

Remote Sensing and GIS applied to the study of an Iberian Iron Age *oppidum*'s hinterland: *La Carencia* project (Valencia, Spain)

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Abstract

This case study presents evidence drawn from an ongoing project at *La Carencia* Iberian *oppidum*. The project aims to analyze the hinterland of *La Carencia* based on a long-term and micro regional approach. The focus is on the genesis and evolution of this Ibero-Roman city, of outstanding political importance, and its immediate territory. The transition from the Iberian Iron Age to the Roman era is of particular interest given the thorough transformation it represented for Iberian cultural practices. The combination of surveying, archaeomorphological analysis, aerial stereographic pair analysis based on old photographs, satellite imagery analysis and GIS-based topographical analyses have aided in the formulation of theories on how the landscape was transited, conceived and exploited throughout time.

The results yielded by the previously mentioned techniques suggest there was a shift towards a more efficient land use during Roman times. Evidence presented in this paper will aim at showing how Remote Sensing and GIS-based techniques can provide an initial approach to the study of long-term landscape change.

Key words: *Remote Sensing, GIS, Roman, Iberian, landscape archaeology*

1 INTRODUCTION

This case study presents evidence drawn from an ongoing project at *La Carencia* Iberian *oppidum*. The project aims to analyze the hinterland of *La Carencia* based on a long-term and micro regional approach. Iberian Iron Age societies were organized around *oppida*, which were political centers from where land and trade were controlled. These nuclei were generally fortified and located on prominent sites which “facilitated visual control over the surrounding countryside and nearby subordinate sites”¹.

Over the last decades, many Iberian city-states and their territories have been excavated and studied within the Valencian Autonomous Community²,

²Enrique Dies et al., “La Bastida de les Alcuses (Moixent): Resultados de los Trabajos de Excavación y Restauración. Años 1990–1995,” *Archivo de Prehistoria Levantina* 22 (1997): 215-95;

Helena Bonet and Consuelo Mata, “Organización del Territorio y Poblamiento en el País Valenciano entre los Siglos VII al II a.C.,” *Bibliotheca Archaeologica Hispana* 8 (2001): 175-86; Ignaci Grau, “Romanization in Eastern Spain: A GIS Approach to Late Iberian Iron Landscape,” in *Temps et Espaces de l'Homme en Société, Analyses et Modèles Spatiaux en Archéologie, XXVe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*, ed. Jean-François

¹ Ignaci Grau, “Settlement Dynamics and Social Organization in Eastern Iberia during the Iron Age (Eight – Second Centuries BC),” *Oxford Journal of Archaeology* 22.3 (2003): 261.

which can be regarded today as one of the areas in Spain with a more exhaustively documented and extensive Iberian archaeological record. *La Carència oppidum* is an Ibero-Roman city located at 379 m.a.s.l. on the the *Portell* range (*Torís*), 30 km west from the Mediterranean coast (see fig. 1). Its geographical location between the well known Iberian cities of *Edeta*, *Kelin*, and *Bastida de les Alcuses* somewhat completes the geopolitical map of the Valencia area in Iberian times³.

Berger, Frédérique Bertoncello, Frank Braemer, Gourguen Davtian, and Michiel Gazenbeek (Antibes: Éditions APDCA, 2005), 325-334; Consuelo Mata et al., “Cosas y Casas del Campo: el Paisaje Agrícola en los Territorios de Edeta y Kelin (Siglos V-III a.n.e.),” in *El Espacio Doméstico y la Organización de la Sociedad en la Protohistoria del Mediterráneo Occidental*. Actas de la IV Reunión Internacional de Arqueología de Calafell, 6–9 de marzo 2007, Calafell, Tarragona, VVAA (Barcelona: Universitat de Barcelona, 2007), 143-152; Helena Bonet, Consuelo Mata, and Andrea Moreno, “Iron Age Landscape and Rural Habitat in the Edetan Territory, Iberia (4th–3rd Centuries BC),” *Journal of Mediterranean Archaeology* 21.2 (2008): 165-189; Joan Bernabeu, Helena Bonet, and Consuelo Mata, “Hipótesis sobre la Organización del Territorio Edetano en Epoca Ibérica Plena: el Ejemplo del Territorio de Edeta/ Llíria” in *Iberos. I Jornadas sobre el Mundo Ibérico, Jaén, 1985*, VVAA (Jaén: Ayuntamiento de Jaén y Junta de Andalucía, 1987), 137-156.

³ Enrique Díes et al., “La Bastida de les Alcuses (Moixent): Resultados de los Trabajos de Excavación y Restauración. Años 1990–1995,” *Archivo de Prehistoria Levantina* 22 (1997): 215-95; Helena Bonet and Consuelo Mata, “Organización del Territorio y Poblamiento en el País Valenciano entre los Siglos VII al II a.C.,” *Bibliotheca Archaeologica Hispana* 8 (2001): 175-86; Consuelo Mata et al., “Cosas y Casas del Campo: el Paisaje Agrícola en los Territorios de Edeta y Kelin (Siglos V-III a.n.e.),” in *El Espacio Doméstico y la Organización de la Sociedad en la Protohistoria del Mediterráneo Occidental*. Actas de la IV Reunión Internacional de Arqueología de Calafell, 6–9 de marzo 2007, Calafell, Tarragona, VVAA (Barcelona: Universitat de Barcelona, 2007), 143-152.

Previously this site was merely the subject of test pit digging and occasional finds⁴. However, from 2001 a research project, directed by the Valencian Provincial Council began a thorough archaeological study of this outstanding site and its immediate territory. Results yielded by this research have helped to enhance the heritage value of this site, to the point of being recently listed (2008) as a Cultural Heritage Site (BIC). Excavation and intensive surveying within *La Carència* site have shown evidence of a first occupation phase dating back to the Bronze Age. From then on the site was continuously occupied until the Late Roman period. It covered an area of 8.6 ha and evidenced the presence of three walled perimeters and several towers of which only five have been documented⁵. Its relative height over its immediate territory of ca 90 meters confers the site a clear visual dominion over its surroundings. Its size, long span and the quality and diversity of the structures and materials discovered within this area –particularly, a collection of one thousand Greek, Roman and Iberian coins– contributed to regard *La Carència oppidum* as one of the principal Iberian city-states of the Valencian territory. Only recently has *La Carència* been identified as the unknown city of *Kili / Gili* on the basis of numismatic studies⁶.

Although the archaeological landscape study covers the periods from the Bronze Age until the Middle Ages, in this article only the Iberian (Iron Age) to Roman transition will be discussed, this is

⁴ Milagros Gil-Mascarell, “Resumen de las Excavaciones Realizadas en el Poblado Ibérico de la Carencia, Turís, Valencia,” in *Crónica del XIII Congreso Arqueológico Nacional*, VVAA (Zaragoza: Universidad de Zaragoza, 1975), 693-696.

⁵ Rosa Albiach et al., “Prehistoria i Historia Antiga,” in *Turís, Geografia, Història, Art*, VVAA (Valencia: Universitat de Valencia, 2007), 112.

⁶ Pere Pau Ripollés, “Historia Monetaria de la Ciudad Ibérica de Kelin,” *Los Íberos en la Comarca de Requena- Utiel*, coord. Alberto J. Lorrio (Alicante: Universidad de Alicante, 2001): 109.

of particular interest given the thorough transformation it represented in the way that Mediterranean territories were used and conceived⁷.

Many studies have recently stressed the unparalleled choice that the conjunction of Remote Sensing and GIS techniques offer when it comes to studying ancient landscapes from an archaeological perspective⁸. Nonetheless, the

application of a sensitive combination of Remote Sensing, GIS-based techniques, archaeomorphology and archaeological survey to the Iberian-Roman shaping of landscapes has so far not been addressed within the methodological approaches that currently characterize Iberian territorial research. The results provided by this methodological approach are explored here for the first time.

⁷ Josep Maria Carreté, Simon Keay, and Martin Millet, *A Roman Provincial Capital and its Hinterland. The Survey of the Territory of Tarragona, Spain, 1985-1990* (Michigan: Journal of Roman Archaeology. Supplementary Series 15, 1995), 278-279; Josep Maria Palet and Santiago Riera, "Organización Territorial y Dinámica del Paisaje en Zonas Litorales del Nordeste de Hispania," in *Arqueologia da Antiguidade na Península Ibérica, Actas do 3º Congresso de Arqueologia Peninsular VI*, ed. Jorge V. Oliveira (Porto: ADECAP, 2000), 33-45; Josep Maria Palet, "L'Estructuració dels Espais Agraris en Època Romana a Catalunya: Aportacions de l'Estudi Arqueomorfològic del Territori," *Cota Zero* 20 (2005): 53-66; Josep Maria Palet, Jose Ignacio Fiz, and Héctor A. Orengo, "Centuriació i Estructuració de l'Ager de la Colònia Barcino; Anàlisi Arqueomorfològica i Modelació del Paisatge," *Quarhis* 5 (2009), 106-123; Ignaci Grau, "Romanization in Eastern Spain: A GIS Approach to Late Iberian Iron Landscape," in *Temps et Espaces del l'Homme en Société, Analyses et Modèles Spatiaux en Archéologie, XXVe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*, dir. Jean-François Berger, Frédérique Bertoncello, Frank Braemer, Gourguen Davtian, and Michiel Gazenbeek (Antibes: Éditions APDCA, 2005), 325-334.

⁸ Josep Maria Palet, Héctor A. Orengo, and Jose Ignacio Fiz, "Análisis Planimétrico Digital de la Red Viaria y del Parcelario en el Ager Tarraconensis: Formas del Paisaje y Articulación del Territorio," *Anejos del Archivo Español de Arqueología*, in press; Laure Nunniger and Kristof Ostir, "Contribution à la Modélisation des Paléo-Reliefs de la Plaine Littorale de l'Étang de Mauguio (Languedoc, France): Premières Approches par Télédétection," in *Temps et Espaces del l'Homme en Société, Analyses et Modèles Spatiaux en*

Archéologie, XXVe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes, dir. Jean-François Berger, Frédérique Bertoncello, Frank Braemer, Gourguen Davtian, and Michiel Gazenbeek (Antibes: Éditions APDCA, 2005), 123-34; Giovanna Pizziolo and Lucia Sarti, "Landscape Archaeology in Sesto Fiorentino: a GIS Analysis for Investigating Settlement Strategies in Wetland Area," in *Temps et Espaces del l'Homme en Société, Analyses et Modèles Spatiaux en Archéologie, XXVe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*, dir. Jean-François Berger, Frédérique Bertoncello, Frank Braemer, Gourguen Davtian, and Michiel Gazenbeek (Antibes: Éditions APDCA, 2005), 441-450.

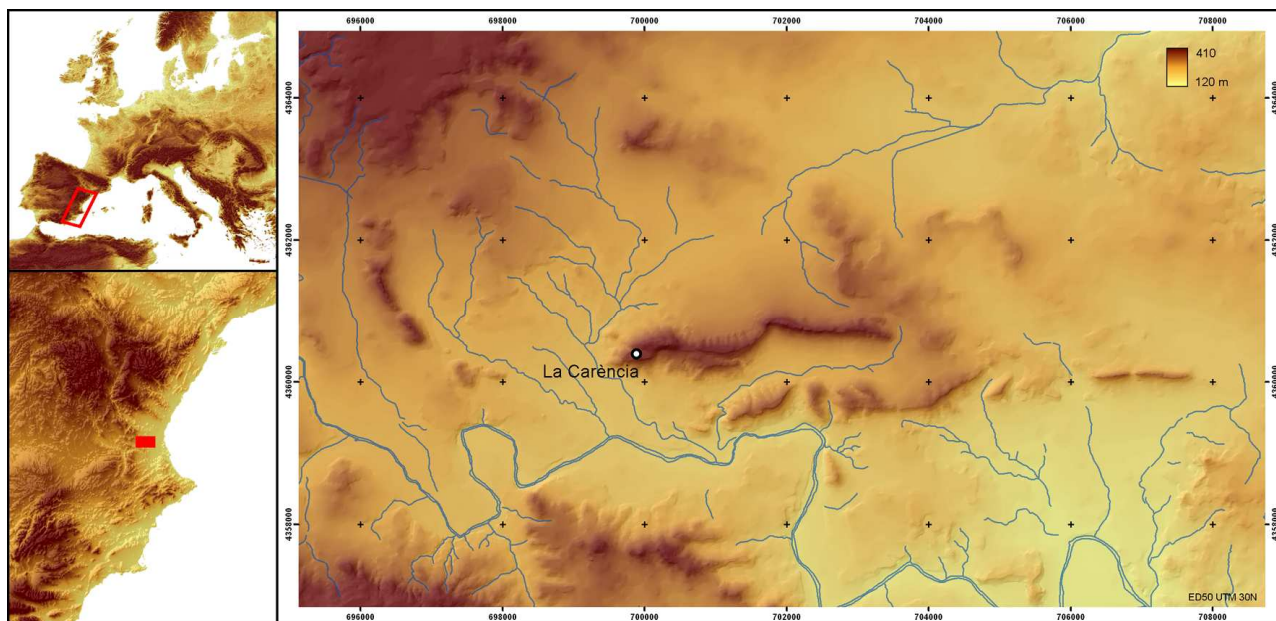


Figure 1. Location of the study area

2 METHODOLOGY

A first approach to the archaeology of the study area was obtained by intensive surveying and ceramic analysis, which enabled the investigation of nearby human occupation from the Bronze Age to Medieval times. Besides, archaeomorphological research was undergone using old aerial photographs in order to relate the sites distribution to the main landscape's human morphological features such as roads, paths or field systems. The steps followed to create the geodatabase used in such archaeomorphological analyses can be found in Palet et al. in press⁹. The use of GIS and multispectral imagery was deemed necessary in order to validate these hypotheses.

ASTER and Landsat multispectral satellite imagery analysis was performed to verify traces of ancient buried roads and other landscape macrostructures. Satellite images were sharpened, corrected and georeferenced. Together with

topographical and geological maps, they were helpful in determining which areas had developed different types of land use. Despite their lower spectral resolution; the high spatial resolution of wide band aerial photographs allowed the location of small landscape structures and complemented the results obtained by satellite image analysis.

In order to perform topography-based GIS analyses, a Digital Terrain Model (DTM) of 5m/cell was interpolated from spot heights obtained from high resolution stereoscopic orthophotographic pairs and 120 GCPs (fig. 2). The DTM underwent a process of sink detection and filling to eliminate false depressions caused by the interpolation process which resulted in a depressionless DTM. Quarrying activities in the study area have substantially modified the landscape from the 1960s onwards. It is for this reason that 1956 orthophotographic stereopairs were employed to develop a second DTM. A cut and fill analysis was performed to obtain a clear image of those areas which underwent major modifications. These could be restored by employing the values procured from the 1956 stereopairs. In this way a DTM suited for most of the topographic analyses was developed.

⁹ Josep Maria Palet, Héctor A. Orengo, and Jose Ignacio Fiz, "Análisis Planimétrico Digital de la Red Viaria y del Parcelario en el Ager Tarraconensis: Formas del Paisaje y Articulación del Territorio," *Anejos del Archivo Español de Arqueología*, in press.

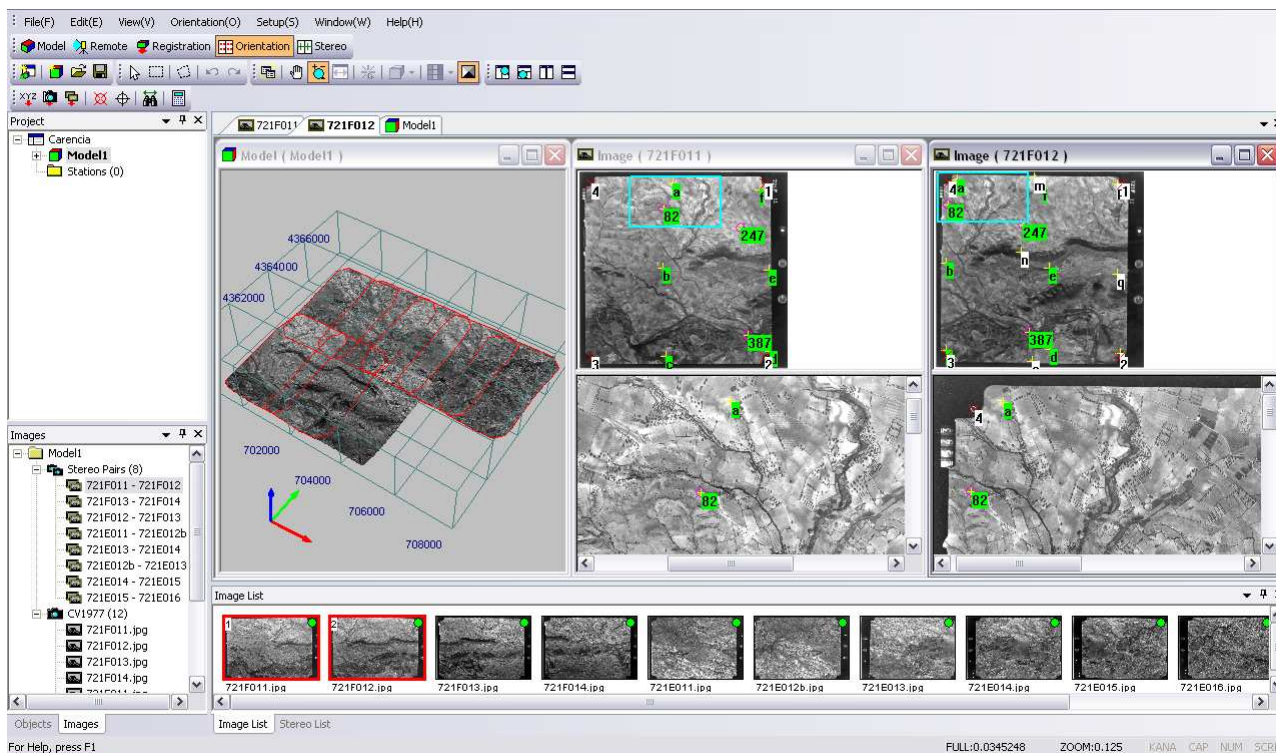


Figure 2. Photogrammetry-based DTM creation

Hydrologic factors have been acknowledged elsewhere¹⁰ of primary importance in the modeling of human settling and movement through the landscape. The fact that a trend towards warmer temperatures and increased water availability during Roman times had been recorded in

¹⁰ Jose Ignacio Fiz and Héctor A. Orengo, "Simulating Communication Routes in Mediterranean Alluvial Plains," in *Layers of Perception. Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Berlin, Germany, April 2-6, 2007, Kolloquien zur Vor- und Frühgeschichte, vol. 10.*, ed. Axel Posluschny, Karsten Lambers, and Irmela Herzog (eds.) (Bonn: Habelt, 2008), 316-321.

Mediterranean areas¹¹ converted hydrologic factors into a specific conditioning feature for this case study. Consequently, flow accumulation and direction rasters were created so as to get information on how and how much water moved through the landscape and where it accumulated. Also incorporated was information on flood occurrences: their extension, range and frequency on the study area were supplied via WMS by the Regional Ministry of Environment, Water, Urban Development and Residential Planning (Conselleria de Medi Ambient, Aigua, Urbanisme i Habitatge" of the Generalitat Valenciana). Finally, a more detailed flood model was developed in order to define with more precision the areas

¹¹ Santiago Riera et al., "Variabilite Climatique, Occupation du Sol et Paysage en Espagne de l'Age du Fer a l'Epoque Medievale: Integration des Donnees Paleoenvironnementales et d'Archeologie du Paysage," in *Société et Climats dans l'Empire Romain*, ed. Ella Hermon, E. (Naples: Editoriale Scientifico de Naples, 2009), in press.

covered by seasonal flooding episodes, frequent in coastal Mediterranean environments¹².

Viewshed analysis was also performed to assess the differences in site distribution and visual dominion between those sites belonging to the Iberian and Roman periods. The existence of towers or lookouts inside the sites provided by the archaeological data was incorporated in the OFFSETA field on the site database. When this information was otherwise not available, the existence of a viewing height of 4 meters was assumed. Regarding the generation of viewsheds from Iberian sites, only those that showed continuous occupation since the Middle Iberian period were employed. Sites founded during the Late Iberian period, which did not display traces of Roman ceramics, were also included. Viewsheds from Roman sites were otherwise restricted to those sites of recent foundation and all those which showed previous Iberian occupation were discarded. As this article is interested in the sites displaying Roman settlement dynamics, the newly founded sites would provide more precise evidence and would avoid possible interferences from Iberian settling patterns in the analysis. Furthermore, it has to be taken into account that chronological and cultural site ascription was mainly based on survey-recorded sherd scatters. From a ceramic analysis perspective, the transitional phase between Iberian and Roman periods shows simultaneous use of both Roman and Iberian ceramic types for which it is difficult to be certain of the sites cultural ascription. Thus,

the approach followed intends to overcome these data biases.

As in the viewshed case, Least Cost Route analysis (LCR) was also carried out between the selected sites. Different cost surface models were employed in order to explore the adaptation of the proposed routes to the archaeomorphological study. It was also used to compare differences between hypothetical movements though the landscape from the Iberian to the Roman period.

3 RESULTS

Intensive field survey documented seventy-one archaeological sites, among which fifty-one show proof of Iberian or Roman occupation. On the basis of ceramic evidence they were chronologically attributed to different periods covering the Bronze Age to Late Medieval times. GPS recorded locations and attribute data were introduced into a GIS-linked database. Afterwards, data query procedures allowed the selection of Iberian and Roman sites and both chronologic and typological thematic maps were generated.

Archaeomorphological analysis produced a relative chronological stratification of paths within the examined area. The analysis highlighted a series of paths that linked some ancient *alquerias*¹³ in the study area. These paths displayed some morphogenic character¹⁴: they organize and distribute the landscape minor paths, field systems and sites. In fact many sites from different historical periods are associated to these major traces (fig. 3). Archaeomorphological analysis also permitted the identification of historically irrigated areas, a series of palaeorivers no longer in existence and a possible palaeowetland in the *Cortixelles* sector (fig. 3). Hydrologic modeling confirmed both the existence of the palaeorivers and a water accumulation area coincident with the paleowetland (fig. 4).

¹²Jose Ignacio Fiz and Héctor A. Orengo, "Simulating Communication Routes in Mediterranean Alluvial Plains," in *Layers of Perception. Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Berlin, Germany, April 2-6, 2007, Kolloquien zur Vor- und Frühgeschichte, vol. 10.*, ed. Axel Posluschny, Karsten Lambers, and Irmela Herzog (eds.) (Bonn: Habelt, 2008), 316-321; Josep Maria Palet, Héctor A. Orengo, and Jose Ignacio Fiz, "Análisis Planimétrico Digital de la Red Viaria y del Parcelario en el Ager Tarraconensis: Formas del Paisaje y Articulación del Territorio," *Anejos del Archivo Español de Arqueología*, in press.

¹³ Islamic village. The Islamic period in this area of Spain spans from the eighth the thirteenth century.

¹⁴ Gerard Chouquer, *L'étude des Paysages. Essais sur leurs formes et leur histoire* (Paris: Errance, 2000).

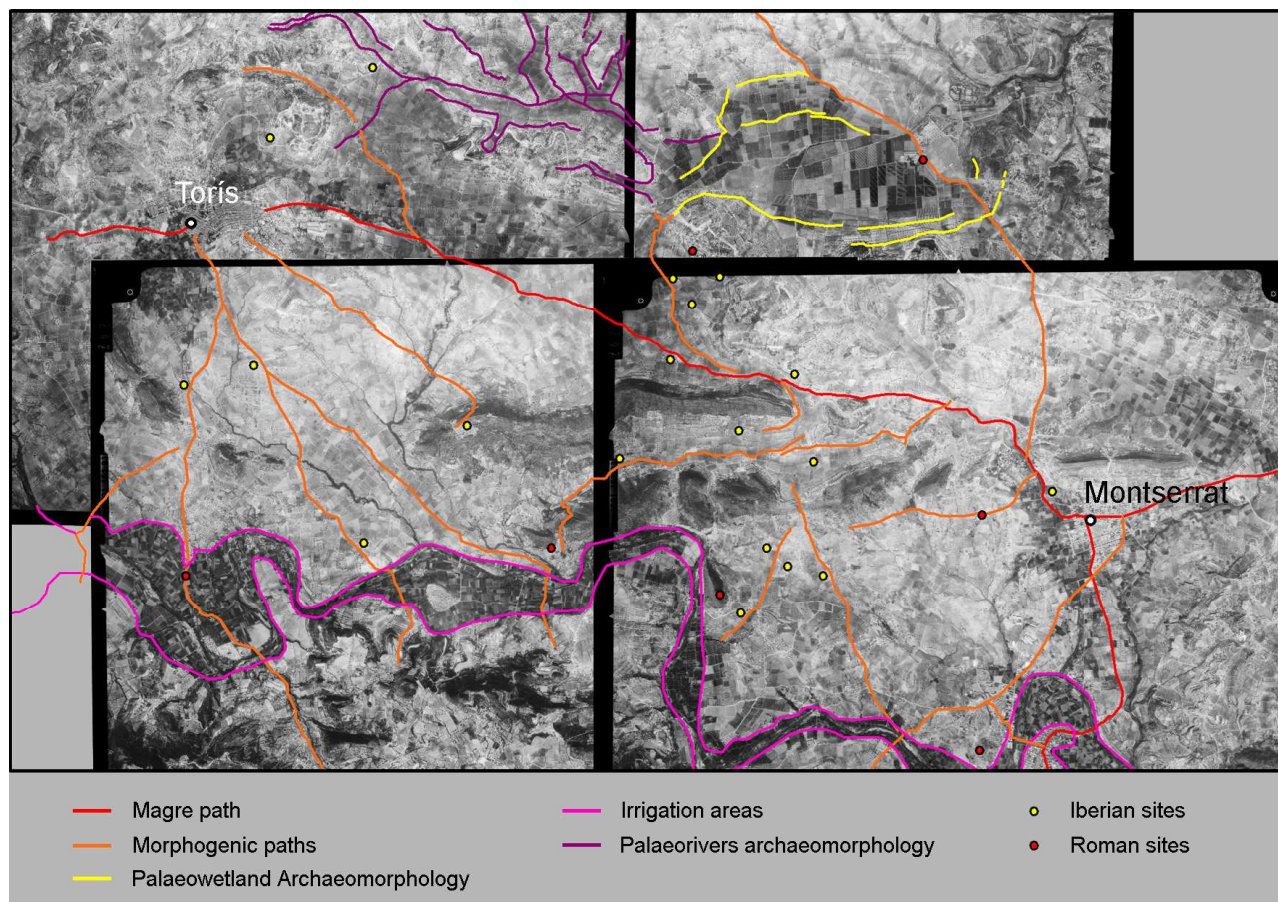


Figure 3. Archaeomorphological analysis of the study area

Multispectral imaging analysis revealed traces of buried paths and defined the extent of the palaeorivers network. Unsupervised classification of a Landsat image helped to define the areas with higher moisture content. As a result, the *Cortixelles* moisture accumulation area could be also confirmed. Finally, wide band aerial photography interpretation allowed the detection of a buried structure in the *Cortixelles* sector (fig. 4).

4 DISCUSSION: THE STUDY OF CONTINUITY AND DISCONTINUITY OF IBERIAN CULTURAL PRACTICES DURING THE FIRST STAGES OF ROMAN OCCUPATION

Archaeological literature has traditionally acknowledged a strong tendency towards the settling of flat areas in Roman times contrary to the Iberian preference of selecting elevated spots to

settle¹⁵. However, thematic maps show that *La Carència's* hinterland presents an Iberian settlement pattern characterised by the occupation of flat areas. The results of viewshed analysis from *La Carència* prove an absolute visual dominion of the city over its surrounding sites in that period (fig. 5). The proximity of the fortified city-state probably rendered the easily defensible spots unnecessary and the most suitable areas for agricultural purposes were accordingly selected, regardless of their defensive possibilities. Only the sites located at marginal areas where the city viewsheds were no longer effective are placed in prominent locations. This might be related to the

¹⁵ Helena Bonet and Albert Ribera, *La Conquista Romana y el Proceso de Romanización en el Mundo Ibérico. Romanos y Visigodos en las Tierras Valencianas* (Valencia: Museu de Prehistòria de València, Diputació de València, 2003), 88.

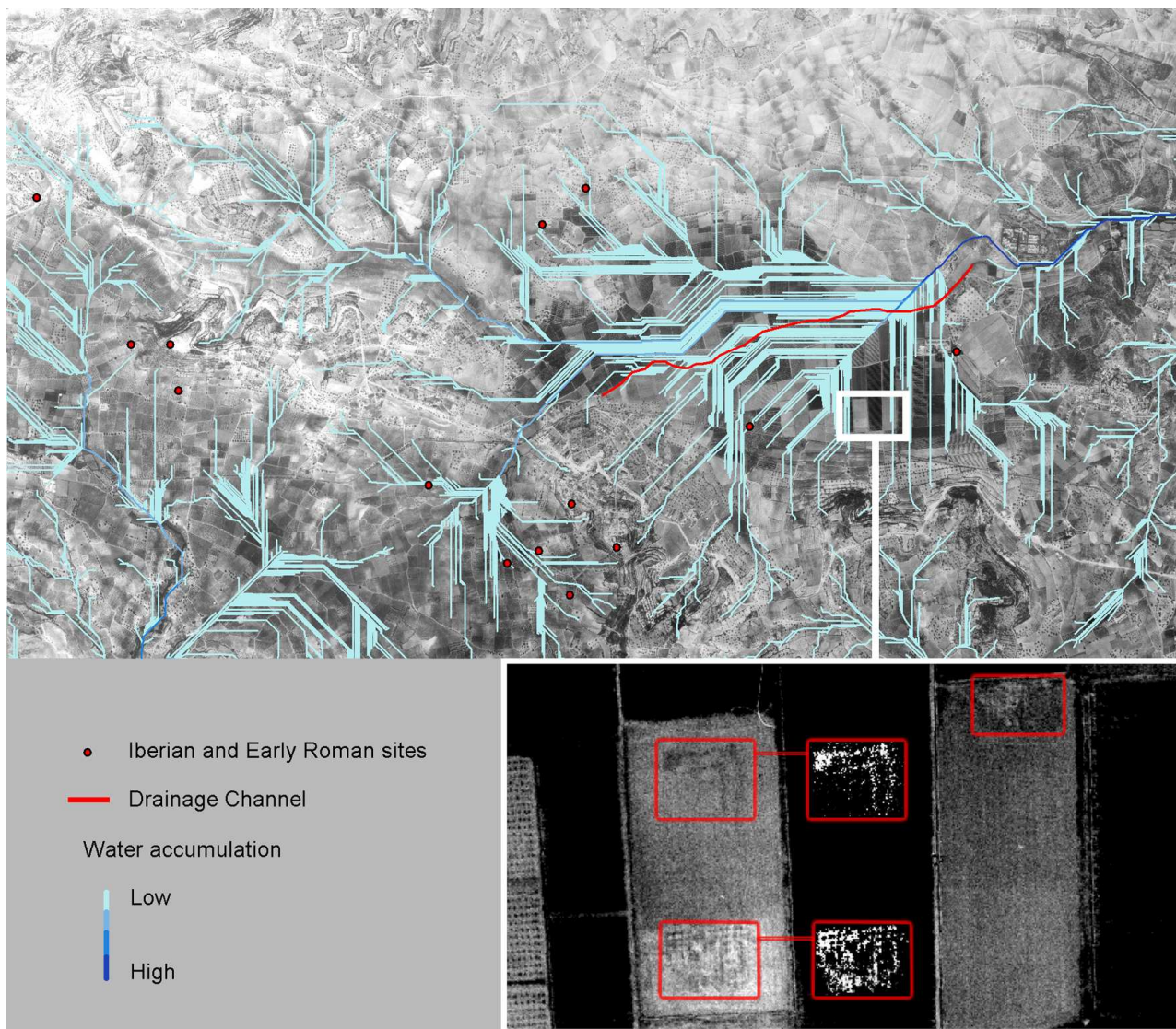


Figure 4. Water accumulation and detail of buried structures in the *Cortixelles* area

city's concern to control areas beyond its immediate surroundings. Future surveying works will help to define the settlement dynamics and the means of control on this territory's outlying areas.

Continuity is the main trend during the early stages of the Roman period; many Iberian sites continue to exist during the republican period. The location of most sites in flat areas is probably due to agricultural reasons. The spatial pattern of the newly founded Roman sites shows settlements on elevated positions, contrary to the common tendency of occupying flat areas (figs 5 and 6). The tendency towards a more significant site concentration alongside the *Magre* River may

explain the choice of an elevated settling as to avoid the river's periodical flooding episodes. In this respect, the flooding model evidences that Roman sites located in close proximity to the river are situated in non floodable zones (fig. 6). This underlines the Roman knowledge of the Mediterranean hydrologic system and the suitability of these elevated locations in such setting.

One of the most remarkable characteristics in the territorial organization of this area during both Iberian and Roman periods is the sustained importance of *La Carència oppidum* as a political centre. Despite the previously mentioned change in

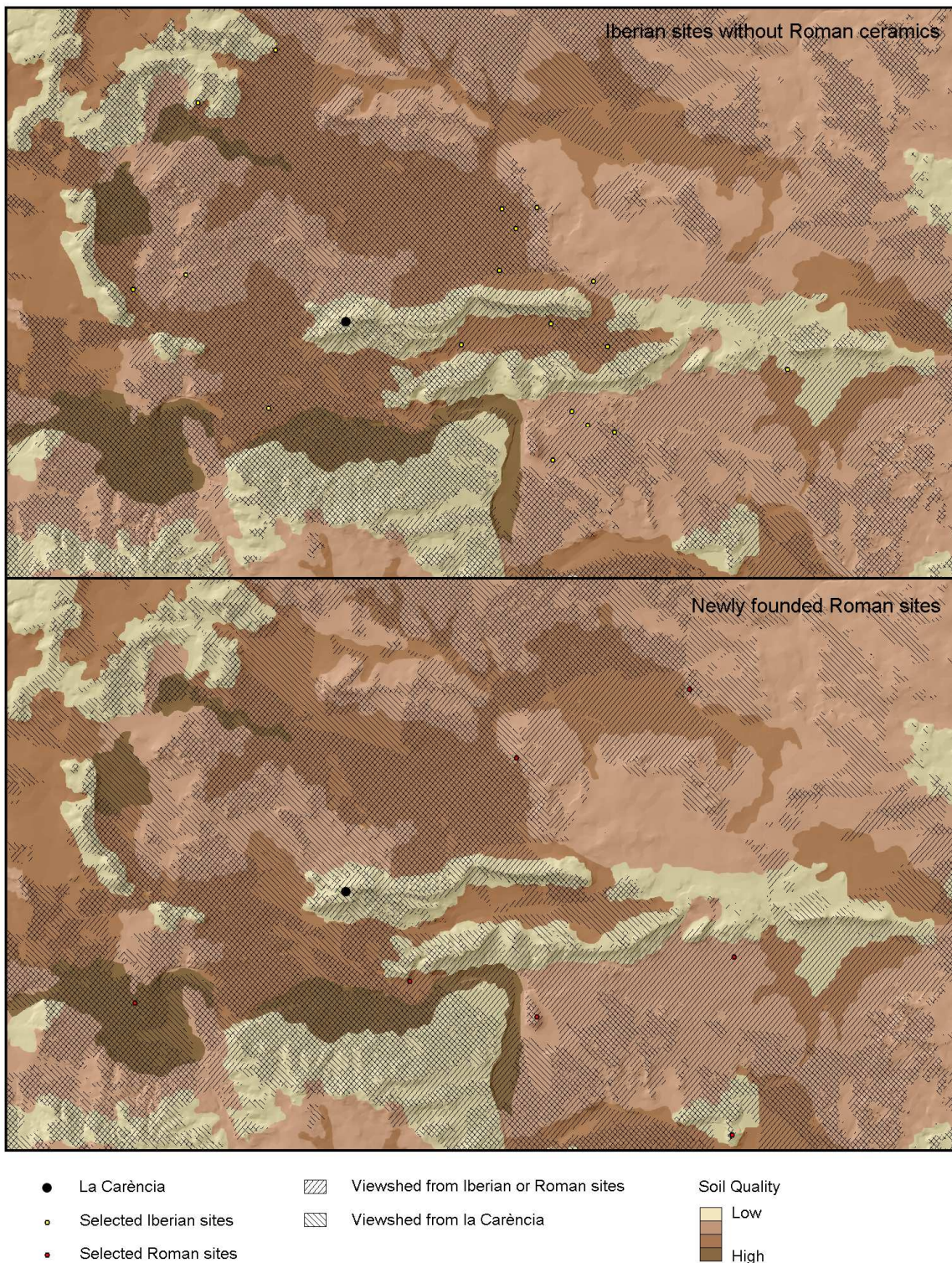


Figure 5. Viewsheds from the selected Iberian and Roman sites overlaid on a soil quality map

the settlement pattern, viewshed analysis results confirm that all new Roman sites maintain a direct visual relationship with *La Carència* (fig. 5) which

confirms the continuous relevance of this city as a territorial centre during Roman times. This tendency is consistent with that documented at

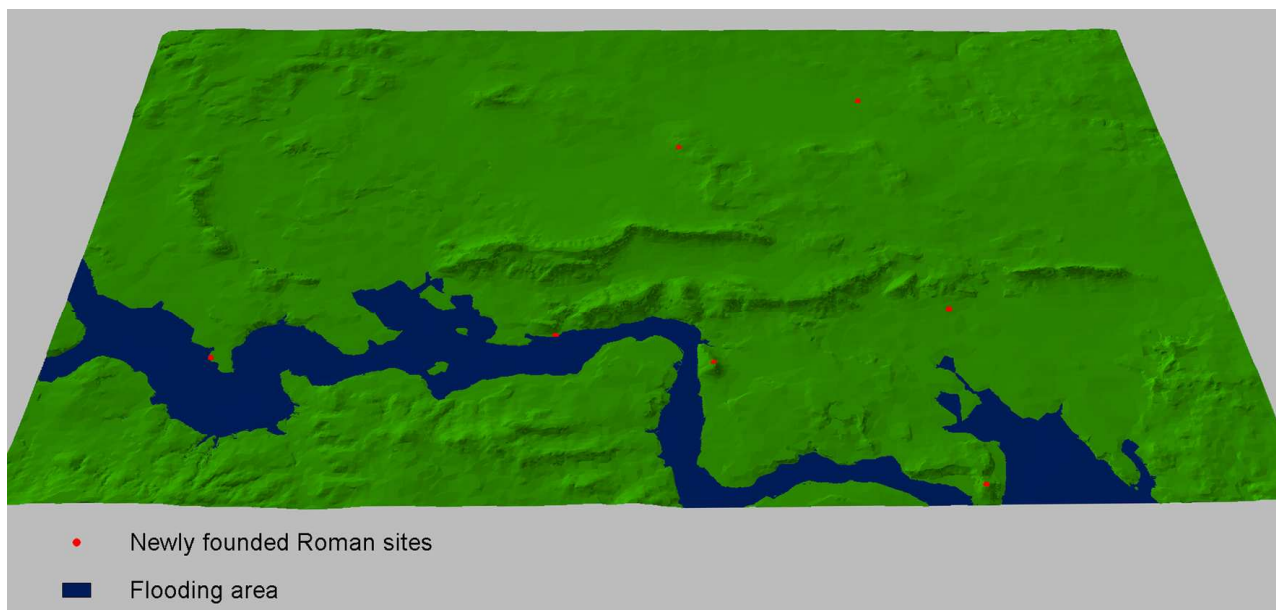


Figure 6. *Magre* River flooding area

other Iberian territories in which the traditional urban nuclei kept their role in structuring the landscape during the first stage of Romanization¹⁶.

The newly founded Roman sites exerted a strong visual dominion over the *Magre* River and its surrounding areas. The *Magre* basin has been considered as an important route towards inner areas as it connects the Iberian cities of *Kelin* and

*La Carència*¹⁷. However, the path which connected those cities was probably not located at the close vicinity of the river due to the difficult topography of the river basin and the river floods. It is, thus, more likely that this route coincided with the path that connected the towns of *Toris* and *Montserrat* (fig. 3). The distribution of several Iberian sites along this path might indicate this path existence and relevance within the local communication network at this moment. However, the subjacent link between this river's prominence and agricultural purposes has to be stressed as its periodically swamped surrounding areas present highly productive soils, (fig. 5) according to data supplied by the Regional Ministry of Environment, Water, Urban Development and Residential Planning (Conselleria de Medi Ambient, Aigua, Urbanisme i Habitatge, of the Generalitat Valenciana). Equally, water from the river could have been used to irrigate farmland crops in these deep soils. It has generally been acknowledged that

¹⁶ Ferrán Arasa, *La Romanització de les Comarques Septentrionals del Litoral Valencià. Poblament Ibèric i Importacions Itàliques en els Segles II-I a.C.* (Valencia: Servicio de Investigación Prehistórica. Diputació Provincial de Valencia, 2001), 31; Ignaci Grau, "Romanization in Eastern Spain: A GIS Approach to Late Iberian Iron Landscape," in *Temps et Espaces del l'Homme en Sociéte, Analyses et Modèles Spatiaux en Archéologie, XXVe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*, dir. Jean-François Berger, Frédérique Bertoncello, Frank Braemer, Gourguen Davtian, and Michiel Gazenbeek (Antibes: Éditions APDCA, 2005), 325-334.

¹⁷ Helena Bonet and Consuelo Mata, "Organización del Territorio y Poblamiento en el País Valenciano entre los Siglos VII al II a.C.," *Bibliotheca Archaeologica Hispana* 8 (2001): 176-178; Rosa Albiach et al., "Prehistoria i Historia Antiga," in *Turis, Geografia, Història, Art*, VVAA (Valencia: Universitat de Valencia, 2007), 97.

irrigation agriculture had been introduced in the Iberian Peninsula during the Roman period. While it has not been yet proved the use of irrigation practices during Iberian times¹⁸, Roman use of irrigated crops has been widely acknowledged¹⁹.

Another indication of this Roman tendency towards a higher agricultural production can be observed in the *Cortixelles* area. The results of the archaeomorphological analysis, hydrologic modeling and multispectral imagery classification show the simultaneous existence of a palaeowetland at this spot. Early Roman and pre-Roman sites avoided this area and its palaeorivers (fig. 4). However, wide band aerial photography recorded a buried structure inside this palaeowetland which closely resembles a Roman villa plan. The finding of surface Roman pottery in this area is otherwise consistent with this hypothesis. All these data suggest a temporary desiccation of the palaeowetland after the Early Roman period. Fieldwalking also provided data on the existence of a drain that traversed the lower axis of the palaeowetland. The presence of this drain (fig. 4) seems to confirm the wetland desiccation. The stratigraphy of this channel shows four different construction phases, a fact that

suggests a prolonged use of this structure. The flat surface and its rich soils made the area highly valuable for cultivation, reason for which the drainage was presumably performed and the villa site established. A similar process of desiccation by means of drains has been profusely documented in wetlands during Roman times²⁰.

3 CONCLUSIONS

In this first approach to the archaeology of this study area, the use of GIS and other digital techniques have been invaluable to generate initial work hypotheses which now should be tested by case-directed fieldwork.

Settlement patterns do not show evidence of a major shift during the Romanization process although there is evidence of new agrarian preferences. This might be appreciated in the integration of areas which required complex technical skills and an elevated degree of environmental knowledge to be effectively exploited. In this sense, the results exposed suggest that wetlands were drained, flooding soils were agriculturally exploited and new areas were inhabited due to a shift towards a more intensive

¹⁸ José Luis Araus et al., Identification of Ancient Irrigation Practices Based on the Carbon Isotope Discrimination of Plant Seeds: a Case Study from the South-East Iberian Peninsula,” *Journal of Archaeological Science* 24 (1997): 729–740

¹⁹ Philippe Leveau, “Irrigazione, Drenaggio e Economia Demaniale Romana nelle Pianure del Basso Rodano : l’Apporto delle Ricerche Geoarcheologiche nella Valle dei Baux,” in *Uomo Acqua e Paesaggio*, Atti dell’Incontro di Studio: Irreggimentazione delle Acque e Trasformazione del Paesaggio Antico. S. Maria Capua Vetere, 1996, 22-23 Novembre, ed. Lorenzo Quilici and Stefania Quilici (Roma: L’Erma di Bretschneider, 1997), 301-310; María Juana López, “El Agua en el Sureste Peninsular durante Época Romana: su Aprovechamiento para la Agricultura,” in *Agricultura y Regadío en Al-Andalus, Síntesis y Problemas: Actas del Coloquio, Almería, 9 y 10 de Junio de 1995*, coord. Lorenzo Cara and Antonio Malpica (Almería: Instituto de Estudios Almerienses, 1995), 13-16.

²⁰ Knut Ødegård, “Drainage and Colonization: the Case of Cales,” in *Uomo Acqua e Paesaggio*, Atti dell’Incontro di Studio: Irreggimentazione delle Acque e Trasformazione del Paesaggio Antico. S. Maria Capua Vetere, 1996, 22-23 Novembre, ed. Lorenzo Quilici and Stefania Quilici (Roma: L’Erma di Bretschneider, 1997), 213-223; Giovanna Cera, “Interventi di Bonifica nella Piana Spoletina su una Presunta Bonifica Teodoriana nei Pressi di Spoleto,” in *Uomo Acqua e Paesaggio*, Atti dell’Incontro di Studio: Irreggimentazione delle Acque e Trasformazione del Paesaggio Antico. S. Maria Capua Vetere, 1996, 22-23 Novembre, ed. Lorenzo Quilici and Stefania Quilici (Roma: L’Erma di Bretschneider, 1997), 335-350; Philippe Leveau, “Arles et les Plaines du Bas-Rhône dans l’Antiquité: Colonisation Militaire Romaine et Milieu Naturel (A Propos des Moulins de Barbegal et du Canal de Marius,” *Geographia Antiqua* II (1993): 51-62.

agricultural production. The landscape was apparently rearranged with the purpose of creating a new space to be inhabited and exploited during Roman times.

GIS was also useful in providing a first landscape assessment thanks to which future work can be planned. In this regard, the discovery of a palaeowetland through a combination of GIS and Remote Sensing will facilitate in obtaining a palaeoecological register by coring the drainage channel located at *Cortixelles*. The palaeoecological and geoarchaeological study of this profile may provide data for the reconstruction of human environment interactions during the Iron Age - Roman transition. This will aid in addressing questions such as the introduction of irrigated crops in Roman times, the extent of desiccation

processes and other Roman landscape rearrangements or the importance of pastoralist activities in their economy. Future survey work will also be directed towards the confirmation of the results from the archaeomorphological analysis, particularly, the relationship of major morphogenic paths and the Iberian and Roman sites distribution.

Finally, data drawn from this case study has shown how a sensitive combination of GIS-based techniques and Remote Sensing can offer valuable insights on to the shaping of landscapes and the role humans played on it. These techniques are thus highly useful in aiding and complementing more traditional archaeological approaches to the analysis of ancient landscapes.

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