Evolution of the lower Rhine-Meuse delta (The Netherlands) in the Early and Middle Holocene -linking offshore and onshore-

MARC P. HIJMA (1,2), K.M. Cohen (1,2), A.J.F. Van der Spek (3), S. Van Heteren (3)

Universiteit Utrecht
Faculty of Geosciences

(1) Utrecht Centre of Geosciences, Utrecht, The Netherlands
(2) Department of Physical Geography, Utrecht University, Utrecht, The Netherlands
(3) Deltares / Geological Survey of the Netherlands, Utrecht, The Netherlands
Correspondence to Marc Hijma: m.hijma@geo.uu.nl, +31 30 253 2766 (www.geo.uu.nl/staff/hijma)

SETTING, STUDY AREA, RESEARCH QUESTION

The landscape below Rotterdam (Fig. 1) changed dramatically during the Early and Middle Holocene. 12000 years ago sealevel stood 57 m lower than today. Now buried below15-20 m of Holocene sediment, lies a wide Rhine river valley bordered by slightly higher terrain (dune fields on river terraces). 9000 years ago, delta formation set on. 6000 years ago, sea level had risen to within 5 m of the present level. The landscape had evolved into a barrier-lagoon system, with river outlets functioning as estuaries. In the back-barrier lagoon, the Rhine-Meuse delta developed.

How, where and when did the Rhine-Meuse system transform from a fluvial to an estuarine system during the Early-Middle Holocene period?

METHODS: CORES, DATES, SEISMICS

A huge amount of data has been made available: >50000 corings and >50000 cone penetration tests, detailed offshore seismic data, > 50 new ^{14}C and OSL dates, and pollen and diatom analysis. Three cross sections spanning the entire delta have been constructed. Data was used from the DINO-database (TNO), Utrecht University-database, muncipalities of Rotterdam and Zoetermeer and the Ministry of Transport, Public Works and Water Management.

RESULTS

We show three examples of transition from fluvial to estuarine conditions. The cross sections display the complex nature of the transition in time and space, both onshore and offshore. Fig. 4 shows a facies change from fluvial to estuarine sediments.

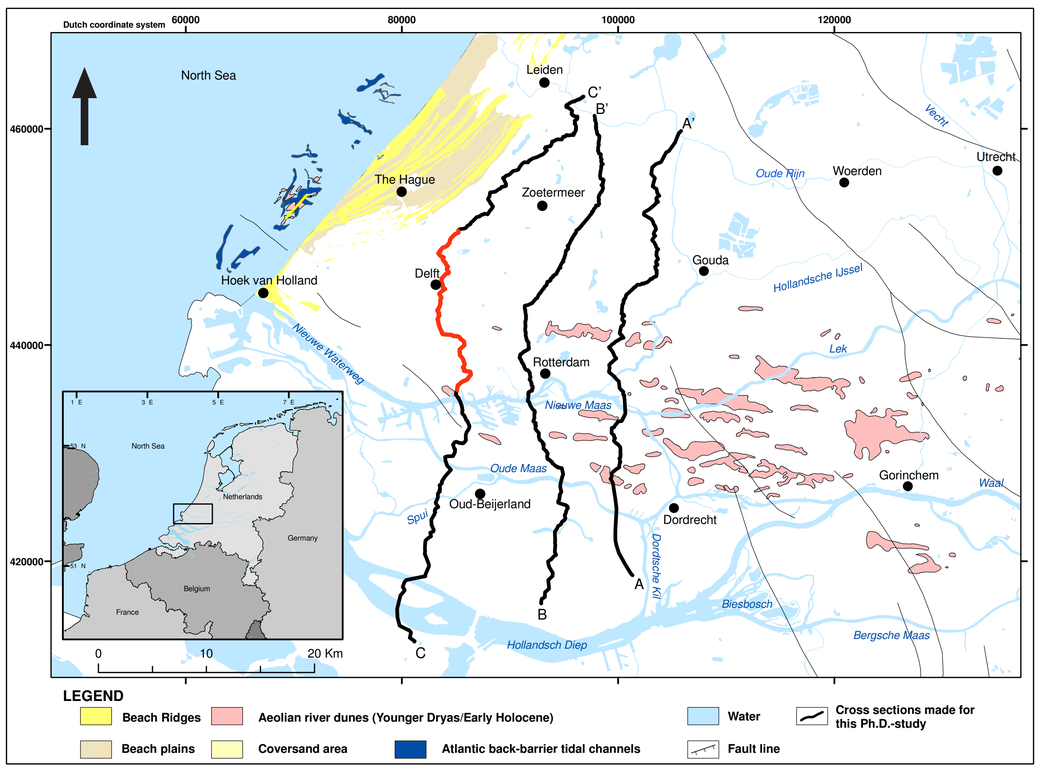


Fig. 1. The study area around Rotterdam, The Netherlands, showing the position of the constructed cross sections. The red line of C-C' indicates which part is shown in Fig. 2. West of The Hague, tidal channels and aeolian dunes have been recognized in seismic data (yellow line indicates position Fig. 3).

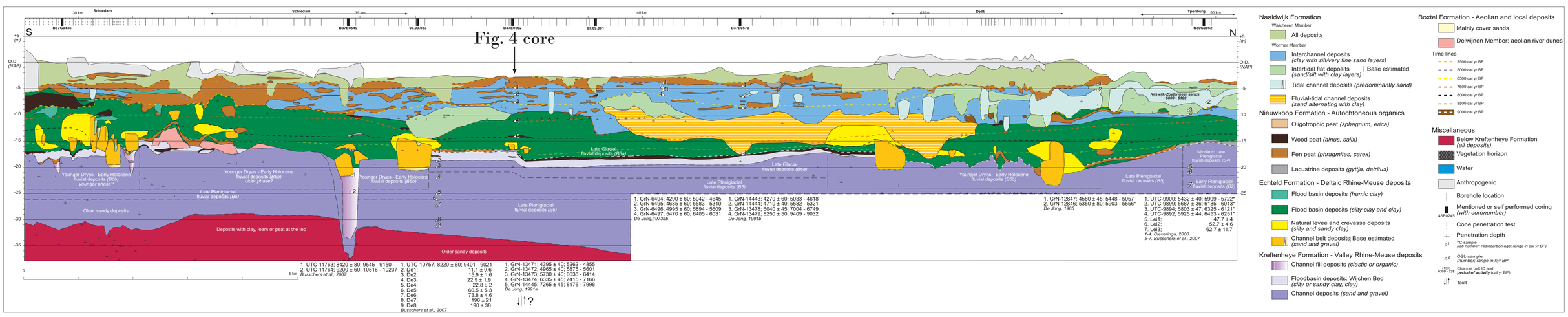
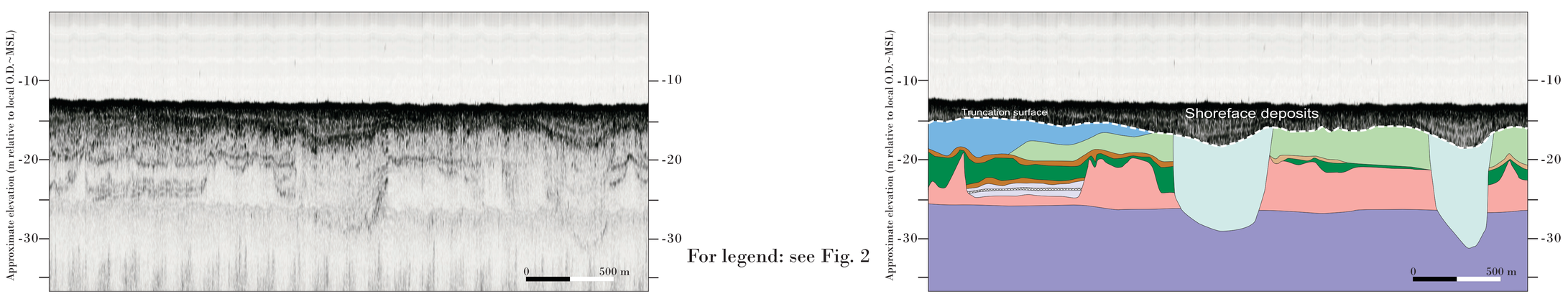


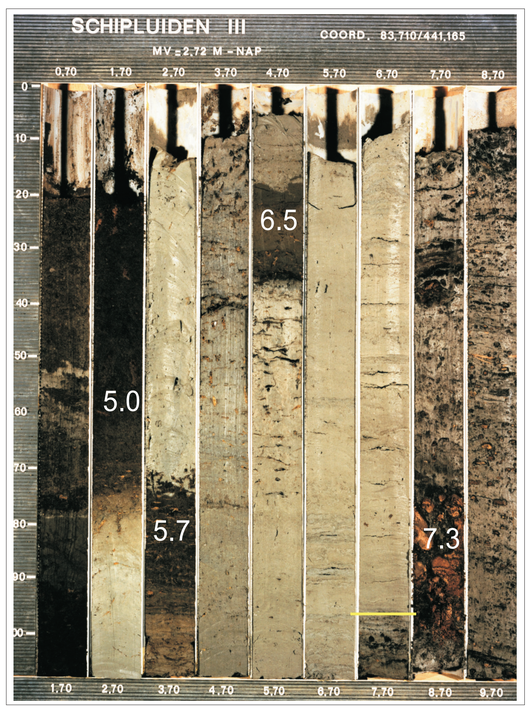
Fig. 2. Cross section from the Delft area (see Fig.1 for location). A transition from fluvial deposits (Echteld Formation) to marine/estuarine deposits (Wormer Member, Naaldwijk Formation) is visible that differs strongly in time and place. The timelines illustrte the established chronological framework that has been built for the deposits. The fluvial-tidal feature below Delft is identified as a bayhead delta. After this river outlet became largely abandoned, marine ingression occurred. The low lying area int the upper right corner was formed when the peat was dug away and used as fuel. The striking channel fill at km 35 is remarkably deep and a poorly understood feature. The interpretation of the different Kreftenheye units follows and refines Busschers et al. (2007).



For legend: see Fig. 2

Fig 3. Seismic section from offshore The Hague. The left panel shows the original data, while the right panel shows the tentative interpretation, based on the facies model that has been constructed for the onshore part and a few offshore cores. A well preserved Early Holocene landscape has been recognized in the seismic data. Drowned aeolian river dunes are visible that are capped by a continuous peat layer at 20 m -NAP, probably dating from the early Atlantic. Back-barrier tidal channels entered the area between 8000 and 6800 years BP (Rieu et al., 2005). As the coastline migrated landward, the tidal deposits were truncated and are now overlain by shoreface deposits.

Fig 4. A photo of a core showing the transition from fluvio-tidal to brackish estuarine -the position of the core is given in Fig. 2. The fluvial-tidal deposits (below the yellow line) are very rich in layered wood fragments. Apparently, large wood swamps were present upstream of the fluvial tidal zone. Shortly after 7.3 cal kyr BP (white numbers indicate cal kyr BP) a transgression occured and intertidal deposits were deposited. First rapidly, ~3 m in 500 years, but gradually sedimentation rates decreased and sometimes peat could form. After 6 cal kyr BP the coastline started to close, culminating in large scale peat formation after 5 cal kyr BP.



References

Busschers, F.S., Kasse, C., van Balen, R.T., Vandenberghe, J., Cohen, K.M., Weerts, H.J.T., Wallinga, J., Johns, C., Cleveringa, P. & Bunnik, F.P.M., 2007. Late Pleistocene evolution of the Rhine-Meuse system in the southern North Sea basin: imprints of climate change, sea-level oscillation and glacio-isostacy. Quaternary Science Reviews 26 (25-28): 3216-3248.

Rieu, R., van Heteren, S., van der Spek, A.J.F. & De Boer, P.L., 2005. Development and Preservation of a Mid-Holocene Tidal-Channel Network Offshore the Western Netherlands. Journal of Sedimentary Research 75 (3): 409-419.

CONCLUSIONS AND OUTLOOK

Onshore, the Early to Middle Holocene transition from a fluvial to an estuarine system is generally well preserved, but deeply buried and therefore hard to study. New detailed cross sections provide new insight and understanding of the fluvio-tidal environment. The established chronological framework allows palaeogeographical reconstructions.

Offshore, the same stratigraphic sequence is visible in high resolution seismic data. The upper 5-10 m have been eroded by marine transgressions, but the base of the Holocene deltaic wedge has been preserved. A detailed time frame has not been constructed yet, but considering the lower and more seaward position of the offshore data, deltaic formation and the change to estuarine environments obviously occurred earlier in time.

Future work will focus on the integration of onshore and offshore data and will complete the palaeogeographical reconstruction of the Rhine-Meuse delta. Besides this, sea-level rise during the Early-Middle Holocene in the Rotterdam area is a major part of the Ph.D.-project of Marc Hijma that will finish late 2009.