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Spina revisited: the 2008 geophysical prospection in the light of the excavation results

In 2008 the British School at Rome (BSR) and Archaeological Prospection Services of Southampton (APSS) conducted a geophysical survey at the Etruscan site of Spina (Comacchio, Emilia Romagna) on the behalf of the University of Southampton, the University of Zurich and the Soprintendenza Archeologia, Belle Arti e Paesaggio per la Città Metropolitana di Bologna e le Province di Modena, Reggio Emilia e Ferrara. The survey was conducted during a period of excavations in a central area of the site and aimed to place the excavation results in a wider context. This paper re-examines the geophysical survey results ahead of a new programme of research being led by the University of Bologna.

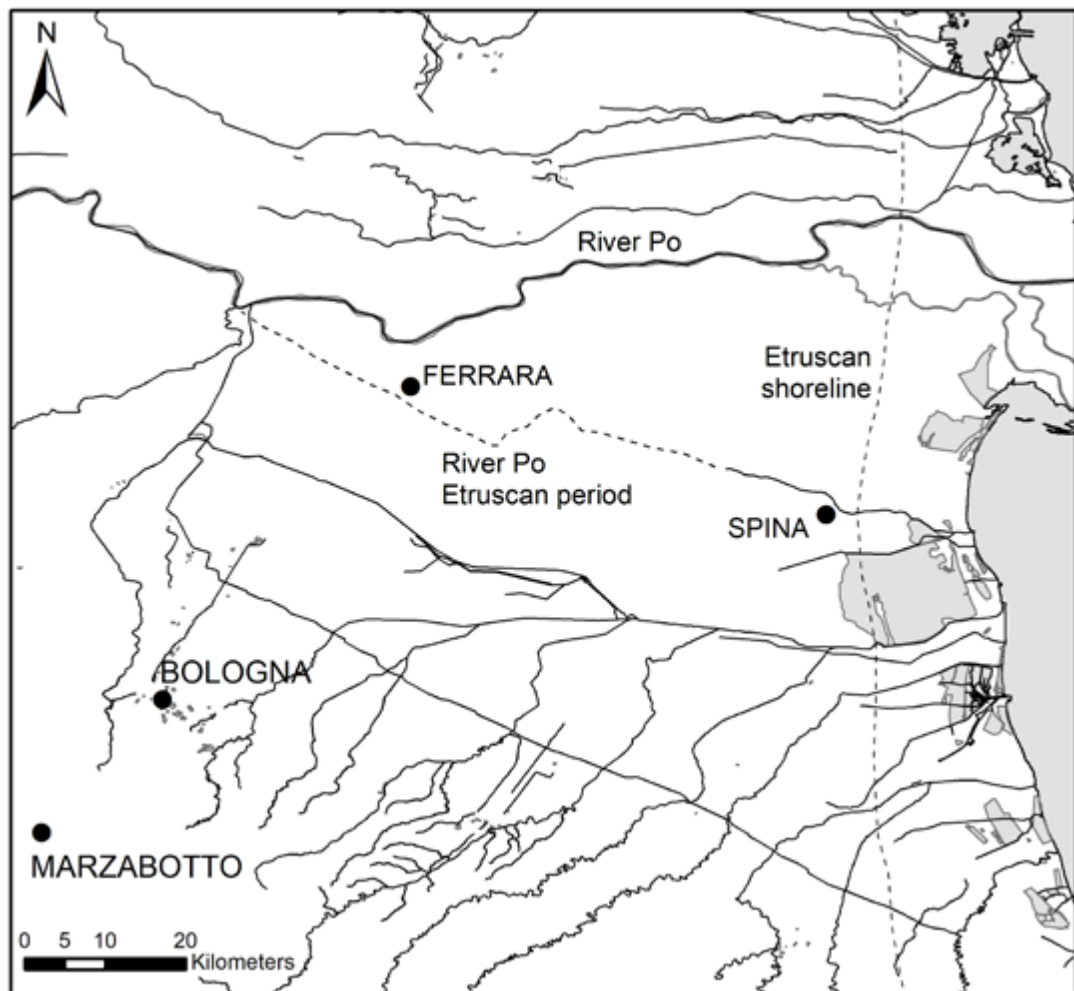
Introduction

The Etruscan site of Spina, founded in the second half of the 6th century BC, was discovered in the late 1950s during a programme of land reclamation work that drained the Valli di Comacchio (Fig. 1). Previous work had discovered the rich cemeteries in the Valle Trebba, recently the subject of a new research project (Govi, 2017) and Valle Pega (the lagoons around Spina) with over 4000 tombs now having been documented. When identified, the site of Spina had already been damaged by dredging activities and the construction of a large drainage canal that divides the site. From 1965 onward a series of archaeological excavations began, the first immediately to the north of the aforementioned Canale Mezzano which brought to light parts of the habitation and a north – south channel 8m in width. The sides of the channel were reinforced with wooden posts, and evidence was recorded of perpendicular narrower east-west channels leading away from the main channel (Zamboni 2016b, 131). Subsequently a series of excavation campaigns were undertaken on the opposite bank of the Canale Mezzano as well as to the north in order to try to define the extent of the site.

The geophysical survey formed part of a new programme of excavations that begun in 2007 led by the University of Zurich and the Soprintendenza Archeologia, Belle Arti e Paesaggio per la Città Metropolitana di Bologna e le Province di Mo-

dena, Reggio Emilia e Ferrara¹. The aim of the survey was to assist in establishing the size and urban nature of the site as well as provide further detail to the central area of the settlement. The results of part of the geophysics were published in an article by Izzet (2010) which discussed aspects of urbanisation that were revealed by the survey. However, the uniqueness of the site for geophysical prospection and the later excavations provides an opportunity to look more in depth at the full results of the survey².

Fig. 1. The location of the Etruscan cities of Spina and Marzabotto.



- 1 The survey was undertaken on the behalf of Vedia Izzet with the support of Christoph Reusser and the then Soprintendenza per I Beni Archeologici dell'Emilia Romagna.
- 2 The text will use the generic term 'excavations' to refer to all excavations undertaken at the site, regardless of the institution.

The environmental setting

The site of Spina was situated in fertile alluvial wetlands alongside a minor river that was a branch of the River Po. It lay close to the mouth of the river, although today lays 12km from the coast as by the 9th century AD the river had dried up and the coastline had substantially retreated (Fig. 1).

Excavations have shown that the city was created on a series of artificial islands where the ground level was constantly raised and stabilised using tree trunks, reeds, branches and other organic materials (Zamboni 2017, 52; Cappuccini and Mohr 2017, 25). The location of Spina at the mouth of the river was strategically important for its role as one of the principal commercial centres of Etruria Padana (Fig. 1). Despite its estimated small size in comparison with other Etruscan cities such as Marzabotto (30 hectares) or sites in South Etruria such as Tarquinia (120 hectares) and Vulci (90 hectares), the archaeological evidence indicates, in particular through the discovery of quantities of Greek amphorae, that Spina was a commercial port but also a city in its own right (Gras 1994, 63). Whilst Spina was closely tied with Bologna, it seems it performed a different function to the city – port relationship seen elsewhere, such as Caere and Pyrgi or Vulci and Regisvilla. The town functioned more as independent centre, as testified by the evidence that it was one of the few Etruscan cities (together with Caere) to have a treasury at the sanctuary of Apollo at Delphi.

Survey methodology

The geophysical survey at Spina, conducted in February 2008, covered a total of 10.5 hectares divided across three areas (Fig. 2)³. As noted above, an aim of the survey was to test the application of geophysical prospection at the site, as well as to verify the extent of Spina and locate previous excavation trenches (Izzet, 2010: 118). The form of settlement, with wooden structures and a network of channels, would be expected to appear in the archaeological record as a series of post-holes and ditches, therefore it was decided to investigate the site using magnetometry. The technique records the positive magnetic infill of these features against the homogenous neutral background, whilst also recording positive features such as hearths or furnaces.

The survey was undertaken using Bartington Grad 601 fluxgate gradiometers with data collected in regular 30m grids with a sample interval of 0.25m and zig-zag traverses at an interval of 0.5m (Fig. 3).

3 The survey was undertaken by a joint team from the Archaeological Prospection Services of the University of Southampton and the British School at Rome.



Fig. 2. Geophysical survey areas at Spina.

ge of structures, discussed below. In terms of the geophysical prospection results, magnetometry was shown to be a suitable technique. Other methods commonly used, such as Ground-Penetrating Radar and electrical resistivity would presumably be significantly more affected by the high water-table. Furthermore, the nature of the alluvial sediments that filled the valley allowed features to be recorded by the gradiometry to a considerable depth.

The survey to the north of the 'Collettore Mezzano' canal covered an area of approximately 5.5 hectares in a flat and open field with some north-south divisions generated by disused drainage ditches (Fig. 4). An open excavation was located in the central area and was surrounded by large spoil heaps, therefore preventing the collection of data. To the south of the canal a second area of 1.5 hectares was investigated which surrounded open excavations. In the same way as the survey to the north, the area of investigation was limited due to large spoil heaps that lay along the field boundaries. The third area of approximately 3.5 hectares lay to the south east and extended for 400m. The study area had previously been divided into 50m quadrants with metal poles used as markers, which are visible in the magnetic data as circular features of no data.

The methodology adopted by the 2008 survey was successful in mapping a ran-

Survey results

The magnetometer survey was divided across three areas (Fig. 5). The majority of the archaeological features were recorded in the northern area of the survey (Fig. 6), as well as potential further features in the south-eastern area (Fig. 8).

The survey in the northern area recorded a range of positive and negative magnetic features against a general low magnetic background reading. The results have been summarised in an interpretation plan (Fig. 7), based upon the geophysical survey and information deriving from published excavations. The magnetic data follows a regular pattern, with rectangular areas measuring approximately 70m by 17m, interspaced with areas of low magnetic noise, ranging around 3.2m in width. The positive anomalies that were recorded have a regular linear geometry and are also scattered, a reflection of the different types of materials that were recorded and the organisation of space. Immediately to the south of the central excavations (area of



Fig. 3. Magnetometer survey at Spina (Photo Sophie Hay).



Fig. 4. Survey area to the north of the 2007-2009 excavations (Photo Sophie Hay).



Fig. 5. Magnetometer survey results.

gular feature on a different alignment (northwest -southeast) was recorded, at approximately 17m to the west on the defined edge noted above.

The central survey area to the south of the 'Collettore Mezzano' and the earlier open excavations was affected by the limited space available and the disturbance caused by these excavations, as well as excavations which were ongoing at the time of the survey. In the eastern part a continuation of the paleochannel was recorded, identifiable by the low magnetic readings relating to the build-up of alluvial

no data) the readings were affected by stronger magnetic disturbance, however a number of features, in particular a north-south stretch of lower background readings were recorded.

In the east section of the central survey area, the magnetometer survey recorded broad geological features that appear to be associated to an earlier river channel. This follows the same alignment as the feature recorded to the southwest and traverses the area in a northwest-southeast direction, creating a triangular shape to the area of positive magnetic readings. The magnetometer readings provide a clear edge, suggesting that the river channel was contemporary with the archaeological features.

To the west in the central area the positive and negative features have a clear north-south edge, beyond which the magnetometer survey recorded very low magnetic readings. In the southwestern area a rectan-

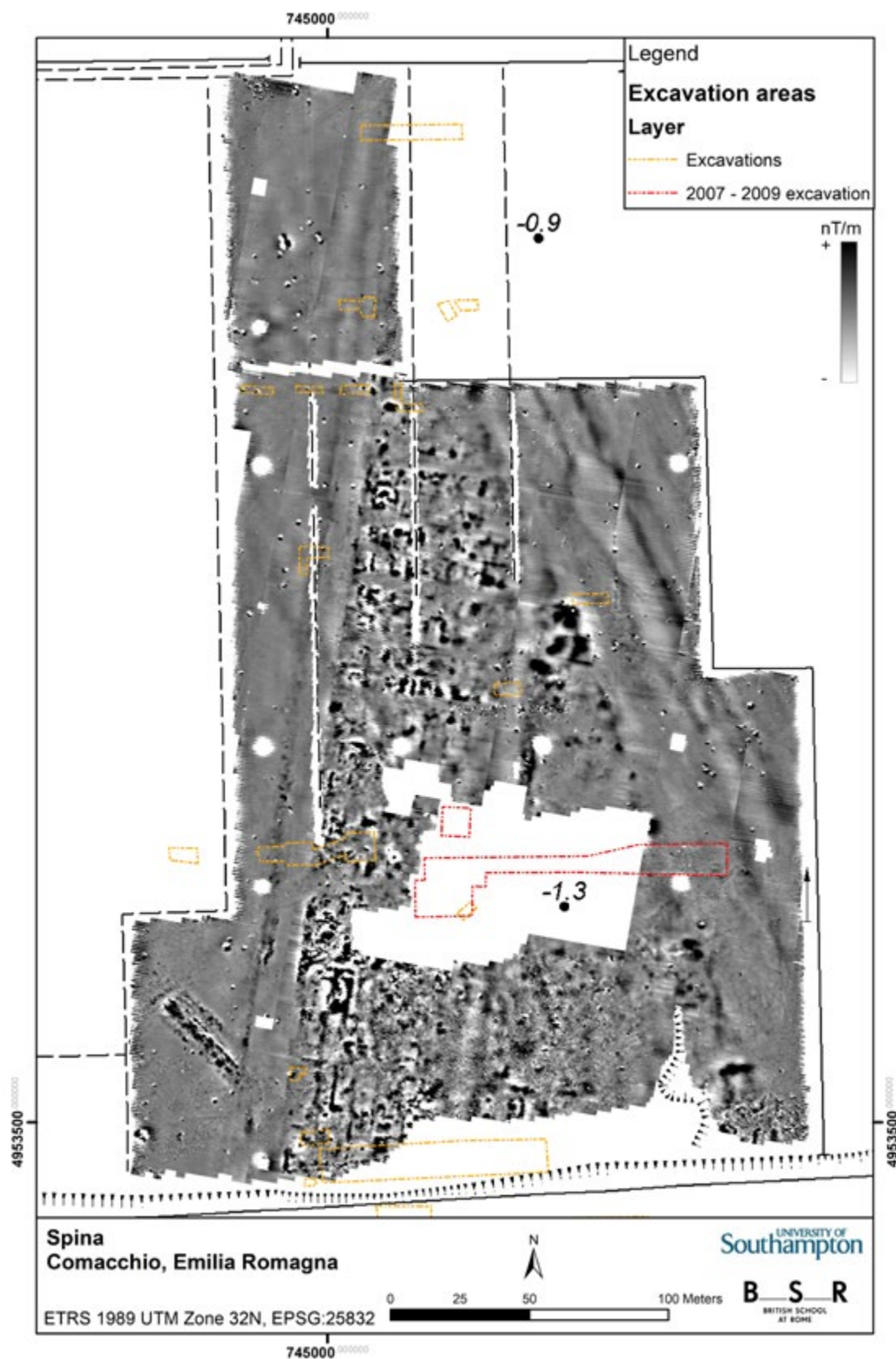


Fig. 6. Detail of the magnetometer survey results of the northern area.

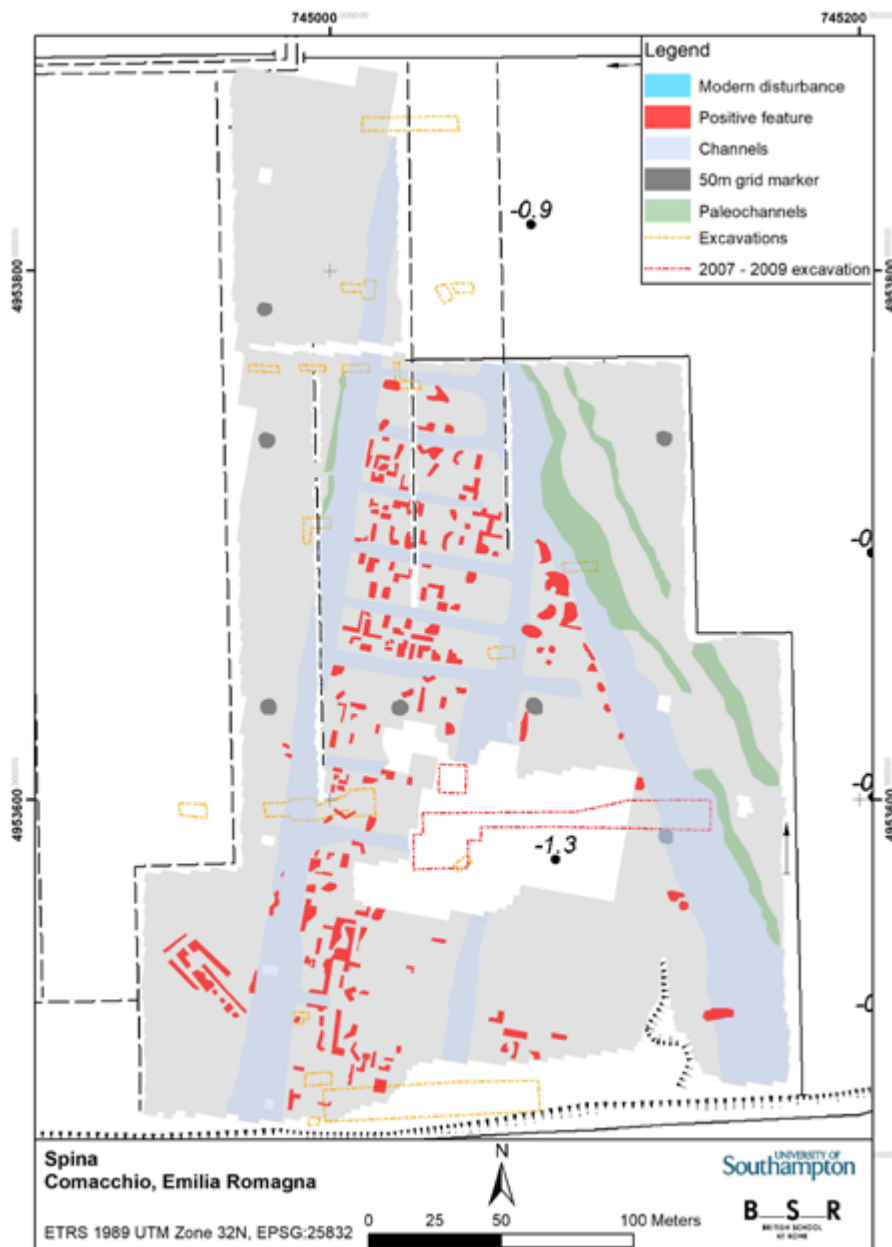


Fig. 7. Interpretation of the magnetometer survey results.

recorded against the weaker background value. At the eastern extent of the survey, the magnetometer survey recorded numerous positive features, interspersed with multiple strong magnetic dipole readings. Whilst these readings mask the less magnetic features, it is clear that there is considerable anthropogenic activity in this area of the site. The strength and alignment of the magnetic dipole anomalies suggest that they are contemporary with the positive linear anomalies. These may therefore be a result of cultural activity in the area, such as production or heaths, that have a significantly stronger magnetic field. Overall, there is a clear indication

soils that subsequently filled the channel. In a more central area, immediately to the south of the excavations, an area of both positive and negative anomalies was recorded, similar to those to the north of the modern channel. The limited size of the study area restricts the interpretation that can be made of the features.

The previous publication of the geophysical prospection results (Izzet 2010) presented the findings from the central area, as the focus was upon the clear traces of the settlement organisation that had been recorded. However, the 2008 survey also extended to the southeast, covering an area of approximately 3.5 hectares (Fig. 8). The paleochannels, recorded as irregular positive features in the dataset to the north were also mapped in the south-eastern area (Fig. 9). Furthermore, several backfilled trenches (probably relating to the excavations of 1973) were also re-

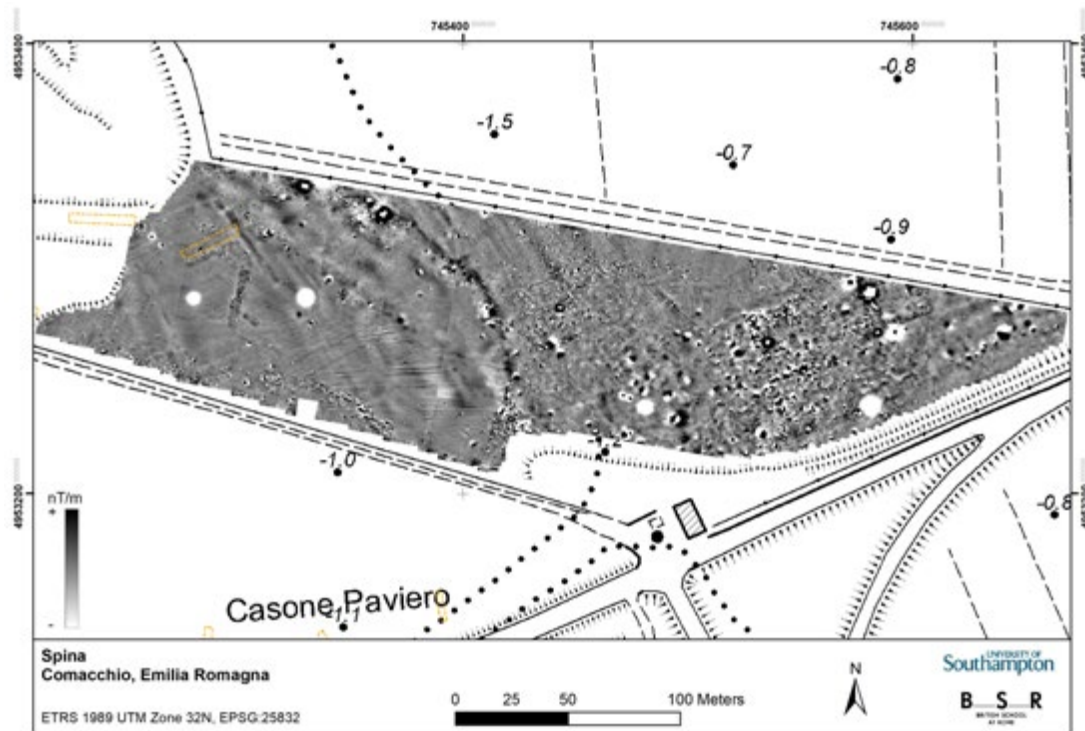


Fig. 8. Magnetometer survey results in south-eastern area.

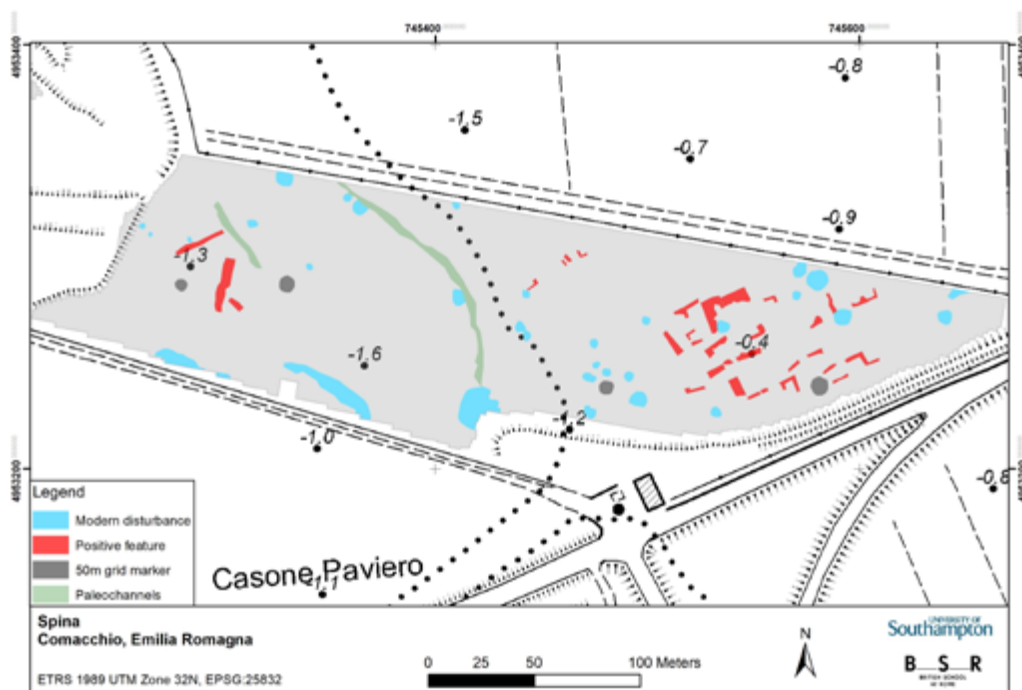
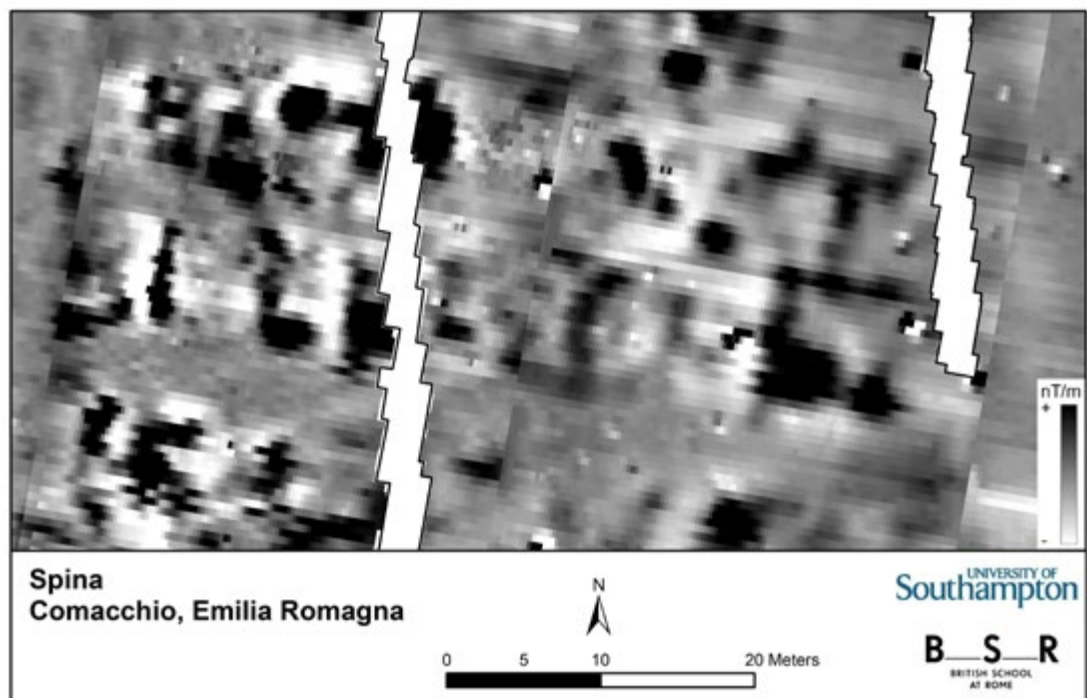


Fig. 9. Interpretation of the magnetometer survey results in south-eastern area.

Fig. 10. Detail of the magnetometer survey results of one insula.



of activity on an approximate east-west alignment with some indication of channels as noted in the survey area to the north.

Discussion

The excavations conducted at Spina provide an opportunity to better understand the typology of the features that were recorded by the magnetometer survey. Furthermore, as Spina was abandoned by the third century BC (Desantis and Gaucci, 2019) and never reoccupied, the site provides an opportunity to assess the Etruscan layout of the settlement. Other Etruscan centres that were conquered and settled by the Romans, such as Veii and Vulci, had much of their urban settlement pattern destroyed or obscured in the archaeological record by the continued occupation of the site.

The site of Spina has been shown through the excavations to have been created on a series of partially artificial islands divided by one main central channel and various other smaller channels. This division has been interpreted as the islands representing individual *insulae* following an urban pattern recorded at other sites of the 5th century BC such as Marzabotto (Govi et al, 2020). This urban system of waterways is seen in the geophysical data as a series of linear low magnetic anomalies, with the north – south channel the widest of the features. At regular intervals, in particular to the west of the central channel, other narrow long linear features were recorded that relate to the smaller waterways separating the *insulae*. Excava-

tion has revealed that the central channel, between 8–10m in width and recorded over a distance of 300m, was reinforced at the edges by two rows of vertical posts and horizontal planks. In terms of the survey results, it therefore appears that the fluxgate gradiometer recorded the negative fill of the channel, which differed to the positive values of the areas of habitation. Furthermore, excavation has shown that the edges of some channels, whilst lined with rows of wooden posts, were also filled behind with large fragments of ceramic vases and amphorae (Cappuccini and Mohr 2017, 25). This regular use of fired material may have also helped to define the edges of the waterways.

As noted by Zamboni (2017, 52) the individual *insulae* were sometimes also divided by smaller channels that separated the houses. These features appear in some areas of the magnetometer survey as narrow linear negative anomalies, however excavation has shown that pottery was regularly discarded into these channels in huge quantities, with these features originally being misinterpreted by the early excavators as walls made of ceramic material (Zamboni 2016b, 133). If these channels had substantial quantities of dumped pottery, these features would be recorded by the magnetometer as positive features.

The geophysical survey of the central area at Spina recorded a series of houses with probable internal subdivisions. The recent excavation of a house (Cornelio Cassai *et al.*, 2013) provides the opportunity to examine in detail the features that were recorded by the geophysical survey. The magnetometer recorded a series of rectangular areas on an approximate east–west alignment, measuring 70m by 17m (Fig. 10). Within these blocks of both positive and negative anomalies areas of lower readings were recorded on a north–south alignment at approximately 8.5m, and east–west at 35m. This division fits with the layout that was recorded by the excavation, whereby a house (in the 6th century BC) occupied an area of circa 8m by 7.2m, and one *insula* was composed of four houses (Zamboni 2016, 135).

The construction style in the earliest phase (late 6th century BC) made use of joined wooden planks, reeds and unfired clay for the walls and roofs constructed of reeds and hay (Zamboni 2017, 55). The organic materials used would provide little trace in the geophysical record in terms of their magnetism, although there are some examples of the use of plaster slabs as a form of protection from dampness and this material may perhaps be detected by the magnetometer. Therefore, whilst the geophysics recorded the overall layout of an *insula* and houses, it difficult to associate the features, such as the linear positive anomalies, as belonging to this first construction phase.

In the second phase, dated to the beginning of the 4th century BC the excavations revealed that there was a change in construction style with the use of shallow foundation trenches (0.2 – 0.3m) with post holes but importantly also the use of terracotta tiles laid horizontally and vertically which were used to prevent humi-

dity in the overlying wooden beams (Cappuccini and Mohr 2017, 22). Therefore, as the roofs were still made of reeds and hay, the floor of unfired pressed clay and sand, the threshold of stones and cobbles, it seems likely that the geophysical survey recorded these wall foundations as well as the small hearths (measuring approximately 0.80m by 0.50m). The linear features, clearly recorded at the eastern end of the *insula* in Fig. 10, may therefore be associated with these foundation preparations. The *insulae* also contained areas outside of the houses which have been identified as workshops. Evidence for this comes from the excavation of a small forge for metal working that was excavated. These areas of activity, and in particular a furnace, would have been recorded by the magnetometer survey. This would therefore explain some of the less regular positive features that were recorded within the individual *insulae*.

The 2007 excavation also recorded evidence for the destruction of the house in the final phase, seemingly caused by a fire (Cappuccini and Mohr 2017, 21). Whilst the burnt organic material will not have been recorded by the magnetometer, the layer contained clay that had been exposed to intense heat as well as ceramics, which together will have created a positive magnetic anomaly. This destruction layer may be the cause of some of the larger areas of positive readings, where the concentration of pottery masks deeper less magnetic features.

A further feature of interest recorded by the magnetometer survey lies to the southwest of the central survey area, 50m to the north of the Canale Mezzano. The set of positive anomalies are on a different alignment to the *insulae* that have been recorded 17m to the east. The features are separated by a wide north-south area of low magnetic readings that are interpreted as a water channel running along the western edge of the *insulae* blocks. The set of positive readings form a rectangular shape, 45m in length and 14m in width. The anomalies have been interpreted a potential mole (Zamboni 2016b, 140, Tav.4) as a further paleochannel has been hypothesised to the west, beyond the magnetometer survey. The feature is of particular interest as it appears to be contemporary with the other geophysical features, on the basis that it respects the north-south channel, but lies on a different alignment to all the other magnetic features recorded by the survey. Likewise, as noted in the south-eastern area of the survey, areas of backfilled excavations also show against the weaker background magnetic readings. It is therefore a further hypothesis that the long rectangular area may also represent the location of an earlier excavation.

A comparison with the geophysics undertaken at Spina can be made with early geophysical surveys conducted in 1981 and 1983 at the site of Forcello di Bagnolo S. Vito by the Fondazione Lerici using a proton gradiometer (De Marinis 1988) and a recent new survey of the site using multiple fluxgate gradiometers conducted by the Deutsches Archäologisches Institut (Komp *et al.*, 2020). The survey conducted by the Fondazione Lerici covered an extent of around 6 hectares and

was successful in recording areas with a density of ceramic material. Furthermore, the survey also recorded blocks of higher magnetic intensity aligned in a NE-SW direction as well as a central road which was subsequently confirmed through excavation. The houses of Forcello also followed a similar style and dimensions, with houses measuring 17m by 10m. The recent new study at the site completed using a multi-channel fluxgate system re-examined part of the area investigated by the earlier work but also extended the survey, revealing traces of an embankment as well as multiple buildings (Komp *et al.* 2020, 236).

The geophysics results of the central area of the 2008 survey at Spina were published by Izzet, including an interpretation of the magnetometry data (Izzet 2010, Plate 1, 2). A schematic interpretation was subsequently proposed by Zamboni (2016a, 41; 2016b, 140; 2017, Table 27a) using additional locational data from the excavations at Spina. In the light of the various excavations that have followed the 2008 geophysical survey, there is an opportunity to update the previous interpretation of the geophysics (see Figs. 7 and 9). The original interpretation, and Zamboni's later synthesis, identified the broad features, such as the north-south channel and the positive linear features on each of the *insulae*. However, the excavations confirmed that the east-west anomalies were also water channels, although much narrower. It is unclear from the magnetometer data if these channels also existed to the east of the main north-south channel, as has been hypothesised by Zamboni (2016a, 41). Likewise, the smaller channels within an individual *insula*, are now recognisable in some areas of the geophysics and positive linear anomalies can be associated to the foundations of houses (Fig. 10).

Conclusion

The site of Spina offered a unique challenge for a magnetometer survey of an urban centre. In the absence of walls and floors constructed from stone or brick, it relied upon the presence of filled channels, ceramic materials, hearths and furnaces to provide an indication as to the potential layout of the town. The Etruscan sites in Etruria Padana region such as Spina, Marzabotto and Forcello appear to differ from those in South Etruria, such as Tarquinia and Veii, by implementing regular urban grids, although at Spina the roads were substituted by a network of waterways. Recent geophysical surveys at Veii (Campana 2019) and at the Città di Tarquinia (Bagnasco *et al.*, 2018) have shown that these sites did not follow a strict plan and seemingly developed according to the local topography of the plateaus on which they were built. However, the geophysical survey at Spina illustrates that there existed as early as the beginning of the 5th century BC an urban framework model which divided the cities into distinct spaces. The geophysical survey at Spina does not appear to have recorded areas of public space in the Etruscan town such as been recorded at the regularly laid out city of Marzabotto where the main temple

neatly fitted into the plan (Smith 2014, 69). However the survey has recorded the urban organisation, where a network of water channels were constructed in place of roads and artificial islands were the equivalent of *insulae*.

The reassessment of the 2008 geophysical survey at Spina has illustrates how excavation data can inform the interpretation of the geophysics, and vice versa. The need for an open dialogue between geophysics and archaeology, as has been argued elsewhere (Keay *et al.*, 2008), shows how much more can be learnt from a dataset. In the case of Spina, following the recent excavations, a revision of the magnetometer data has revealed more details about the Etruscan city. One aspect that requires further investigation is the extent of the site. The 2008 survey was limited by modern field boundaries that may not reflect the true extent of the site. It remains unclear if the excavated area represents just one island group of dwellings, with other beyond the limits of the survey. Indeed, the results of the survey in the southeast area, whilst less coherent than the northern area, suggest that there was also settlement activity in this area. Future investigations may perhaps extend the geophysical survey further to the east to assess the extent of this activity.

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