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During Sea-Level Highstands:
A Global Synthesis with implications
for management of future coastal change

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# How subsoil morphology and erodibility influence patterns of late Holocene tidal channels with implications for future coastal change: case studies from the Belgian coastal lowlands

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## Abstract

This paper presents the results of on-going research aimed at improving our understanding of the coastal evolution in the late Holocene, a period characterized by a stable sea-level highstand. The research is carried out in the western coastal plain of Belgium located along the southeastern coast of the North Sea.

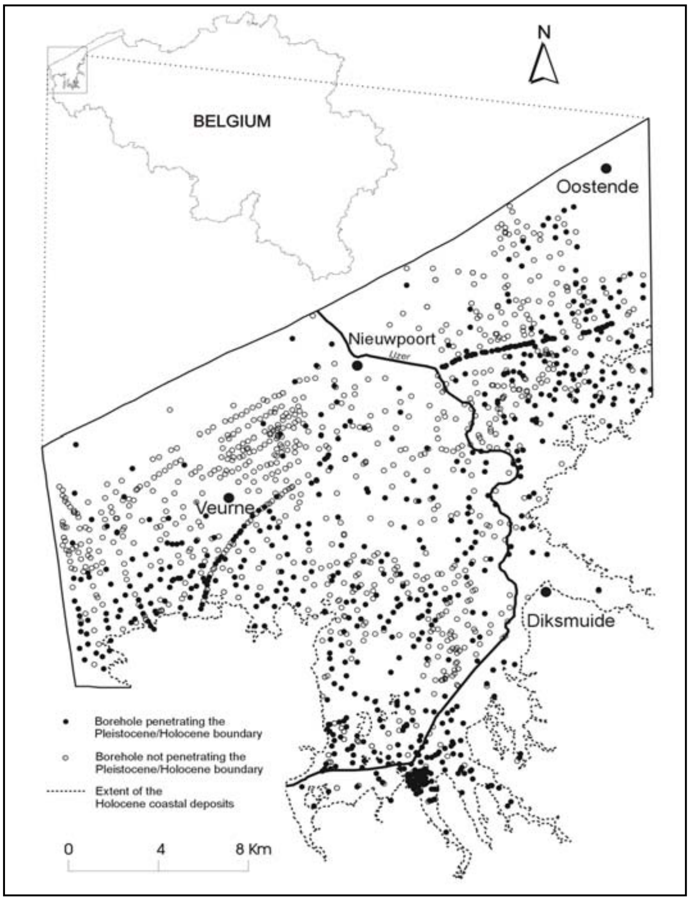


**Figure 1** Map of the western coastal plain Belgium with the location of the boreholes.

The area is an embanked coastal lowland which developed in a tide-dominated environment.

The late Holocene deposits mainly consist of a 1 to 2 m thick clay overlying a 1 to 3 m thick peat bed which developed between about 5000 and 2500 cal BP. However, more characteristic are the numerous sand-filled tidal channels which deeply incised into the older Holocene sediments. Some of the channels also eroded completely the underlying Pleistocene deposits until the stiff Tertiary clay. Age determination of peat fragments from deep-seated channel lags indicate a late Holocene erosion. The late Holocene deposits are the result of the re-entrance of the tidal system after a period of about 2500 years. The renewed landward migration of the tidal system was accompanied by shoreface erosion, shifting of the shoreline and landward expansion of the tidal area (Baeteman, 1999). The same feature, dated at about the same time, is also observed in The Netherlands (Beets et al., 1992, Beets and van der Spek, 2000, Vos and van Heeringen, 1997) and in southern England (Long et al., 2000, Brew et al., 2000). The deeply incised channels, however, are not reported in southern England. The mechanism of the return of the tidal sedimentation is rather well understood, but the initial cause of it is not exactly known yet. A sea-level rise seems to be excluded in that period. Some hypotheses to explain the cause of this re-entrance have been put forward such as a negative sediment balance (Beets et al., 1994) and compaction of the peat due to human activity (Vos and van Heeringen, 1997).

The aim of this investigation is to provide additional information about the late Holocene (young) channels. Investigation about the chronology of the late Holocene sediments (Baeteman et al. 2002) revealed that their sedimentation pattern and chronology are very much related to the development of the channel network.

Therefore, the location of the young channels in relation to the underlying sediments and Pleistocene subsoil was examined.

Stratigraphic cross-sections clearly show that several young channels are located in the same place as the palaeovalleys (Baeteman and Declercq, 2002). In order to check whether this is also the case when considering the spatial extension of the channels, a contour map of the original Pleistocene relief, i.e. the pre-transgressional surface, was produced. This map shows overdeepened areas representing palaeovalleys which developed during the Weichselian lowstand. These valleys were important as conduits in form of tidal channels for the waters and sediments of the Holocene transgression entering these areas. The presence of basal peat overlain by mudflat deposits (also underneath old channel deposits) proves that the initial transgression happened in a low-energy environment without erosion. The contour map of the pre-Holocene surface was then compared with the contour map indicating the real depth of the Pleistocene deposits. Seaward areas are excluded in this comparison, because the relief of the Pleistocene deposits has been altered by shoreface erosion since about 8000 cal BP. The comparison of these two maps revealed the locations where deep and vertical erosion took place during the late Holocene. The contour map of the pre-Holocene surface was also compared with the sequence map (profile-type map) showing the spatial distribution of tidal channels throughout the entire Holocene sedimentary sequence. From the comparison, it seems that most of the important tidal channels are located in the same position as the palaeovalleys. Only a portion of the major young channel is situated outside the palaeovalley. The easily erodible sand from the early and middle Holocene tidal channels (which developed in the palaeovalleys) most probably formed a suitable setting for the young channels to re-establish. The young channels reached as far as the landward limit of the coastal plain as from the beginning of the re-entrance of the tidal system (i.e. at least since about 3400 cal BP). This suggests that the initial renewed activity of the channels was possibly caused by an event from the mainland, such as excessive run-off via the extention of the palaeovalleys which are well expressed in the morphology of the outcropping Pleistocene region. It still has to be investigated whether such a runn-off was caused by climate change or by anthropogenic activity altering the natural vegetation. This run-off would have “cleaned” the channels which during the long period of peat growth remained open for the drainage of the peat bog. However, the channels were almost completely silted up. After this initial cleaning, tidal waters were able to enter again.

The further erosion was caused by catastrophic flows during storms or extreme highwater levels bringing along too much water for the existing channels. The latter had to adapt their size by vertical scour into the sand which is much easier to erode than the thick cohesive beds of mud and peat occurring aside the sand-filled channels. This most probably explains the typical cross-section of the young channels. With time, new tributaries from the main channels developed and the channel network enlarged and prograded landward because of the increasing tidal prism as a result of peat and mud compaction and subsidence.

The channels also tended to develop along the landward limit of the (new and expanded) tidal area. Only in these restricted areas the incision was not controlled by the subsoil erodibility because the composition is variable.

The subsoil consists of easily erodible Pleistocene sand as well as less erodible Pleistocene sandy clay. Here, the position of the channels was controlled by the existing relief of the newly flooded Pleistocene deposits.

Since apparently most of the young channels are located in the same place as their predecessors, their sand-filled courses in the subsoil represent vulnerable areas in the case of possible future catastrophic flows and/or a possible future sea-level rise.

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