RECENT DEVELOPMENT OF THE BACK-BARRIER TIDAL BASIN BEHIND THE ISLAND OF SPIEKEROOG IN THE EAST FRISIAN WADDEN SEA

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Introduction

Land reclamation and dike construction over almost one thousand years along the mainland coast of the Wadden Sea greatly reduced the tidal catchment area. Consequently, the tidal basin morphology and biological communities changed significantly (FLEMMING & NYANDWI, 1994; MAI & BARTHOLOMÄ, 2000). Accordingly, in order to document and understand this morphodynamic evolution of the back-barrier tidal basin response to changes in tidal and wave energy flux, three long vibracores taken along the main channel behind the island of Spiekeroog in the Wadden Sea were investigated.

Materials and methods

The sedimentary vibracores were obtained along the main channel margins, Janssand Nord, Neuharlingersieler Nacken, and Gröniger Plate, respectively (Fig. 1).

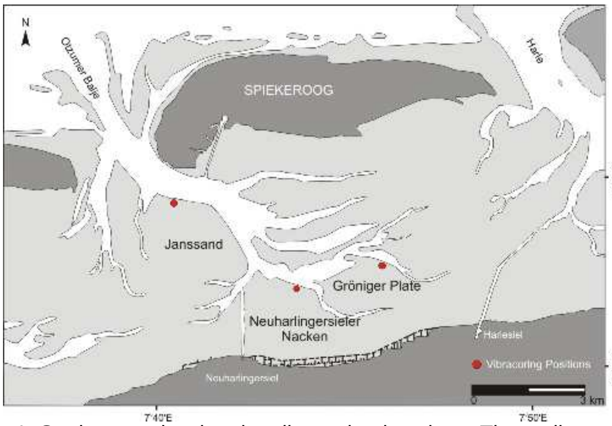

Fig.1. Study area showing the vibracoring locations. Three vibracores were obtained along the main channel from the inlet mouth to the end of the inner channel.

Recovered core lengths ranged from 3 m to 6 m. In the laboratory, the vibracores were cut and conserved in sediment peels using epoxy resin. Then the cores were described in terms of colour, lithology, grain size, and sedimentary structures. Sediments in one half-section were sub-sampled for grain-size analysis at 20 cm intervals as well as at distinctive lithological boundaries.

Facies analysis and depositional units

From the analysis of the vibracores ten sedimentary facies were recognized on the basis of grain size and sedimentary structures. Three general grain-size classes are defined by the sand to mud ratio: Class S (sand; >75% sand), Class SM (sandy mud and muddy sand; 25-75% sand), and Class M (mud; <25% sand). Each class is further subdivided into individual sedimentary facies using primary sedimentary structures (Table 1).

On the basis of this facies analysis and associations, the back-barrier tidal deposits can be divided into three lithostratigraphic units: Unit I, Unit II, and Unit III (Fig. 2).

Unit I

The mud-dominant Unit I was detected only in the lowermost parts of the core of Neuharlingersieler Nacken. This unit is characterized by greenish gray or pale olive mud with plant remains. It consists mainly of homogeneous mud (Facies Mm) and parallel-laminated mud (Facies Mp). The mud content is usually greater than 75%. Faint and thin sand laminae are present as alternations of sand- and mud-rich layers, those becoming dominant in the uppermost part of the unit. Plant stems and leaves, and shell fragments are also present in some layers in the lower part of the unit. The presence of sand streaks, shell debris and plant remains in the lower part of the unit indicate that the muddy sediments were formed in a salt marsh and experienced intermittent inundation during storm. The dominance of lenticular bedding in the upper part of the unit is considered to represent deposition in the upper mud flat rather than in a salt marsh.

Unit II

Tide- and wave-dominant sand sequences of Unit II directly overlie Unit I and are conformably overlain by the topmost Unit III. Unit II is characterised by ripple-laminated and cross-laminated sand. This unit consists of large-scale cross-laminated sand (Facies Sxd), ripple sand (Facies Sxr), and parallel-laminated and cross-laminated muddy sand (Facies SMp and SMx). Unit II also contains massive and shelly sand (Facies Sm and Ssh), and deformed sand (Facies Sd). Shelly sand layers in the lowermost part of Unit II represent parts of tidal channel deposits. Horizontal tidal beddings and cross-bedding with tidal bundles and mud drapes are dominant in

Table 1. Ten sedimentary facies types and their characteristics observed and classified from the vibracores.

Facies Types		Characteristic Feature	Interpretation
Facies Sm		massive sand, scattered shell fragment and organic debris included, rare mud chips and lumps included, partly bioturbated	storm
	Sp	parallel (subparallel) laminated sand, partly organic debris included	bar migration
Sx	Sxd	large-scale cross-laminated sand,	dune migration
	Sxr	small-scale cross-laminated sand, flaser bedded sand common, climbing ripples found,	ripples
	Sd	deformed sand, cross-laminated sand highly deformed and convoluted.	deformation of channel fill deposits
	Ssh	shelly sand, shell densely concentrated and aligned, sharp erosional base, small gastropods included	channel lag
Facies SMp		parallel inter-laminated sand and mud, sand/mud laminae alternations, wavy bedded	tidal bedding
	SMx	cross-laminated sand and mud, mud drapes	tidal bundle
Facies Mm		homogeneous mud, plant stems and leaves, shell fragment included	supratidal flat, salt marsh
	Mp	parallel laminated mud, thin sand streaks, lenticular bedded, greenish gray color	upper tidal flat

the upper part of the Unit. These suggest deposition in sand to mixed flat environments. Some of small-scale fining-upward succession that grades upward from massive sand to ripple and mud top were also found in the unit. These are considered to be deposited from migration of small tidal creeks. The presence of deformed thick sand layers suggest deposition near the channel margin.

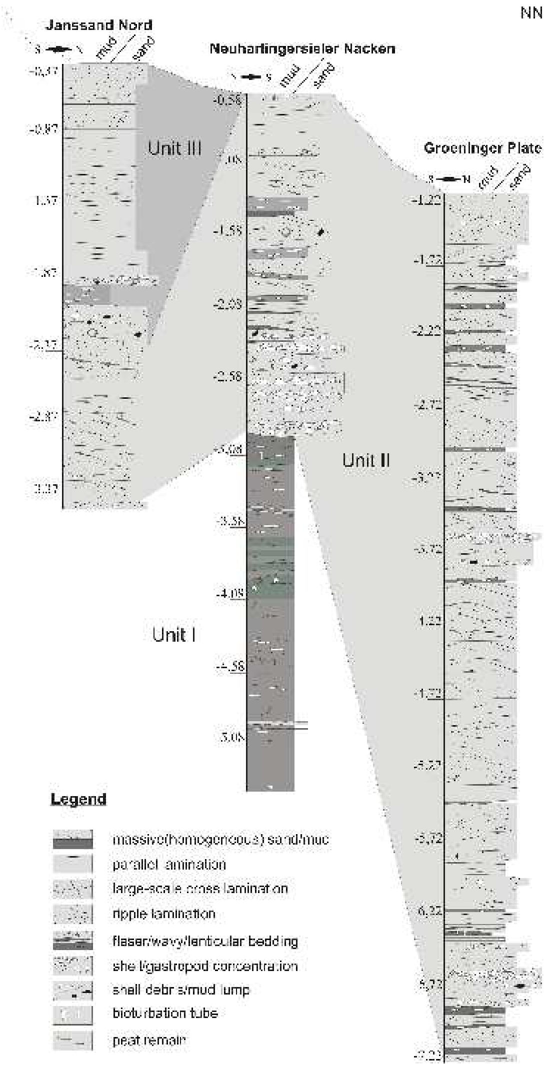

Fig. 2. Stratigraphic cross section of the back-barrier tidal basin based on detailed description of vibracores. Section shows a coarsening upward stacking pattern of Unit I,II and III. NN is normal null.

Unit III

The sand-dominant Unit III was only found in the Janssand core. This unit is characterized by parallel-laminated and low-angle cross-laminated medium sand. Unit III consists of massive (shelly) sand (Facies Sm), parallel-laminated and large-scale cross-laminated sand (Facies Sp and Sxd). The sand content being greater than 95%, no bioturbation and a well-developed near-horizontal lamination of Unit III are suggestive of a swash bar environment under high-energy conditions.

Discussion and conclusions

From the Janssand core, severe facies changes were recognised. The core is characterised by well-sorted medium sands with parallel and cross-laminations. It can be divided into two significantly different parts. Common ripples and the presence of flaser-bedded layers in the lower part of the core are suggestive of deposition in a sand-flat environment. In the upper succession the parallel-laminated and cross-laminated sands are dominant, suggesting deposition in a swash bar environment. Between both successions coarse-grained massive sand layers with mud balls and scattered shells were intertwined, these being interpreted as a transition facies. The occurrence of those layers and the abrupt change of depositional environments suggest that this area has experienced dramatic changes in the hydrodynamic regime. It may have been formed by an abrupt rise of the local sea level. Alternatively, dike construction and land reclamation could have led to these severe morphological changes in the back-barrier area such as watershed and main channel shifting due to the reduction of the tidal prism (OOST, 1995).

This sudden transition of facies was also observed in the core from the Neuharlingersieler Nacken. Muddy sediments were suddenly terminated by shelly coarse sand with an erosive base, upwards grading into ripple sands. The lower mud-dominant succession can be assigned to upper mud flat and salt marsh environments. Channel lag deposits directly overlie these lower mud sediments and gradually pass upwards into mixed to sand flat environments. Although both explanations mentioned above are plausible explanations for these changes, the former argument is a more likely explanation in this case, because there were no transitional facies and the presence of a sharp erosional base. Indeed, the upper succession shows a small-scale fining-upwards succession showing different directions of migration of small channels directly above the channel lags. Sand flat facies occurred in the uppermost part. This change seemed to be led by a decrease in the size of the tidal prism.

The core from the Gröninger Plate is characterised by an alternation both of tide-dominated and wave-dominated sand facies of the sand-flat environment. This core shows only channel-fill successions controlled by their migration. No abrupt change of the depositional environment is found in this core. Storm deposits occurred rarely.

Vibracore data from the back-barrier tidal basin show that the intertidal deposits overlie the muddy, salt marsh deposits and form a coarsening-upwards succession. More core data are required to fully understand and reconstruct the stratigraphic evolution. Age dating of shells and wood fragments can give further information about human intervention.

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