Les Jardins de l'Archevêché in Bourges: How Geophysics Can Help to Evaluate the Archaeological Potential of Urban Land

Julien Thiesson, Mélanie Fondrillon, Ludovic Bodet, Audrey Burzawa, Camille Lanéelle, Amélie Laurent

Les jardins de l'archevêché **in Bourges: How geophysics can help to evaluate the archaeological potential of urban land**

Highlights:

- How geophysical data can inform the archaeological potential of urban land
- How geophysical prospecting strategies can be adapted to urban contexts
- How geophysical prospecting setups and results can be constrained with geotechnics and geomatics

Main Text

With large-scale excavations increasingly rare in urban contexts archaeologists have recently been confronted with having to assess the archaeological potential of urban land. An archaeological study carried out in a very popular public park, *Les jardins de l'archevêché,* in Bourges, France (Fig. 1) illustrates how geophysics as a prospecting tool can be harnessed for the purpose.

Les jardins de l'archevêché are located in the vicinity of the Bourges cathedral and they have been repeatedly transformed in the course of their existence. Without a full documentation (only parts of the gardens have been documented) a number of archaeological questions arise, namely (1) are there any medieval remains like walls or underground tunnels in the northern part of the garden? and (2), can an Iron Age defensive ditch from the Gallic War be traced in the southern part (Troadec 1988 ; Krausz and Ralston 2009). The first model of the substrate was proposed based on a preliminary urban topography survey and an examination of archaeological data from rescue digs in the 1980s; the depth of archaeological deposits was estimated and distinct functional activities were identified to suggest the intensity of use of this urban space (Fondrillon et al., 2013). The validity of the proposed model was checked with geophysical and geotechnical prospection.

Taking advantage of an undergraduate student internship (in 2016) and an engineering school field camp (in 2017), Electro-Magnetic Induction (EMI), Electrical Resistivity Tomography (ERT), Ground Penetrating Radar (GPR) and seismic methods were applied to different parts of the gardens (for the location and variety of tested methods see Fig. 1). A prime objective of the training was to demonstrate the practical applications of geophysical methods but the results were of very low quality despite the fact that the survey setup was designed for archaeological targets. While for EMI this was more or less expected, for GPR and ERT it was surprising, conditioned perhaps by the two major obstacles encountered in urban contexts: deploying geophysical tools and interpreting data collected (Lambo and Chan 2007). Belonging to these categories we have:(1) the highly 3D character of both surface and underground structures; (2) the great variety of materials involved (from natural and artificial soils and embankments to concrete and metallic structures); (3)the dramatic number of aerial and underground networks (cables and pipes providing electricity, gas, water, sewage and rainfall-draining channels etc.); (4) the 'natural' human electromagnetic and mechanical activities (various types of electronic devices and vehicles). Data collected from such contexts are usually very disturbed, but they are at least informative with regard to extant networks to be avoided during drilling or excavation. Subsequently it offers the chance to deploy additional tools, such as dynamic penetrometer tests (DCP) and core drilling. In addition, geophysics can offer, e.g., interpolation between 1D geotechnical borings to provide 2D interpretations of geotechnical results (which are usually modest and local).

The EMI method was selected for prospection in the northern part of the gardens (A in Fig. 1) because the archaeological target, a medieval defensive wall and tower remains were assumed to be at a shallow depth (about one meter). A CMD mini explorer GF instrument was used and the results (Fig. 2), despite being perturbed by an irrigation system with metallic valves and tap, showed some slightly

resistive trends in the northern part of the northern rectangle which could correspond to these remains.

As for the second archaeological target, the Gallic defensive ditch, it was assumed to be deeper (at least 6 m) and covered with random fill and gravel (expected to be resistive). The southern part of the garden was prospected chiefly with the ERT, GPR and seismic methods. The GPR and ERT methods both failed, mainly because of the layer of disturbed fill. The seismic method showed promise, but the lines were too short (insufficient depth of investigation) and too noisy (poor signal-to-noise ratio). Seismic profiles have been extended and urban-context noise minimized as we carried out the survey on a full-moon night. The results of a N–S seismic profile (named PS2) and a DCP cross section (Tr1) are shown in Fig. 3. The Gallic defensive ditch appears as a rather small oscillation between the 55 m and the 80 m points on the seismic profile. At the northern end, a large and poorly characterized digging zone evident in the DCP profile appears clearly as a lower velocity anomaly between 20 m and 45 m on the seismic line. This consistency between the DCP interpolation and the seismic model leads us to consider this feature as a potential candidate for the ancient '*murus gallicus*' of the *oppidum*.

These preliminary results are promising in terms of demonstrating the potential of the seismic survey results as a valid dataset for interpolation of DCP results. This study opens the way to a more ambitious approach, aimed at combining seismic surveys, extant archaeological data and geotechnical constraints for a better understanding of the archaeological potential of urban land.

Figure captions

Fig. 1. Overview of the location of different techniques for assessing the archaeological potential of *Les jardins de l'archevêché* in Bourges.

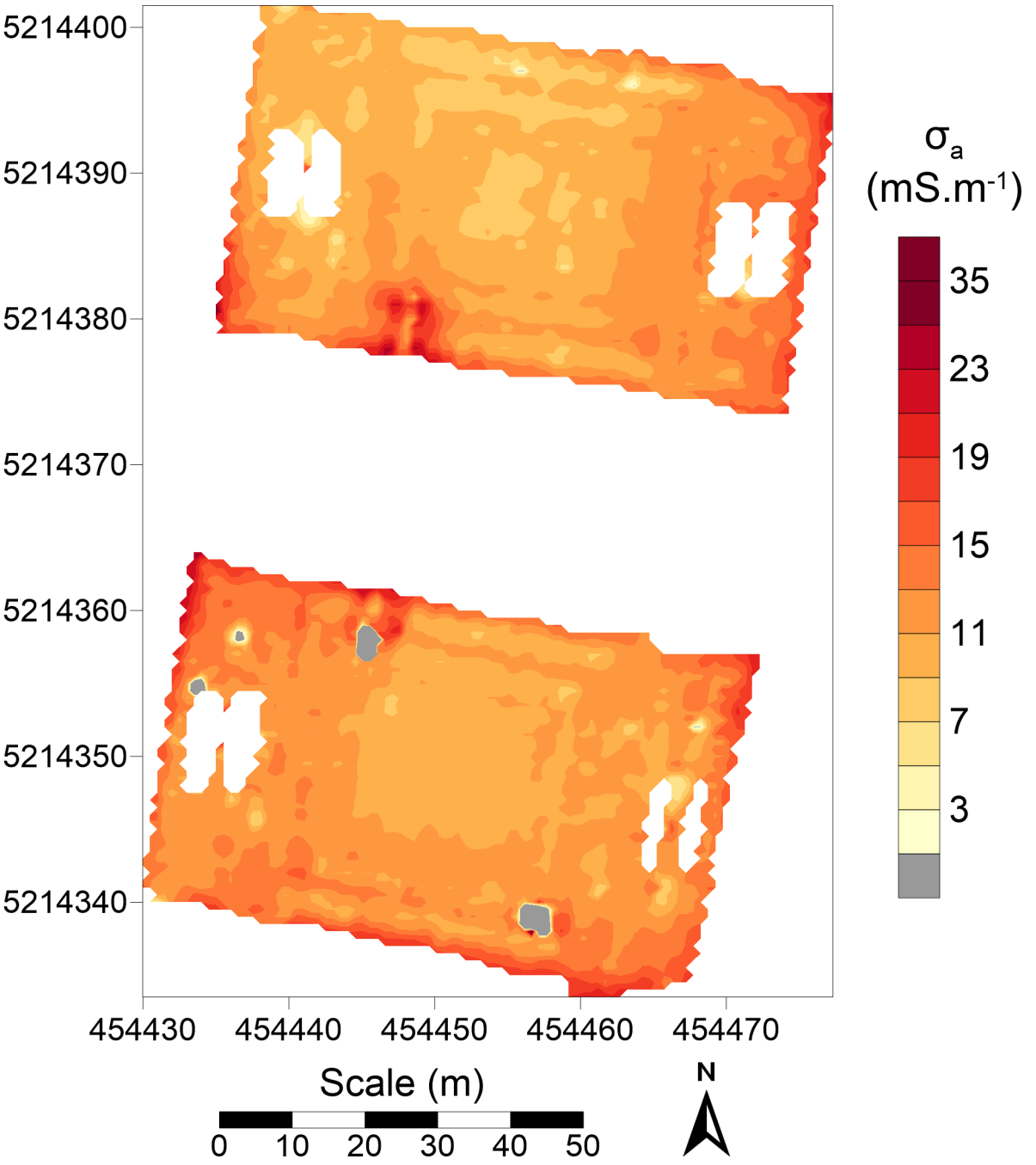

Fig. 2. EMI maps of the northern part of the garden, obtained with the third channel of the CMD mini explorer from GF instruments. Grey patches indicate negative values of apparent conductivity linked to metallic objects. The dashed line marks the layout of the medieval tower and wall.

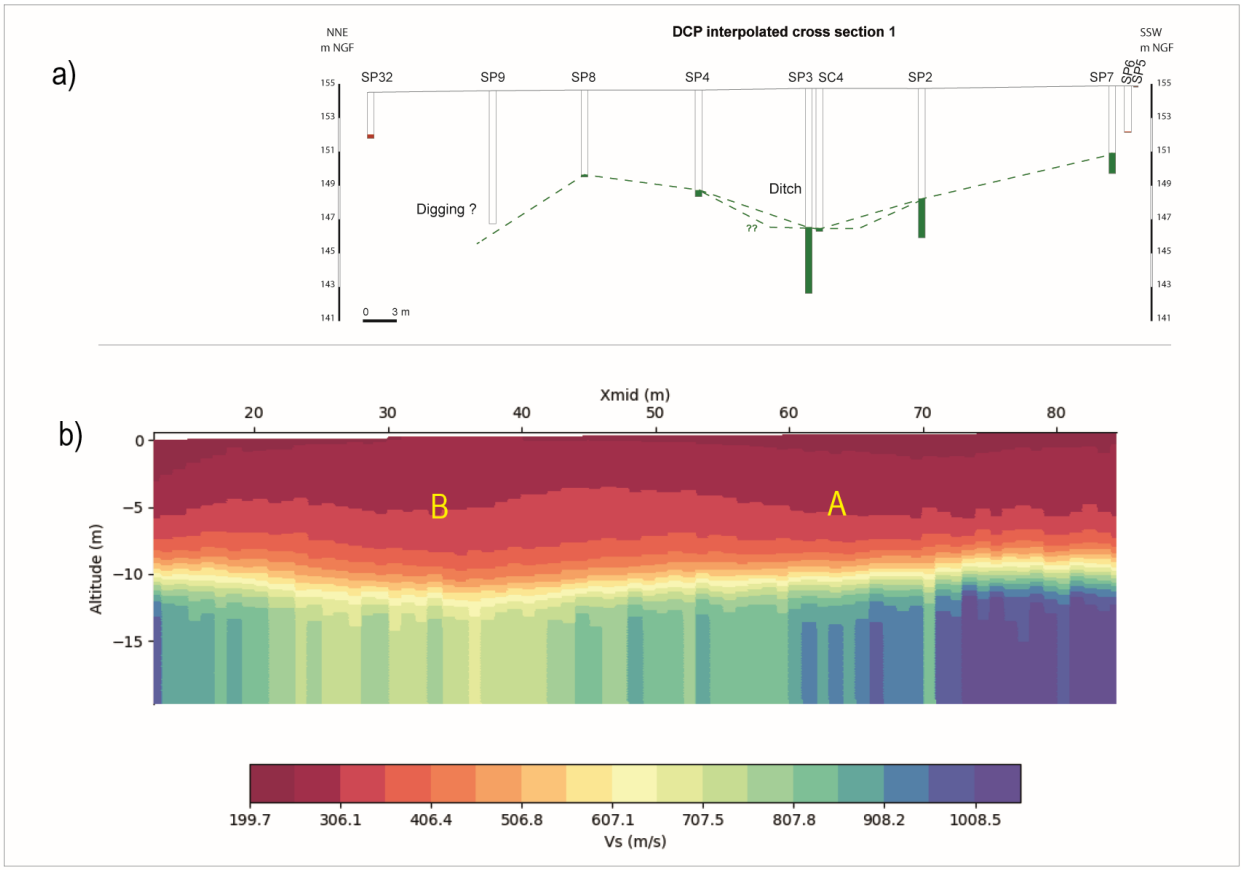

Fig. 3. DCP cross section Tr1 (a) and preliminary pseudo-2D section of average shear-wave velocity (VS) models obtained from surface-wave analysis (b), showing a good consistency for both the Gallic defensive ditch (A) and the potential '*murus gallicus*' (B)

References

Fondrillon, M., Augier, L., Laurent, A., & Rolland, X. 2013. Évaluation et modélisation du potentiel archéologique urbain à Bourges. In Lorans, E., & Rodier, X. (Eds.), *Archéologie de l'espace urbain.* Presses universitaires François-Rabelais. doi :10.4000/books.pufr.7683 (in french)

Krausz, S., Ralston, I., 2009. Le siège d'Avaricum en 52 avant J.-C. ou comment les Gaulois se sont défendus contre les Romains. In Buchsenschutz, O., Chardenoux, M.-B., Krausz, S., Vaginay, M. (Eds), *L'Âge du Fer dans la boucle de la Loire. Les Gaulois sont dans la ville, XXXIIe colloque de l'AFEAF (Bourges, 2008)*, Paris/Tours, 2009, Supplément à la Revue Archéologique du Centre de la France, 35. (in french)

Lanbo L., Chan, L. S. 2007. Sustainable urban development and geophysics, *Journal of Geophysics and Engineering*, 4, (3): 243–244, https://doi.org/10.1088/1742-2140/4/3/E01

Troadec J. 1988. *Opération archéologique du Haut de la rue Moyenne à Bourges (Cher), campagne 1987,* Service d'archéologie municipal de Bourges-Avaricum, Bourges (in french)