Grain-size & sedimentological characteristics of glacigenic sediments from the southern Baltic Sea

Linn Merelius

Department of Geological Sciences

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Supervisors: Richard Gyllencreutz & Sarah Greenwood

Stockholm University

Abstract

The Baltic Sea contains sedimentary records that preserve evidence of past glacial and marine processes associated with retreat of the Fennoscandian Ice Sheet. Sedimentological investigations can be used for understanding depositional processes and environmental conditions within glacially influenced environments. This project analyses four sediment cores from the southern Baltic Sea in order to investigate sedimentary processes and depositional environments associated with retreat of the Baltic Ice Stream. Visual core descriptions, grain-size analysis and magnetic susceptibility measurements were used to identify variations in sediment composition. Results show broad grain size distribution with generally broad sorting throughout the analysed cores. The sediments are predominantly fine-grained and dominated by silt and clay fractions, although variability occurs between the cores. Dispersed angular clasts occur within several fine-grained intervals, while one core contains a distinct gravel-rich unit composed of relatively well-sorted and subrounded to rounded clasts. The sediment cores had been stored unrefrigerated, which caused them to dry out. This affected the physical conditions of the sediment and limited the range of analyses that could be reliably performed and introduces uncertainty to the result. The analysed sediment cores indicate that depositional enviroments in the southern Baltic Sea varied during the deglaciation. Variations in grain size, clast content and sediment structure between the cores indicate differences in sediment supply and depositional processes across the study area. The sedimentological observations provide further insight into local depostional varaibility and sediment reworking, which in future work can complement existing geomorphological reconstructions off the deglacition. The integration of sedimentlogocial and geomropholoical observations therefor contributes to a more detailed understanding of glacial and deglacial enviroments in the Baltic Sea basin.

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1 Introduction

The Baltic Sea is an epicontinental sea with a geological history strongly influenced by repeated glaciations during the Quaternary (Jakobsson et al., 2017). As a result, the basin contains sedimentary records that reflect the interaction between glacial and marine processes, making it an important area for studying past depositional environments. Recent studies based on high-resolution bathymetric and geomorphological data have significantly improved the understanding of glacial landforms and ice-sheet dynamics within the Baltic Sea basin (Greenwood et al., 2024; Szuman et al., 2024). In particular, Greenwood et al. (2024) reconstructed the Baltic Ice Stream as a major fast-flowing drainage corridor within the Fennoscandian Ice Sheet during deglaciation. These data have provided detailed insights into the extent and behavior of the ice stream and its changing in flow pathways. However, such approaches primarily reflect large-scale geomorphological patterns and do not directly capture the processes of sediment deposition.

Understanding past glacial environments therefore requires the interpretation of sedimentary records in addition to geomorphological data. Sediment cores can improve interpretation of depositional processes and ice-margin retreat (Prothro et al., 2017). However, interpreting glacial and glaciomarine sediments is often challenging because similar sediment characteristics may form through different depositional processes. For example, poorly sorted diamictons may represent either subglacial till or ice-proximal glaciomarine deposition (Prothro et al., 2017). In addition, sediments within the Baltic Sea basin may have been modified by post-depositional marine processes following deglaciation, including bottom-current reworking and later marine sedimentation (Winterhalter, 1992).

The aim of this study is to analyse sediment cores from the Baltic Sea in order to interpret sedimentary processes and depositional environments. By combining visual core descriptions with grain-size analysis and magnetic susceptibility data, the study seeks to understand how sedimentary records reflect variations in glacial influence and depositional conditions within the Baltic Sea basin compared to relevant research.

2 Background

2.1 The Baltic basin

The Baltic Sea basin is a shallow semi-enclosed sea located in northern Europe and represents one of the largest brackish water bodies in the world (Jakobsson et al., 2019; Rosentau, 2017). It is connected to the global ocean through shallow and narrow straits, while simultaneously receiving large volume of freshwater from its extensive drainage basin (Rosentau et al, 2017). The basin has a mean depth of 53 m and is subdivided into 17-sub-basins separated by bathymetric sills which structure the internal basin configuration (Jakobsson et al., 2019).

The Baltic basin lies within the former extent of the Fennoscandian Ice Sheet and was largely covered by grounded ice during the last glacial cycle (Greenwood et al., 2024). During deglaciation, the basin hosted a large freshwater body, the Baltic Ice Lake, which formed as meltwater was dammed by the retreating ice margin (Björck, 1995; Andrén et al., 2011).

Drainage likely occurred via lower-lying valleys in Denmark and through the Öresund region between Sweden and Denmark, which acted as key pathways for glacial meltwater outflow (Andrén et al., 2011).

The development of the basin is therefore closely linked to glacial processes, where repeated glaciations have controlled erosion, sediment transport and deposition (Hall and Van Boeckel, 2020).

2.2 The Baltic Ice Stream and Deglaciation

The Fennoscandian Ice Sheet covered large parts of northern Europe during the last glacial cycle and extended across the Baltic Sea basin to its maximum extent during the Last Glacial Maximum (Stroeven et al., 2016; Hughes et al., 2016). Ice flow within the ice sheet included zones of fast flow, referred to as ice streams, which act as the primary pathways for ice and sediment transport (Bennett, 2002), and the Baltic Ice Stream has been described as a major fast-flowing sector of the ice sheet associated with the Baltic Sea basin (Greenwood et al., 2024).

However, direct evidence for ice-flow organisation within the basin has only recently become available. Greenwood et al. (2024) provides the first basin-scale, systematic description of submarine glacial landforms, offering new constraints on ice flow-patterns. These data indicate that ice flow within the basin was temporally and spatially variable, with shifting and discrete flow pathways rather than a single continuous ice stream (Greenwood et al., 2024; Szuman et al., 2024). Interpretation of this glacial record is limited by the availability of high-resolution bathymetric data (Greenwood et asl., 2024), as well as by burial and potential reworking of glacial landforms beneath younger marine sediments (Dowdeswell et al., 2016). Moreover, previous sedimentary studies have predominantly focused on the Holocene evolution of the Baltic Sera as a lake-marine basin (Andrén et al., 2011; Björck, 1995), with comparatively little integration of the underlying glacial record.

Deglaciation of the Baltic region did not occur as a continuous retreat of the ice margin. Instead, the ice sheet retreated in a stepwise manner, with periods of retreat interrupted by periods of stillstand or readvance (Stroeven et al., 2016; Szuman et al., 2024). The timing and pattern of retreat varied across the region, resulting in differences in ice margin position through time. The final disappearance of the Fennoscandian Ice Sheet occurred after approximately 9.7 ka in northern Sweden (Stroeven et al., 2016).

2.3 Sedimentary Evidence

Variations in seafloor morphology, such as terrain ruggedness, influence ice-flow processes both in the present and in the past, involving ice flow, glacial melt water, glacial erosion and sediment transport (Jakobsson et al., 2019). These variations provide a basis for identifying subglacial landforms preserved on the Baltic seafloor.

Subglacial landforms such as mega-scale glacial lineations, drumlins and ribbed moraines reflect evidence of former ice-flow conditions. Mega-scale glacial lineations are associated with fast-flowing ice streams, where their elongation indicates sustained high ice-flow velocities (Greenwood et al., 2021), while drumlins and ribbed moraines commonly occur in regions of slower flow (Greenwood et al., 2021). Changes in landform patterns, such as transitions from lobate ice margins with splaying lineations to parallel lineations in deeper part of the basin, indicates shifts in ice-flow behavior through time (Szuman et al., 2024).

These geomorphological features are complemented by sedimentary evidence, which provides insight into depositional processes at the ice margin. Glacial sediments formed beneath grounded ice are associated with processes such as deformation, sliding and lodgement at the ice–bed interface (Evans et al., 2006). These deposits commonly occur as poorly sorted diamictons containing grain sizes ranging from clay to boulders. Diamictons may also occur in glaciomarine environments, where debris is released from glacier ice or icebergs (Licht, 2009). In more distal settings, lower-energy conditions favour the deposition of fine-grained sediments dominated by silt and clay. Together, these sedimentary records provide evidence for reconstructing depositional environments and ice-margin dynamics.

3 Methods

3.1 Sediment cores

The sediment cores analysed in this study were collected by Geological Survey of Sweden from the southern Baltic Sea during campaigns in 2004 and 2007, using a vibrocore. Vibrocorers are the technique where a vibrating core barrel is driven into the seafloor to recover sediment cores, and the method is particulary useful for penetrating firmer and coarser-grained sediments where wire-line gravity or piston coring are ineffective (Paull et al., 2001). Four of the cores were analysed, with their locations shown in figure 1 and their characteristics summerised in table 1. Prior to analysis, the cores had been stored unrefrigerated, which caused them to dry out. This affected the physical conditions of the sediment and limited the range of analyses that could be reliably performed.

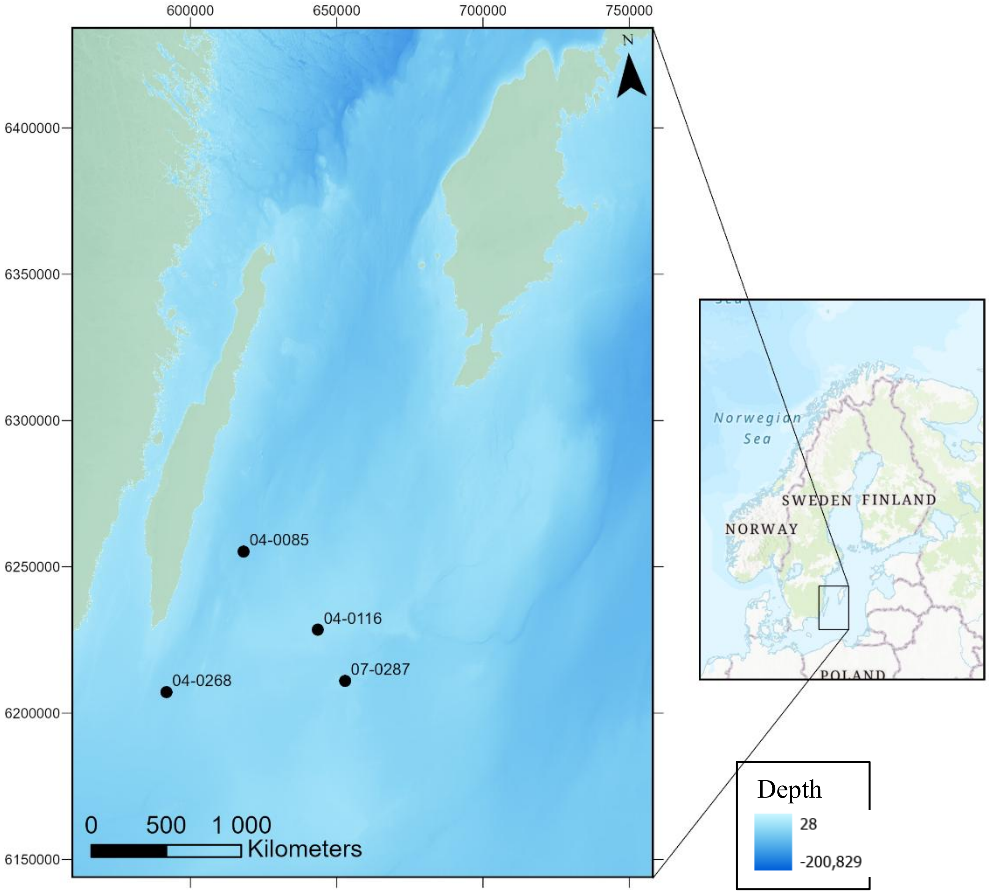

Figure 1. Location of the sediment cores analysed in the southern Baltic Sea.

Core ID	Lat N	Lon E	N. of sections	Core Length (cm)
04-0085	6255294N	618209E	4	0 - 387
07-0287	6228466N	643558E	4	0 – 380
04-0268	6211061N	652852E	2	20 - 120
04-0116	6228466N	643558E	1	0 - 100

Table 1. Coordinates, number of sections, and total length of the analysed sediment cores.

The cores were described visually with respect to sediment colour, grain size, sedimentary structures and the presence of bioturbation or plants/animals. Core lengths were measured, and sketches were produced to document sediment characteristics and any visible disturbances. Sediment colour was determined using the Munsell Soil Color Chart, and grain size was estimated visually as part of the sediment description before the grain-size analysise was made.

3.2 MSCL

The sediment cores were analysed using Multi-Sensor Core Loggers (MSCL), which was used to obtain high-resolution core images and measurements of magnetic susceptibility. Gamma-ray-density was not measured, as the cores had dried out prior to analysis. Dring can alter sediment porosity and density in an unpredictable way, making such measurements unreliable. Magnetic susceptibility was measured using a loop sensor with a diameter of 10 cm. The cores were advanced through the instrument using a motorised pusher, with a sampling interval of 1 cm and a measurement time of 2 seconds per point.

3.3 Grain size analysis

Grain-size samples were collected at 20 cm intervals along the cores. In some sections, sampling was not possible due to the presence of coarse material or gaps in the sediment. The samples were treated with deionized water and mixing using a vortex mixer to disaggregate the sediment particles. Grain-size distributions were analysed using a Malvern Mastersizer 3000, with a measurement range of 0.01-3500 µm. However, particles larger than 1000 µm could not be measured, because individual grains make up too much of sample size.

Prior to each measurement, a dispersing solution consisting of 3 ml sodium metaphosphate was added before every background measurement. Each sample was allowed to settle for 3 minutes, including 60 seconds of ultrasonic treatment before measurement. Five replicate measurements were conducted in a row for each sample. The resulting data were exported to Excel, and average values were calculated from the five measurements of each sample.

4 Results

4.1 Core description

4.1.1 Core 04-0085

Core 04-0085 was recovered from the southern Baltic Sea (Fig. 1). Based on sedimentary structures and grain size, the core is divided into three sediment units. Frequent fractures are visible throughout the core, drying-related features.

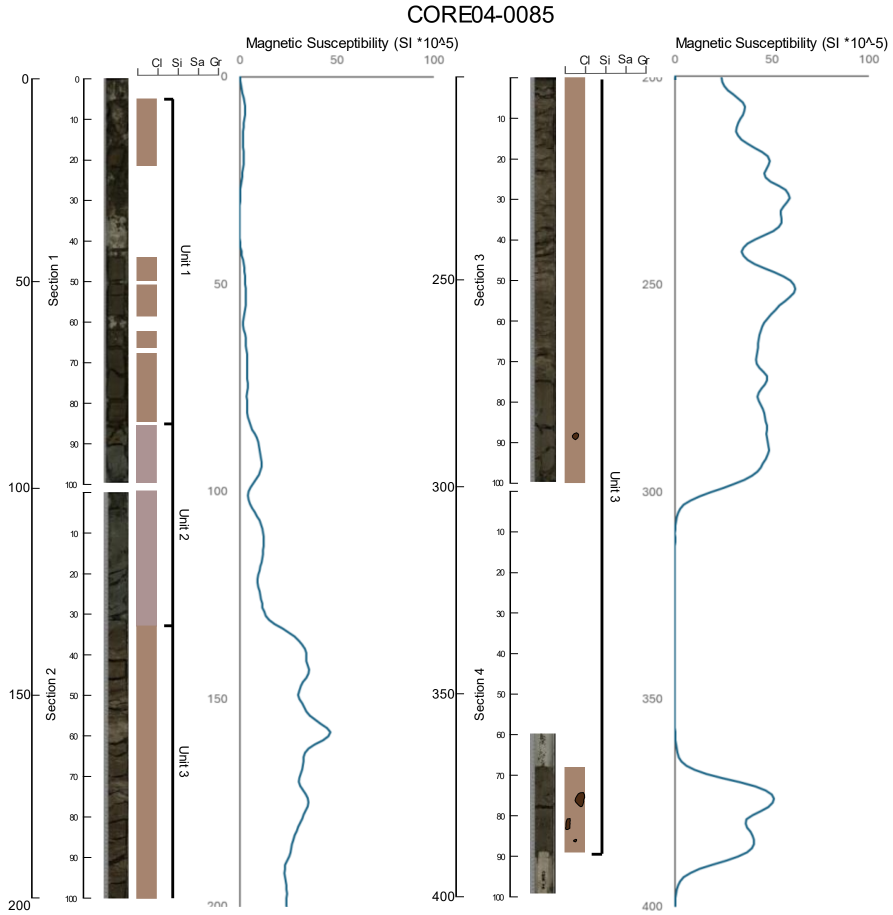

Figure 2. Sediment core log for core 04-0085 showing core photograph, lithological interpretation and grain-size composition (clay, silt, sand and gravel). The vertical axis represents depth (cm). Magnetic susceptibility values are shown to the right of the core.

Unit 1 consists of reddish brown (5YR 5/3) fine-grained sediment, dominated by clay. Small, dark spots are found in parts of the interval, giving the sediment a slightly mottled appearance. The sediment has undergone extensive shrinkage and partial disaggregation.

Unit 2, at approximately 85 cm, an abrupt transition to blueish grey (GLEY2 6/1 10B) clay is observed. Compared to unit 1, the sediment appears firmer and more compact, with a blocky structure.

In unit 3, below 133 cm, the clay transitions sharply to a light reddish brown (5YR 6/3) colour with continuous clayey sediment. Lamination is present in several parts of the unit and is generally mm-scale. Clasts occur sporadically and become more frequent towards the base, where they increase in size to 1 cm and appear angular in shape.

Magnetic susceptibility is low in the upper part of the core, corresponding to unit 1 and 2, before becoming more variable below approximately 133 cm. Several peaks occur within unit 3.

4.1.2 Core 07-0287

Core 07-0287 was recovered from southern Baltic Sea (Fig 1). Based on sedimentary structures and grain size, the core is interpreted as consisting of a single sediment unit.

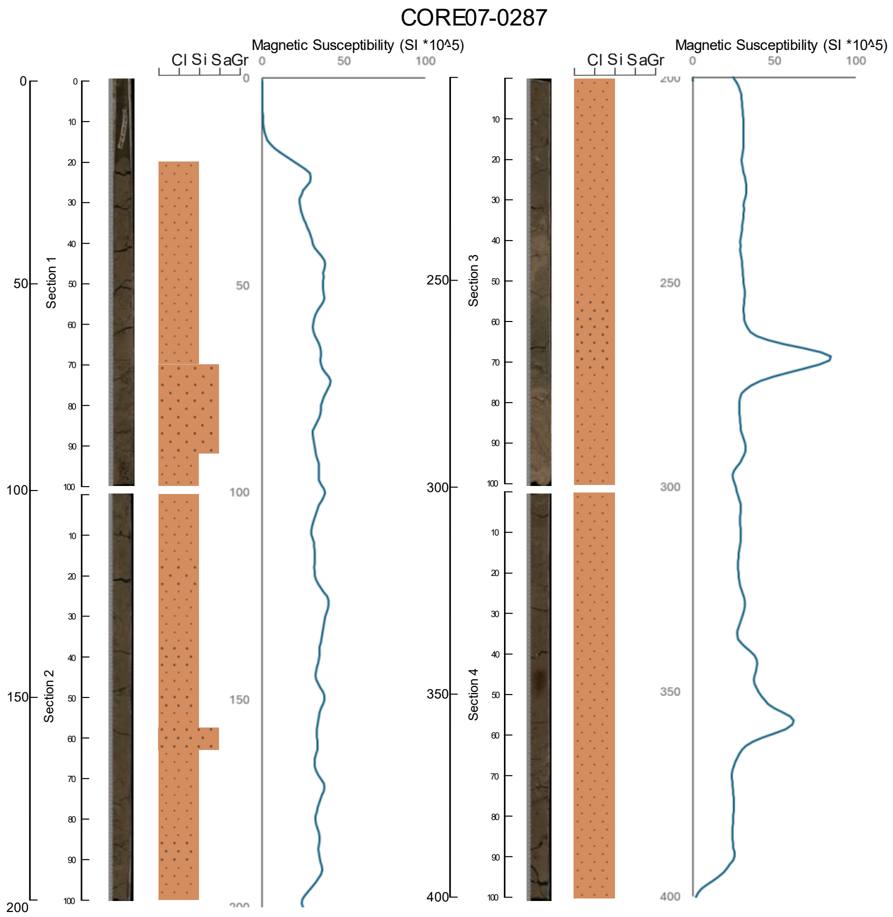

Figure 3. Sediment core log 07-0287 showing core photograph, lithological interpretation and grain-size composition (clay, silt, sand and gravel). The vertical axis represents depth (cm). Magnetic susceptibility values are shown to the right.

The core is composed of fine-grained sediment with a uniform appearance throughout. Variations are expressed as changes in the abundance of coarser material, with some intervals appearing slightly sandier. A few larger clasts appear throughout the core. Magnetic susceptibility values are uniform throughout the core apart from two small peaks at 260 and 370 cm core depth.

4.1.3 Core 04-0268

Core 04-0268 was recovered from southern Baltic Sea (Fig. 1). Based on sedimentary structures and grain size, the core is divided into three sediment units.

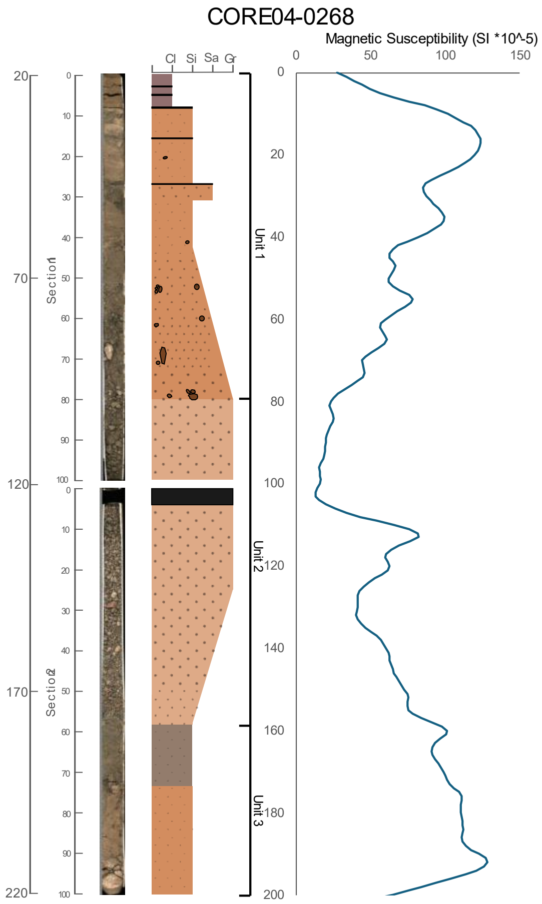

Figure 4. Sediment core log 04-0268 showing core photograph, lithological interpretation and grain-size composition (clay, silt, sand and gravel). The vertical axis represents depth (cm). Magnetic susceptibility values.

Unit 1 consists predominantly fine-grained sediment with a light brownish grey (10YR 6/2) colour. The uppermost part (0-10 cm) is compact and muddy appearance. Between 10-40 cm, the sediment is dominated by sandy silt and contains occasional greyish layers. From 40-80 cm, the sediment remains fine-grained but shows a gradual increase in sand content and clast abundance down-core, indicating a transition towards slightly coarser material.

Unit 2 is characterized by a distinct change to significantly coarser sediment at approximately 80 cm. The interval is dominated by mm- to cm-sized clasts gravel, with clasts sizes decreasing down-core, forming a vertically inverse graded sequence.

Unit 3 begins with an abrupt transition back to sandy silt at 160 cm. The sediment is greyish brown (10YR 5/2) in the upper unit, below this, the sediment shifts in colour to pale brown (10YR 6/3). Large clasts are present towards the base of the core and reach up to 5 cm, appearing quite angular.

Magnetic susceptibility is highest in the upper part of unit 1 and decreases downcore through the unit, broadly coinciding with the gradual increase in sand content and clast abundance. Within unit 2, magnetic susceptibility continues to decrease in the upper part of the gravel-dominated interval, before increasing in the middle of the unit and decreasing again towards its base. Magnetic susceptibility then increases as the sediment becomes finer grained.

4.1.4 Core 04-0116

Core 04-0116 was recovered from southern Baltic Sea (Figure 1). Based on sedimentary structures and grain size, the core is interpreted as consisting of a single sedimentary unit.

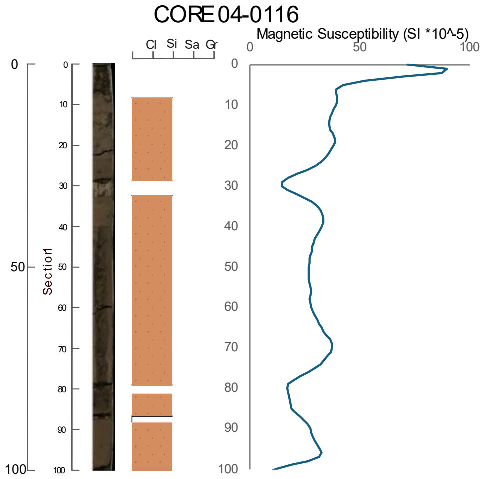

Figure 5. Sediment core log 04-0116 showing core photograph, lithological interpretation and grain-size composition (clay, silt, sand and gravel). The vertical axis represents depth (cm). Magnetic susceptibility values.

The core consists predominantly of silty fine-grained sediments with several angular clasts (< 1 cm). The sediment is light brownish gray (10YR 6/2) in colour and appears relatively homogeneous throughout the interval. A mollusk shell fragment is observed at the core top. Magnetic susceptibility is uniform throughout the core with minor fluctuations.

4.2 Grain Size analysis

The grain-size distribution varies both within and between the analyzed cores. These results represent the fine-grained sediment matrix, as discrete clasts and the coarser sand fraction were not included in the grain-size analyses. The distributions are generally broad, indicating poor sorting and a wide range of grain sizes. Clear differences in the relative proportions of sand, silt and clay are observed between the cores, as well as variations with depth within individual cores.

4.2.1 Core 04-0085

Core 04-0085 is characterised by predominantly bimodal grain-size distributions, reflecting the presence of two distinct grain-size populations (Fig. 6). A silt-dominated fraction is consistently present, accompanied by a finer clay component. In the upper part pf the core, the distributions extend towards coarser grain sizes, indicating a minor contribution from fine sand. With increasing depth, the separation between finer and coarser fractions becomes more clearly defined, strengthening the bimodal character. The distributions are broad throughout the core, indicating very poor sorting and a wide spread of grain sizes within individual samples.

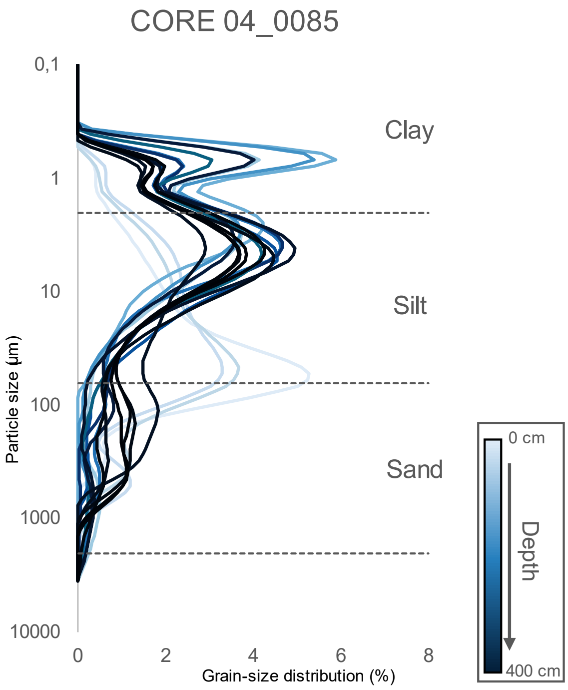

Figure 6. Grain-size distributions for core 04-0085 plotted as individual curves for each sampled depth. The x-axis represents grain-size distribution (%), and the y-axis shows particle size (µm) on a logarithmic scale. Dashed lines indicate the boundaries between clay, silt and sand fractions. Colour variation reflects sample depth.

4.2.2 Core 07-0287

Core 07-0287 is dominated by the silt fraction and is generally characterised by unimodal to weakly bimodal distributions (Fig. 7). A consistent concentration of grains occurs within the silt range, with a smaller contribution from clay. In the upper part of the core, a slightly increased proportion of coarser material is observed, forming a subtle extension towards larger grain sizes. This coarser component decreases in depth, where the sediment becomes more consistently fine-grained. The distributions remain broad, indicating poor sorting, although with less variability compared to core 04-0085.

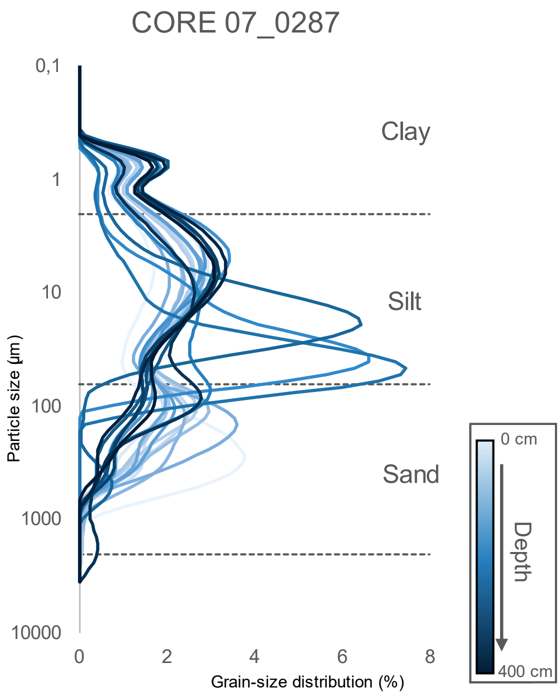

Figure 7. Grain-size distributions for core 07-0287 plotted as individual curves for each sampled depth. The x-axis represents grain-size distribution (%), and the y-axis shows particle size (µm) on a logarithmic scale. Dashed lines indicate the boundaries between clay, silt and sand fractions. Colour variation reflects sample depth.

4.2.3 Core 04-0268

In Core 04-0268 the grain-size record is incomplete in the central part of the core due to the presence of gravel that could not be analysed (Fig. 8). The core has a wide range of grain sizes with two depths of high sand concentrations, otherwise a gradual distribution. However, the available data indicates very poor sorting and a wide range of grain sizes throughout the core.

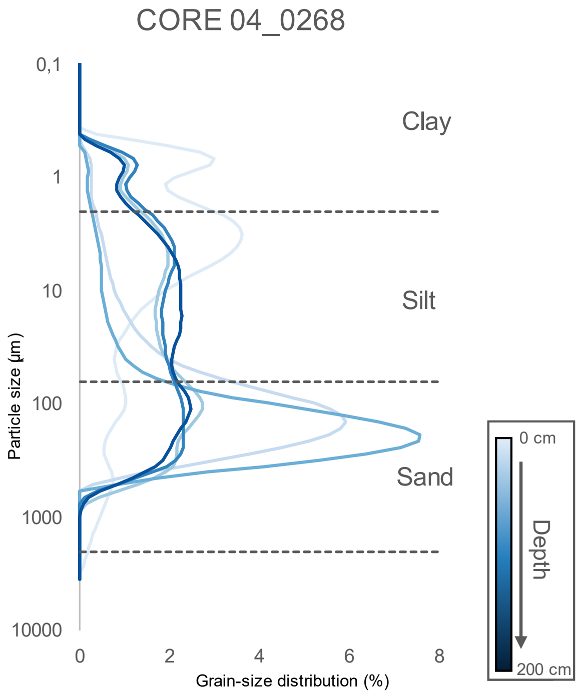

Figure 8. Grain-size distributions for core 04-0268 plotted as individual curves for each sampled depth. The x-axis represents grain-size distribution (%), and the y-axis shows particle size (µm) on a logarithmic scale. Dashed lines indicate the boundaries between clay, silt and sand fractions. Colour variation reflects sample depth.

4.2.4 Core 04-0116.

Core 04-0116 is characterised by relatively smooth and consistent grain-size distributions and is predominantly unimodal (Fig. 9). The sediment is dominated by the silt fraction, with smaller contributions from both clay and sand. The transition between grain-size fractions is gradual, more uniform, although still relatively broad, indicating poor to moderate sorting.

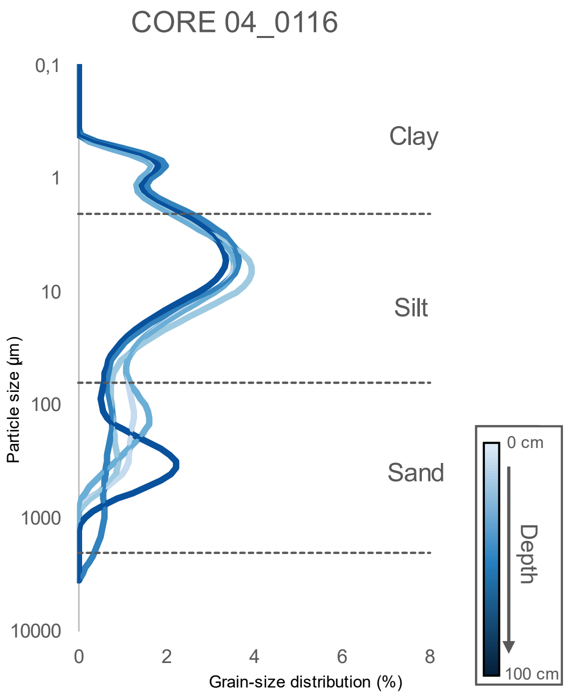

Figure 9. Grain-size distributions for core 04-0116 plotted as individual curves for each sampled depth. The x-axis represents grain-size distribution (%), and the y-axis shows particle size (µm) on a logarithmic scale. Dashed lines indicate the boundaries between clay, silt and sand fractions. Colour variation reflects sample depth.

5 Discussion

5.1 Stratigraphic and depositional interpretation

5.1.1 Core 04-0085

Core 04-0085 is dominated by clay-rich sediments throughout the succession, although the sediment characteristics vary between units. Unit 1 consists of brown clay-rich sediment and differs from the underlying units in its response to drying during storage. While fractures occur throughput the core, unit 1 has undergone substantially greater shrinkage, in some intervals causing the sediment to partially disaggregate. In contrast, unit 2 and 3 remain more structurally intact despite the presence of extensive fractures throughout the sediment. The presence of small dark spots, together with the shrinkage, in the upper unit may be related to organic material within the sediment.

Unit 2 is distinguished by an abrupt colour change from brownish to bluish grey clay and displays a more compact, blocky structure with continuous fractures throughout the unit.

Unit 3 contains parts of laminated clay together with dispersed angular clasts and increased magnetic susceptibility. The coexistence of laminations and poorly sorted, clast-bearing sediment suggests fluctuating depositional conditions rather than uniform low-energy settling. Laminated intervals commonly associated with suspension settling (Cofaigh and Dowdeswell, 2001), while the occurrence of angular clasts and the broad bimodal grain-size distributions indicate continued input of coarse glacial material (Dowdeswell et al., 1998).

5.1.2 Core 07-0287

Core 07-0287 differs from 04-0085 by lacking major lithological transitions or distinct coarse-grained intervals. Grain-size distribution remains relatively consistent throughout the succession and magnetic susceptibility values show only minor variation, suggesting that sediment input remained comparatively stable during deposition. Although clasts occur throughout the core, they are not concentrated into distinct layers or intervals, suggesting limited variability in coarse sediment input though time. This may suggest that the site remained relatively distal from mote dynamic ice-margin processes during deposition (Licht, 2009).

5.1.3 Core 04-0268

Core 04-0268 records variations in sediment characteristics throughout the succession. In unit 1, the gradual increase in sand content and clast abundance down-core indicates a transition to the gravel-rich sediment of unit 2. This trend broadly coincides with decreasing magnetic susceptibility values.

Unit 2 is dominated by mm- to cm-sized gravel and differs from the surrounding fine-grained sediment. The gravel interval indicates a temporary increase in energy conditions, where finer particles are removed and coarser fractions remain. Andersson et al (1980) suggest that the lack of finer grades may be caused by winnowing removing finer material. An alternative interpretation is that it may be a primary feature of the ice-rafted material, where finer sediments have been kept in suspension while coarser grades have settled, or be a combination of both processes (Elverhøi and Roaldset, 2016). However, the gravel appear quite sorted and subrounded which may reflect deposition or reworking by meltwater-related processes as transport by meltwater can concentrate coarse sediment and reduce finer fractures.

Unit 3 begins with an abrupt transition back to silt-rich fine-grained sediment. Magnetic suceptibility values increase as the sediment becomes finer grained.

5.1.4 Core 04-0116

Core 04-0116 is characterised by consistent sediment properties throughout the succession. The grain-size distribution is smooth and predominantly unimodal, suggesting uniform sedimentation through time. The sediment is dominated by silt-rich fine-grained material, while magnetic susceptibility values remain relatively stable throughout the core. Despite the generally homogeneous character of the core, angular clasts occur and range in size up to 1 cm. The occurrence of angular clasts indicates intermittent unput of coarse material that experienced limited abrasion prior to deposition (Benn and Ballentyne, 1994). A mollusk shell fragment observed at the top of the core may indicate later marine influence or reworking following deglaciation.

5.2 Implications for glacial dynamics

Greenwood et al. (2024) identified a range of glacial landforms within the southern Baltic Sea indicating spatial variability in ice-flow behavior and retreat dynamics during deglaciation.

Cores 04-0085, 07-0287 and 04-0116 are located within areas where grounding line landforms have been identified (Greenwood et al., 2024). These cores are dominated by fine-grained sediment suggesting that sedimentation was mainly controlled by suspension settling in relatively low-energy settings at some distance from the active grounding line. However, all three cores contain intermittent coarse material in the form of dispersed angular clasts. The angularity of the clasts suggests limited transport or abrasion prior to deposition (Benn and Ballantype, 1994), consistent with its distance to the glacial margin and continued glacial sediment input during retreat. In core 04-0085, laminated intervals together with angular clasts in unit 3 suggest fluctuating sediment input during deposition where periods of relatively quit fine-grained sedimentation include coarser sediment delivery.

In contrast, core 04-0268 records substantially greater lithological variability and is located within an area of identified subglacial lineations. The core contains abrupt transitions between fine-grained sediment and a gravel-rich interval, indication major shifts in sedimentation through time. The gravel in unit 2 is relatively well sorted and the clasts appear subrounded to rounded, suggesting that the material experienced transport or reworking prior to deposition. Together with the absence of finer-grained material in unit 2, this supports the interpretation that flowing meltwater or winnowing processes may have influenced formation of the unit rather than direct deposition of unsorted glacial debris alone. Because the core location is not directly associated with a grounding line landform, the gravel-rich interval is less likely to represent groundling line deposition and may instead reflect local sediment redistribution following retreat.

5.3 Limitations

The sediment cores analyzed in this study were collected in 2004 and 2007 and have not been preserved under optimal conditions. As a result, the sediments have dried over time, leading to shrinkage and compaction, as well as the development of fractures within the core. These alterations complicate the interpretation of sedimentary structures, as natural features may be difficult to distinguish from cracks and disturbances caused by long-term storage and handling.

In core 04-0085, small dark and light spots are observed within the sediment. These features may be related to mould or other growth that developed during storage. As such, they are not necessarily representative of the original sediment characteristics.

The drying of the sediment also limits the range of analyses that can be performed. For example. It has not been possible to measure density or water content, and the original sediment colour may have been altered during storage. These factors also reduce the reliability of certain sedimentological interpretations.

Furthermore, the interpretation of the sedimentary environment is constrained by the limited availability of reginal studies on glacial sediments in the Baltic Sea. As a result, interpretations are partly based on analogues from other glaciated regions, particularly Antarctic environments. While the fundamental sedimentary processes are comparable, potential local differences in depositional conditions may not be fully captured.

6 Conclusions

The analysed sediment cores indicate that depositional enviroments in the southern Baltic Sea varied during the deglaciation. Variations in grain size, clast content and sediment structure between the cores indicate differences in sediment supply and depositional processes across the study area. The sedimentological observations provide further insight into local depostional varaibility and sediment reworking, which in future work can complement existing geomorphological reconstructions off the deglacition. The integration of sedimentlogocial and geomrophloical observations therefor contributes to a more detailed understanding of glacial and deglacial enviroments in the Baltic Sea basin.

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