The bespoke Magnitude Surveys' incarnation of the magnetic 'workhorse': four fluxgate sensors with GPS that can be mounted on a hand-pulled cart, carried by hand or towed behind a quad bike, depending on the terrain. Credit: Magnitude Surveys Ltd

Multichannel GPR in use at Ripon Cathedral. Credit: Magnitude Surveys Ltd

TAILORING SOLUTIONS TO STREAMLINE OUTCOMES

Hannah Brown ACIfA (9599), Reporting Officer, Magnitude Surveys

Arguably PPG 16 was the principal catalyst through which geophysical survey came into its own as an archaeological tool, at least in the British Isles. This piece of planning guidance led to the mainstream use of cost-effective non-intrusive prospection, primarily by means of magnetometer survey; five years later, the fluxgate magnetometer was described as the 'workhorse' of British geophysics (Clark 1996, 69). As the case studies below demonstrate, in addition to increasingly sophisticated options for large-scale magnetic survey, we are now in a position where appropriate alternatives can be deployed at a commercial scale or combined to provide complementary information to tackle project-specific questions. Meanwhile, aerial remote sensing methods offer opportunities for rapid capture of high-resolution data, such as multispectral imagery or detailed topographic survey, to augment subsurface investigation. In other words, we are no longer reliant on the old magnetic 'workhorse' alone.

Effective geophysical survey has never been a case of 'one size fits all'. Happily, technical innovation has focused less on the quest for a 'Universal Ditch Detector' (Gaffney & Gater 2003, 180) and more on instrumentation and software that allows increasing nuance and discrimination in the resulting interpretation. Alongside the applied expertise of geophysicists across the sector, its use in heritage management is invaluable, providing clients with a means of de-risking, developers with more sustainable heritage strategies, and the public with lower costs and higher quality mitigation. In the light of attempts to 'streamline and modernise' the planning process (MHCLG 2020, 4), the value of geophysical contributions is more important than ever.

Magnetometry remains an indispensable option in many cases, working on the principle that human activities can cause magnetic enhancement, which can then be detected. The resulting data, when interpreted by a skilled professional, can potentially reveal a range of information about the subsurface, including the location, extent and character of archaeological remains, but also the local geology, modern features and agricultural activity. The current 'workhorse' is already a world away from the 1990s hand-held instrument. Mounting multiple sensors on carts with satellite guidance is now the norm, and magnetometry rightly plays an effective role in mitigation for large infrastructure and development projects.

While familiarity (and a demonstrable track record) has made magnetometry synonymous with archaeological geophysics, there will always be circumstances in which the technique 'doesn't work'. This might, more fairly, be considered a problem of over-expectation by those commissioning the surveys (or over-promising by survey operators) rather than dismissed as a 'failure' of geophysics. In most of these cases, the instruments record data as they should, but if the magnetic contrast between a feature and its surroundings does not exist – either because the enhancement itself is minimal, the feature is deeply buried, or the background is magnetically 'noisy' – it cannot be identified as anomalous.

Magnitude's 2019 survey around Shire Hall, Cambridge, (for Cambridge Archaeological Unit) is a typical example of a case in which magnetometer survey would not produce useful information, with sensors swamped by interference from the surrounding modern clutter of a city-centre location. Instead, a ground penetrating radar (GPR) survey was undertaken over approximately 0.8ha, in advance of building improvements on a site that required excavation. The area was known to have seen multiple phases of use (from a late prehistoric defended settlement to civil war stronghold, via a Roman fort and two castles), but the GPR survey focused on several substantial 19th-century buildings that occupied the site prior to the construction of the current Shire Hall by the County Council in 1928.

GPR works by sending pulses of energy into the ground and compiling the returning reflection. The results show strong reflections caused by the buried masonry of foundations. By analysing the three-

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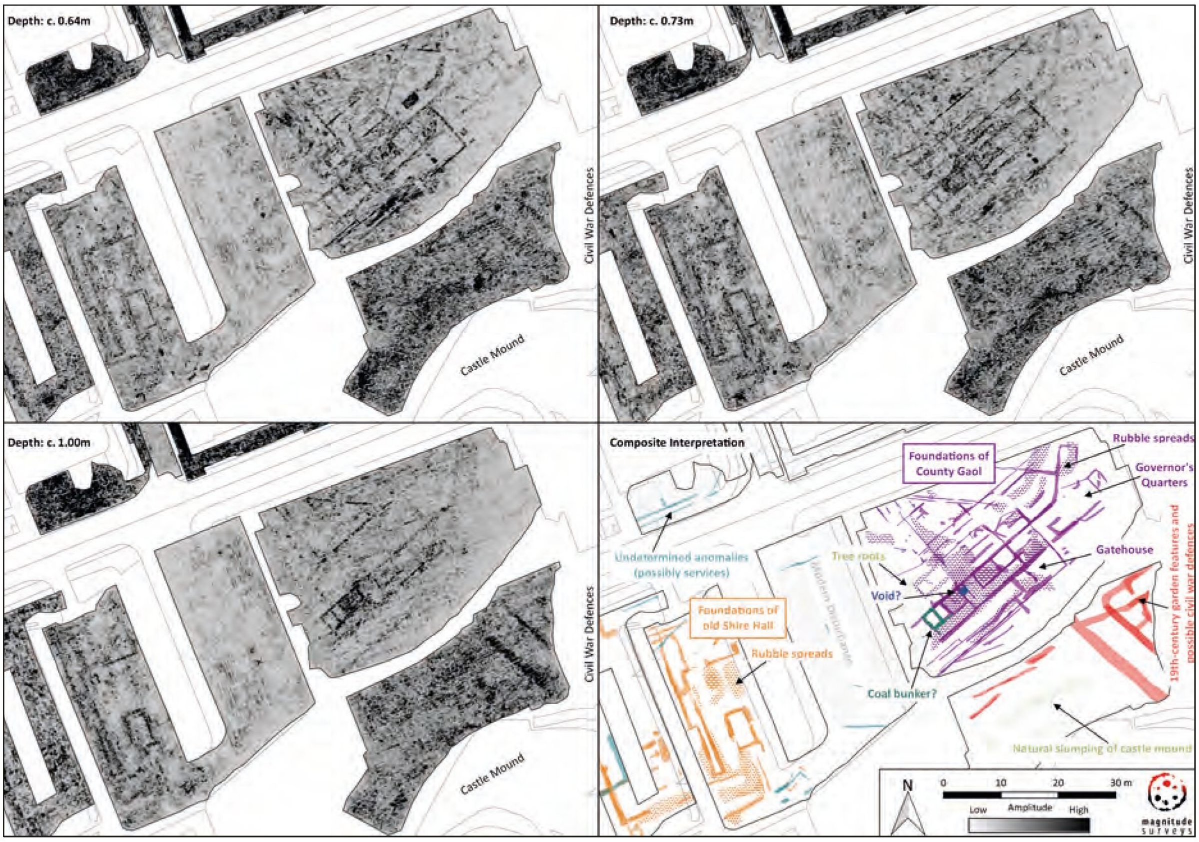


Detail from the indicative timeslices and composite interpretation (c 0–1.4m depth) from the GPR survey conducted at Shire Hall, Cambridge. Credit: Magnitude Surveys Ltd; contains vector mapping provided by the client

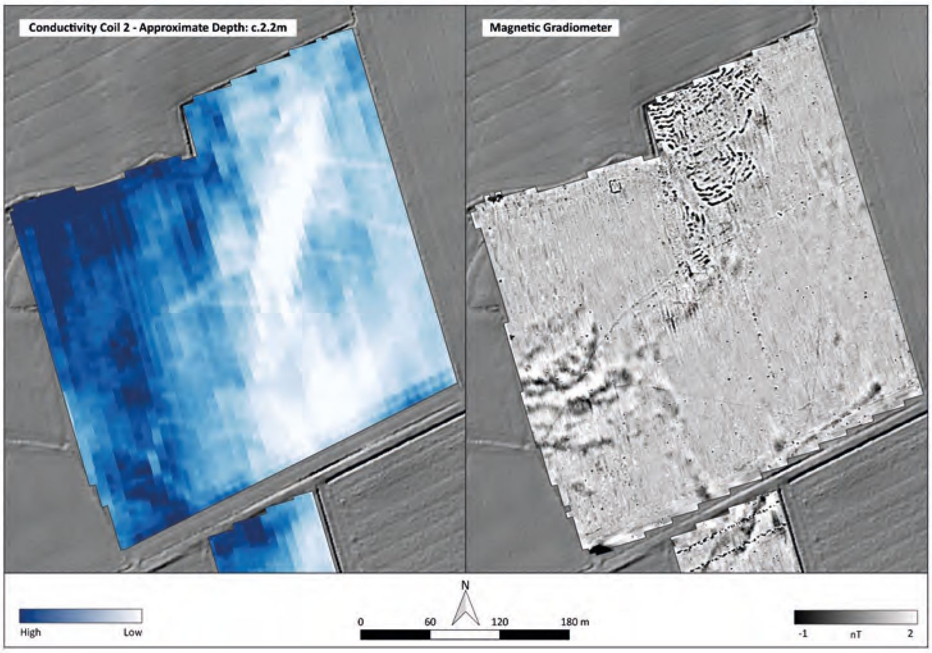
Simultaneous collection of magnetic (vertical white sensors) and EM (horizontal orange sensor) data on a larger scale. Credit: Magnitude Surveys Ltd

Handheld electromagnetic induction instrument being used to investigate earthworks possibly relating to a medieval manor, Buckinghamshire. Credit: Magnitude Surveys Ltd

dimensional dataset alongside the historical sources, it was possible to differentiate between the remains of the 19th-century county gaol and the former law courts. The GPR survey identified specific features known from floor plans and previously unknown structural remains. In addition to mapping the lateral extent of archaeology, GPR also offers indications of depth, preservation and stratigraphy, in this case identifying buried ground surfaces and probable levelling events. As well as informing practical heritage management and responsible development in the immediate term, the geophysical data also have value in providing a more tangible way to visualise and understand the local civic environment.

Whatever the technique, geophysical data will always be a plot of soil properties, as opposed to a ready-made map of buried features. Accordingly, the wider the range of physical properties measured during the survey, the less ambiguous the interpretation. For example, electromagnetic (EM) survey collects data related to the electrical conductivity and magnetic susceptibility (linked with, but crucially different to regular magnetic survey) and multiple depths, by way of induction coils carried over the surface. Depending on the resolution and coil separations, this method can be applied to investigate targets ranging from individual archaeological features to wider palaeolandscapes. Earlier this year, Magnitude surveyed at Thorpe Marsh, South Yorkshire, on the edge of the Humberhead Levels; following specific discussions about the aims of the project with the consultant, Landgage Heritage, simultaneous EM and magnetic survey was conducted over approximately 120ha. The EM data, interpreted in conjunction with digital elevation data and existing borehole records, provided significant context for the magnetic results and markedly refined our understanding of the evolution of the natural and human landscape. This allowed us to determine the character and distribution of superficial deposits, which in turn afforded a more confident explanation of the detailed magnetic results, including areas that would appear archaeologically 'empty'. The survey objectives focused on buried geomorphology as a proxy for areas with higher potential for earlier prehistoric activity, which typically does not leave features with strong enough contrasts to be directly detected. The synthetic interpretation provided a strong foundation on which to base future intrusive work and devise mitigation strategies.

Despite the emphasis of current government publications on 'standardising' the planning process, bespoke geophysical solutions will always increase the value of the data, and multi-method surveys will generally prove more useful than the sum of their parts. These benefits will increase further with continued cross-sector dialogue and integrated programmes of work.



Comparison of detail from the electromagnetic and magnetic datasets collected during the Thorpe Marsh survey. Credit: Magnitude Surveys Ltd; contains LiDAR data. © Environment Agency copyright and/or database right 2021 Hannah Brown

References

Clark, A, 1996 *Seeing beneath the soil*. Revised edition. Abingdon: Routledge

Gaffney, C and Gater, J, 2003 *Revealing the buried past*. Stroud: Tempus.

Ministry of Housing, Communities & Local Government, 2020 *Planning for the Future. White Paper August 2020.* http://www.gov.uk/government/consultations/planning-for-the-future

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Hannah ended up in archaeology via a modern history degree at Oxford University, where 'modern' includes everything since the Romans. After an MA in Medieval Studies, she decided to specialise in archaeological geophysics and completed an MSc at the University of Bradford in 2011. Since then, she has worked for several commercial units in the UK and Ireland and is now the Reporting Officer for Magnitude Surveys. As a result of her PhD, she is a prehistoric field system geek, and is particularly interested in human use of landscapes, GIS analysis and interdisciplinary approaches.