Combining teaching and research: a BIP on geophysical and archaeological prospection of North Frisian medieval settlement patterns

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Abstract
We performed a research-oriented EU Erasmus+ Blended Intensive Program (BIP) with participants from four countries focused on North Frisian terp settlements from Roman Iron Age and medieval times. We show that the complex terp structure and environment can be efficiently prospected using combined magnetic and EMI mapping, and seismic and geoelectric profiling and drilling. We found evidence of multiple terp phases and a harbor at the Roman Iron Age terp of Tofting. In contrast, the medieval terp of Stolthusen is more simply constructed, probably uni-phase. The BIP proved to be a suitable tool for high-level hands-on education adding value to the research conducted in on-going projects.

Keywords
archaeological prospection; education; integrated geophysical interpretation; wetlands

Introduction

A Blended Intensive Program (BIP) is an international university teaching format promoted by the European Union ERASMUS+ program. It has been created to foster the international connectivity of students and teachers and to stimulate inventing and practicing ways of hybrid teaching and learning. We tested the BIP format as a tool for combining geophysical and geoarchaeological teaching and research. Through a cooperation of the universities of Bratislava, Ghent, Kiel, Mainz and Vienna we realized a BIP in the form of a hands-on field and online course. The thematic focus was set on the geoarchaeological prospection of North Frisian medieval settlement patterns using geophysical methods and downhole sediment sampling. Scientifically, the course was embedded into major on-going research projects.

The investigated sites are located in a clay and peat district colonized in several waves that transformed the natural landscape. Settlers of the Roman Iron Age and the Early Middle Ages favored elevated river embankments and formed large village terps. Terps are artificial dwell-

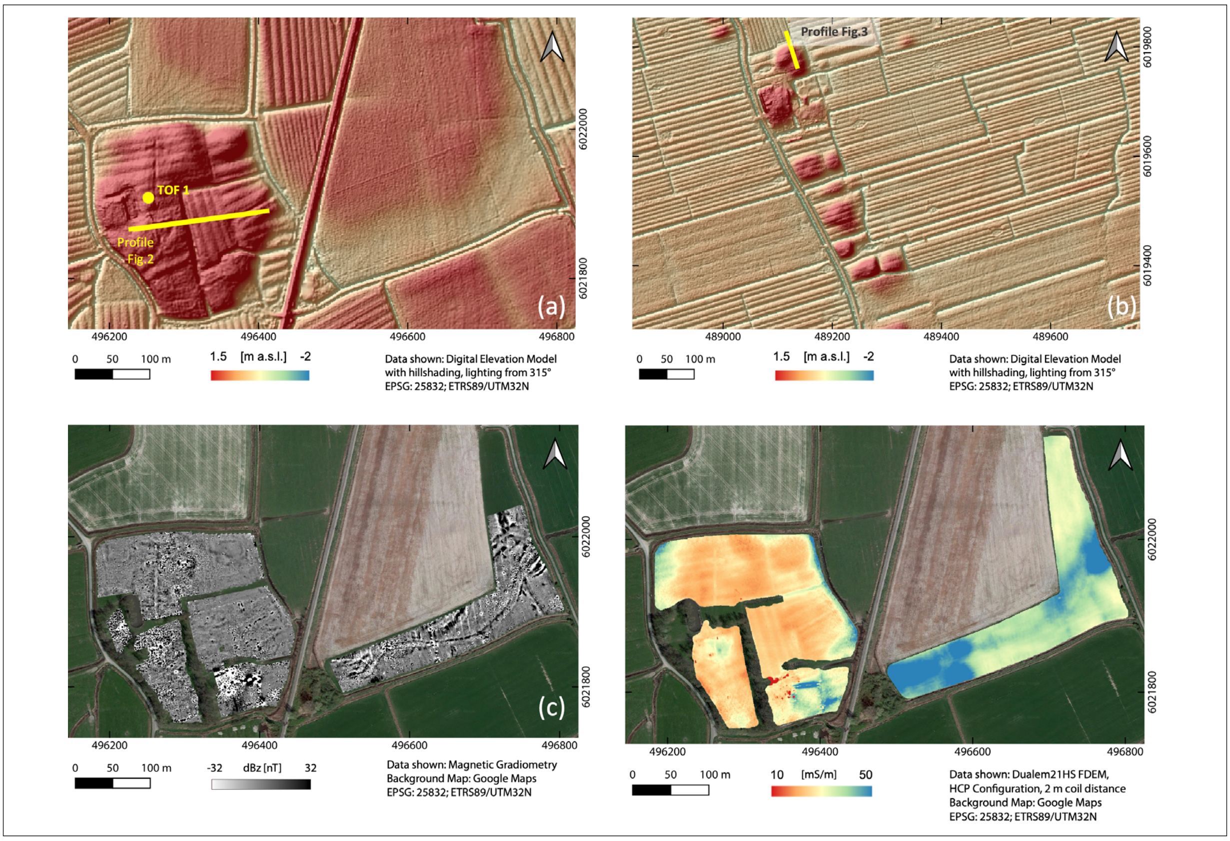

Fig. 1: General setting of the investigated terps: a) Lidar microtopography scan at Tofting, the yellow line and dot show the location of the profile and drill hole (TOF 1) in Figure 2, b) LiDAR microtopography scan at Stolthusen, the yellow line shows the location of the profile in Figure 3, c) magnetic map of Tofting (vertical component gradiometer), d) EMI conductivity map of Tofting (HCP 2m coil spacing). Both Lidar scans: ©GeoBasis-DE/LVermGeo SH/CC BY 4.0, Datengrundlage: DGM1. Background maps: ©2023 Google, Pictures ©GeoBasis-DE/BKG, GeoContent, Maxar Technologies, Map data ©GeoBasis-DE/BKG (©2009).

ing mounds to protect settlements from storm surges. In the High Medieval Period, new settlers reclaimed the large peat bog areas. Starting from straight chains of small farm terps, they transformed the landscape significantly (Bantelmann 1975; Bazelmans et al. 2012). During the course, we investigated an early village terp founded in the 1st century BC and a medieval chain of small terps from the 12th/13th century AD with respect to their environmental setting, internal construction, especially multiple phases, and to their archaeological remains.

Educational goals and set-up of the BIP

The educational goals of the BIP were the following:

- bring relevance to teaching contents through conducting field research on targets that had been the subject of little or no previous investigation,
- practice context-related teaching through refreshing students' methodical knowledge on-site, using instruments under field conditions, demonstrating pros and cons of field methods and practicing targeted integrative data interpretation,
- produce relevant scientific output presentable to the scientific public.

The course was set up in the following way:

- The field part was scheduled for one week, while the obligatory online part was held in the semester after the field course. It comprised eight combined lectures and practical work of three hours each, covering data interpretation and preparing the presentation of results.
- Working groups of four to five persons each with participants from each country were formed for field and online work. The number of participants was restricted to 20 persons.

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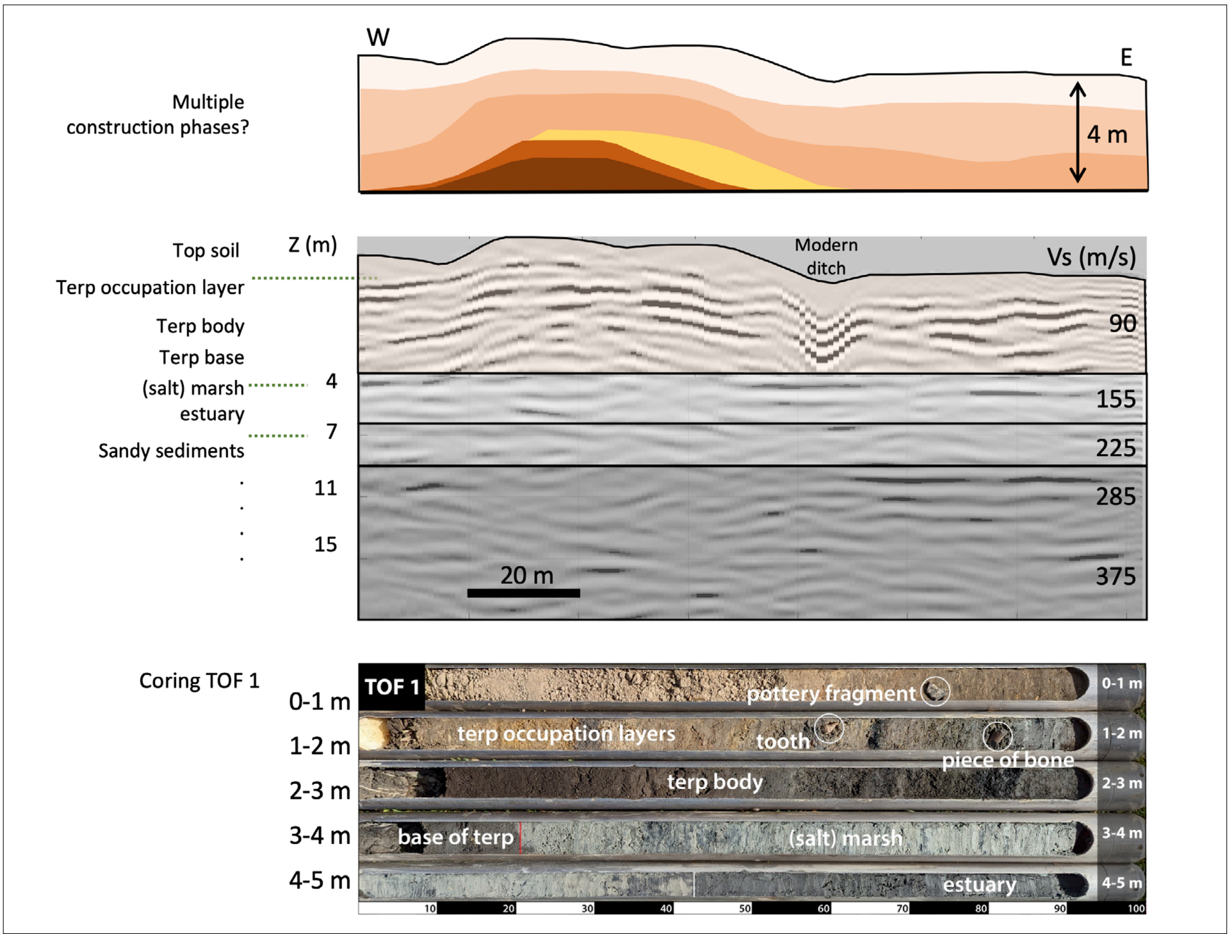

Fig. 2: Seismic and geological depth structure of the Tofting terp along the profile in Figure 1a (yellow line). Middle: Average shear wave velocity-depth function (grey layers, Vs indicated) overlain by seismic reflection image (migrated CMP-stack). Vs-depth function determined from refracted waves using the slowness-intercept time method. Bottom: Nearby drill core; the interpretation on the left of the seismic profile is based on this core. Top: tentative interpretation of the seismic reflections of the upper 4 m showing possible construction stages of the terp.

- As a final goal we defined the creation of scientific posters showing the results of the course to be presented at the ICAP 2023 conference.

Field methods applied

For the field measurements the working groups provided magnetic fluxgate-gradiometer arrays (six probes on a cart, 0.5 m crossline and 0.65 m gradient distance), electromagnetic induction (EMI) devices, multi-electrode geoelectric unit, ground penetrating radar (GPR), 72-channel seismograph with horizontal crossline-oriented geophones, drilling equipment for sampling and geophysical down-hole measurements. Differential GNSS was applied for positioning.

For investigating archaeological remains we applied magnetic, EMI and GPR mappings. Positions of the invasive geoarchaeological investigations were chosen based on geophysical measurement results. For ground truthing we applied drillings and direct-push electric conductivity measurements.

Results

General setting of the terps of Tofting and Stolthusen

LiDAR scans of the microtopography (Fig. 1) reveal that the investigated terps differ in size and structure: Tofting (Fig. 1a) is originally a cluster of smaller terps that were merged to a large village terp over time. In its final exten-

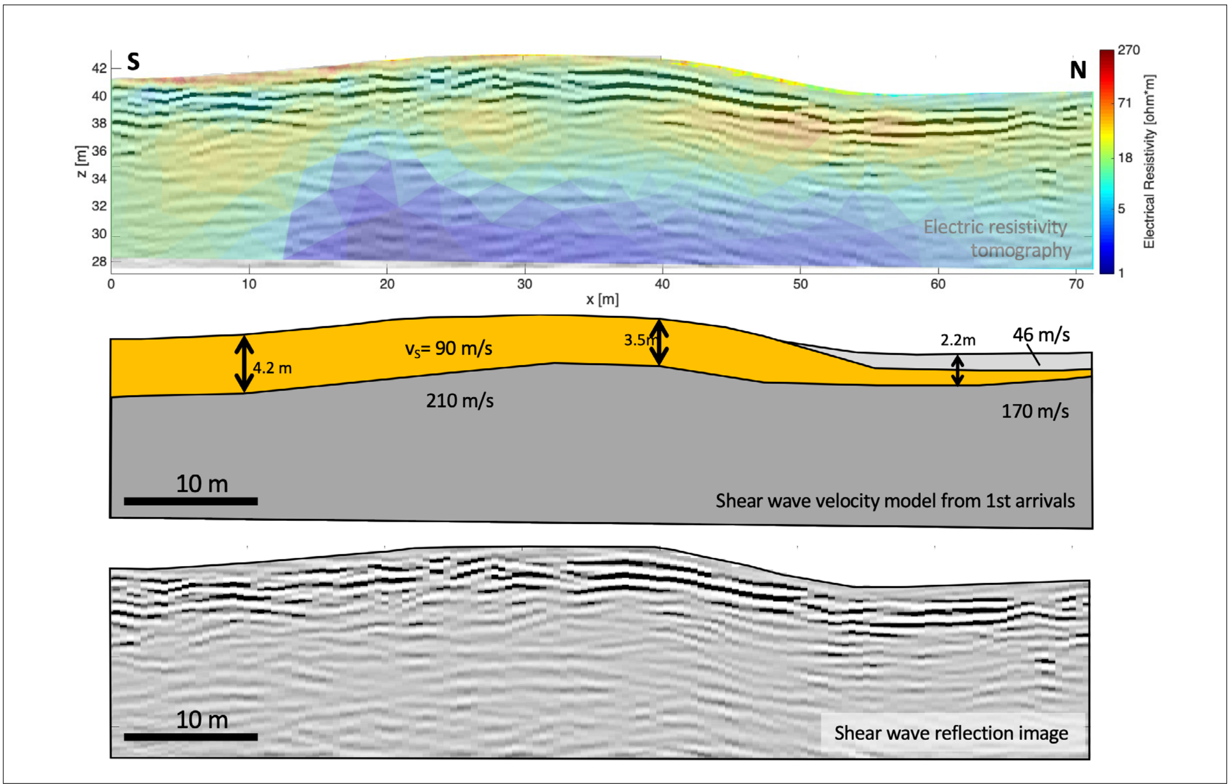

Fig. 3: Seismic and geoelectric depth structure of the Stolting terp. The data was acquired along the profile in Figure 1b (yellow line). Bottom: Seismic reflection image (migrated CMP-stack). Middle: Shear wave velocity structure from first arrivals using the slowness-intercept time method. Top: Electric resistivity tomography (ERT, Wenner-ß-configuration inverted using Res2dinv software) overlaying seismic reflection image.

sion the Tofting terp is four times as large in diameter as the single terps of Stolthusen aligned along a traffic route (Fig. 1b). The Tofting site is covered with clusters of small-scale magnetic anomalies (Fig. 1c) originating from modern building debris mainly. The electric conductivity map (Fig. 1d) shows some lows (brownish areas), which coincide with microtopographic highs and may indicate the initial terps. East of the terp, the magnetic map (Fig. 1c) shows two WSW-ENE directed, curvilinear anomalies, which correspond to a high in electric conductivity (blue in Fig. 1d). These could indicate a silted riverbed or channel leading to a small harbor at the SE tip of the terp.

Depth structure of the Tofting terp

The Tofting terp was investigated with shear-wave profiling, EMI, GPR, ERT and drilling. The stratigraphy shows up best in the W-E directed seismic depth section (Fig. 2 and 1a, yellow line). It consists of four units identifiable in terms of shear wave velocity (Vs) and in a core drilled near the seismic profile (Fig. 2 middle and bottom): The terp body (Vs ~ 90 m/s) is a 3-4 m thick layer of clayey sediments enriched in organic construction material (dung, sods) and archaeological findings (sherds, bones). It was erected on the original salt marsh consisting of fine-grained sediments (Vs ~ 155 m/s). Underneath follow coarser-grained, silty to sandy laminated layers (Vs = 225-375 m/s).

The corresponding seismic reflection section, overlain on the velocity diagram (Fig. 2 middle) shows that the terp body (upper 3-4 m) has an internally variable stratification. We interpret it as evidence of different construction phases and materials (Fig. 2 top). The dark brown layer at the bottom may represent an initial stage, next expanded into the yellow layer, then to the middle-brown layer etc.

Geophysics and coring agree well with archaeological excavations from 1949–1952. These found stratified settlement terps with multiple house phases, thick layers of dung and settlement debris and applied clay layers. The top meter is made up of applied clay layers, which merge the initial terps to one large terp body and may date to the early medieval to early modern periods (Bantelmann, 1955).

Depth structure of the Stolthusen terp

The uppermost layer of the Stolthusen terp is also 3-4 m thick and shows an average shear wave velocity of 90 m/s (Fig. 3 middle). A nearby drilling clarified that it is composed of the actual terp body underlain by peat and the original salt marsh. This sequence is underlain by a sandy layer (Vs = 210 m/s), which gets more fine-grained only outside the terp (Vs = 170 m/s). The seismic reflection image (bottom) shows the layering of the heterogeneous construction material and the peat and marsh units underneath. In Stolthusen this layering is laterally more continuous than in Tofting. Different construction phases are not obvious. This may be due to the shorter lifetime of the Stolthusen terps compared to Tofting.

The electric resistivity tomogram overlain on the seismic reflection section (Fig. 3 top) shows that seismics and geoelectrics agree well in stratigraphy and structural detail. At ~5 m depth the electric resistivity anomalies can be associated with lateral changes in grains size that are visible in the reflection image, too, but are not resolved in the seismic velocity model.

Discussion

Through combining personnel and equipment of five universities we could familiarize the students with a wide variety of state-of-the-art instrumentation. The concept of a BIP field course in the frame of on-going research projects proved to be justified, first, because the participants confirmed that it increased the motivation and demonstrated the relevance of the undertaken steps, and second, because the scientific results considerably contributed to the projects. However, it must be noted that five days duration of the field course was too short given the complexity of the investigated targets leaving too much of the discussion to the online part of the BIP, which is difficult to transmit even with modern communication technology. Still, we feel it confirmed that the general course layout was successful in educational and scientific terms, even though details would have to be improved for follow-up runs.

Conclusion

The investigations have shown that the terps' structure and environment can be efficiently prospected using a combination of magnetic and EMI mapping complemented by seismic and geoelectric profiling and drilling. GPR turned out to be of only little depth penetration due to the high conductivity of terp and marsh soils. We found evidence of multiple terp phases and a harbor at the Roman Iron Age terp of Tofting. The medieval terp of Stolthusen has a rather simple uni-phase construction.

Acknowledgments

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References

Bantelmann A. Tofting. Eine vorgeschichtliche Warft an der Eidermündung. Offa-Bücher 12. Neumünster: Wachholtz; 1955. German.

Bantelmann A. Die frühgeschichtliche Marschensiedlung beim Elisenhof in Eiderstedt. Landschaftsgeschichte und Baubefunde. Studien zur Küstenarchäologie Schleswig-Holsteins, Serie A, Elisenhof 1. Bern, Frankfurt a. M.: Lang; 1975. German.

Bazelmans J, Meier D, Nieuwhof A, Spek T, Vos P. Understanding the cultural historical value of the Wadden Sea region. The co-evolution of environment and society in the Wadden Sea area in the Holocene up until early modern times (11,700 BC–1800 AD): An outline. Ocean & Coastal Management 2012;68:114-126. doi: 10.1016/j.ocecoaman.2012.05.014