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SPATIAL AND TEMPORAL VARIATIONS IN MAGNETIC SUSCEPTIBILITY OF COASTAL SANDS RESULTING FROM RECENT STORM ACTIVITY, SAAREMAA ISLAND, ESTONIA

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Abstract: Coastal strandplains on Saaremaa Island, Estonia, contain a rich archive of past events, which are recorded as geomorphic and lithological indicators of reworking (erosional) and depositional (accretionary) phases. This study presents a new dataset of low-field bulk magnetic susceptibility (MS) values from coastal sands as a rapid means of characterizing the ferrimagnetic and paramagnetic fraction in morphosedimentary units related to cyclone Gudrun (January 2005). Combining spatial and temporal patterns in MS (e.g., >600 SI for most peaks) with granulometric and geophysical databases provides the basis for applying similar integrated approach to reconstructing past extreme coastal events.

Keywords: magnetite, beach, aeolian, storm Gudrun, Baltic Sea.

Introduction: Most coastal accumulation forms serve as morphosedimentary archives of past oceanographic forcings, with beach/dune ridges (strandplains) preserving records of wave climate, storm impacts, and near-surface wind activity [1-3]. In siliciclastic lithosomes, geological evidence of past events is preserved as erosional (discontinuities, density lag) and depositional geoindicators.

This study focuses on a coastal strandplain along Harilaid Peninsula (Saaremaa Island, Estonia; Fig. 1), which has been impacted by a series of well documented storms in the 20th and 21st centuries [4-6]. Morphostratigraphic analysis allowed correlation of a specific beach-dune ridge with an intense cyclone Gudrun (Erwin) during early January 2005 [3, 4].

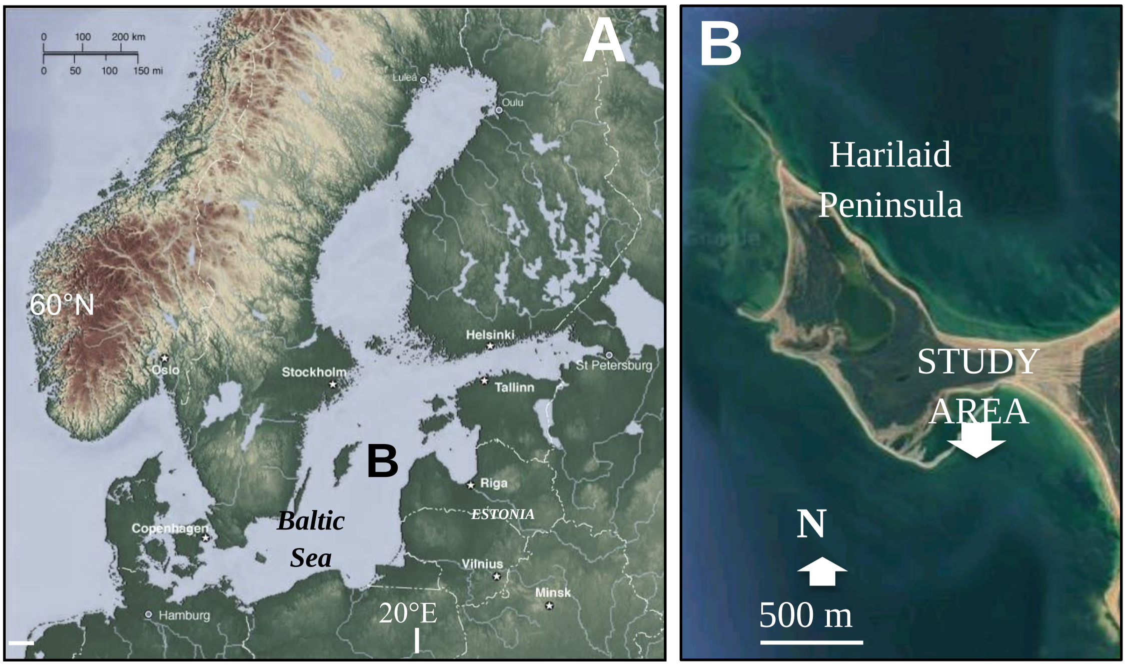

Figure 1. A) Location map of the study area in western Saaremaa Island, Estonia. B) Study site is a north-facing strandplain on the Harilaid Peninsula tombolo. Two shore-normal transects cross a ridge correlated to storm Gudrun (2005). Image source: GoogleMaps™.

Two shore-normal transects, which have been investigated using georadar and coring studies, were used to assess the spatial (cross-shore and alongshore) and temporal (stratigraphic) patterns in low-field bulk magnetic susceptibility (MS) as a rapid means of characterizing the ferrimagnetic and paramagnetic fraction in lithological units related to reworking (erosional) and depositional (accretionary) phases of Gudrun [7, 8].

The aim of this paper is to present the first MS dataset from the post-storm ridge and to highlight trends related to key event phases.

Methodology: For assessing the relative magnitude of heavy minerals (driven primarily by the ferrimagnetic fraction, e.g., magnetite), 88 bulk volume magnetic susceptibility values were obtained *in situ* in November 2022.

We used a portable Trimble® Nomad® 900 handheld computer with a high sensitivity Bartington® MS3 meter and the MS2K field scanning sensor (operational frequency: 0.93 kHz). Most samples in this study have a mean grain size in a medium sand range (0.2-0.5 mm), with microscope analysis indicating that nearly all opaque and non-opaque heavy minerals (density > 2.7 g/cm^3) comprise a finer fraction in each sample. Measurements were made at 10 cm intervals in trench walls guided by visible sedimentological variations.

Differential RTK GPS was used for horizontal and vertical geolocation of the eight trenches (2 transects x 4 trench sites: beach, aeolian ramp, dune top, backdune swale).

Results and Summary: The key trends in magnetic susceptibility (MS) are shown in Figure 2. MS peaks for each trench are used for tentative correlation of lithological units, partially guided by georadar records collected during sampling. Most of these peaks due to mineralogical anomalies exceed 600-700 μSI, with background values in a 200-400 SI range.

At least two HMC anomalies can be traced in each trench (Fig. 2) and are attributed to a reworking phase of storm Gudrun. Anomalies at the base of the landward swale are tentatively attributed to an older event (the 1999 storm Anatol) [4].

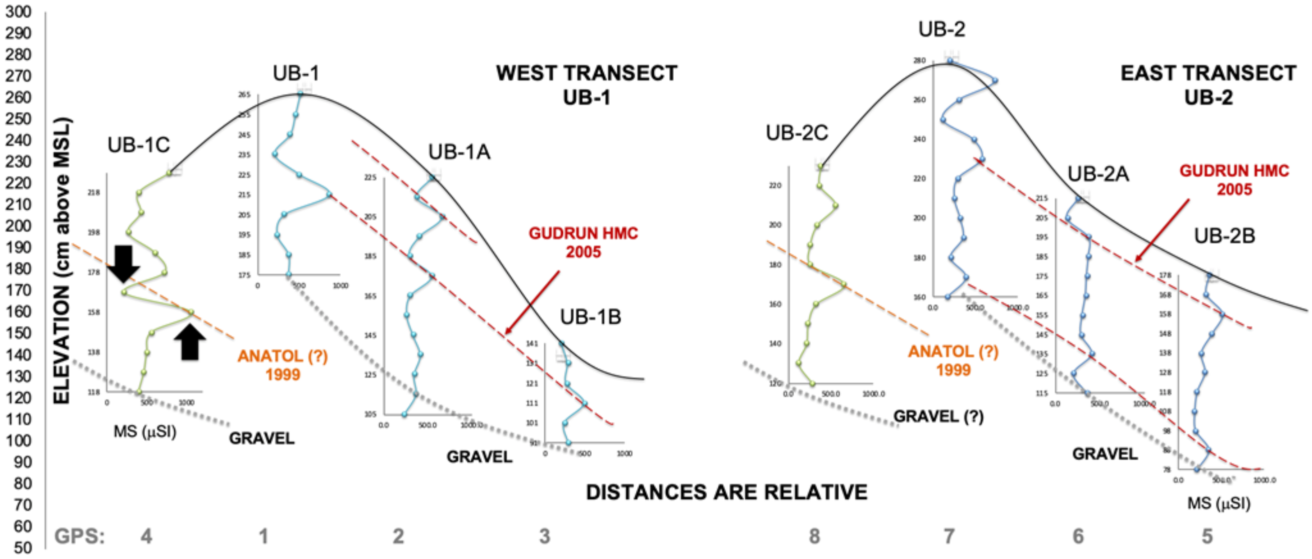

Figure 2. Magnetic susceptibility (MS) values at 10 cm intervals at transects UB-1 and UB-2 (four trenches each). High values (>500 µSI) are attributed to storm-related wave reworking and aeolian segregation (higher in the ridge). Note that the highest peaks are commonly followed by the lowest values (e.g., black arrows at left) due to an accumulation phase following an erosional episode. Cross-shore distances are relative (see GPS points at bottom).

It is worth noting that many MS peaks (erosional phase) are followed by some of the lowest values (e.g., see arrows in UB-1C in Fig. 2), which may be attributed to a post-storm influx of magnetite-depleted sand (accretionary phase). Some high values near dune tops may be related to aeolian concentration during ridge aggradation [8]. Future research will involve correlation of MS and granulometric data with geophysical records and synoptic database in order to assess the geological signature of a known storm event. By integrating spatial and temporal patterns with sedimentological, geomorphological, geophysical, and instrumental meteorological databases, our study provides the basis for assessing the applicability of this approach to reconstructing past extreme coastal events [5, 6].

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