Identifying archaeological potential in alluvial environments

An evaluation of remote sensing techniques at the River Lugg, Herefordshire, UK

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The successful application of archaeological prospection techniques to complex geomorphological areas, such as alluvial environments, remains a significant challenge for heritage practitioners, particularly in advance of sand and gravel extraction activity which is also common in these areas. This is primarily because large parts of these landscapes are covered with a thick layer (or layers) of fine-grained alluvium that prevents the effective visualisation of any archaeological remains that may be deeply buried. However, such settings provide attractive locations for archaeological activity and when remains are located, they can be exceptionally well preserved. Moreover, the valley floor contains an assemblage of landforms such as paleochannels, terraces and gravel islands which record of the evolution of the river system (Brown, 1997). These geomorphological features often contain important ecofactual and archaeological remains and understanding their location, morphology and sedimentary sequences is important for predicting archaeological potential. Thus, whilst the geoarchaeological investigation of alluvial landscapes is well established (e.g. Needham and Macklin, 1992; Howard, Macklin and Passmore, 2003), the application of appropriate remote sensing technologies to determine archaeological potential within complex depositional environments requires more research (Challis and Howard, 2006).

Remote sensing and complex geomorphology

The use of LiDAR has been highly effective at mapping geomorphological features that are expressed as extant topographic variation (Carey *et al.*, 2006; Challis, Kincey and Howard, 2009; Stein *et al.*, 2017). However, as alluvial deposition can blanket important geomorphological features, and subsequent ploughing can also smooth out topography, the identification of geomorphological features can be problematic. The use of complementary information from geoarchaeological coring/test-pitting goes a long way towards reducing this, but normally requires the use of costly intrusive ground investigations. Geophysical survey methods and deposit modelling from pre-existing geotechnical datasets can provide a non-intrusive means of identifying features that are not expressed topographically, but there has been relatively limited consideration of how other remote sensing techniques can be deployed to assist in this regard.

Multispectral sensors co-collect imagery from discrete (narrow) wavelength ranges over parts of the electromagnetic spectrum, whereas panchromatic aerial imagery is sensitive to a broad spectral range covering the visible part of the spectrum (Beck, 2011, p. 88). This can be advantageous as crop stress and vigour variations that may relate to subsurface archaeological/geomorphological features, are sometimes better expressed in non-visible wavelengths (e.g. Powlesland, Lyall and Donohoe, 1997). Though archaeological applications of satellite and airborne multispectral sensors are not new, there has been a relatively limited uptake of this technology in alluvial environments. This is largely due to the cost of deploying systems that can provide suitable spatial resolution for the definition of individual features. However, with the development of lightweight multispectral sensors that can be mounted on Small Unmanned Aerial Systems (SUAS), imagery can now be provided at very high spatial resolution and relatively low cost. Although the spectral resolution of these sensors is low, being limited to portions of the visible and near-infrared parts of the spectrum, they have potential to assist in the analysis of surface landform assemblages. Moreover, recent research has also shown enormous potential for archaeological applications of this technology in less complex geomorphological environments (Colomina and Molina, 2014; Themistocleous *et al.*, 2015; Agudo *et al.*, 2018; Moriarty *et al.*, 2018).

In addition to multispectral sensors, low-cost devices that measure omitted radiation of the ground in the thermal region of the electromagnetic spectrum can also be mounted on SUAS. These have also demonstrated a great deal of potential for archaeological research (e.g. Casana *et al.*, 2014, 2017; Agudo *et* *al.*, 2018; Šedina, Housarová and Raeva, 2019), but have yet to be deployed in a targeted manner to investigate complex geomorphological areas. However, as the emissivity and temperature of the ground is dependent on its bulk composition, as opposed to its surface characteristics, thermal imagery has potential to provide information about the subsurface (Thakur *et al.*, 2016).

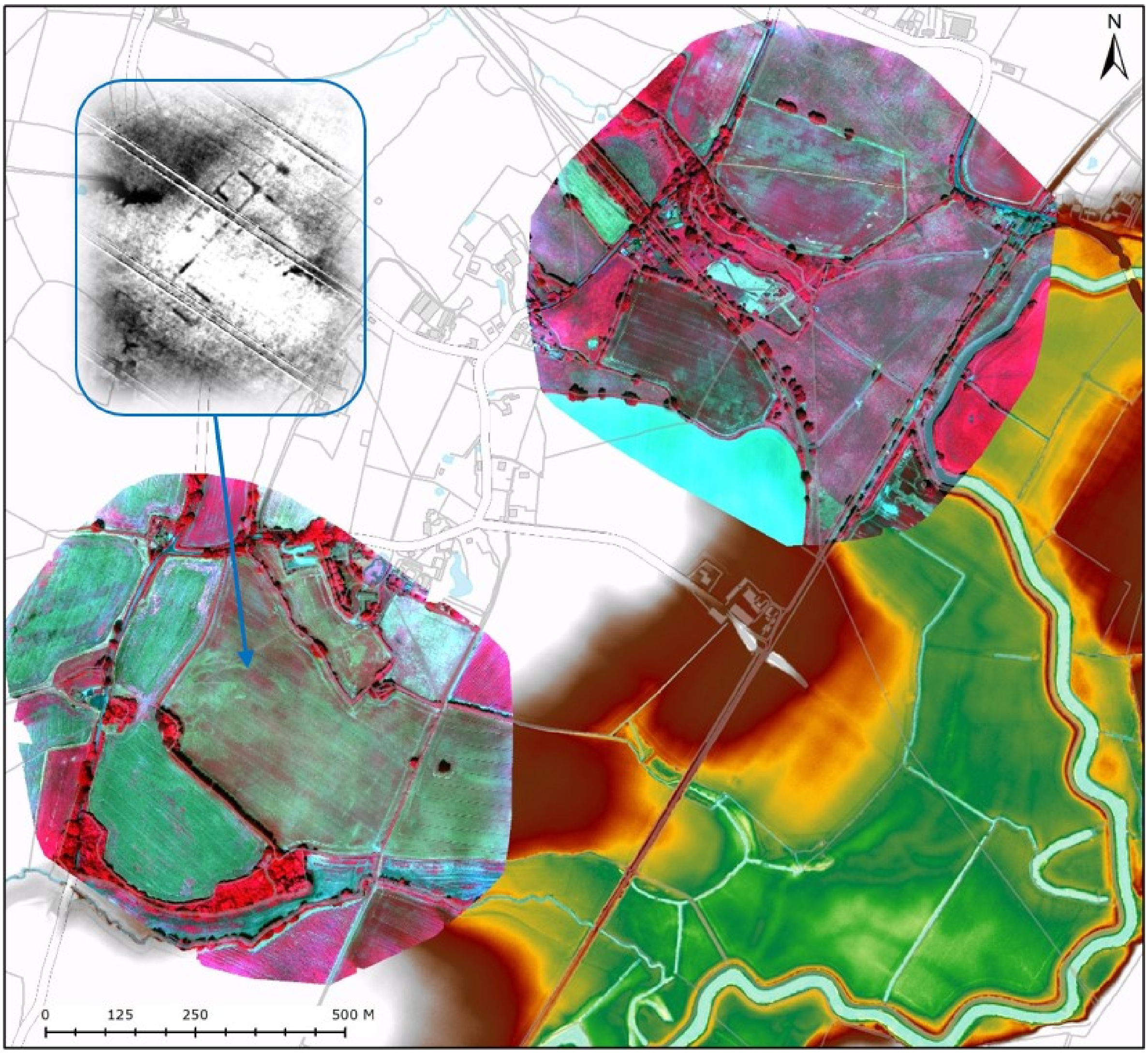

Fig. 1. LiDAR DTM constrained to 2 - 9 m (aOD), with false colour composite imagery (R = NIR, G = Red, B = Green) overlain and a detailed view of Romano-British Villa (inset; greyscale NDVI).

The Lower Lugg Valley, Hereford, UK

This paper will present a case study from the Lower Lugg Valley in Herefordshire, where the capability of SUAS mounted multispectral and thermal sensors to contribute an increased understanding of complex alluvial environments has been investigated. As use of a SUAS platform also enables the production of elevation models through Structure from Motion (SfM) photogrammetry, a comparison with LiDAR data (freely available from the UK Environment Agency) is also considered.

Preliminary results have shown that the high spatial resolution of the SUAS mounted sensors enables the clear visualisation of small-scale individual archaeological features (Figure 1). It has also established that various alluvial landforms such as paleochannels could also be identified, although these can sometimes be hard to define, emphasising the importance of topography when understanding their morphology. In addition, broad trends can also may also indicate variation within the sub-surface deposits. Thus, although it is not possible achieve the same area coverage as many LiDAR datasets, targeted application of complementary techniques can assist their interpretation. Despite this, this evaluation has also shown that ground-based sediment sampling, reconstructing the sediment sequences of the valley system and examining their relationship to near surface and sub-surface sediment, are often necessary to provide an increased understanding of subsurface sediment architectures. However, through such a combined approach, it is possible to make predictions to be made of regarding archaeological potential.

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