Geoarchaeological evidence of marshland destruction in the area of Rungholt, present-day Wadden Sea around Hallig Südfall (North Frisia, Germany), by the Grote Mandrenke in 1362 AD

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A B S T R A C T

Geophysical and geoarchaeological investigations were carried out in the Wadden Sea of North Frisia (Schleswig-Holstein, Germany) to elucidate major environmental changes that considerably altered the coastal landscape since medieval times. Between the 12th and 14th cent. AD, the present-day tidal flats around the marsh island Hallig Südfall belonged to the historical Edomsharde district and its main settlement Rungholt. For North Frisia, it is well known that during medieval and early modern times, extreme storm surges caused major land losses associated with a massive landward shift of the coastline. Today, cultural traces like remains of dikes, drainage ditches, terps or even plough marks are still visible in the Wadden Sea and provide evidence of the once cultivated marshland.

Based on a multi-proxy analysis of sediment cores retrieved from the tidal flat area around Hallig Südfall and from the Hallig itself, we identified a late medieval paleosol associated with the formerly cultivated marshland most probably belonging to the Edomsharde and local trade centre of Rungholt. Around Hallig Südfall, remains of medieval marsh deposits were found partly eroded and covered by a coarse-grained high-energy deposit including abundant shell debris and artefacts. Based on sedimentological, micropaleontological, geochemical and geochronological data, we conclude that these deposits are associated with the 1st Grote Mandrenke (or St. Marcellus’ flood), an extreme storm surge event in 1362 AD. Our results, for the first time, provide geological evidence of this 1362 AD storm surge for the Wadden Sea of North Frisia. Moreover, marshland on Hallig Südfall dating to the 17th-18th cent. AD was found covered by a thick layer of storm surge sand and shell debris which seems to be associated with one of the major storm events that hit the German North Sea coast in modern times, e.g. the 2nd Grote Mandrenke (or Burchardi flood) in 1634 AD or the Christmas flood in 1717 AD.

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1. Introduction

As a transition zone from Pleistocene glacial Geest and Holocene fens and marshes to the recent tidal flats of the Wadden Sea, the coastal landscape of North Frisia (Schleswig-Holstein, Germany) was repeatedly influenced by strong geomorphological dynamics. Throughout the Holocene, both long-term processes like the post-glacial sea level rise as well as short-term events like extreme storm surges caused severe natural environmental changes (Koehn, 1954; Bantelmann, 1966; Harck, 1980; Hoffmann et al., 1984; Lorenzen-Schmidt, 1999; Hoffmann, 2000; Behre, 2008, 2007). But also extensive impact by man significantly altered the coastal landscape, especially in historical times. From the 12th cent. AD onwards, the building of dykes and subsequent reclamation and cultivation of marshland drastically changed the morphodynamics of North Frisia, for example by increasing the tidal range and at the same time significantly restraining the marsh-growth (Reinhardt, 1983; Kühn and Panten, 1989; Lorenzen-Schmidt, 1999; Kühl, 2000; Hoffmann, 2004; Newig, 2014). When major medieval storms such as the 1st Grote Mandrenke in 1362 AD hit the weakly protected marshland, large areas of cultivated land were turned into tidal flats. However, because conditions for geoarchaeological research in the Wadden

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Sea tidal flats are unfavorable, rather little is known about the appearance of the North Frisian coastal area in the 12th and 13th cent. AD.

By investigating the present-day tidal flats in the surroundings of the marsh island Hallig Südfall, the major objectives of this case study are (i) to study cultural traces in the Wadden Sea and elucidate man-environment interactions for the time they were formed, (ii) to investigate devastating coastal changes since medieval times, and (iii) to define the role of major storm surges for the development of today's coastal landscape.

2. Regional setting

Between Blåvandshuk, Denmark, in the north and Den Helder, Netherlands, in the southwest, the North Sea coast is characterized by the extensive tidal flats of the Wadden Sea, up to 30 km wide (GWS, 2005; Ehlers, 2008). The study area of this paper belongs to the Wadden Sea National Park of Schleswig Holstein (northern Germany) and is located in the southern tidal flats of North Frisia. Coastal dynamics are determined by meso-tidal conditions and frequently occurring storm surges that are capable to exceed the mean high tide up to several meters (Jensen, 1998).

A unique feature within the Wadden Sea landscape are the so-called Halligen, small marsh islands with artificial terps that are closely related to the coastal evolution of North Frisia. Constructed out of local clay and organic material and with their top above storm surge level, artificial terps are the characteristic way of coastal marshland colonization in northern Germany; their elevation was occasionally increased due to the ongoing rise in sea level during the late Holocene. The present study focusses on different sites in the surroundings of Hallig Südfall (Fig. 1), which is located between the islands of Pellworm and Nordstrand, some 7 km north of the Eiderstedt Peninsula and 20 km west of Husum.

2.1. North Frisia — a changing coastal landscape

During the early Holocene, the landscape of southern North Frisia was widely dominated by Pleistocene outcrops and glacial outwash plains (the so-called Geest) sloping gradually down from east to west (Prange, 1967; Hoffmann, 2004). From the 4th cent. BC, the ongoing sea level rise of the North Sea caused by both, post-glacial eustatic sea level rise as well as a permanent subsidence of the region by isostatic rebounding led to a widespread formation of peat that was subsequently flooded as the North Sea advanced further east (Hoffmann, 2004; Vink et al., 2007; Behre, 2007). Somewhere west of the present day Wadden Sea, wave dynamics constantly eroded Pleistocene outcrops while ocean currents subsequently formed a S—N trending system of beach ridges. From the 2nd cent. BC, these newly developed ridges induced a back-barrier environment with quiescent shallow water conditions towards the Geest fringe (Dittmer, 1952; Bantelmann, 1966; Hoffmann, 2004).

Until the late 1st millennium BC, the North Frisian coastal landscape turned into a kind of extensive lagoonal environment characterized by intense siltation, marsh formation and peat growth. At the same time, the constant sediment upload caused a dewatering of the fine-grained deposits that in turn caused widespread compaction and subsequent lowering of the ground surface (Bantelmann, 1966; Hoffmann, 1988; Wartenberg et al., 2013). Throughout the 1st millennium AD, decelerated sea level rise initiated extensive peat formation throughout wide areas of coastal North Frisia (Dittmer, 1952; Bungenstock and Weerts, 2010). From the 11th cent. AD onwards, the influence of the North Sea increased again as documented by storm surge deposits found on top of early medieval settlements in the southern North Frisia (Hoffmann, 2004).

Starting approximately in the 12th cent. AD, marshland reclamation significantly changed the coastal dynamics and the appearance of the so far natural North Frisian coastal landscape. Within less than 200 years, namely between the 12th and the 14th cent. AD, dykes were built to protect wide areas that were subsequently drained for cultivation (Bantelmann, 1939; Prange, 1986; Kühn and Müller-Wille, 1988). While the tidal range significantly increased because the inundation potential at the sea side was strongly reduced (Newig, 2014), artificial dewatering of the already low-lying marshes favoured sediment compaction and subsidence of the ground surface (Hoffmann, 2004). Additionally, superficial peat, nowadays only preserved below terps and dykes, was removed for melioration purposes and as combustible material (Dittmer, 1952). When the cultivation of marshland had reached a maximum expansion in the 14th cent. AD, many coastal areas of North Frisia had already subsided below the level of mean high tide (Hoffmann, 2004).

As a consequence, major storm surges like the 1st Grote Mandrenke (or St. Marcellus' flood) in 1362 AD had devastating effects and caused major losses of land by breaching dykes and flooding the low-lying marshland. Within days, once cultivated land again turned into tidal flats (Müller and Fischer, 1936: Bähr, 1987; Kühn, 2007; Behre, 2008; Newig, 1981, 2001). At the same time, the coastline of North Frisia, originally located west of Pellworm (Fig. 1), was shifted up to 20 km further inland. Only in some areas it was possible to reclaim the marshland that had become lost during the 1362 AD event. Several other storm events and especially the 2nd Grote Mandrenke (or Burchardi flood) in 1634 AD again caused considerable damage and severe land loss (Newig, 2014).

2.2. Historical background - Rungholt and the Edomsharde

Early medieval coastal settlements in North Frisia were mainly situated along the mainland Geest fringe and northern Geest islands (e.g. Sylt) and rather seldom on isolated flood-protected terps in the frequently flooded marshland (e.g. Eiderstedt, Stümpel, 2002).

Extensive reclamation and embankment of land thus provided a new potential for the seaward extension of settlement activities. In the 12th cent. AD, the newly reclaimed marshland around present-day Hallig Südfall belonged to the historical administrative district called Edomsharde (engl. also Edoms Hundred). From the 12th cent. AD onwards, the settlement of Rungholt evolved within this area. Since it held the local jurisdiction and had a collegiate church, Rungholt probably represented the principal settlement of the Edomsharde (Hansen and Jessen, 1904; Bantelmann et al., 1995; Henningsen, 2000; Panten and Kühn, 2000).

It is believed that Rungholt had a river harbour that was connected to the North Sea by the former river Hever (Busch, 1936a; Jöns et al., 2017). According to historical documents from the 14th cent. AD, the Edomsharde maintained local commercial relations with the Hanseatic towns of Hamburg and Bremen but also maintained intense and well established supra-regional trade relations with Flanders (Muuß, 1929; Pauls, 1930; Henningsen, 1998, 2000; Panten and Kühn, 2000). Maritime trading activities are also documented by findings of imported basaltic millstones, high-quality Rhenish ceramic sherds and even Moorish jars (Hartmann, 1969; Henningsen, 1998, 2000). The great economic power of the Edomsharde is mirrored by historical documents concerning the comparatively high taxes paid to the Danish king in the 13th cent. AD (Panten and Kühn, 2000). Agricultural goods as well as salt extracted from local saline peat provided a basis for trading activities (Busch, 1936b), probably resulting in a considerable wealth of Rungholt (Häberlin, 1934; Busch, 1936a, b; Panten...
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