Starting to fill the gaps of the Selinus geophysical map

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Abstract
We analyze ground-penetrating radar (GPR) data which was recorded in the tight confined spaces of an overgrown sand dune. The topography of the dune has the same scale as the penetration depth. We developed a 3D topographic migration algorithm and enable the generation and interpretation of layer parallel depth slices.

Keywords
archaeological prospection; GPR; Selinus; 3D topographic migration

Introduction

Selinus was an ancient Greek colonial city at the south-western coast of Sicily destroyed in 409 BCE by Carthage. A street layout for Selinus was proposed by Mertens (2003). The layout has been disclosed on the large-scale magnetic gradiometry prospection, see Figure 1. The city was surveyed only in parts. The main obstacle was a 12 ha sand dune which is located right in the center of the city. With a thickness of up to 4.5 m and dense vegetation magnetic gradiometry was not feasible. This work aims at filling data gaps in the dunes area of the street layout. We have conducted two Ground-Penetrating Radar (GPR) surveys since 2021.

Materials and methods

For this study a GSSI SIR4000 GPR controlling unit with a 400 MHz center frequency antenna was used. The zero-offset data was logged continuously with an inter-profile spacing of 30 cm or less. The data received standard pre-processing. A wave velocity of 14 cm/ns has been determined by diffraction hyperbola fitting.

The traces are binned to a data cube D(x,y,t) with a bin size of 25 cm. The data cube is then topography migrated using a 3D semicircle superposition approach (Wilken et al. 2016). For spatial interpretation, the data cube is usually cut horizontally into depth slices. Due to the strong variations in topography and depth of the cultural layer, this technique would constantly cut into these horizons. Thus, in this study we picked the cultural layer in the profiles and created 60 cm thick slices following the layer. We created 7 x 30 cm overlapping slices, covering an area from 1.2 m above the horizon to 1.2 m below the horizon.

We used coring data provided by Schneider Environmental Reconstruction (Jonasch et al. 2022) to validate the observed GPR reflection events.

Results

The example profile in Figure 2 shows a bright reflective horizon which is visible in almost all profiles recorded during this study. This horizon is independent of the dune's topography. We take this to be the dune's base and the cultural layer of ancient Selinus. This assumption correlates well with the interpretation of the core. While the borehole reached the limestone bedrock, its visibility in the radar data of this profile is unclear. In different profiles a faint horizon below the dunes base

Fig. 1: The figure shows the magnetic gradiometry map of the ancient city of Selinus in front of the proposed street layout. The sand dunes extend is shown in red. The dense vegetation of the dune and its surveyable areas are visible below the red shading. The area surveyed by GPR is marked in blue. The extent of Figure 3 is shown by a gray square.

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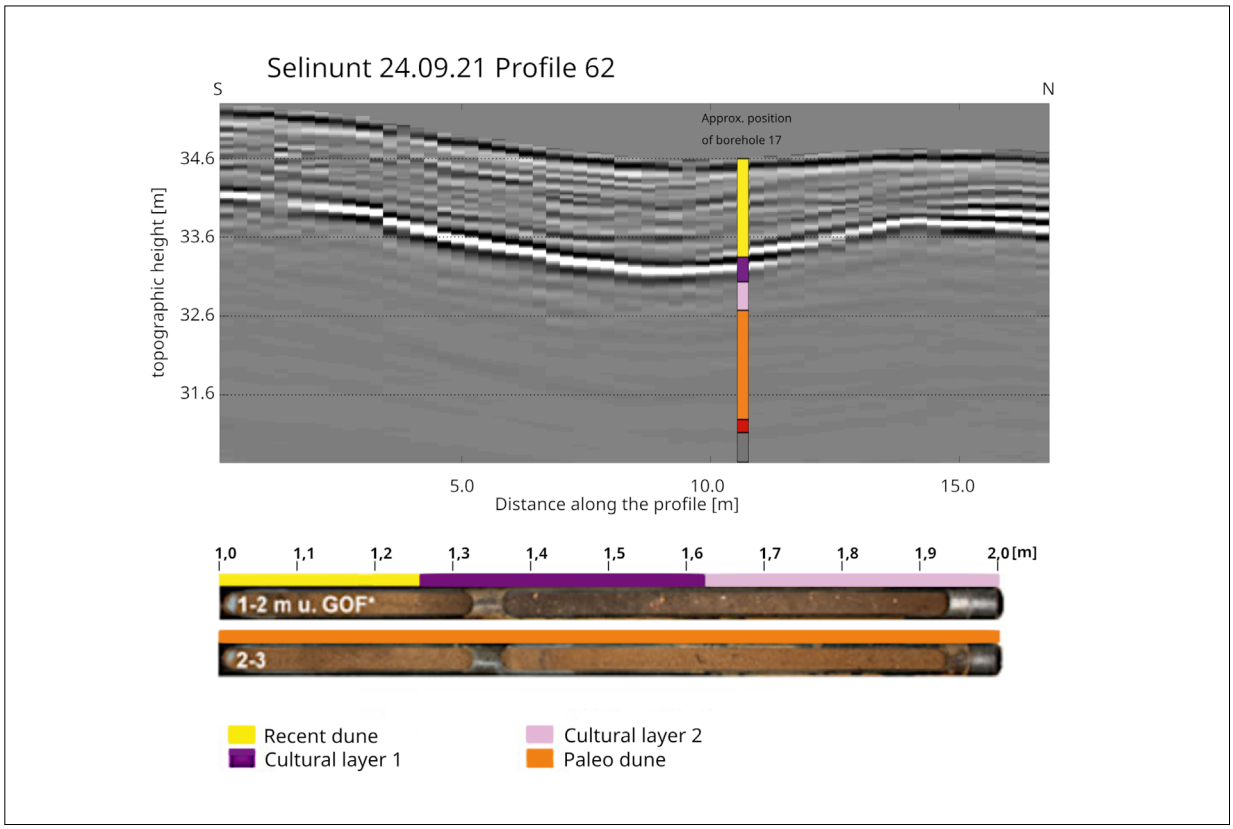

Fig. 2: Example profile 62. The approximated position of borehole 17 is marked. The corresponding core and its preliminary interpretation are shown. Note that the first meter of the core, containing only the dune's sand is not presented.

is visible. In these cases, we assume to have reached the bedrock.

In Figure 3 slice A marks two orthogonal wall-like structures in blue. They are of 1.5 – 2 m width and 1.5 m height. Profile A shows a cross-section with the wall-like structure marked in a blue square. Adjacent to this wall and 60 cm below, a rectangular structure with several subdivisions is visible. The orientation of the blue-marked structures does not match the proposed street layout in this area.

Slice B includes several spots of low amplitudes marked in green circles. The spots are orientated on what appears to be a section of a circle. The circle would have a diameter of 24 m. While the position of the spots is not regular enough to be an architectural feature, they might be collapsed remnants of a once circular building. Profile B shows a cross-section through two of the spots. From this perspective the spots appear more like dug-out holes.

Discussion and outlook

This abstract is an insight into an ongoing project. Therefore, any results stated here are preliminary. We can conclude, that GPR is a reasonable method in the sand dunes complex terrain. The shown data looks promising and allows a glimpse into unknown parts of Selinus. An analysis of the remaining data set will hopefully produce a coherent picture of the actual street layout. For now, at least in some areas the proposed street layout does not match the remnants found underground. Either the proposed layout is inaccurate in the dunes area or we see a younger phase of settlement in the data, after the colonies' destruction.

The dunes topography and heavy vegetation restricts the area recordable with GPR. The area consists of several irregularly shaped free spaces of 150 to 850 m². In the future we want to expand the surveyable area by surveying below free-standing bushes with a pair of antennas in transmitter and receiver arrangement.

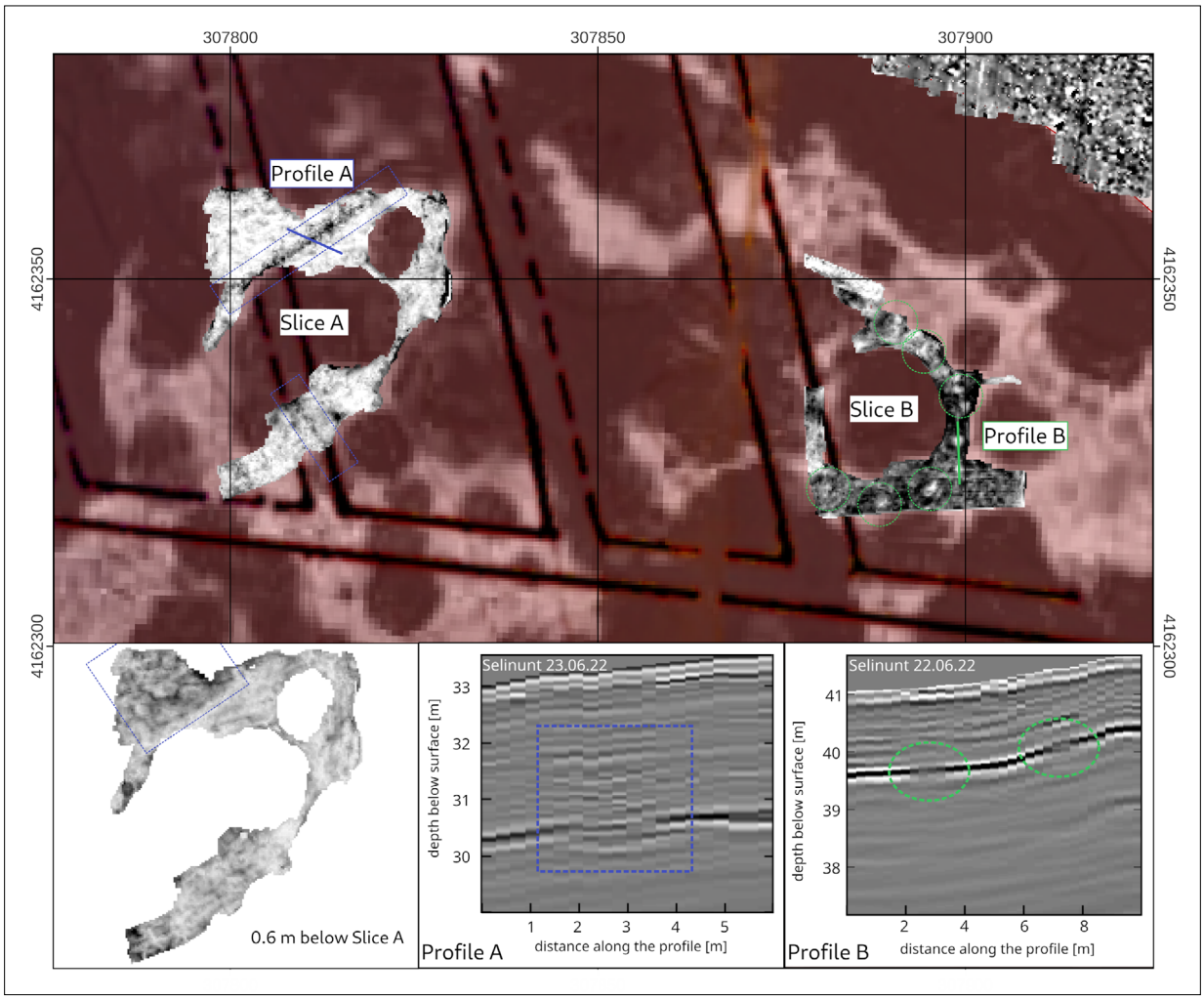

Fig. 3: Three depth slices. The background is composed of the proposed street layout and the red shaded dune as in Figure 1. In slice A a large wall like structure is marked in a dotted blue line. The blue solid line marks the position of the cross-section profile A. The bottom left corner shows a slice 0.6 m below slice A with a rectangular structure marked in blue. Slice B shows a circular structure of white low amplitude spots marked in green circles. The corresponding profile B below is marked with a greed line.

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