direction of displacement of the parabolic dunes (N 72° to N 75°) differs only slightly from the general direction of the coastline (N 64°). Together with the disturbances induced by man this creates a complex internal topography of the Younger Dune area with parabolic dunes, large almost uncovered transversal dune ridges and other secondary dune forms. This makes it difficult to identify separate series of parabolic dunes as a result of which one would eventually be able to identify different phases of eolian activity and dune stability. However it is known that by the end of the 18th century man tried to stabilise the areas threatened by moving dunes by among other things the planting of trees. He only succeeded partially.

The coastline had reached its present location already at the end of the 16th century A. D.; this can be deduced from maps of that time. However there are indications of periodical small scale changes of the coastline within the last centuries (sea also DE MOOR 1979). Only 10 years ago for instance the coast between Koksijde and Oostduinkerke was still prograding, but at present this area is again eroding.

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2) Oostends Peil (O. P.) =  $-2,36$  m N. N. or  $-2,33$  m N. A. P.

#### 4. Conclusions

In the area west of Nieuwpoort three dune systems can now be distinguished:

1) The "Older Dunes" of Adinkerke, which are believed to be older than 4300 B. P.; at that time the coastline was just north of the dunes.

2) The "older dunes of De Panne" with sediments dating from the 8th century B. C. to the 11th century A. D.; these dunesediments have been found only near De Panne and are at present completely covered by the "Younger Dunes". At about 2300 B. P. the coastline must have been situated north of the actual one.

3) The "Younger Dunes", which are, according to the present results, not older than the 11th century A. D.; here two subphases can be distinguished:

3.1. Prior to the 14th century A. D. a level plain was formed with a height of 6 to 7 m O. P. (near De Panne); part of the polders were buried underneath dune sands; the coastline had retreated from its more northern position during the so-called Dunkerque 2- and 3-transgressions, and in the 13th century the coastline almost coincided with the present one, except near Nieuwpoort.

3.2. During the 14th and 15th centuries A. D. large parabolic dunes were formed and more of the polders became covered with sand; since, the movement of dunes never ceased totally, mostly because of human influence; at the end of the 16th century the coastline had reached its actual location, but afterwards small changes still occurred.

It is tempting to relate the evolution of the dunes with the transgressive and regressive phases recorded in the coastal area. In order to present a hypothetical scheme evidence from other areas of the Belgian coast must be adduced but that is beyond the scope of the present contribution.

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