The City Beneath the Soil: Mapping a Roman Town with Caesium Vapour Magnetometry

A team of scientists from the University of Nottingham and the University of East Anglia (UK), describe procedures and instruments used to accurately record positional data of sub-surface features of a former Roman site in Caistor St. Edmund, Norfolk.

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On Friday 20th July 1928 the Royal Air Force took a series of remarkable aerial photographs over fields near the village of Caistor St Edmund in Norfolk (UK). They showed the clear outlines of the streets and buildings of a buried Roman town as parched lines in the ripening barley crop. The summer of 1928 was exceptionally dry and the buried streets and buildings lying beneath the surface of the fields restricted the moisture available to the crops that lay above them. The result was that the plan of the Roman town of Venta Icenorum was revealed with unprecedented clarity.

The site lies 2km south of the city of Norwich. Like Silchester and Wroxeter, Caistor is a green-field site, unencumbered by modern settlement. Its walls enclose some 14ha, although the aerial photographs showed that the earlier phases covered an area twice the size of the walled town. The site was first identified as Venta Icenorum in the Roman sources by William Camden in the 16th century, but the 1928 air photographs caused enormous interest. Excavations were subsequently carried out by Donald Atkinson between 1929 and 1935. These excavations were not fully published, however, and since then the site has remained largely undisturbed. It is now owned and protected by the Norfolk Archaeological Trust and remains one of the most enigmatic and least understood of Britain's green-field Roman towns.

In light of this, in 2006, the University of Nottingham's Caistor Roman Town Project was conceived, with the aim of establishing a long-term research project at Caistor. One of the initial aims was to implement a fast high-resolution geophysical survey, to create a detailed map of surviving sub-surface remains. The site's protected status means that any excavation must be limited and targeted on specific areas and research questions. The geophysical survey would enable the project to identify such areas. To date, the project has surveyed more than 30 hectares of land.

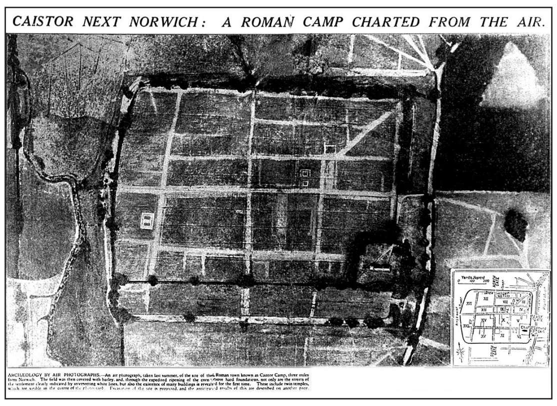

Figure 1. The 1928 aerial photograph of Caistor (Venta Icenorum) as originally published by the Times. Its publication caused tremendous excitement and led to immediate excavations of some of the public buildings. These excavations were unfortunately only partially published.

THE SURVEY

A number of pilot investigations conducted by the University of East Anglia and by the late Peter Cott showed that magnetometry represented a suitable technique for successfully mapping sub-surface remains at Caistor.

The Caistor Survey system is based upon a Scintrex SM-5 NAVMAG, incorporating two caesium vapour sensors and the ability to log NMEA messages from an external GPS device.

This was mounted on a wheeled sensor platform, which was ideal for use on the flat, sheep-bitten grass of Caistor, allowing the operator to survey a large area in a relatively short space of time. The platform allows the operator to maintain a constant sensor height above ground (reducing

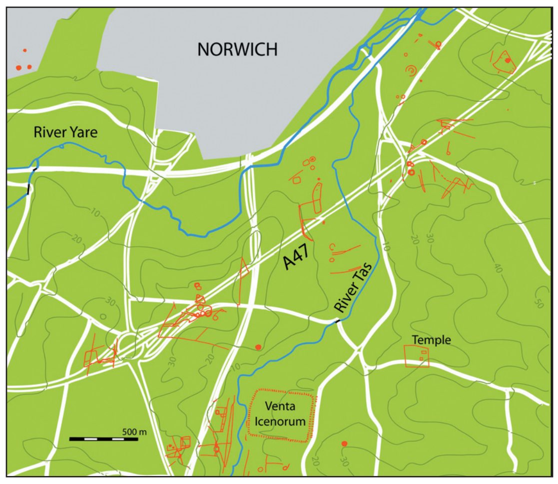

Figure 2.The location of Venta Icenorum in relation to the modern city of Norwich. The town lies within a dense landscape of prehistoric features (shown in red) known from excavations and aerial photography (after Trevor Ashwin).

uncorrelated measurement errors) and allows control electronics, data logger, navigation and associated batteries to be separated from the sensors by around 1.5m reducing instrument noise. The platform was constructed from aluminium tubing although in circumstances where there was greater risk of Electro-Magnetic Interference the use of wholly non-magnetic components could be considered.

Positional information for the sensors is provided by GPS receivers. This offers greater positioning accuracy than the more time-based data recording used in most magnetometry. However, to ensure full coverage and evenly spaced transects a grid of 40m^2 was established over the survey area and the ends of each transect marked with ranging rods to guide the operator. This approach also allows for the easy repetition of sections of the survey in the event of satellite drop out or other instrument problems.

Initial experiments used a sensitive, differentially corrected GPS receiver (Csi wireless Series) which has a very small footprint, giving an absolute positional accuracy of c.>1.0m; the positional accuracy achieved for data points along each transect being much greater. By additionally logging the binary data from the GPS it proved possible to further increase (correct) accuracy through post-processing. More recently, we have switched to using an rtk GPS system (Topcon HiPer Pro) offering greater positional precision and absolute positional accuracy. The real advantage of using GPS is that it enables specific features found during the survey to be accurately located at any point in the future. This may seem obvious but all too often in the past the locational data associated with geophysical surveys has been insufficient, with the result that survey data cannot be reliably located on the ground!

Remedial data processing was undertaking using MATLAB routines providing corrections for positional errors and the removal of dropouts and high frequency, single point spikes. For display purposes, linear interpolation of the survey data to a resolution of 0.5 x 0.5m was performed using a Delaunay triangulation routine. The dynamic range of the results has been clipped to display magnetic field strengths between ± 11 nT/m in order to achieve an adequate contrast between smaller values of magnetic field strength.

THE RESULTS OF THE SURVEY

The survey provided a clear plan of the Roman town, showing the streets and public buildings very clearly. The forum, temples and baths known from the 1930s excavations were revealed with particular clarity.