DIRECT PUSH VIDEO IMAGING: AN INNOVATION IN PREHISTORIC PALEOLANDSCAPE SURVEY

Jeroen Verhegge, Simon Delvoie, Hiep Luong

Presses universitaires de Rennes | « ArcheoSciences »

2021/1 n° 45-1 | pages 223 à 227

ISSN 1960-1360
ISBN 9782753585874
DOI 10.4000/archeosciences.9744

ArcheoSciences
Revue d'archéométrie

45-1 | 2021
14th International Conference of Archaeological Prospection

Direct Push Video Imaging: An Innovation in Prehistoric Paleolandscape Survey

Jeroen Verhegge, Simon Delvoie and Hiep Luong

Electronic version
URL: https://journals.openedition.org/archeosciences/9744
DOI: 10.4000/archeosciences.9744
ISSN: 2104-3728

Publisher
Presses universitaires de Rennes

Printed version
Date of publication: 16 August 2021
Number of pages: 223-227
ISBN: 978-2-7535-8587-4
ISSN: 1960-1360

Electronic reference
Jeroen Verhegge, Simon Delvoie and Hiep Luong, “Direct Push Video Imaging: An Innovation in Prehistoric Paleolandscape Survey”, *ArcheoSciences* [Online], 45-1 | 2021, Online since 16 August 2021, connection on 30 August 2021. URL: http://journals.openedition.org/archeosciences/9744 ; DOI: https://doi.org/10.4000/archeosciences.9744

Direct Push Video Imaging: An Innovation in Prehistoric Paleolandscape Survey

Jeroen Verhegge [a], Simon Delvoie [b] and Hiep Luong [c]

Highlights:

- *Direct push video imaging maps buried prehistoric landscapes in soft geology.*
- *Subtle subsoil variability is detectable through a combination with CPT-E and EC logs.*
- *Validation remains crucial pending color calibration- and hardware improvements.*

Keywords: cone penetration testing, direct push sensing, in situ camera imaging, paleolandscape mapping, prehistoric landscape survey.

INTRODUCTION

Archaeological prospection greatly depends on surveying (buried) paleolandscapes. Invasive survey methods (e.g. test pitting or coring) are widely used but are inefficient for mapping purposes, due to the reliance on direct (recovered) soil or sediment observations, specifically in (deeply) buried landscapes. Non-invasive, mobile (near-surface) geophysical survey methods are all characterized by a trade-off between the depth of investigation and the resolution of detectable paleolandscape features. Direct-push sensing is used less frequently but is a compromise between both approaches, due to its rapid, continuous and in-situ data recording as a sensor is pushed down into the soil profile. Therefore, the target discrimination potential is independent of the burial depth, but dependent on the horizontal extent of the target instead. In addition, direct push geophysical data provide an efficient means to constrain models of near-surface geophysical data (e.g. Wunderlich *et al.*, 2018).

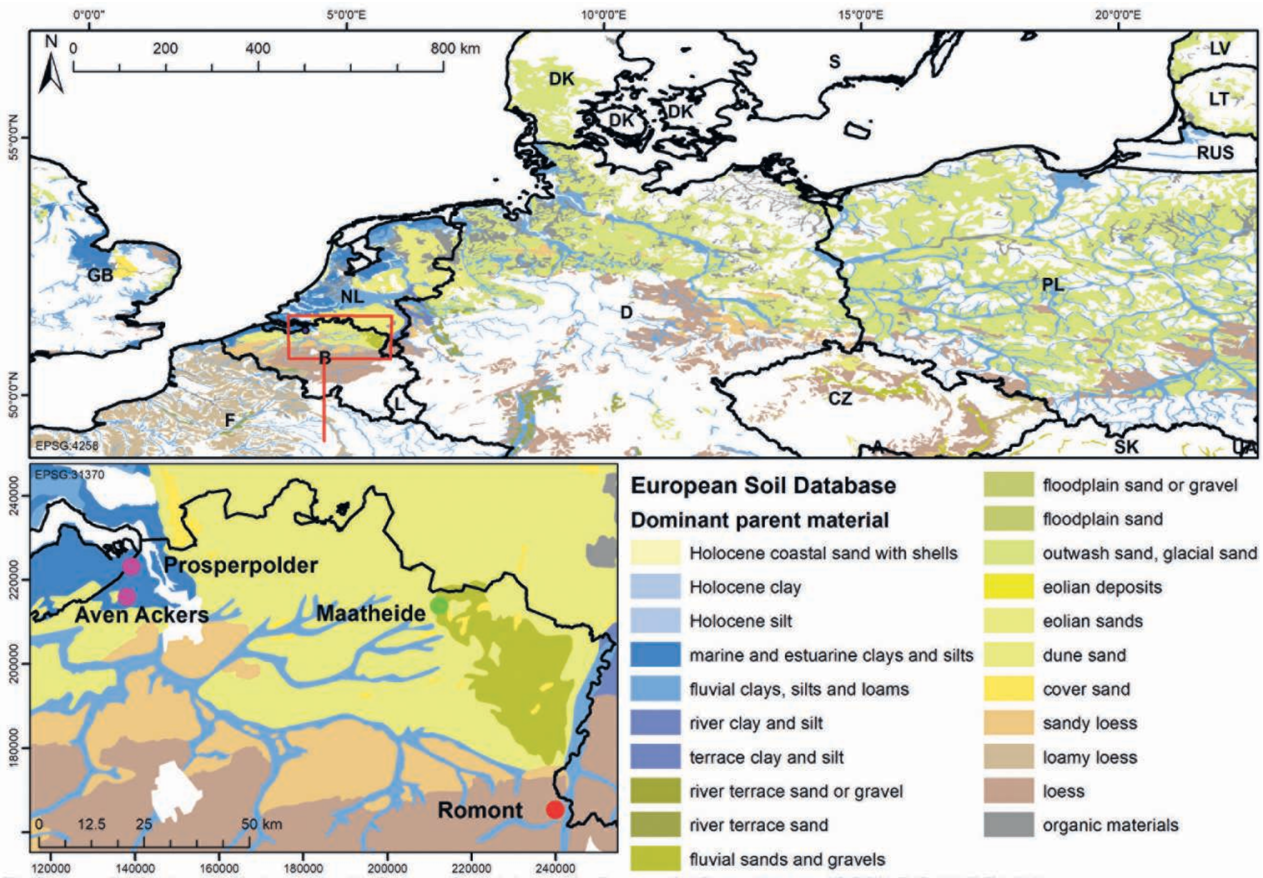
As such, direct push sensing is key in mapping deeply buried, subtly contrasting targets with a large horizontal extent and a complex overburden, such as deeply buried prehistoric landscapes. However, since the introduction of e.g. cone penetration testing in prehistoric paleolandscape mapping, applications have been limited to mapping relatively thick and strongly contrasting lithological units in fluvial and estuarine floodplains (e.g. Missiaen *et al.*, 2015). Although thin sediment layers or subtle soil horizons also register a subtle signal, this is not interpretable unequivocally. Direct push color logging (Hausmann *et al.*, 2016) and/or – camera imaging (Verhegge & Delvoie, 2021) refutes these issues.

STUDY REGION

Direct push sensing is only applicable in soft soils, because the sensors are unable to penetrate and register data in hard rock geology. Northern Belgium is a representative region to test these methods: it includes a large variation of soft soils, ranging from estuarine and river floodplain sediments to thick eolian sand and loess deposits (Fig. 1). In addition, these soils contain buried traces of Early to Middle Holocene, Late Glacial and Pleniglacial Weichselian paleolandscapes with Middle to Final Paleolithic, Mesolithic and Neolithic sites. The test sites were selected based on the availability of direct

---

[a] *Corresponding author, Department of Archaeology, Ghent University, Belgium, Department of Environment, Ghent University, Belgium*
[b] *Department of Architecture, Geology, Environment and Civil Engineering, University of Liège, Belgium*
[c] *Department of Telecommunications and Information Processing, Ghent University – imec, Belgium*



The European Soil Database distribution version 2.0, European Commission and the European Soil Bureau Network, CD-ROM, EUR 19945 EN, 2004.

Figure 1. Bottom left: locations of the direct push video imaging test sites in soft geology: estuarine and/or river floodplain (pink), eolian sand (green), löss (red dot). Background and top: selected soil parent materials illustrating the possible geographical application region of direct push video imaging for buried paleolandscape mapping.
From Verhegge & Delvoie, 2021: Fig. 1, with permission from Elsevier.

soil observations from cores and/or (artificial) geological outcrop data and their potential association with prehistoric sites.

METHODOLOGY

The potential of electrical cone penetration testing and electrical conductivity logging for prehistoric paleolandscape mapping has been investigated already (e.g. by Verhegge *et al.*, 2016), but detecting subtler layers and horizons was desirable. Therefore, potential advances through direct push in-situ video imaging, an old but rarely applied direct push method (Hryciw *et al.*, 1998), were explored. This technique employs analog VGA video cameras (approximately 640*480 pixel, interlaced video) filming soil passing by a ca. 1 cm sized sapphire glass window as the conus is pushed down the soil, preferably at max. 5 mm/s. The analog signal is digitized above-ground.

Two different camera bearing conus designs were tested: the Geoprobe Optical Image Profiler (OIP) and the Eijkelkamp GeoPoint SoilSolutions videoconus. The OIP orients amongst others a white LED obliquely to the vertical window and records only 1 videoframe per 1.5 cm with the respective depth. As such, the OIP does not provide continuous image data and a simple vertical image mosaic was concatenated after deinterlacing. The GeoPoint Soil Solutions videoconus employs multiple LEDs parallel to the camera and records the video signal continuously. Therefore, image stitching could be employed to convert the recorded video (frames) and time-depth data to a vertical mosaiced overview image. Due to the entanglement of conus- and sediment movement, stitched images were limited to 10 mm height and mosaiced afterwards using the stringpotentiometer data (Fig. 2). The resulting images were contrast enhanced, if necessary.

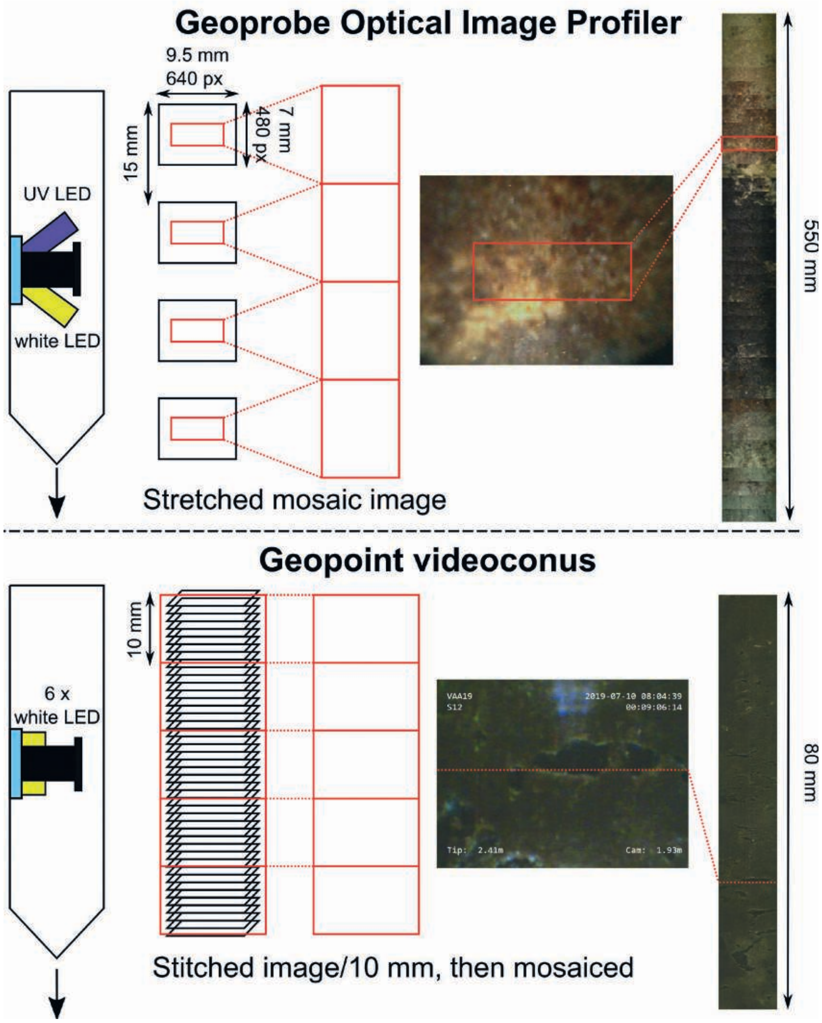


Figure 2. Left: Schematic design of Geoprobe OIP and GeoPoint videoconus. Middle: Schematic image overview image composition. Right: Raw video frame and resulting vertical overview image sample.

Results

Both methods resulted in a ca. 1 cm wide RGB image of the penetrated soil profile, albeit with differing representativeness: the OIP frames are stretched and extrapolated, while the GeoPoint video is converted to a continuous image. These images were interpreted in combination with mechanical (CPT-E) and electrical sediment or soil properties and correlated to core or outcrop data. In the floodplain tests, thin peat layers or detritus were interpretable unambiguously and organic rich mud, hemic and fabric peat were distinguishable, which improves Mesolithic to Neolithic paleosurface reconstructions (e.g. Fig. 3). Within eolian sands, the images mapped thin organic soil horizons as well as leaching horizons of Late Glacial paleosols after contrast enhancement. Final Paleolithic (*Federmesser Gruppen*) sites are often associated with these Usselo soils. In the loess, the Humiferous complex of Remicourt and the Rocourt Pedocomplex were detectable. These are important contexts for Middle Paleolithic finds (Delvoie *et al.*, 2016).

Discussion and conclusion

The results point towards a strengthened discrimination potential in organic (rich) sediments, thin sediment layers and subtle paleosol horizons, which is challenging using CPT-E or EC logging. As such, direct push camera imaging is a substantial novel tool for buried prehistoric paleolandscape mapping and it would be usable in archaeological applications beyond that. Nevertheless, independent validation of the interpretations by direct soil observations is still required. Further hardware and software improvements, such as color calibration, increased camera resolution and capture speed, could reduce this dependency.

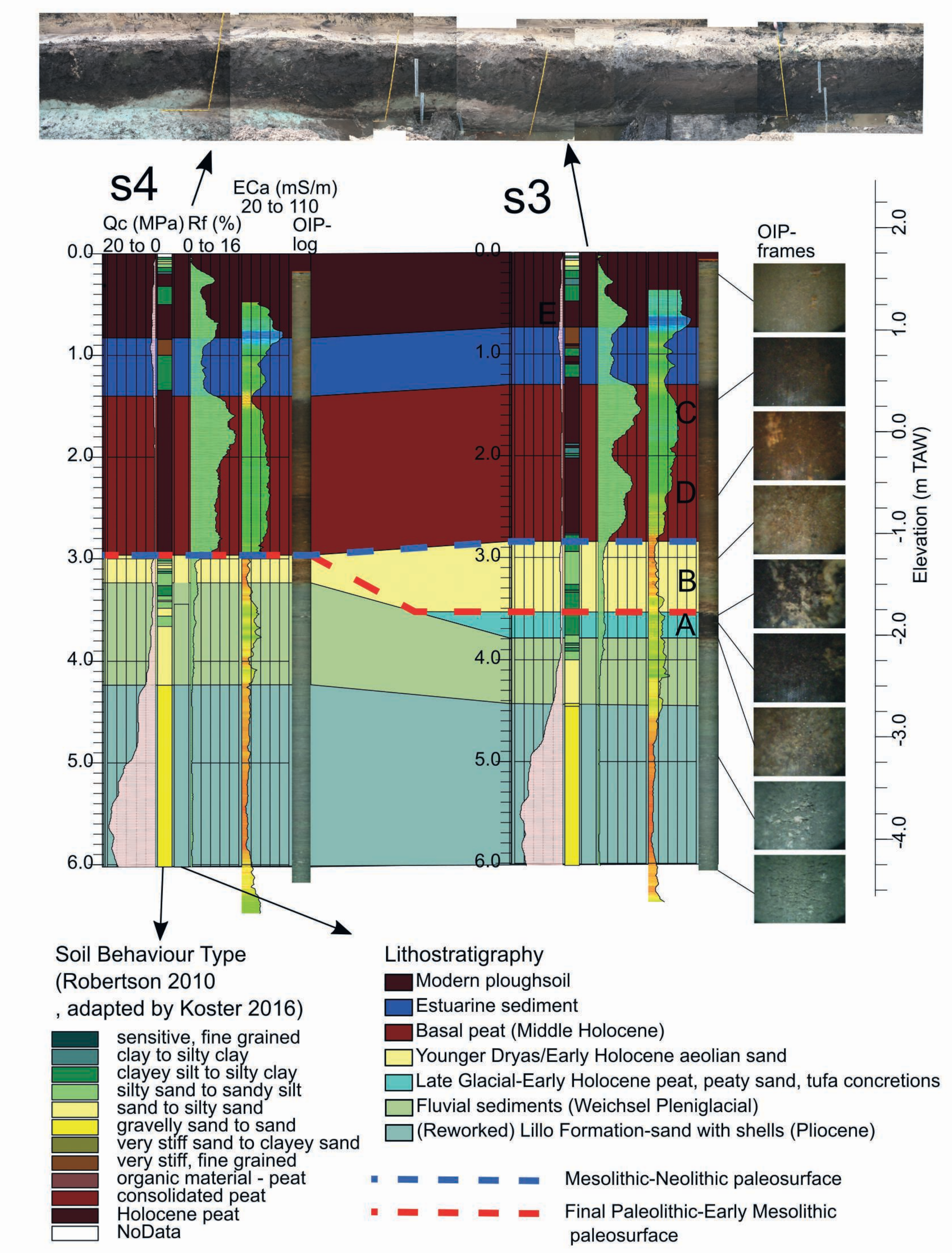


Figure 3. Test results from Holocene floodplain context at Aven Ackers (location on Figure 1-bottom-left). From Verhegge & Delvoie, 2021: Fig. 3, with permission from Elsevier.

References

Delvoie, S., Boulvain, F., Charlier, R., Collin, F., 2016. Detailed characterization of the Late Pleistocene loess sequence stratigraphy of Remicourt (Hesbaye region, Belgium) with cone penetration tests. *Geologica Belgica*, 19(3-4): 281-289.

Hausmann, J., Dietrich, P., Vienken, T., Werban, U., 2016. Technique, analysis routines, and application of direct push-driven in situ color logging. *Environmental Earth Sciences*, 75(11): 957.

Hryciw, R., Ghalib, A.M., Raschke, S.A., 1998. In situ soil characterization using Vision Cone Penetrometer (VisCPT). In P. K. Robertson, P.W. Mayne (ed.), *Geotechnical Site Characterization,* Balkema Rotterdam.

Missiaen, T., Verhegge, J., Heirman, K., Crombé, P., 2015. Potential of cone penetrating testing for mapping deeply buried palaeolandscapes in the context of archaeological surveys in polder areas. *Journal of Archaeological Science*, 55(0): 174-187.

Verhegge, J., Delvoie, S., 2021. Direct push, in situ video imaging of buried prehistoric landscapes in soft soils: First results in the polders, coversands, and loess belt of Belgium. *Geomorphology*, 373: 107483.

Verhegge, J., Missiaen, T., Crombé, P., 2016. Exploring Integrated Geophysics and Geotechnics as a Paleolandscape Reconstruction Tool: Archaeological Prospection of (Prehistoric) Sites Buried Deeply below the Scheldt Polders (NW Belgium). *Archaeological Prospection*, 23(2): 125-145.

Wunderlich, T., Fischer, P., Wilken, D., Hadler, H., Erkul, E., Mecking, R., Günther, T., Heinzelmann, M., Vött, A., Rabbel, W., 2018. Constraining electric resistivity tomography by direct push electric conductivity logs and vibracores: An exemplary study of the Fiume Morto silted riverbed (Ostia Antica, western Italy). *Geophysics*, 83(3): B87-B103.