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Effects of peat compaction on floodplain morphology and delta evolution, a field study in the Cumberland Marshes, Canada

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During the Holocene, the relatively warm interglacial climate and rising groundwater levels due to global sea-level rise following deglaciation (MIS 2) favoured formation of peat. Especially during the Mid-Holocene, extensive peat formation occurred in many lowland deltaic environments throughout the world. Consequently, thick peat layers are now often found in distal parts of deltas, areas that are often densely populated. Of all natural soils peat has the highest compaction potential, which has important implications for both human activities and natural processes. Concerning societal implications, land subsidence due to compaction of peat may for example causes damage to construction works and may increase flooding risk, due to subsidence of floodbasins creating steeper cross-valley gradients. In a densely populated delta such as the Rhine-Meuse delta (The Netherlands), artificial groundwater level lowering is applied to enable land reclamation and to prevent inundation of the land. This leads to increased land subsidence however, due to compaction and oxidation of peat above the groundwater level. Consequently, groundwater levels are further lowered, causing huge problems in such densely populated areas.

Effects of peat compaction on natural processes occurring in deltaic systems are less clear. Land subsidence due to (peat) compaction creates accommodation space, but how this affects delta evolution is not known yet, due to a lack of reliable field data and methods to measure peat compaction on longer time-scales. Current hypothesis are that (1) differential peat compaction influences the occurrence of avulsion, as cross-valley gradients are steepened and (2) peat compaction results in thick natural levees and vertical aggrading river channels. The ultimate goal of this research is to determine effects of peat compaction on delta evolution on different time scales (1-10^3 yr). To determine effects of peat compaction on relatively short timescales (1-10^2 yr), an extensive field campaign using new methods to reconstruct the amount and rate of peat compaction has been carried out in the Cumberland Marshes (Canada), an area with a similar natural landscape as the Mid-Holocene western Rhine-Meuse delta (The Netherlands). In this last mentioned area, research will be carried out later to determine effects of peat compaction on longer time scales (10^2-10^3 yr). The first method used is based on relations between bulk densities of compacted and uncompacted peat. The original thickness of a compacted peat layer can be calculated based on the dry bulk density of uncompacted peat of the same type. A new peat coring device is developed and successfully used to take sufficiently large (to take into account the heterogeneity of peat characteristics) and undisturbed samples of uncompacted peat. The second method focuses on the relation between dry bulk density values of different peat types and the thickness and type of overlying river deposits at different locations, for which detailed lithostratigraphic cross-sections are needed.

As peat characteristics are highly variable, especially in a fluvial dominated environment, relations between peat compaction and fluvial processes are not straightforward. Still, it can be concluded that the amount of peat compaction is highly dependent on the type of peat, organic matter content and thickness and type of overlying sediments. In general, highest volume reductions due to compaction occur in peat layers having a high organic matter content that are loaded with a relatively thick layer of sandy material, such as underneath natural levees. Due to the high amount of compaction at such places, additional accommodation space is created which results in thick natural levees (provided the sediment load of the river is sufficiently high). This would suggest that peat compaction fixes river channels and prevents avulsion. This hypothesis is supported by the fact that peat is a highly cohesive material, and thus, river dissection into a peat substrate leads to stable banks which prevents lateral migration of the river channel.