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*The timber structure after excavation. The large, open pit within the structure is visible in the centre, with the straight end wall beyond (photo credit Murray Archaeological Services).*

‘gable end’ of the structure. There is also some indication of an internal partition. At the moment there appear to be tantalising differences in plan between this and the other two excavated examples at Balbridie and Claish Farm, but no detailed comparisons are possible until the whole building can be excavated.

Two large pits at either end of the building were originally thought to have been for massive posts supporting a roof ridge-pole. Excavation of one of them suggests it was actually an open pit, possibly lined with branches of alder and hazel. When the building burnt down this pit became filled with a mixture of debris and occupation material from the interior, including large quantities of remarkably fine Early Neolithic pottery, flint and Arran pitchstone artefacts. The cereals recovered include barley, emmer and bread wheat – the latter extremely unusual in the Scottish Neolithic, but paralleled at Balbridie – and a grain of spelt, which until now has not been recognized in Scotland before the first millennium BC. Most exciting of all, fragments of carbonized birch wood survived, some with carved decoration, which appear to be pieces of turned bowls or other small objects. This is an incredibly humbling reminder of the range and quality of objects made of wood, leather, basketry and textile that rarely survive from Neolithic Scotland.

The pit alignment, lying some 150m west of the building, remains enigmatic. Topsoil was cleared from a 30m length, revealing five large pits and a number of smaller post-pits – the latter, too small to show up as cropmarks, suggesting that the monument is potentially of greater complexity than appears from aerial photographs. One of the large pits was excavated, revealing a charcoal-rich deposit over a thin build up of silt and gravel, probably representing an initial phase of erosion. Although flint flakes were recovered from the ploughsoil above the pit alignment, no artefacts or environmental evidence were found within the excavated feature.

That charcoal from the fill has produced a radiocarbon date range analogous to that of the timber structure is

fantastically satisfying, confirming the Warren Field project to be an enormously important opportunity to examine two rare monument types within their wider landscape context, rather than as isolated phenomena, and to begin to tease out the details of Early Neolithic inhabitation of the valley. The very close proximity of Balbridie, only a kilometre away on the opposite bank of the Dee, highlights the importance and particularity of the place in any assessment of the nature of changing lifeways in eastern Scotland some 5,500-6,000 years ago.



*A carbonized fragment of birch wood with carved decoration (32 X 18mm), excavated from the large pit within the timber structure (photo credit AOC Archaeology Group).*

Given this unparalleled opportunity to explore the specific expression of new frameworks for living as they developed in northeastern Scotland during this period, we are undertaking a further season of excavation in June 2005. We will be examining the sites in more detail and exploring other elements of the wider crop-mark complex at Crathes, which may shed light on the relationship between massive timber buildings and the more ephemeral settlement features commonly associated with the Early Neolithic in Scotland.

*Shannon Fraser, The National Trust for Scotland  
Hilary Murray, Murray Archaeological Services*

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## **LONG MEG: ROCK ART RECORDING USING 3D LASER SCANNING**

For more than a century, the documentation of most British prehistoric rock art has been undertaken by a small number of antiquarians and avocational archaeologists including James Simpson (1865), Ronald Morris (1981) and, more recently, Stan Beckensall (1999) and the Ilkley Archaeology Group (Boughey & Vickerman 2003). Techniques used to

record the carvings have varied from tracing, free-hand drawing, to photography and wax rubbing, the latter being that most commonly used during the last three decades. Although these approaches provide adequate information to identify each carving and give an impression of the designs, they cannot reproduce the degree of detail and accuracy required by today's researchers and conservationists. The traditional techniques are inherently subjective; they rely heavily on the skill and experience of the recorder as well as on prevailing lighting conditions. The process of transferring a 3D object onto a 2D piece of paper also has obvious limitations. Even the most experienced protagonists acknowledge that repeated visits to the same site may produce different results. 3D laser scanning has the potential to revolutionise rock art recording. It produces highly objective and accurate 3D models providing reliable, detailed information for both researchers and conservationists. Laser recordings may even identify previously unknown carvings, as demonstrated by recent discoveries at Stonehenge (Goskar *et al.* 2003).

The project "Breaking through rock art recording: three dimensional laser scanning of megalithic rock art", sponsored by the Arts and Humanities Research Board (now the Arts and Humanities Research Council) under the Innovation Awards scheme, aimed to explore the potential of this novel technique. The one year project was undertaken by the University of Durham, led by Margarita Díaz-Andreu, and began in March 2004. The main sites analysed were the stone circle at Castlerigg and the standing stone of Long Meg in Cumbria, in addition to the Copt Howe panel, also in Cumbria, and the Horseshoe Rock site in Northumberland where an investigation on 3D representations had been previously undertaken (Simpson *et al.* 2004; Trinks *et al.* forthcoming). This article focuses on the results obtained at Long Meg (NY56933716, CCSMR6154, NMR 23663), comparing two different methods to visualise the rock art data, one developed by Hobbs and Trinks using freely available software, and the other one undertaken by Nick Rosser employing software especially developed for archaeology by Archaeoptics Ltd but no longer commercially available unless the Archaeoptics laser scanning service is also purchased. Two previous recordings existed of the carvings on the western face of the pillar: an early recording first published in 1867 by Simpson in the form of a lithograph by A. Ritchie (Simpson 1867, plate VII), and a wax rubbing produced by Beckensall (2002, fig. 70).

The recording of Long Meg with 3D laser scanning was undertaken in several phases. The first phase included the laser scanning and pre-processing of data. This was undertaken by a team led by Dr Alan Chalmers, University of Bristol. The data set acquired with a Minolta 910 laser scanner consisted of roughly 45 million points (26 million of which came from the

north-easterly facing panel where the carvings are located), with overlaps in excess of 25% between the coverage of each scan. The recording took approximately twelve hours and involved the creation of 102 'patches' of rock surface which were then 'stitched' together electronically to create the complete 3D model.

The second phase was the development of new processing and 3D visualisation methods to visualize the rock art contained in the data. This was undertaken by two different approaches. A new method was developed by Immo Trinks and Richard

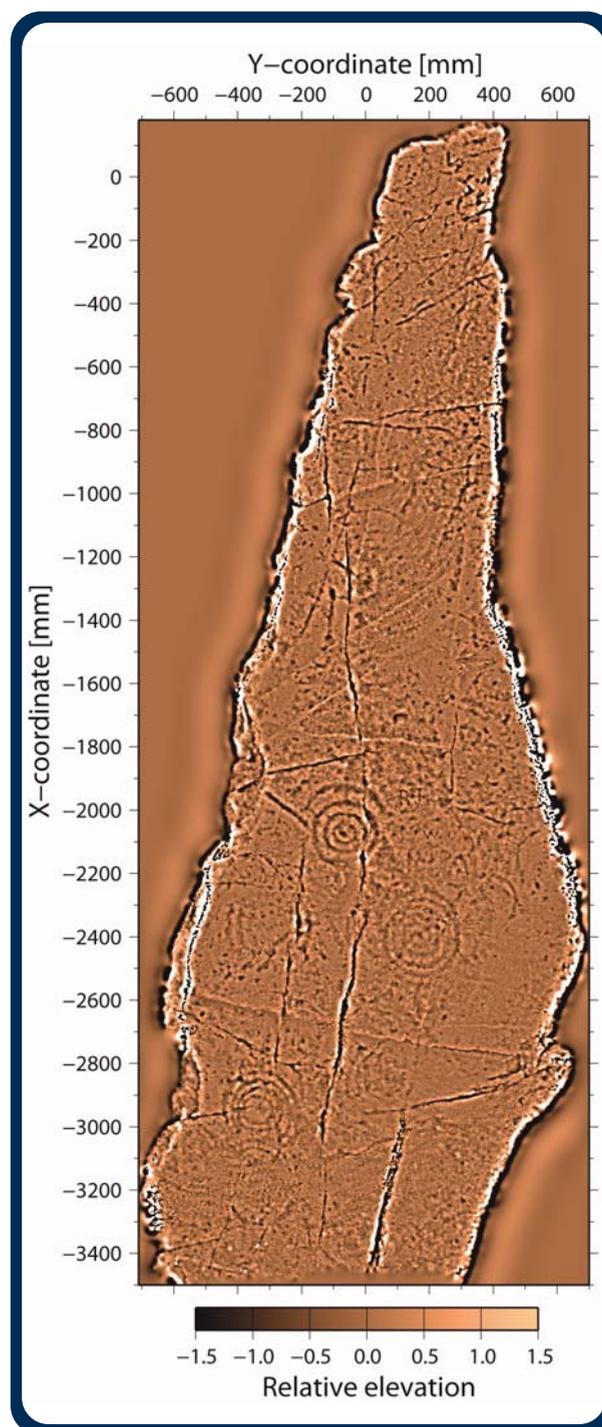


Figure 1: Long Meg 3D laser scanner data coloured according to relative elevation.

Hobbs of the Department of Earth Sciences at the University of Durham using the Visualization Toolkit (VTK) and Generic Mapping Tools (GMT) software. The original data was resampled to 645,432 points since the overlapping scan areas contained a large amount of redundant information. The carved front face of Long Meg was transformed into horizontal orientation and the data points were gridded using a 2D triangulation algorithm (Wessel & Smith 1991). Subsequently a spatial highpass frequency filter was applied to the 3D surface data, removing the long-wavelength surface structure of the rock (Trinks *et al.* forthcoming). Thus, the relative local elevation could be rendered using colour intensity values (Fig. 1). Figure 2 shows that elevation rendering without the removal of the low-frequency content, which represents the large-scale topography of the rock, would fail to highlight the rock carvings. It is possible to map the relative elevation colour values onto a digital 3D rock model, in order to visualize small scale variations in the rock surface. This option is particularly interesting should the rock have strong 3D structure. Due to the relatively plane structure of the front face of Long Meg (Fig. 2) this step was not considered necessary.

A second method of visualising the data was undertaken by Nick Rosser, Geography Department, University of Durham. Data was processed using firstly Demon3D (Archaeoptics Ltd) and then ENVI RT 4.0 (RSI). The initial stage of the processing involved trimming the point cloud of the data beyond the area

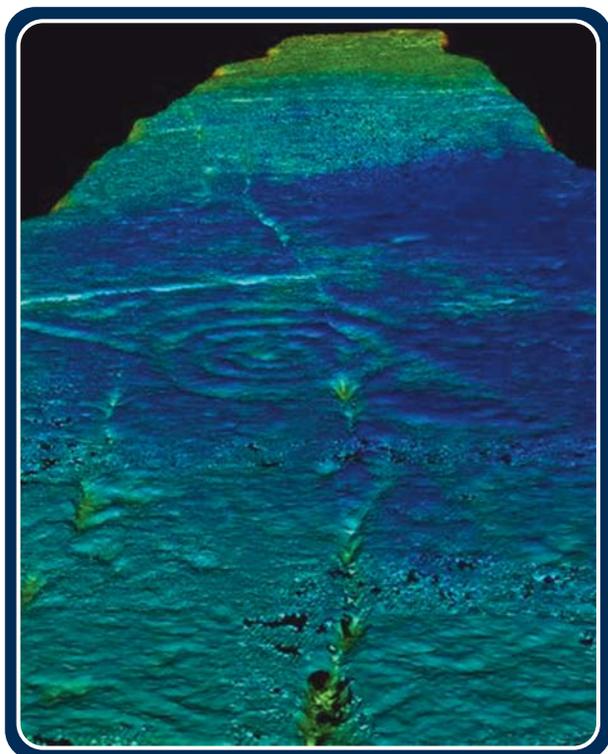


Figure 2: Perspective view of Long Meg laser scanner data using absolute elevation rendering relative to the average rock face plane. The dark region has a higher elevation than the top and bottom region of the face.

of interest to reduce data processing time. The point cloud was then triangulated using a 2.5 dimension view dependant triangulation algorithm. This was conducted from a view angle which was normal to the dominant plane of the rock face. The triangulated surface was edited, with long triangles removed to reduce interpolative errors on the surface. The meshed surface was then rendered and light from 3 directions applied to enhance the differentiation of surface texture and features for visualisation. The second stage of the data processing involved the detection of surface features. Given the curvature of the rock face a simple contour or height rendering does not represent the surface detail well. To overcome this, remote sensing image analysis techniques were applied, using ENVI RT 4.0 (RSI). The edited point cloud data from Demon3D was imported into ENVI, and gridded at 0.0005 m resolution, which derived a raster of the rock surface topography. A high pass convolution filter with kernel width 29 mm was then applied to the image to remove long wavelength surface curvature, but retain surface detail (Fig. 3 left). This kernel size was found to remove the general rock surface topography but maintain surface detail well. A triangulation threshold algorithm was then applied to the resulting image. The level of the threshold revealed different levels of detail on the image and was tailored to filter out noise (Fig. 3 right). Three profiles cut vertically through the surface were extracted using Demon3D (Fig. 4). Profile 1 illustrates profiles across a human made carving, where the carved grooves have a rounded cross sectional form but are distinct indentations on the profile. Profile 2 shows a natural fracture, which is deeper, weathered, and non-symmetrical. Profile 3 shows a weathered carved surface, and here it is noticeable that the surface definition is less clear than that seen in Profiles 1 and 2, with less differentiation between the carved grooves and surrounding surface.

The results of the analysis of 3D laser scanning data demonstrate the power of the technique to capture the features accurately and objectively. Both methods have provided very similar results. In order to describe them we have superimposed the image with a grid (Fig. 3). Because of the limitation in the number of words, a detailed description is not possible here. In brief, our recording has identified three certain cup and ring motifs and one spiral and another five possible cup and ring motifs. The first are located, from top to bottom and left to right, in 45C, 67C and 9B and the spiral in 78CD. The possible cup and ring motifs are placed in 6CD, 78BC, D7, 89C, 910B. There may be some evidence of a circular motif in 34D. There seems to be some evidence of the loops recorded by Beckensall in 6C, but there are not clear. The analysis of profiles taken across the surface shows distinct differences between natural and human made surface features. Additionally, there are considerable differences in the degree of angularity and rounding across the ring

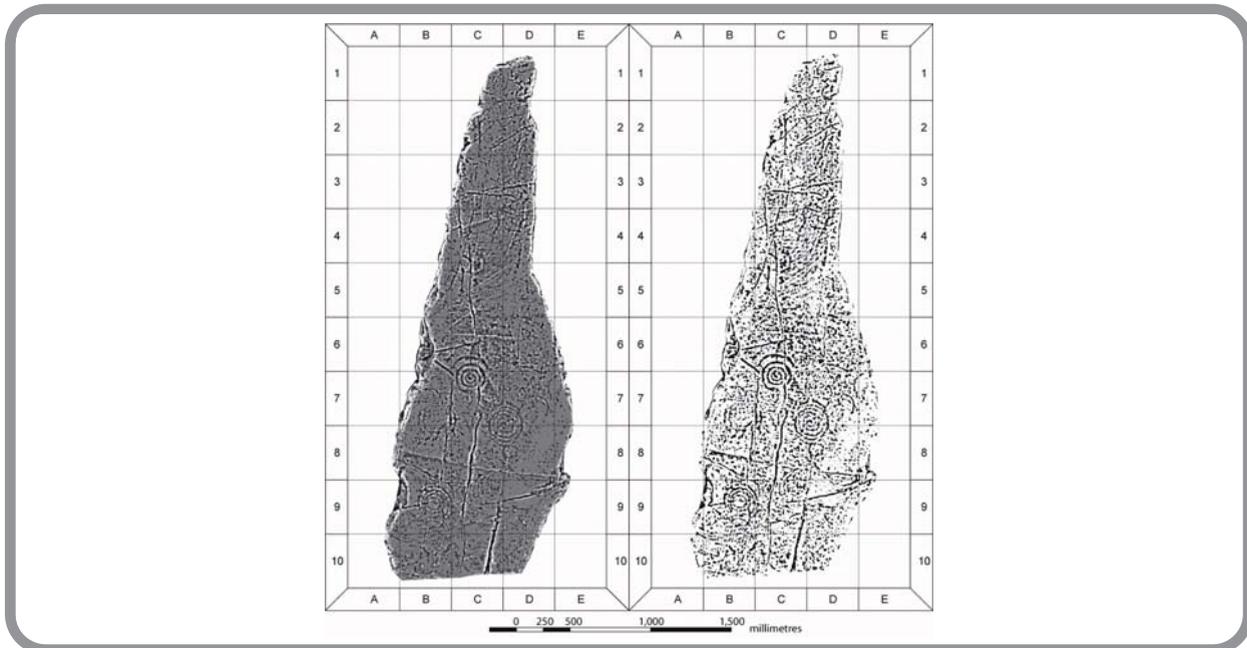


Figure 3: Left – front face of Long Meg, showing the result of the high-pass convolution filter. The grey scales indicate the degree of surface indentation, with black areas showing the deepest cuts. Right – shows the result of the threshold filter applied to the processed surface image. The threshold removes noise from the surface topography and identifies significant features.

motifs identified, which have potential to act as a measure of the relative age of the carvings. In comparison with previous recordings, laser scanning really represents a quantum leap in rock art recording. The technique offers significant advantages over previous methods of recording, namely: objectivity in recording is hugely improved in relation to traditional techniques such as rubbing; results are reliable and reproducible; the level of precision achieved is much greater than that obtained with any other method currently available, including photogrammetry; and the recording process is non-invasive and so not detrimental to fragile rock surfaces.

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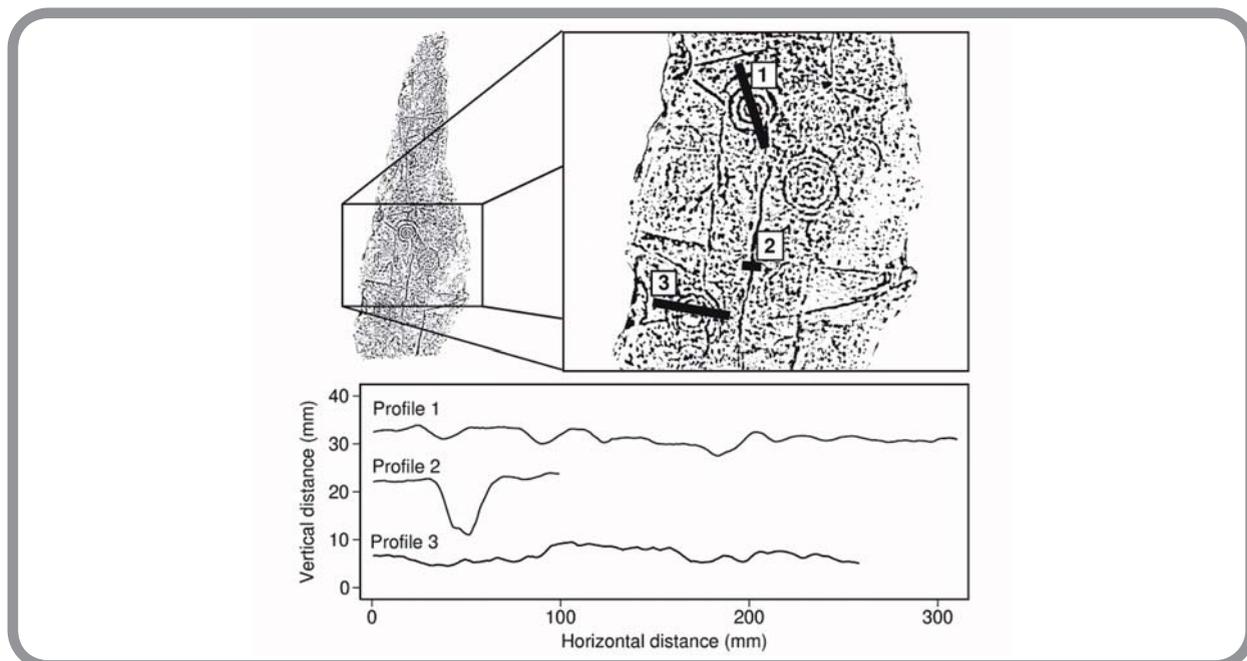


Figure 4: Top – diagram showing the location of profiles 1, 2 and 3 on the carved face of Long Meg. Bottom – graphs showing the three profiles extracted: 1) well defined human made carving; 2) natural rock fracture; and 3) degraded human made carving.

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## A FIRST FOR THE SOCIETY!

This year saw the first Prehistoric Society student study tour make its way to the Lake District. From archaeology departments around the country, undergraduate and graduate students left their books and essays to see some fantastic archaeology in one of the most scenic and diverse landscapes in Britain.

The Lake District is a place that many people have come to see as a holiday destination, to walk the fells, sail, draw, or merely sightsee. It had never occurred to me that the rugged beauty of the Lakes was interwoven and tied up with such a plethora of archaeology and history. It is easy to think that the landscape has always been as the Romantics saw it, immortalised in the literature we know so well, and that it will remain so. Instead, as Mark Edmonds, Bob Bewley and Jacqui Mulville showed us around the wide range of sites in the area, a picture emerged of how the natural and human elements of this landscape had combined and changed over time to create the patterns of settlement and land use which we see today. Not only this, but it began to show a whole new perspective on archaeological sites within their setting, one which can be hard to achieve through just reading about them.

It was on a fine afternoon at the beginning of April that we all came together at Windermere station, and made our way to the National Trust bunkhouse at

Hawkshead. It was a great time of year to be in the Lakes, at the height of spring, as the vegetation recovered from the winter gales, and lambs filled the fields. The bunkhouse itself was set amongst the trees on a hillside, and offered a cosy place to stay. Being both comfortable and spacious, it allowed everyone to gather in the evenings and have a good chat and a drink or two!

On Saturday, we piled into the mini-buses, and set off for Langdale, to climb up to the sites of Neolithic axe production. Walking along the valley, Mark and Bob explained the history of land division, pointing out the areas of cultivation and stone walls. Even the persistent rain did not spoil the beauty of the valley, a patchwork of greens and browns, with jagged teeth of rock rising high to each side. After a tea break in a sheep pen towards the top of the valley, we turned to start climbing up the steep path which zig-zagged its way alongside a gushing stream. Rain turned to snow as we neared the top, and half the group decided to return back down to the warmth of the pub!

The rest of us continued along the path, surrounded by a landscape fast disappearing under a layer of snow. The quarries and worked stone could be identified in many locations once we knew where to look for them, and where the snow did not obscure them from view. Seeing the evidence of Neolithic axe manufacture within an active setting made a huge difference in my perception of objects which are so often encountered in static museum cases. It really gave a sense of why people might have gathered here to work the stone, and the relationships which may have evolved through the manipulation of the landscape. We then descended back into the valley accompanied by amazing views, and made our way straight to the pub, to enjoy a good pint and warm our feet again! On our way back to Hawkshead, we stopped to look at some recently discovered rock art on a large boulder: an interesting

