Ground-penetrating radar survey as the linchpin of a multidisciplinary approach to the study of two Roman cities in Lazio

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Introduction

Our understanding of Roman urbanism relies on evidence from a few sites that have been the subject of large-scale clearance or major excavation campaigns, such as Pompeii and Ostia, which are unrepresentative of typical Roman cities. Non-invasive survey approaches on a multitude of abandoned ancient urban sites in Italy and elsewhere are now rapidly changing our approach to the Roman city. This short paper presents the outcome of the first high-resolution GPR surveys of complete Roman towns in Italy, Falerii Novi and Interamna Lirenas. We review the methods deployed and provide a brief overview of the results. We demonstrate how this type of survey has the potential to revolutionise archaeological studies of urban sites, while also challenging current methods of analysing and interpreting large-scale GPR data sets.

Recent work has demonstrated the value of GPR survey on Roman urban sites. Since 2015, we have deployed GPR on a large scale to generate high-resolution images of these two complete greenfield Roman towns in Lazio. Although such rapid data collection allows entire Roman cities to be mapped at an unprecedented level of detail, interpretation of these large data sets still relies largely on visual analysis and the manual digitisation of anomalies. These traditional, time-consuming interpretative methods are no longer able to exploit fully the potential of geophysical prospection, and here we propose possible ways forward. This includes most of all the integration of the GPR data with the data obtained from full scale geomagnetic prospection of both towns, and the integration with traditional and more innovative topographic and archaeological methods, such as surface survey, drone-based 3D modelling and aerial and satellite photography.

Finally, the presentation will also, in continuation of geophysical surveys carried out in recent years by this Belgo-British team, discuss the current and future strategies for stratigraphic contextualization, focused chronometry, 3D-visualisation of the physical landscape, creation of a DEM, erosion modelling and environmental reconstruction of both urban sites. A systematic augering program, targeted excavation and test-pitting are some of the operations under development.

Falerii Novi

Located approximately 50km to the north of Rome, along the ancient via Amerina, Falerii Novi has a walled area of 30.6 ha. The town was founded in 241 BC, following the destruction by Rome of the nearby Faliscan centre of Falerii Veteres. The exact status of the Republican town has remained uncertain. Occupation at Falerii Novi continued through Roman times and down to the early medieval period (sixth to seventh centuries AD). Today its remains lie mostly buried in open fields occupied only by a church and a former monastery, now used as a farm. Only the impressive ruins

of the Republican town wall, in Medieval times used as boundary for the monastery domain, mark the emplacement of the former city. Falerii Novi has seen little excavation, with the exception of work in the early 19th century and a large trench excavated in the 1960s. As a consequence, our evidence for the town comes almost exclusively from non-invasive methods. It was one of the first Roman towns to be subjected to a complete fluxgate gradiometer survey coordinated by the BSR (Keay *et al.* 2000; Hay *et al.* 2010), providing a very clear plan of the entire intra-mural site and part of its northern suburb. It revealed the overall layout of the town and the original street grid and suggested how this original plan subsequently expanded up to the town walls (Millett 2007). The survey also revealed many details on housing and public buildings (e.g., the central forum complex), as well as a series of temples around the periphery of the town.

To complement the results of the magnetometry survey a new (almost) total coverage GPR survey (26.6 ha) was undertaken at Falerii in three summer seasons between 2015 and 2017, by a team from the universities of Ghent and Cambridge (Verdonck *et al.* 2020). The GPR network, towed by a quad, comprised 15 500MHz antennae, resulting in a vertical profile spacing of 0.125m. In order to meet sample density requirements, a second pass was made, reducing the transect spacing to 0.0625m, and achieving maximum resolution. After following a standard GPR data-processing workflow, including background removal, the output resulted in a series of time-slices, which map the GPR data as a series of images at successive depths below the surface. Detailed archaeological analysis

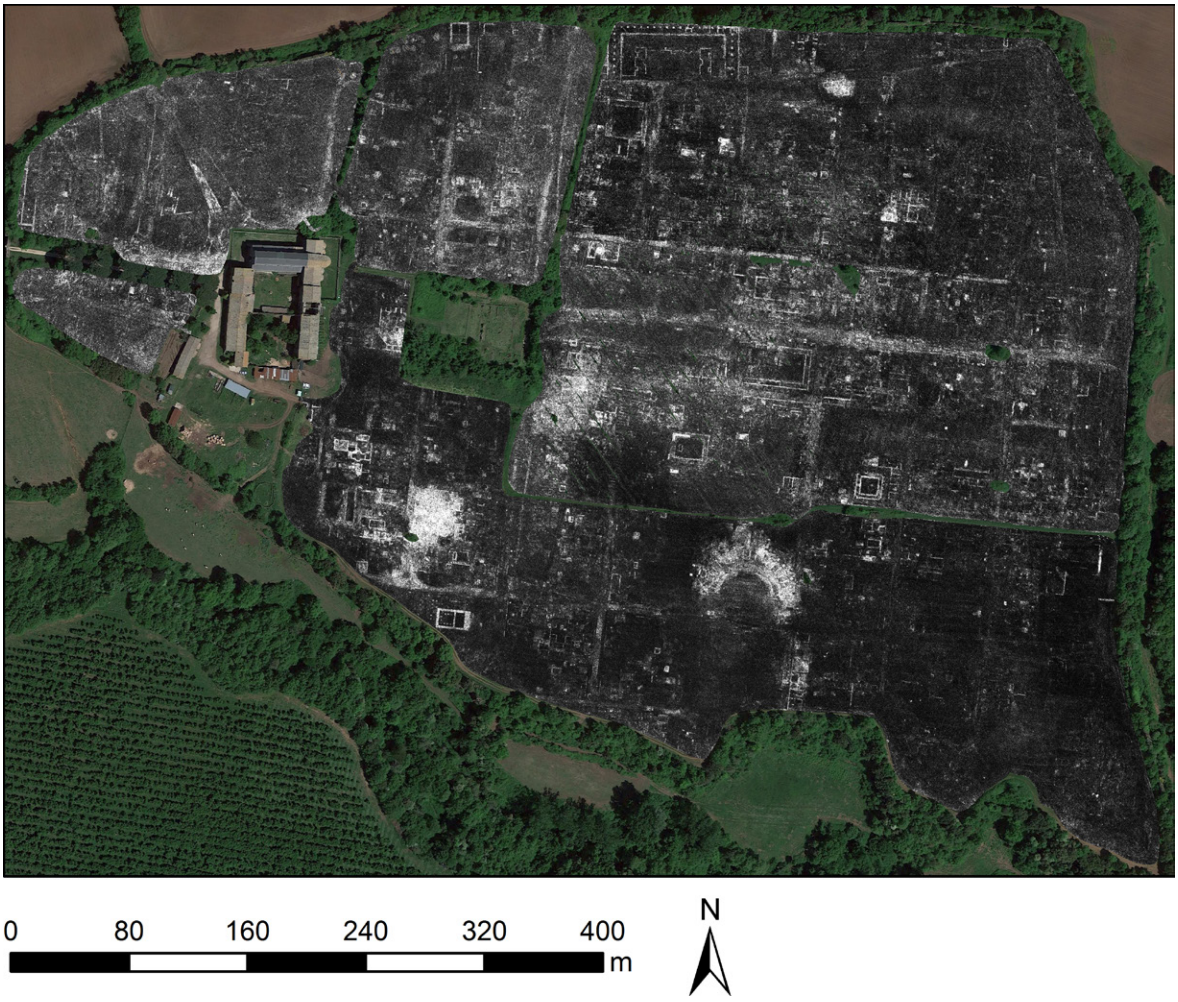

Figure 1. Falerii Novi: GPR time slice (sample area) of the intramural area, at an estimated depth of 0.75-0.80m.

and interpretation was possible only after first examining each separate time-slice individually, manually mapping anomalies in a GIS environment and interpreting the anomalies in terms of known or suspected Roman architectural features and forms. Work in progress, using both GIS and other techniques to explore true 3D visualisation for data analysis and interpretation of the GPR output, can still enhance the results from the field survey. Also, the important issue of the hugely time-consuming manual definition of the detected anomalies is currently being addressed by research into AI approaches exploiting the linear and orthogonal character of many anomalies, which usually represent walls, wall foundations and regular floor spaces in Roman towns.

The results from the Falerii Novi GPR survey show clearly that the high resolution of the data and the ability to distinguish features at different depths provide a much stronger foundation for understanding the town than was previously possible (Figure 1). GPR survey at Falerii Novi has revealed several previously unrecorded public buildings, such as a few temples and presumed sanctuaries (e.g., a huge porticus duplex), a *macellum* and a bath complex. Also, the contribution to the understanding of the city's dense domestic infrastructure is impressive, revealing some of the houses in great detail and suggesting a pattern for the early organisation of housing space in the city, connected with the original foundation plan. But, although the GPR data also help with a problem encountered with the magnetometer survey, providing a clearer view where in the magnetometer data building rubble masked structural detail, neither method is able to produce a complete picture of the buried archaeology. In some locations the fluxgate gradiometer survey produced a clearer image (e.g., the *tabernae* on the forum), underlining the by now well-known need to deploy complementary prospection methods and to fully integrate the results using image fusion and integrated interpretative mapping approaches.

In June 2021 a new phase of systematic prospection activity was initiated at the site, as part of a collaboration of the Ghent/Cambridge team with a team from the universities of Harvard and Toronto and the British School at Rome. Additional work within the intramural extent of the city has four principal objectives:

- to check the accuracy of the previous magnetometer and georadar surveys with respect to the position of the anomalies indicated and to obtain additional information about their stratigraphic contexts;
- to recover a sample of ceramic materials that should help refine the known chronology of occupation throughout the city, as well as the various types of activity that took place there;
- to gather data to clarify and reconstruct the physical landscape at the time of the city's foundation, as well as its subsequent transformation, by means of a digital elevation model (DEM) and erosion modelling;
- to recover samples of organic materials (e.g. pollen) from which information about the ancient environment at the site may be extracted.

To reach these objectives two minimally invasive methods were introduced:

1. a series of approximately 120 small (ca. 0.5 x 0.5 m) test pits dug to an estimated depth of 20-25 cm in a 50m grid systematically covering the ancient city allows to collect diagnostic artefacts and confirm correspondence between the upper archaeological layers and the results of the geophysical surveys undertaken in previous years.
2. a series of circa 50 manual augerings, systematically aligned along two sections (Figure 2) through the intra-mural city area allow to test the potential of the technique at Falerii Novi to yield minimally invasive stratigraphic, geological, and environmental information, with samples taken at different depths for radiocarbon dating, as well as other paleo-ecological and scientific analyses.

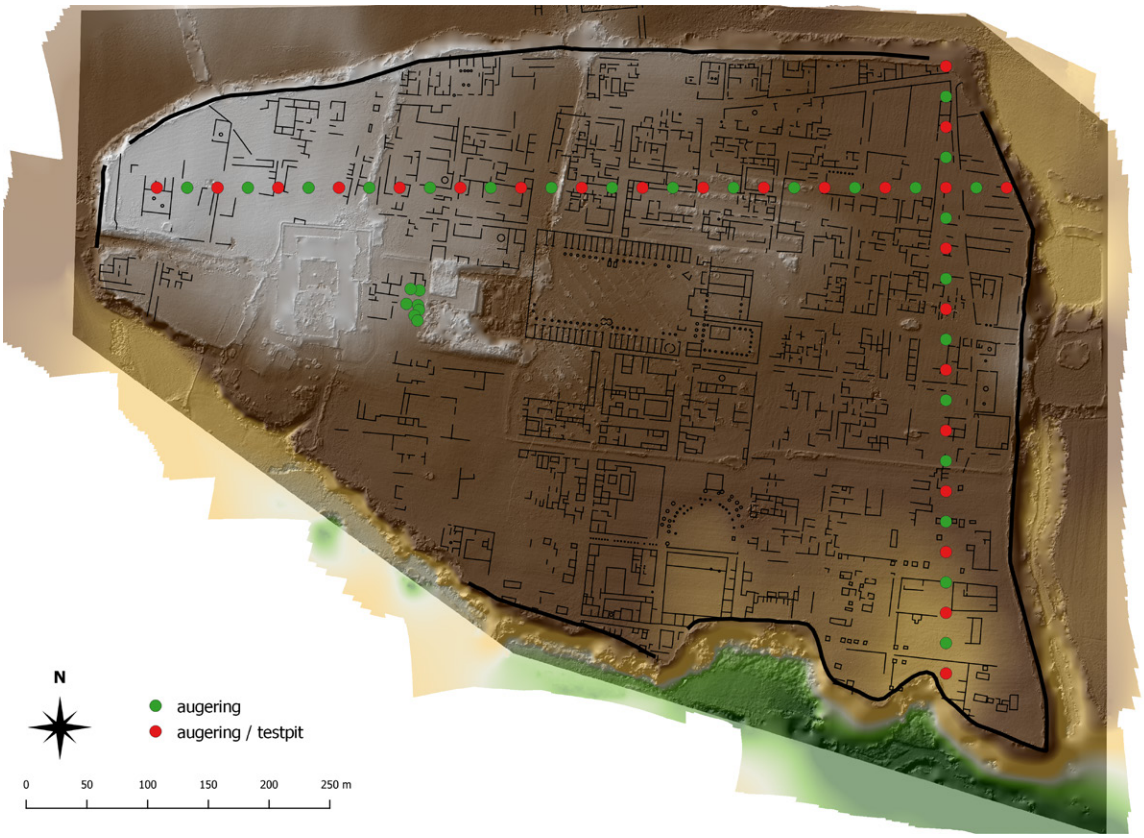

Figure 2. Falerii Novi: strategy of two sections with the location of manual augerings (and testpits) on a background of a LiDAR-based DEM and a map of archaeological structures derived from the magnetic survey.

Interamna Lirenas

The town of Interamna Lirenas was established as a Latin colony in 312 BC. Strategically placed along the via Latina, in a central position within the lower Liri Valley, it occupied a plateau controlling an important crossing over the river *Liris* (then navigable). Apart from some very scant remains of a bridge, a bath complex, an aqueduct and few cisterns, archaeological evidence had for long amounted to potsherds and tile fragments brought to the surface by ploughing (Hayes and Wightman 1984). This situation began to change in 2010, when a new fieldwork project was launched by Cambridge, in partnership with the BSR, the Italian Soprintendenza and the local Municipality (Bellini, Launaro and Millett 2014). A full-scale geomagnetic survey was carried out over the entire site (approx. 24 ha, 2010-12). Although this survey did not produce detailed plans of the buildings in the town, it provided key evidence for the layout of the street system and the location of the forum. In 2012-13, a GPR survey of a limited sector (50x50 m) near the forum led to the discovery of a hitherto unknown (roofed) theatre, whose entire plan has since been brought to light through excavation (2013-19).

Such discovery showcased the high potential of GPR and, in partnership with Ghent, the whole site was surveyed with the same GPR network employed at Falerii Novi (2015-17). This returned a remarkably crisp image of a very dense and articulated urban settlement, featuring a wide variety of buildings, in terms of both typology and size. Although this most likely reflected the situation in the 1st-2nd c. AD (see below), which resulted from considerable modification and rebuilding since the town's foundation, traces of the original (colonial) property plots can be discerned over the

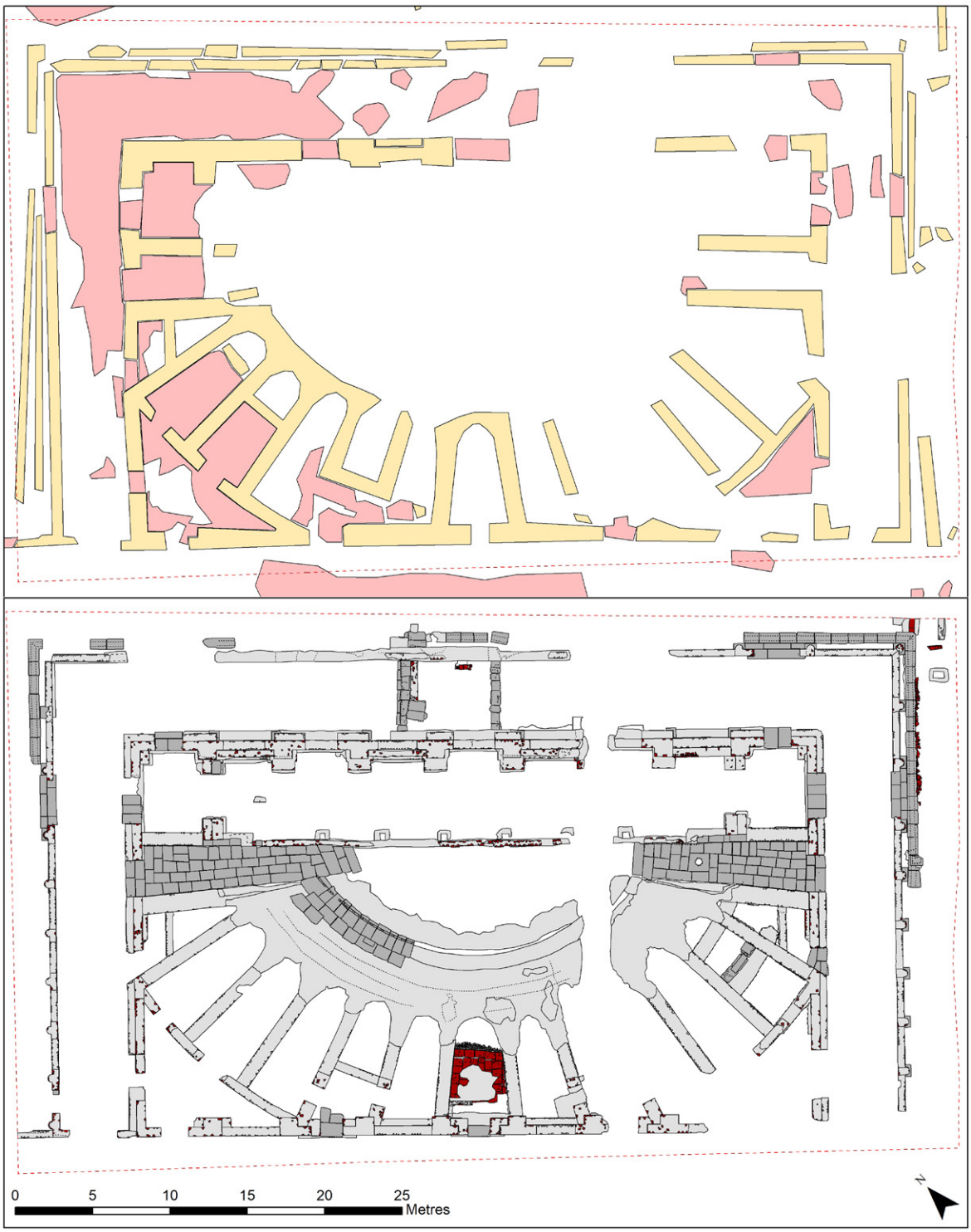

Figure 3. The theatre of Interamna Lirenas: interpretation of the geophysical anomalies (above) and excavation (below).

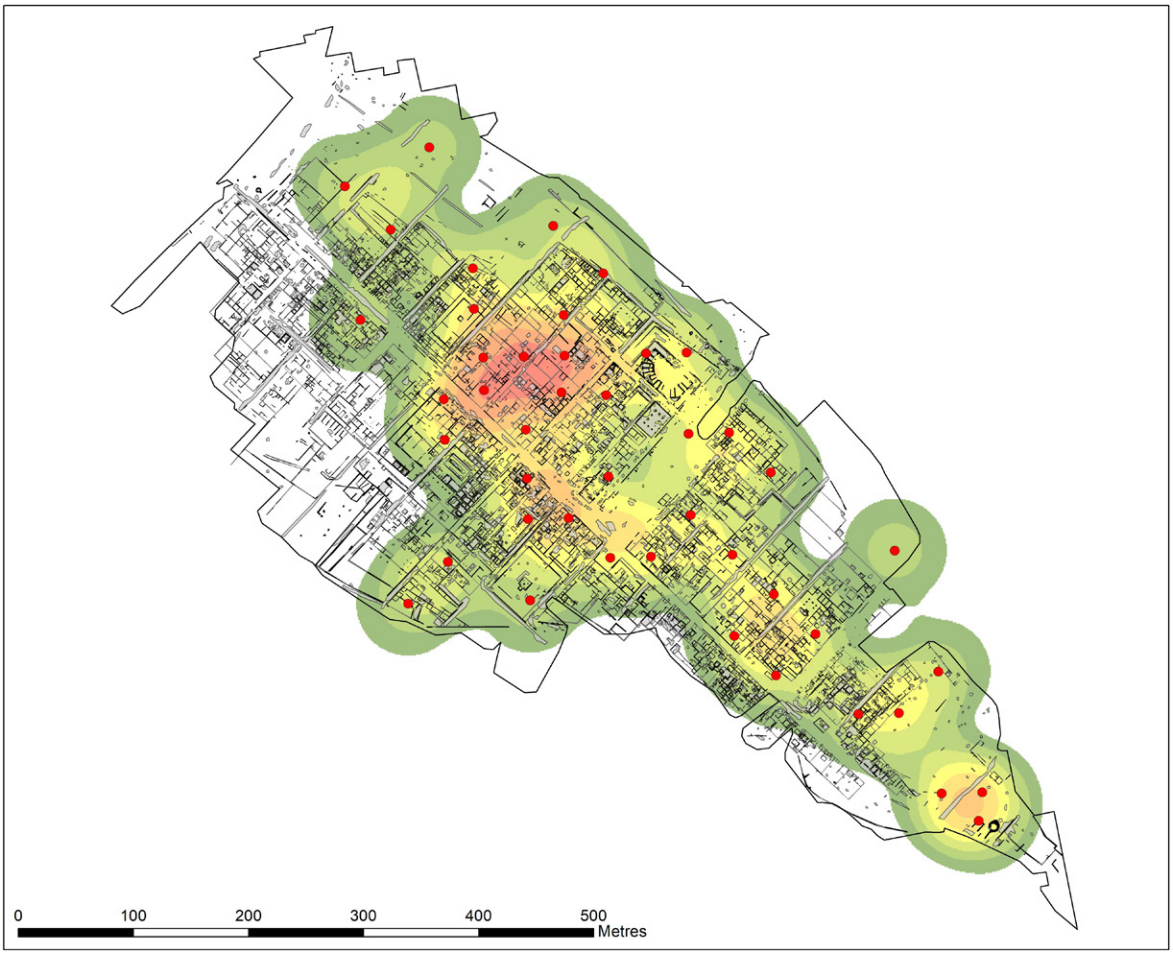

Figure 4. Intensity of occupation at Interamna Lirenas (AD 100-250) as indicated by the spread of commonware pottery.

entire plateau. Leaving aside public spaces, said plots appear to have belonged to two main types, defined by size, location and number (a situation resonant with Cosa, another Latin colony).

As in Falerii Novi, different techniques proved to be complementary: while streets feature way more prominently in the geomagnetic survey, building plans appear incomparably clearer and more detailed in the GPR. The efficacy of both techniques, however, may have petered out in some marginal areas, likely characterised by a deeper soil cover resulting from modern land transformations. Furthermore, although excavations have confirmed the remarkable level of accuracy of the geophysical survey, they also highlighted how its reach did not exceed c. 70 cm in depth (Figure 3).

A systematic survey of ploughsoil finds was also designed to map the chronological development of the town. Rather than attempting complete surface collection, our work combined two complementary approaches. First, all archaeological material from the ploughed surface was collected from a series of circular sample areas (25m^2 each) across the site and placed at c. 30m intervals to provide systematic coverage. Second, within each of them, a test pit was dug (c. 0.5m x 0.5m, 0.3m deep), the soil from which was sieved and all archaeological finds collected. Our aim was to ensure that we would recover reliable samples of material across the site. Earlier research had shown commonware pottery to be a better indicator of past occupation intensity in all periods, both at the site and in the surrounding territory (Launaro and Leone 2018). The spread of potsherds belonging to this class was thus plotted and processed to produce Kernel Density

maps for each period. These maps not only highlighted that the area around the forum had been occupied without interruption from the late 4th c. BC until the 6th c. AD, but also showed how the peak of occupation at the town, reached in the late Republic, persisted well into the 3rd c. AD (Figure 4) – in contrast with ideas of a precocious decline (supposedly undergoing by the end of the 1st c. BC already) which had been put forward by earlier scholarship.

A new phase of research has since been launched in July 2020. Our overall approach is now being extended over parts of the extramural periphery of Interamna Lirenas and has already led to the discovery of what are likely to be structures pertinent to the town's river-port.

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