

GEOPHYSICAL SURVEY AT LAS PIZARRAS ARCHAEOLOGICAL SITE (COCA, SEGOVIA): GPR AS A TOOL FOR DEFINING THE LATE ANTIQUE COMPLEX

**PROSPECCIÓN GEOFÍSICA EN EL YACIMIENTO ARQUEOLÓGICO DE LAS
PIZARRAS (COCA, SEGOVIA): GEORRADAR COMO INSTRUMENTO PARA
DEFINIR EL COMPLEJO TARDOANTIGUO**

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Abstract

During the summer of 2019, a geophysical survey was carried out in the archaeological area of Las Pizarras. The application of Ground Penetrating Radar (GPR), a non-invasive technique, has allowed us to detect and map anomalies related to previously unearthed and un-excavated structural remains linked to this Roman villa, located 2 km North of Coca (Segovia). This first approach to data obtained by the application of this particular auxiliary research strategy, provides new and significant details regarding the arrangement of the villa, its global design and internal articulation, as well as adding to our general comprehension the character and extent of this elite residential complex.

Keywords: *Geophysical survey, Ground Penetrating Radar (GPR), anomaly, radargram, Roman villa.*

Resumen

Durante el verano de 2019, desarrollamos una prospección geofísica en el área arqueológica de Las Pizarras. La aplicación de técnicas no invasivas, como el georradar (GPR), nos ha permitido detectar las anomalías relativas a las estructuras aún desconocidas y soterradas relacionadas con esta villa romana, situada 2 km al norte de Coca. Esta primera aproximación a los datos obtenidos mediante el empleo de esta particular estrategia auxiliar de investigación aporta nuevos y significativos datos relativos a su organización, diseño general, articulación interna, comprensión general, carácter y alcance de este complejo residencial de corte aristocrático.

Palabras clave: *Prospección geofísica, georradar (GPR), anomalía, radargrama, villa romana.*

In 2019, the *IE University Archaeology Unit*, in cooperation with *Magnitude Surveys Ltd.*, carried out a Research project¹ focused on assessing the subsurface archaeological potential of a particular sector at Las Pizarras Roman villa (Coca, Segovia), specifically over its *pars urbana*.

Archaeological and Geographic Background

Las Pizarras Roman villa is located on the opposite bank of the river Eresma, one of the two main watercourses that delimit the ancient *civitas* of *Cauca*. The underlying geology comprises alluvial gravel, sand, clay and silt (GEODE, 2019), while the soils consist of fine grain, freely following alluvial silts, due to its location on the Eresma river basin. The site is bounded by further fields in all directions. This suggests that ground penetrating radar (GPR) is the most useful near-surface technique for investigating stone-built structures in this geological environment, especially where there might be layering of remains, and a need to understand the site in three dimensions. Given the dry nature of the site, at the time of year the survey needed to occur, GPR was judged to be a more appropriate technique than electrical resistance measurements², and the expected stone buildings would not have been especially contrasted with the soil matrix. Further, on these types of sites, experience (Tol *et al.*, 2014) suggests that ceramic building materials can cause noise in magnetic surveys that obscure the detail of any structural remains.

The archaeological background of this site reveals an occupational sequence in the area from Protohistory. The archaeological zone of Las Pizarras covers an area of *circa* 200 has, where there is evidence for human presence from Late Bronze Age³ to contemporary times.

From a geomorphological point of view, the local topography shows a landscape incised by the river, resulting in a deep flat meander where a Roman suburban residence was erected during the Low Roman Empire.

The first stable settlement in this space was on the Cuesta del Mercado hill, a landform resulting from the fluvial process described. During the Iron Age, a population occupied this flat hilltop plateau from the Early Iron Age until the Roman period, although the most relevant occupation occurs under the Vaccaean culture (Blanco, 1994: 75-76).

¹ The geophysical survey was supported by the *Consejería of Culture and Tourism* of the *Junta de Castilla y León* (File Code No: B2019/009783). Title: "Prospección geofísica en 'Las Pizarras', en Coca (Segovia)".

² A previous *caesium*-Magnetometry survey in the surrounding area (Reyes 2017) demonstrated less effective results of this particular technique on mapping archaeological remains affected by human activities, especially when their ancient building fabrics are the object of re-use.

³ Perhaps even earlier, considering the discovery of some artifacts related to the Bell Beaker Culture, as the copper 'Palmela' points used as javelin heads (Blanco, 2005: 27; Blanco, 2012: 18).

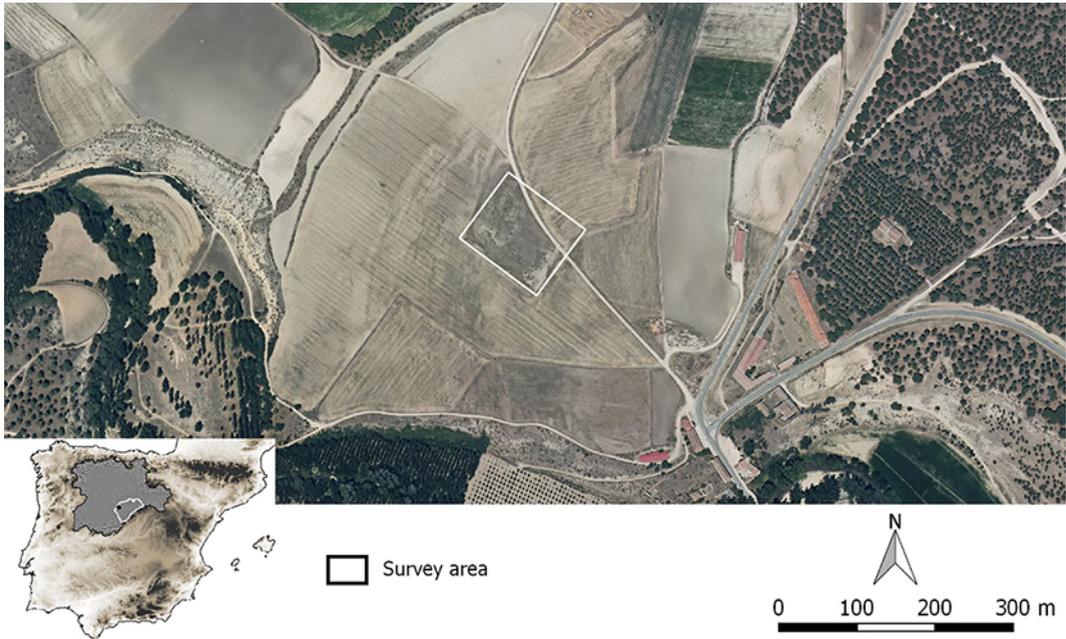


Figure 1. Las Pizarras (Coca, Segovia). Location and survey area [ITACyL].

Under the Romans, Las Pizarras plateau served as the basis of some suburban residences, probably combining the commodities of an urban household with rural-based economic affairs. According to these remains, the first residence here erected is Los Cinco Caños *Domus*. It was excavated⁴ in the '90s, revealing an *atrium* model building, decorated with wall paintings. Due to its location on the slope of the tableland, only the northern half⁵ of this Early Roman dwelling was preserved (Blanco, 2006: 478; *Id.*, 2012: 149).

The second settlement documented in the area of Las Pizarras is the namesake Roman villa. Initially discovered⁶ in the '90s, the first archaeological excavation occurred in 2001, in a particular location⁷ over the *pars rustica* of the complex (Pérez/Reyes, 2000).

Since then, research has been developed over almost twenty years, working in different areas to fill in the gaps concerning the general distribution of the outbuildings, spaces and other structures usually present at similar Roman productive sites.

In view of the results obtained, it is possible to affirm the existence of a suburban villa of the Early Roman period, from the 2/3rd centuries AD, probably organized around a central

⁴ Barrio y López, 1991.

⁵ Basically, the building still maintains about 200 m², probably a 10-15% of the original extension (Blanco, 2002: 149), calculated in 1500 m² (Blanco, 2010: 233).

⁶ As a part of the same archaeological survey campaign (Barrio/López, 1991).

⁷ Parcel No. 1, of Land cadastre of the village of Coca (polygon No. 4).

courtyard; as demonstrated the geophysical survey conducted in 2015 (Reyes, 2017: 50; footnote 12). The outstanding outcomes produced by highly sensitive *caesium* magnetometry, led us to understand the nature of this country residence and its earlier occupation, especially regarding the architecture applied by this elite household.

These data, in combination with the knowledge recovered from the archaeological work carried out in two adjoining plots since 2001, led us to suggest the presence of an important rural complex that experienced an enlargement towards the east in the 4th century (Reyes, 2017: 54). At that time, the complex receives a new peristyle of monumental dimensions with a set of new rooms attached (Reyes/Pérez, 2011: 804). In this particular case, the four ambulatories acquired the function of connecting visitors to the *dominus* in one of the greatest processional routes⁸ designed for Late Hispanic-Roman *villae*.

These suburban foundations apparently endured until the 5th century. At that point, it underwent some changes associated with the re-use and recycling of the building fabric and ornamental materials (Pérez/Reyes, 2017: 389-395). The following centuries witnessed the transformation of this *pars urbana* in a burial zone⁹ and the construction of a large house (*Id.*, 2013: 217-220). The Medieval Ages convert this space in a cemetery, tied to the Holy Trinity Church (*Id.*, 2012b: 208-212), while in Modern times, it turns the seat of the free market¹⁰ granted by Henry IV of Castile (Blanco, 2008: 175), workshops and agricultural installations spread over its surface (Reyes/Pérez, e. p.) until the abandonment of the land to arable farming.

Objective

This initiative is in line with the IE University Research project “*Theodosian Archaeology in the Douro basin. Las Pizarras (Coca, Segovia)*”, developed from the Archaeology Unit, and the aim of this survey is focused on mapping the main structures located around the main corridor, dated to the 4th century.

Although we knew the main structural patterns of the impressive peristyle, the room articulations around it were not clear enough, apart from those known from aerial photography. That’s why the geophysical survey undertook the unexcavated portions of the site, over a 0.57 ha area, to identify any further remains related to the plan villa and shed light on its architectural arrangement. The main aim was to complete the map of this prestige area, which has been strongly affected by human activities (*spolia*, functional transformations, burial practices, ploughing, etc.) and required systematic non-destructive investigation to know its real extent. For that reason, a strategy based on the employment of geophysical techniques, specialized toward the detection of linear anomalies was developed. GPR (Ground Penetrating Radar) was selected because it performs well over structural remains; particularly in those areas

⁸ The estimated dimensions of the four porticoes around the courtyard exceed 4.00m², even more than the total extension of the most important Roman villas registered in *Hispania* (Pérez/Reyes, 2012a: 93).

⁹ For more details about the anthropological study, see Herrerin/Reyes (2011).

¹⁰ A market exempt of royal taxes out of the village of Coca, lordship of the Fonseca Family.

It took place on 5-6th of August, over c.0.57 ha area from Las Pizarras (land parcels 7, 8 and 14, of Land cadastre of the village of Coca; polygon No. 4), surrounded by crop fields.

Geophysical survey¹¹ comprised the application of a Ground Penetrating Radar (GPR) equipped with a MALÅ X3M antenna (450MHz), with a 0.50m traverse separation and 0.05m sampling interval in-line.

The grids were located and set out with the help of metric fiberglass tapes, arranged in a mesh covering the survey surface. They were positioned and controlled with a Carlson BRx6 GNSS Smart Antenna RTK GPS which is accurate to 0.008m + 1 ppm in the horizontal and 0.015m + 1 ppm in the vertical.

Then, GPR data were collected along lines, using the calibrated system odometer wheel to place the sampling points. These profiles of data were acquired at intervals of 0.5m; the radar was set to sample every 0.05m along the line.



Figure 3. Ground Penetrating Radar Survey at Las Pizarras. Surveyors and a team member during the data collection.

¹¹ We are grateful to Magnitude Survey's team (Amedeo Viccari and Andrés Pérez Arana) and IE University field volunteers (Elvira Pastor Almendáriz, Francisco J. Marcos Herrán and Germán de Frutos Palomares) by their help and a great job at Las Pizarras geophysical survey.

Data processing

GPR data were processed in the standard commercial software package, ReflexW 3D, limiting the processing steps to DC Shift¹², bandpass filter¹³ and gain adjust¹⁴.

The individual GPR radargrams obtained in data blocks processed in *ReflexW*, were then combined in the same software into horizontal amplitude maps known as timeslices¹⁵. They offer a greyscale form, from black to white, where high amplitude¹⁶ responses (e.g. an abrupt change with a consistent surface) are presented in black, while low amplitude reflections¹⁷, or areas of signal dissipation, in light grey and white. Typically, structural remains such as walls and floors will produce high amplitude reflections, whereas the homogeneous fills of robber trenches or other cut features, might produce low amplitude responses.

Thereafter, timeslices (time being analogous to depth, depending on the speed of the radar energy in the ground) from all the grids were interpreted in a layered environment¹⁸ (GIS). This interpretation also took into account the single radargrams, as they can aid in visualizing the form of the geophysical response and thus improve anomaly interpretation.

Results

The GPR survey has responded well to the environment of the survey area, with evidence of good signal penetration at depth. The natural geology of fine-grained alluvial deposits and sands allowed us to obtain consistent results across the survey area.

Thanks to the geophysical data, it has been possible to identify additional structural remains associated to the monumental Roman villa. The results from the GPR survey show distinct archaeological activity within all of the survey areas, with no clear limits of the site being detected. Furthermore, where the GPR surveyed over an already excavated location, the radar results have been matched closely with the excavation results (Areas 3 and 4). On the other hand, interruptions in the survey areas seem related to former excavation trenches.

Area 5 was more challenging to interpret (fig. 2), for two main reasons: it is the smallest survey block, providing less context in plan and Area 5 does not record any clear, continuous structural remains, or similar features; as the rest of the areas do (where radargrams record distinct archaeological anomalies in all the depths). However, it was possible to interpret the presence of archaeological features, such as trends or spreads within Area 5.

The majority of responses detected from the structures arise from shallow to middle depths, with reduced continuation through the deeper timeslices. This would indicate that the

¹² The waveform response for each traverse was centred to correct for striping effects caused by small variations in sensor electronics and orientation.

¹³ Frequencies outside the normal range of the measuring antennae were filtered out to remove errors from external sources.

¹⁴ A gain curve was manually calculated to account for signal attenuation with depth. The gain adjust allows features at depth with a weaker signal to be resolved at the same plotting scale as near surface features.

¹⁵ 'Timeslices imaging technique' (Goodman *et al.*, 1995).

¹⁶ Differences in amplitude relate how much radar energy is reflected from the material or change in material properties, not with their origin.

¹⁷ Regions where the radar energy is being absorbed or transmitted rather than reflected

¹⁸ Overlaid against OpenStreetMapping, satellite imagery, historic mapping, LIDAR data, and soil and geology mapping.

GPR survey hasn't recorded buried upstanding walls, but rather the remains of the lower portions and/or the foundations of the walls; consistent with a broad part of the excavated complex.

Areas of noisy reflections seem related to spreads of archaeological material, visible in the shallow to middle depths. These responses may relate to archaeological debris from building collapse or the robbing of masonry material from structural features. However, they could also relate to *in situ* floor surfaces.

On the other hand, the linear responses recorded within the courtyard have been identified as probable archaeology trends in the middle depths. They are too deep to be agricultural, so they were initially considered possible drains or conduits contemporaneous to the surrounding context, possibly related to the *stagnum*. A deeper study made us reconsider this idea because the drainage system of this villa shows the same composition and technique applied as the one present in the rest of the villa structures; as we could examine in the areas excavated in 2008-2009. In that case, they should have been visible during the GPR survey in the same way that structures do. Future excavations in the area may solve this question.

Figure 4. Las Pizarras: guide lines of the pond and peristyle over the indicative GPR Timeslice (middle depth: 308 ns).

To the west and outside the courtyard, numerous linear and curvilinear responses have been identified. They do not share responses similar to the possible structures or have a relatable morphology or extent. They have been classified as possible archaeology due to sharing a depth with probable archaeology. It is possible that they reflect the stages of leveling and esplanade of the construction of the villa, removing any previous construction.

Agricultural activity is recorded in the northeast of the survey area as plough trends. These linear signals are regularly spaced in the shallow to middle depths, which possibly suggest a modern agricultural origin. Finally, undetermined responses have been recorded in the deep depth, whose function and purpose are not obvious, but an archaeological origin cannot be ruled out.

Interpretation

A simple view of the timeslices shows different responses related to the diverse amplitude reflections, where it is possible to detect clear evidence of buried large structures in an orthogonal arrangement, consistent between almost all survey areas. Typically, structural remains will produce high amplitude reflections (black), whereas the homogeneous fills of robber trenches or other cut features might produce low amplitude responses (grey to white). The most useful information is in the middle depths (timeslices 252/308 ns), where it is possible to have an idea of the complete construction; once the depth sequence moves past the noisy responses from collapsed walls, debris and later occupations.

All the recorded structures show north-northeast to southwest orientation across all depths. Additionally, there are no cross-cutting or off-alignment responses identified. The high amplitude reflections describe two concentric squares, typical of a Roman peristyle, in whose centre it is possible to notice the outlines of an inner one, of smaller extent and relatively centred within the outer precinct.

Peristylum

The radargrams and slices also show orthogonal parallel responses, in a concentric layout surrounding the *stagnum* (Areas 1, 3, 4 and 7; fig. 2). This result from the GPR survey has been interpreted as evidence of a large rectangular peristyle of 71m on the diagonal, for its inner square (fig. 3). These parallel anomalies/wall foundations are not visible across the whole subsurface, but in specific zones, with a consistent spacing between the inner and outer linear responses (*c.* 7m wide); similar to the eastern corridor width recorded in 2006 (Pérez/Reyes, 2007: 73). The gaps in the detected features may relate to the absence of the wall foundations, caused by different reasons but all linked to local inhabitants' activities (*spolia*, burials, etc.; *Ibid.*: 64-65); which frequently involved the re-utilization of building materials from the Roman ruins.

Stagnum

The GPR results from the core of the complex reveal the eastern corner of this central pond (Area 2, fig. 3). The middle-depth radargram shows two anomalies that define a right-angled linear response. This distinctive anomaly is adjacent to the previously excavated central *stagnum*, identified by the foundation walls of this ornamental architecture (their northern and eastern edges). The combined GPR and excavation record would suggest a size of c.39.3m on the diagonal for the pond, organized around a rectangular plan (34 x 27 m²) when measuring from its outermost south-western corner to its possible northeastern corner. In this case, it would not be centered within the courtyard, because it is over 11m from the western wing of the peristyle, whilst being just 5m from the opposite one, the east corridor.

A marmoreal floor paved the upper part and the bottom of the *stagnum*, as determined by the 2008-2009 archaeological campaigns (Pérez/Reyes, 2009b: 136). The former is probably the low amplitude response¹⁹ recorded through shallow depths (212 ns; fig. 4, left). It is correctly aligned with the pond orientation and located 3m north of the linear anomaly mentioned.

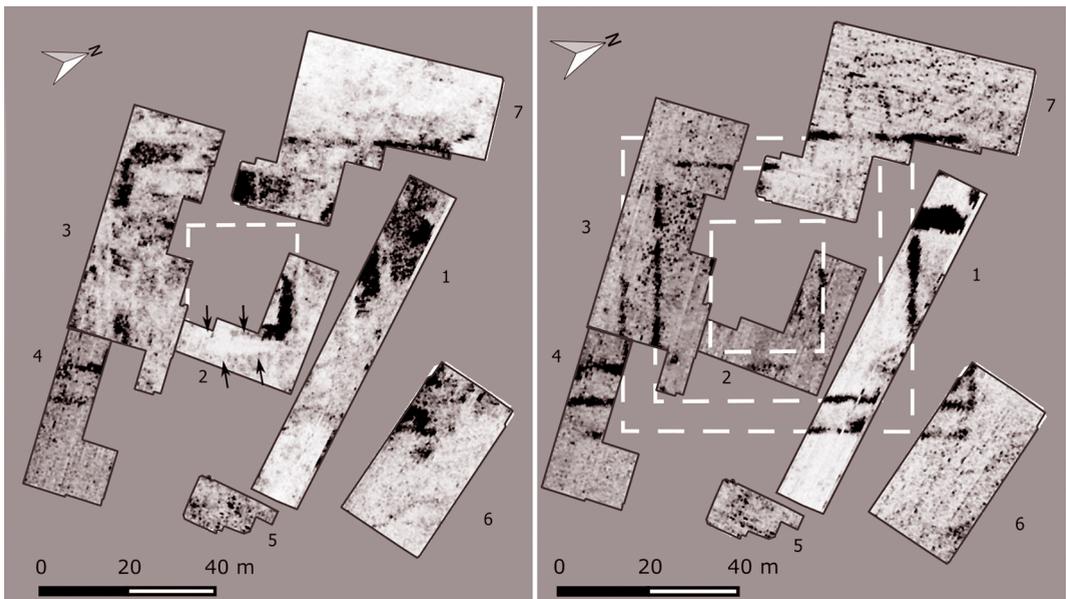


Figure 5. Las Pizarras: *Stagnum*. Interpretations at shallow and middle depths. GPR Timeslices: 212 ns (left) and 308 ns (right).

¹⁹ Arrows show the exact place.

However, we should consider this easternmost high amplitude anomaly from the middle-depth as independent or displaced east from the *stagnum*, for several reasons:

- The angular divergence between the northern edge of the *stagnum* and the discontinuity is higher than a right-angle (97°). This fact is usually more frequent in later constructions (fig. 4, right).
- These volumes break Roman principles of axiality and symmetry²⁰. Particularly, in a space free of earlier structures, where those rules should be essential, demanding a central placement in the courtyard for a structure with these properties.

If we consider the *stagnum* centered in the courtyard, the pond would be equidistant to all the corners of the courtyard c.16m. In any case, we must wait for future excavations to test this hypothesis.

Rooms

Apart from the already studied apsidal rooms, placed along the western and eastern corridor wings, it is possible to identify those recorded in 2001-2004 and reveal the complete solutions employed by the complex builders for these spaces among the sectors as-yet unexcavated. This is particularly visible in the south corner of the complex (Area 4). At middle depth (GPR timeslice: 252 ns), the identification of adjoining structures (two linear parallel anomalies and an internal semi-circular response; fig. 5, left), was originally interpreted as the structures previously excavated²¹. The former presents an orthogonal layout to the peristyle courtyard; Room IV, the eastern one with an apsidal ending. Once it was compared to the whole excavated area dug in 2003, it was possible to identify that only one of its walls was visible at this depth²², the western one.

To the west of this point, and in still in middle depths, weaker responses define a semicircular space (Room I), but not its circular wall, which should be marked with a high amplitude reflection. Spoliation clarifies why the latter is not well defined in the GPR timeslice at 252 ns. As we could see during the archaeological campaign of 2001, the foundations of Room I were almost missing, except near the southern limit of the excavated area. There, we registered the only *in situ* remains of this supporting structure; similar in shape to the dot-shaped anomaly, present both at middle and deep depths.

When compared to archaeological plans, it is possible to identify two well-defined areas: the eastern one, recorded in 2001, and the western middle; not excavated yet and almost invisible. The westernmost linear anomaly detected in this area –with a triangular shape instead of a linear track– defines better the limit of the excavation than a wall foundation; disturbing the correct interpretation of this space.

²⁰ Vitr. 6.2.

²¹ 2001-2003 archaeological campaigns: Rooms IV and I, respectively (Pérez/Reyes, 2011: 797, fig. 2).

²² The eastern wall is visible at a deeper depth (308 ns; fig. 5, right).

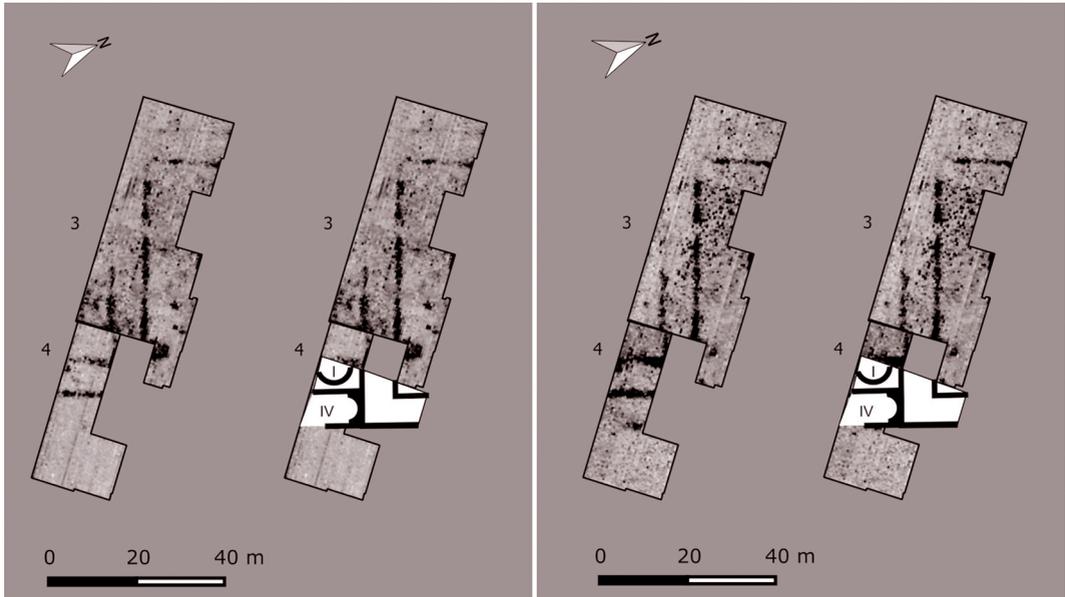


Figure 6. Las Pizarras: Rooms attached at the southern corner of the peristyle (2001-2004 campaigns) compared to GPR Timeslices: 252 ns (right) and 308 ns (right).

Attending to the opposite edge of the peristyle, a new anomaly –the westernmost– shows an outer linear response extending northwards, beyond the suggested square layout of the courtyard (Area 7).

Additionally, the analysis of the north-eastern side of the enclosure reveals other rectilinear features attached (Areas 1, 6 and 7). All these responses are likely related to spaces or rooms located surrounding this northern part of the courtyard. The space between the areas is interrupted by a high amplitude reflection which interferes with interpretation. This activity is near the excavation area²³ developed in 2005, which provided valuable information about the missing foundations of the peristyle outer wall, but this does not match with the discontinuity. The level of the pavements is more superficial on the western edge of the courtyard; due to the unevenness of the ground (0.50m). Perhaps all of these factors, in concert with later human activity in the area, have affected the survey results.

On the other hand, this anomaly keeps the same alignment as the rest of probable rooms attached at the northern corridor and may be the signal of another absent wall and a larger *spolium*.

²³ According to the initial analysis of the second land parcel excavated (parcel No. 8).

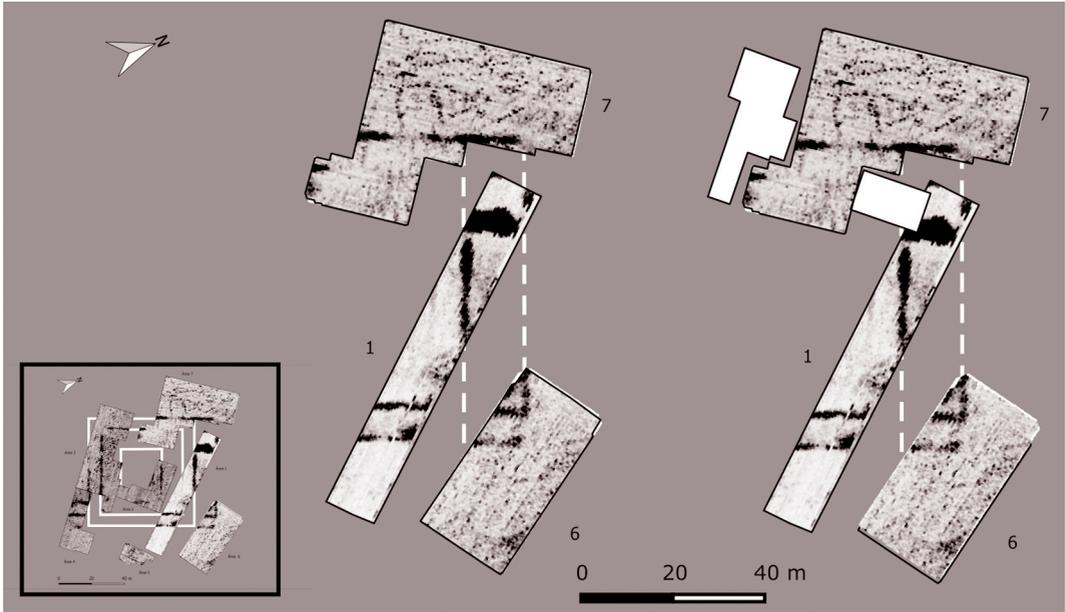


Figure 7. Las Pizarras: guide lines of the rooms attached at the northern wing of the peristyle, at middle depth (GPR Timeslice: 308 ns). Right: 2005 archaeological campaign (white).

Conclusions

Thanks to non-invasive techniques, in combination with archaeological excavation during the last decade, investigation of the Roman villa of Las Pizarras has reached a key point in its overall understanding; the knowledge of its articulation, rooms and enlargement, and that the earlier occupation phases occurred in this central part of the plateau, linked to an elite suburban homestead placed near the *civitas* of *Cauca*.

In this particular case, we have chosen an auxiliary technique, never previously used in this archaeological area. With the aid of the geophysical survey, we analyzed the impact of the Roman structures within the subsurface of the terrain, and other shreds of evidence of later inhabitants.

The results have yielded essential data linked to the spatial articulation and scope of the Roman complex, which we now know was organized around a large peristyle. Also, new spaces have been added to the archaeological record and others have been properly demarcated. The structures appear to be from one phase and show an abrupt end in the data with depth. This is suggestive of a single phase of construction, implying one phase of activity on this part of the site. Besides, the comparison of these GPR data with the archaeological record has allowed

us to corroborate many hypotheses regarding the real extent of the building and the possible contemporaneous relationship with the earlier Roman dwelling.

Over time, human activity has deeply veiled the true identity of this prestige dwelling, once it lost the original functions for which it was designed. As a result, this geophysical survey has helped to fill in the gaps in past of this elite Roman villa.

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