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Image processing and visualisation of rock art laser scans from Loups's Hill, County Durham

Kenneth Lymer

Wessex Archaeology, Portway House, Old Sarum Park, Salisbury SP4 6EB, England

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ABSTRACT

Contemporary rock art researchers have a wide choice of 3D laser scanners available to them for recording stone surfaces and this is complimented by numerous software packages that are able to process point cloud data. Though ESRI's ArcGIS primarily handles geographical data, it also offers the ability to visualise XYZ data from a stone surface. In this article the potential of ArcGIS for rock art research is explored by focusing on 3D data obtained from two panels of cup and ring marks found at Loups's Hill, County Durham, England. A selection of methods commonly utilised in LiDAR studies, which enhance the identification of landscape features, are also conducted upon the rock panels, including DSM normalisation and raster data Principle Component Analysis (PCA). Collectively, the visualisations produced from these techniques facilitate the identification of the rock art motifs, but there are limitations to these enhancements that are also discussed.

1. Introduction

Two panels of rock art located at Loups's Hill, Cotherstone Moor, County Durham (Fig. 1), were recently three-dimensionally (3D) laser scanned and this has provided an opportunity to conduct a pilot study involving an alternative methodology for the visualisation of the point cloud data. Loups's Hill is one of many places containing noteworthy concentrations of rock art that are situated in open-air locations found spread across northern Britain and Ireland. British rock art is currently estimated to date from the Early Neolithic to the Early Bronze Age, approximately 4000–1500 BC (Waddington 2007: 5; Sharpe et al., 2008: 4). The imagery depicted is commonly referred to as cup and ring marks and these were skilfully carved into natural stone surfaces ranging from simple clusters of cups to complex compositions involving cups and rings as well as other elements, such as meandering lines. Their importance to archaeological enquiries is significant as open-air rock art sites provide us with important clues about understanding different facets of the prehistoric landscape.

The two Loups's Hill panels reside within the boundaries of the Battle Hill Range – a Defence Training Estate (DTE) owned by the UK Ministry of Defence (MoD). The Battle Hill Range is one of several training areas found across Britain that contain rock art, prehistoric archaeology and other heritage assets which the MoD monitors through rural management plans (Abramson, 2010). The Defence Infrastructure Organisation (DIO) in conjunction with the DTE deployed the 135 Geographic Squadron to laser scan the panels in 2012. The collected point cloud data was, in turn, image processed and visualised by Wessex Archaeology (Cripps and Lymer, 2013; Lymer and Cripps 2013). This paper is the result of the collaboration between the MoD and Wessex Archaeology that aims not only to document the recent state of these fragile rock art panels at Loups's Hill, but also offer visualisations of the laser scan data with the intention of informing future conservation management strategies.

There are numerous software packages currently available with the ability to process point cloud data acquired from laser scans, and each one offers different options for image rendering and visualisation. Though the commercial package ArcGIS by ESRI is primarily intended for geospatial analysis at a geographic scale, its ability to convert a set of 3D coordinates into a digital surface model (DSM) provides a relatively unexplored approach in rock art research. Instead of the macroscale modelling of the landscape, it is possible to treat the surface of a rock as a microscale DSM from which localised morphology can be rendered into different scenarios. ArcGIS also offers the ability to enhance features in images through raster data Principal Components Analysis (PCA) – a technique that potentially provides another method for identifying anthropogenic modifications. This article presents the results of the application of these techniques in a limited trial that primarily focuses upon the two rock art panels laser scanned by the MoD from Loups's Hill.

2. Loups's Hill and Cotherstone Moor

2.1. Loups's Hill (340 m OD) rises above the grasslands of the eastern part of Cotherstone Moor. The moor is situated in a region of the Teesdale valley which runs along the eastern side of the

E-mail address: k.lymer@wessexarch.co.uk

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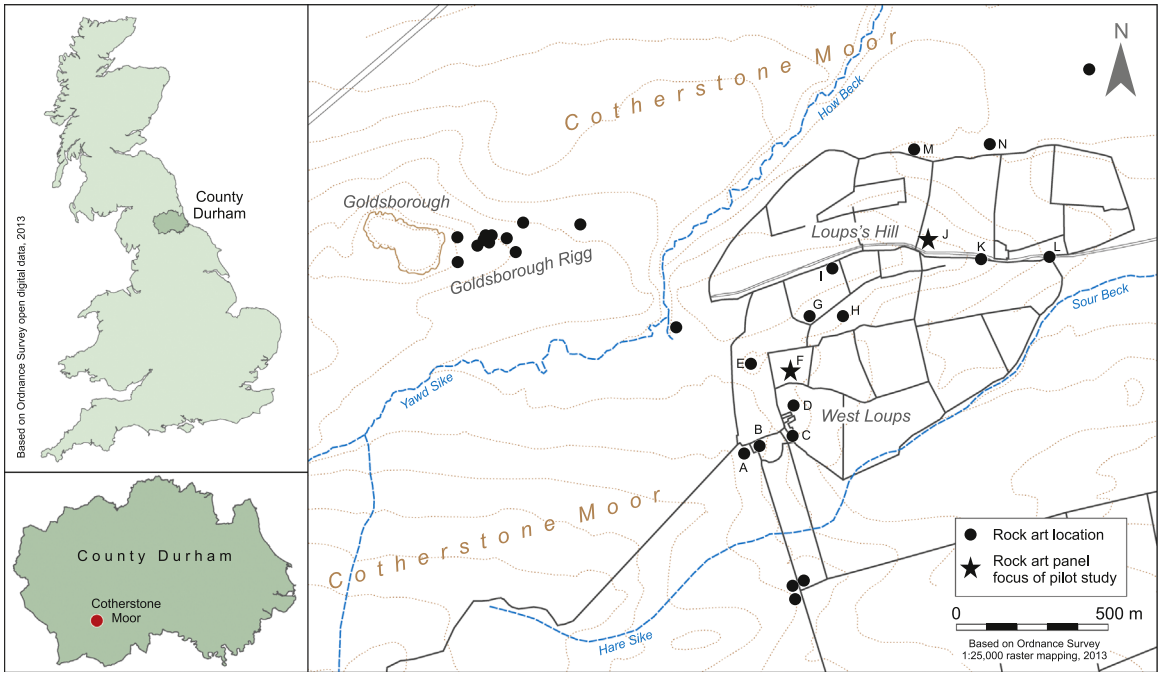

Fig. 1. The location of rock art panels at Loups's Hill and Cotherstone Moor (gazetteer of alphabetically labelled sites is found in Appendix 1).

Pennines. The underlying geology is classified by the British Geological Survey as belonging to the Stainmore Formation and comprises of sandstones, siltstones, mudstones, thin limestones and some coal deposits. Cotherstone Moor is also noted for its special biodiversity as it is a transitional mix between northern upland and lowland bogs comprising of a unique mixture of contemporary habitats, including an extensive blanket bog, dry heather communities, acid grasslands and freshwater flushes (Natural England, 1993).

The Loups's Hill panels belong to a collection of rock art sites situated in various open-air locations around Cotherstone Moor (Fig. 1). These have come to our attention through the discoveries made by local researchers and independent archaeologists over the past few decades (Beckensall and Laurie, 1998: 72; Brown and Brown, 2008: 281–285; Abramson, 2010: 133). Many of the rock art panels of Cotherstone Moor are situated on elevated ground that lies south of the river Balder, a tributary of the river Tees. In addition to the loose grouping of sites spread around Loup's Hill, there is a cluster of panels situated along the eastern ridge of Goldsborough Hill (389 m OD), which is known as the Goldsborough Rigg.

There have been no discoveries, as of yet, of rock art along the crags of Goldsborough Hill, but at its summit there is the remains of a ring cairn. It consists of a circular bank made of earth and stone and corresponds with types found in northern England that are dated to the Early Bronze Age (SWAAG, 2012). Moreover, directly to the south of Cotherstone Moor is Bowes Moor which contains several Bronze Age cairn fields that have been excavated by archaeologists (Vyner et al., 2001: 59–60).

It is also important to note that the phenomenon of cups and rings in northern England is directly associated with prehistoric burials. There are many examples of carved portable stones that were deliberated placed in Early Bronze Age burial cairns recovered from excavations in North Yorkshire, County Durham and Northumberland (Mazel, 2007: 240–245; Brown and Brown, 2008: 10). Additionally, there are also some cists and cairns that feature decorated covers and kerbstones found in North Yorkshire and Northumberland (Beckensall, 1986: 31).

Fourteen locations of rock art have been so far identified within the vicinity of Loup's Hill (Fig. 1 and Appendix 1). Nine of these panels became listed as Scheduled Ancient Monuments (SAM) (also known as Scheduled Monuments), which provide statutory protection for these important archaeological sites in England. Seven of the SAMs reside within the boundaries of the Battle Hill Range, while the remaining two are located just outside the northern and western perimeters.

Many of the rock art panels of Cotherstone Moor have been reclaimed by the moor and have turf coverings, while some of the Loups's Hill panels have stones placed atop them in an attempt to protect them from weathering. However, two of the SAMs on Loups's Hill – BH Stones 5 and 7 (Appendix 1F and J) – have not been covered and the states of their preservation has been identified as requiring more closer monitoring (EH, 2009: 32; MoD, 2011: 34).

BH Stone 5 is situated upon the north-facing slope of Loups's Hill (Fig. 2a) and was discovered by Paul Brown in 1993 (Brown and Brown, 2008: 281). It was initially covered in turf that was carefully replaced after recording, but this had completely disappeared by 2006 (P. Brown, personal communication). The rock art motifs were carved or pecked into a relatively flat stone composed of coarse-grained sandstone (ERA, 2008a). It measures approximately 2.1 × 1.83 m and slopes at approximately a 5° angle along the gradient of the hillside. The rock art carvings are noticeably eroded (ibid.) and their concavity is quite shallow; they can only be seen at certain viewing angles by moving around the stone and their visibility is greatly assisted by oblique lighting conditions. Identifiable motifs consist of a complex composition featuring a cup and ring placed on the upper slope of the stone that is surrounded by two arcing lines of cup marks. Further south-west from the cup and ring there is also a faint row of three cups.

BH Stone 7 is located on the southern part of the hill in an area known locally as West Loups (Fig. 2b). The circumstances of its discovery are unclear but the rock became designated as a SMR in 1998 (EH, 2014). Eight cup-like depressions were found on the flat upper surface of a coarse-grained sandstone boulder, which