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The Holocene Marine Transgression in the Region of the North Frisian Islands

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Sequences, marine transgression, sedimentary sequences,
deposits, marsh, mud flats, Upper Holocene.
Northwest German Plains, North Frisian Islands, North Sea

A b s t r a c t : To demonstrate the diverse Holocene development in the region of the North Frisian Islands, the sedimentary sequence of the coastal Holocene in the area of Sylt and Pellworm is compared. Near Sylt, the deposits which do not exceed 10 m can be subdivided into three sedimentary units. During the last 2000 years, the surface of the marsh was higher than MHW. Its extension was however decreased by erosion. In the area of Pellworm, although the sedimentary succession sometimes exceeds 20 m in thickness, a subdivision is not possible because of frequent lateral and vertical lithofacies changes. Due to considerable compaction of the sediments during the first millennium AD and human activity, the surface of the marsh was considerably lowered. During two storm surges in 1362 AD and 1634 AD large marsh areas became part of the tidal flats and were abandoned by the population. The reasons for these catastrophes are partially due to the geological development and to the activity of man. Local factors have to be considered in time and space in interpreting the Holocene events in the area.

[Die holozäne Meerestransgression im Bereich der Nordfriesischen Inseln]

K u r z f a s s u n g : Um die unterschiedliche Entwicklung des Küstenholozäns im Bereich der Nordfriesischen Inseln darzustellen, wird die relativ gering mächtige — weniger als 10 m — Schichtenfolge von Sylt mit der teilweise über 20 m mächtigen bei Pellworm verglichen. Bei Sylt läßt sich das Küstenholozän in drei Sedimentdecken untergliedern, die durch eine Torflage oder humosen Klei und durch einen Humusdwog voneinander getrennt werden. Seit 2.000 Jahren lag die Marschoberfläche höher als das MThw. Die Größe der Marsch nahm seit dem Mittelalter als Folge ständiger Erosion ab. Im Gebiet um Pellworm ist eine Gliederung der vor Chr. Geb. abgelagerten Sedimente wegen des kleinräumigen Fazieswechsels nicht möglich. Als Folge erheblicher Setzungen während des ersten nachchristlichen Jahrtausends und der Kultivierungsarbeiten seit dem Mittelalter wurden die Marschoberflächen niedriger gelegt. In den Jahren 1362 und 1634 n. Chr. Geb. wurden sie von Sturmflutkatastrophen betroffen, große Teile ins Wattenmeer einbezogen und von den Siedlern verlassen. Die Gründe für diese Ereignisse sind teils auf die geologische Entwicklung, teils auf die Einwirkung des Menschen zurückzuführen. Der Ablauf der vor allem jüngeren Landschaftsgeschichte wurde in den verglichenen Gebieten in erheblichem Maße von lokalen Faktoren beeinflusst.

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1. Introduction

It is well known that the discussion about the recent drowning of the coastal area in the German Bight was initiated by investigations carried out by SCHÜTTE (1908) in the Jade Bight. Soon similar results were obtained from the southern part of the North Frisian Islands. The surface of the medieval landscape and remnants of settlements lying in this area below present day MHW seemed to indicate a serious sinking of the land. This interpretation was called into question when marsh surfaces of the Roman Imperial Period were discovered in adjacent regions (e. g. Dithmarschen), whose levels today remained as high as modern ones. To explain these contradictory findings, BANTELMANN (1966) and DITTMER (1952) pointed out that in the southern parts of the North Frisian tidal flats, the height of the landscape was considerably influenced by the activity of man when he drained the land, cut peat or prepared the marsh for agricultural use by removing a layer of peat which was situated close to the surface. However, there were also other flooded areas where the above mentioned works have not been carried out. Therefore compaction especially of organic sediments might be responsible for the low seated medieval surfaces in the southern North Frisian tidal flats. Until now, no details were available on the compaction of the clastic sediments, especially because the Holocene sequence is not as yet fully known. New investigations on the history of this landscape carried out since 1974 (HIGELKE, HOFFMANN & MÜLLER-WILLE 1982) and establishment of the correlations between the older and younger geological developments could improve this knowledge.

In the area of the North Frisian Islands, the Pleistocene surface plunges in a southerly direction. Due to this, the thickness of the coastal Holocene increases more or less regularly to the south (fig. 1). Therefore it is useful to compare the development of the coastal Holocene in the area of Sylt with that of Pellworm.

2. The coastal Holocene of Sylt

The coastal Holocene of Sylt considered in this paper is situated between the remnants of terminal moraines which formed the cores of the islands Sylt and Föhr. A sand bar covered with dunes and shifting in an easterly direction protects the tidal flats from the open sea. This sand bar has probably existed since the early Holocene, permitting the deposition of fine-grained sediments in the tidal flats.

The oldest sediments of the coastal Holocene are basal peats. Their development began already towards the end of the Pleistocene and ceased in the early Boreal (AVERDIECK 1980). Later Atlantic peat began to develop, initiated by the rise of the ground water level as a result of the sea level rise. The coastal Holocene of Sylt can be subdivided into three sedimentary units (fig. 2). The oldest was deposited up to about 4000 y. BP (fig. 5). Its surface is situated between NN -2.5 and NN -2.0 m. Close to the Pleistocene outcrops it is composed of peats and further away of humus clay. A middle sand layer separates the lower from the upper clay within this sedimentary unit. The second transgression began about 3500 y BP and lasted till the last 500 years BC. The surface of this sedimentary cover is formed by a vegetation horizon which is situated today between NN $+0.6$ and NN $+1.3$ m. The lithologic sequence within this sedimentary cover is rather similar to that of the oldest, but without sand deposition in areas

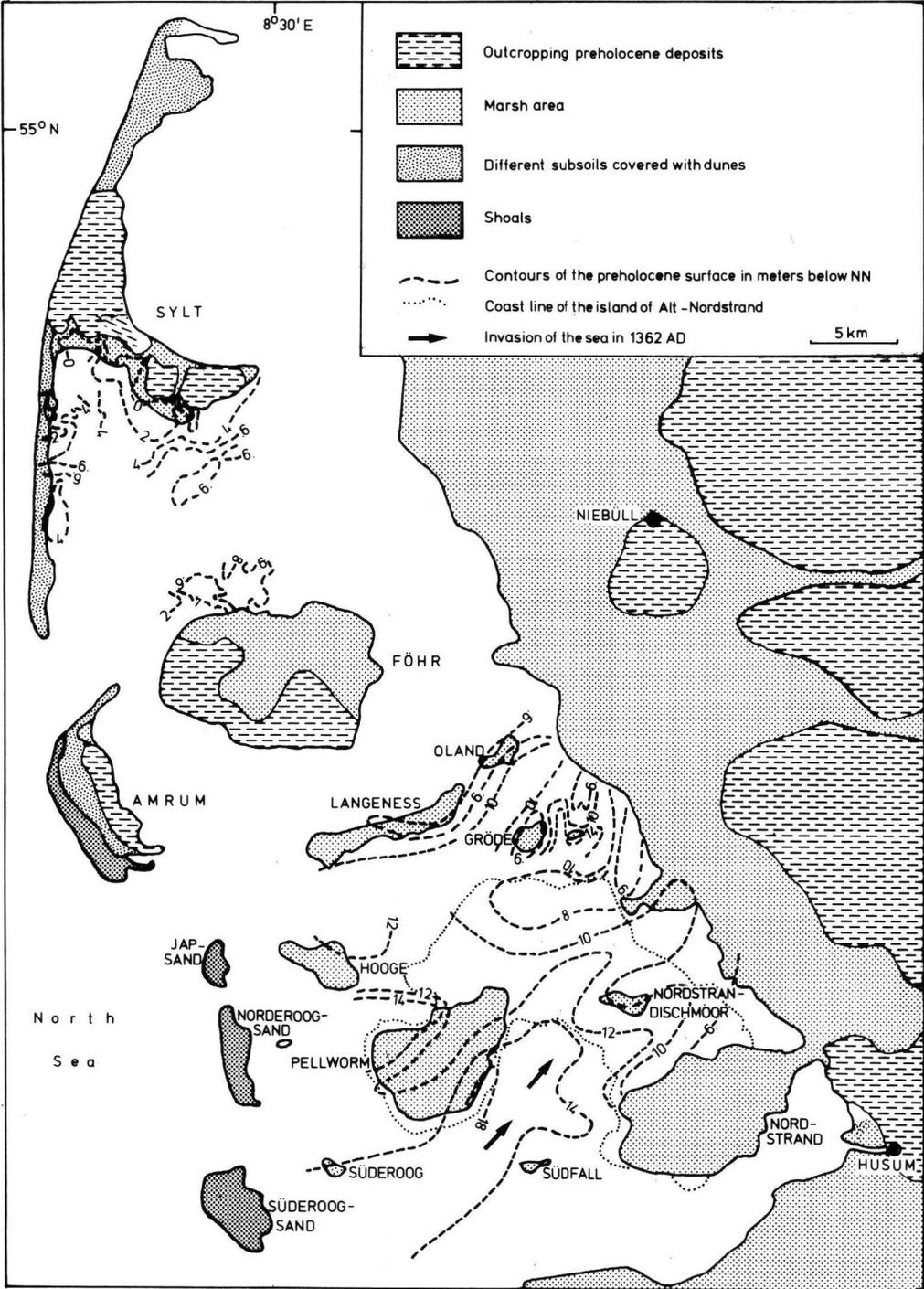


Fig. 1: General map of the North Frisian Islands.

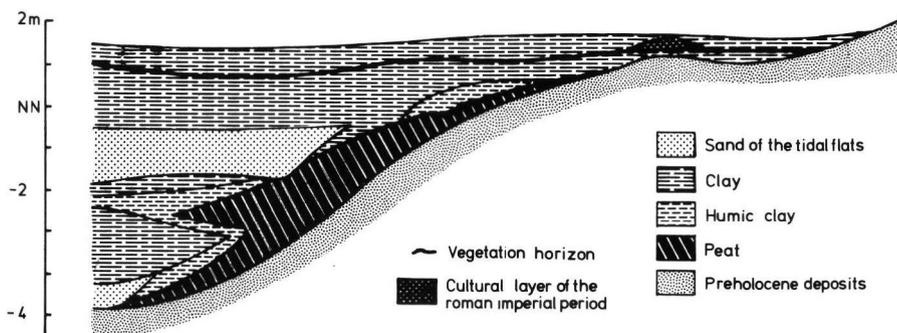


Fig. 2: The sequence of the coastal Holocene in the marsh area of Sylt (generalized section).

proximal to the sand bar mentioned above. The vegetation horizon on top of these deposits came into existence a short time before Christ at the latest. This is evidenced by a settlement of the early Roman Imperial Period situated on top of this horizon. These features indicated that the sealevel rise stopped at the end of the last millennium BC. Dependent upon the thickness and the lithology of the sediments differential compaction occurred during the first millennium AD and a relief of the surface with differences up to 0.7 m was formed. During this time sedimentation stopped. It recommenced not earlier than the late Middle Ages, probably in the 14th century AD. The marsh area was covered and its surface raised by storm surge deposits. Dikes which prevented the flooding of the marsh area existed only for short periods. By studying old maps and the course of old dikes which today are running in many places from the marsh into the tidal flats, it is obvious that the marsh area of Sylt has become smaller since the Middle Ages.

The complete sequence of the coastal Holocene described above is fairly well preserved in the marsh area. In the tidal flats most of the older Holocene is eroded and substituted by younger fine-grained sand (fig. 3).

3. The coastal Holocene in the area of Pellworm

In the area around Pellworm, the transgression began earlier than near Sylt (fig. 5) because the Pleistocene surface was situated lower. Exact dates are not available because there are no sediments suited for radiocarbon dating. The thickness of the coastal holocene varies from more than 20 m to less than 10 m from the beginning of the transgression up to about 3000 years BP, only marine clastic sediments were deposited. They cannot be subdivided because of their frequent lateral and vertical lithofacies changes. In the last millennium BC, the marine influence decreased and brackish clay turning into fen peat developed. This is confirmed by pollenanalysis (MENKE, pers. com.) which indicated that the area came more and more under the influence of freshwater. It may be assumed that the erosion of remnants of terminal moraines by the sea provided material for the sand bars that closed this area to the sea. Between the outcropping

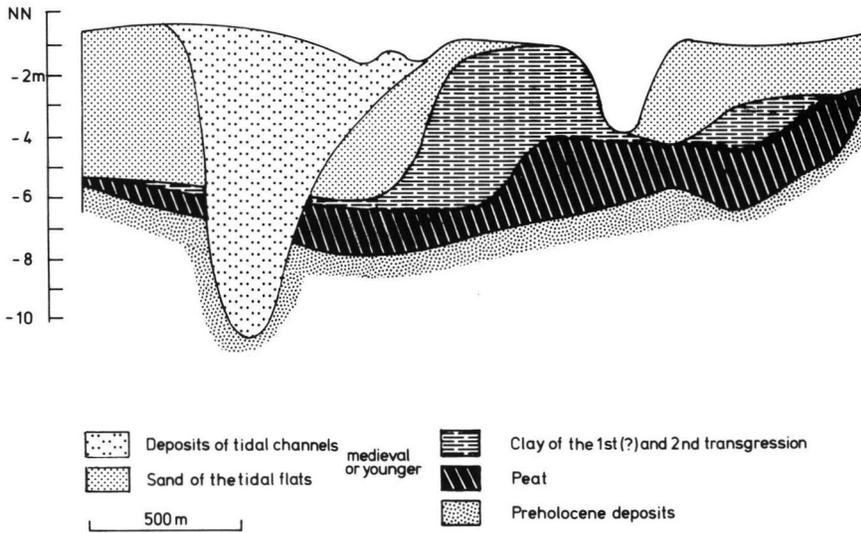


Fig. 3: The coastal Holocene in the tidal flat area of Sylt.

Pleistocene in the east and the sand bars in the west, freshwater gathered and initiated the forming of brackish clay and later on of fen peat. Its surface was closely connected to the freshwater level during its development and therefore, it originally lay all over the area nearly at the same level. Today there are differences up to 2.5 m. There was almost no sedimentation during the first millennium AD. Clay was deposited in some places only, where the fen peat was situated very low. Similar to Sylt, this indicated that the sealevel did not rise any longer but remained constant or even fell down.

Archeological excavations on the island of Pellworm yielded further informations about its geological development. The area was settled during the 9th/10th century AD, considerably later than in the adjacent marshes (HIGELKE, HOFFMANN, KÜHN & MÜLLER-WILLE 1979). The first houses were built on top of the marsh surface at NN +0.4 m. Therefore it may be assumed that the surface of the marsh below this settlement was not seriously affected by storm surges at the end of the first millennium AD. It must be pointed out that the subsoil of this settlement is formed by remnants of the peat layer which was developed during the last millennium BC. The influence of storm surges in the 11th/12th century could be observed as the cultural layer of this settlement was covered with deposits of storm surges containing ceramics of this time. At the latest in the 12th/13th century, dwelling mounds were built and the cultivation of the country began by drainage, peat cutting and diking. According to historical sources, the area was heavily attacked by storm surges at 1362 AD. Large portions of the populated southern part of the study area were inundated and became part of the tidal flats because of its low surface; for example, in the area between Pellworm — Nordstrand — Südfall where the peat was discovered at NN -1.8 m in an extremely low position. In contrast to this, it is situated at NN +0.6 m on the island of Pellworm. After the formation of peat, synchronous with the Sylt area, compaction of sediments occurred.

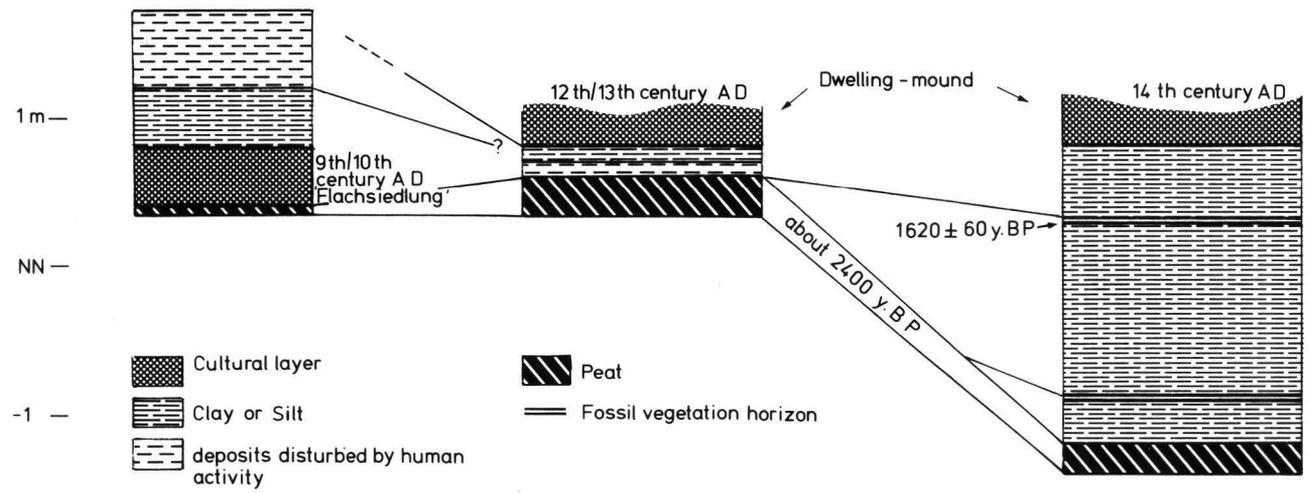


Fig. 4: The upper coastal Holocene of Pellworm, generalized.

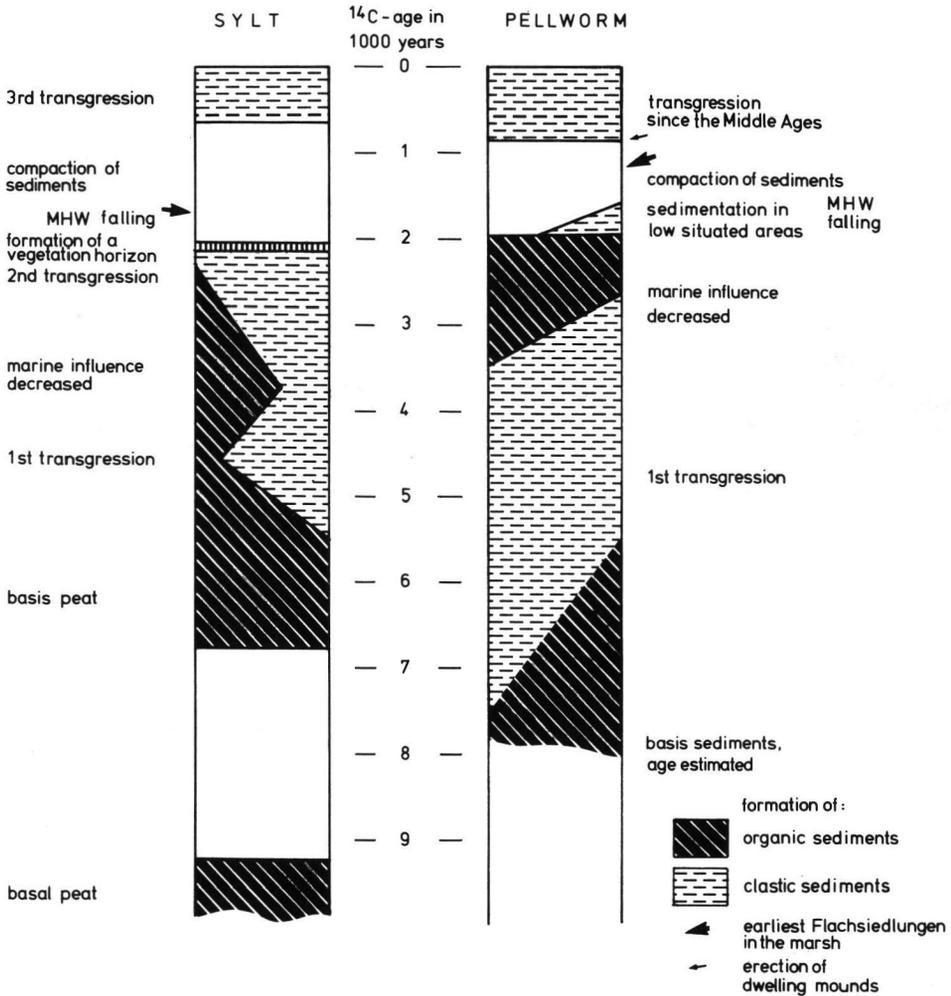


Fig. 5: Comparison of the Holocene development in the area of Sylt and Pellworm.

Its amount depends, among other, upon the thickness of the coastal Holocene the lithology of the sediments and their water content. The rate of compaction was different in various parts of the area. Because no major sedimentation that evened out the landscape occurred until the beginning of the second millennium AD differences in its surface were created. Looking once again at the region of Pellworm — Nordstrand — Südfall which was flooded in 1362 AD and abandoned by the population, it must be pointed out that the coastal Holocene consists almost entirely of clay whose thickness exceeds ten meters. Therefore it must be assumed that as a consequence of the compaction during the first millennium AD a depression was created which was flooded by the sea in 1362 AD. Peat was not cut in this area due to its limited thickness which made salt production uneconomical and to a thicker clastic sediment cover which allowed cultivation.

In 1634 AD another storm surge catastrophically attacked the North Sea coast of Schleswig-Holstein. Especially affected was the Alt-Nordstrand island (fig. 1) which was flooded completely when the dikes breached. The 'Hallig' Nordstrandischmoor survived because it was the remnant of a raised bog peat with a fairly high situated surface. Only the islands of Pellworm and Nordstrand could be reclaimed and most of the area became part of the tidal flats. Looking for the reasons of this second big catastrophe in the second millennium AD it should be noted that the areas which are now part of the tidal flats were not affected by considerable compaction. Therefore it is assumed that man is mainly responsible for the losses of land in the 17th century. During many centuries peat was cut for various purposes and the land was drained. Consequently in large regions the surface was artificially lowered. On the other hand, the sealevel rose and at least the surfaces of the marshes were lower than the MHW level. Only dikes prevented the sea from entering this area (BANTELMANN 1966). In 1634 AD, when the storm surge took place, the dikes were obviously too weak.

4. Conclusions

The coastal Holocene developed differently in both areas of the North Frisian Islands, although it was dependent upon the same sealevel movements. To explain this, local influences were taken into consideration. Differential settling of sediments due to sediment type, water expulsion as well as to activity of man lowered the surface of the land in the southern part of the North Frisian Islands. Areas affected became part of the tidal flats when the sea flooded. Areas not affected were only temporarily flooded during stormsurges, as in the region of Sylt. The formation of a sand bar, another local event, had converted the southern region from a marine into a freshwater area, thereby favouring peat formation instead of clastic sedimentation for a long time. In the Sylt area, peat did not form. Different sedimentary units may prevail in time and space and do not necessarily indicate a different development of the sealevel, but may also be caused by lokal factors. Consequently not every sedimentary cover should be directly integrated into the scheme of transgressions.

5. Acknowledgement

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6. References

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