Offa's Dyke Journal

A Journal for Linear Monuments, Frontiers & Borderlands Research

Volume 7

Edited by Howard Williams

Aims and Scope

Offa's Dyke Journal is a peer-reviewed venue for the publication of high-quality research on the archaeology, history and heritage of linear monuments, frontiers and borderlands. The editors invite submissions that explore dimensions of Offa's Dyke, Wat's Dyke and the 'short dykes' of western Britain, including their life-histories and landscape contexts. *ODJ* will also consider comparative studies on the material culture and monumentality of land divisions, boundaries, frontiers and borderlands from elsewhere in Britain, Europe and beyond from prehistory to the present day. We accept:

1. Notes and Reviews of up to 3,000 words
2. Interim reports on fieldwork of up to 5,000 words
3. Original discussions, syntheses and analyses of up to 10,000 words

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Front cover: Detail of John Speed's map of Flintshire from 1610 showing the earliest cartographic depiction of Offa's Dyke (private collection)

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Rhwydwaith Clawdd Offa's Dyke Collaboratory

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A Drone Photographic and Photogrammetric Portrait of Offa's Dyke

Julian Ravest and Howard Williams

This preliminary article applies drone photograph and photogrammetry visualisations to four significant sections of Offa's Dyke to provide fresh insights into specific features of the monument. Also demonstrated is the role of drones as a means to record the present state of features for future reference, and as a tool for the discovery of subtle features not previously recorded. The four case studies chosen for this article are part of a drone survey that covers an effectively continuous 16km ribbon of the Dyke plus the sections of Hergest Corner and Rushock Hill. Together with the complete set of Offa's Dyke drone photography undertaken, they establish a platform for future work.

Keywords: Aerial photography; drone; photogrammetry; Offa's Dyke: Hergan Corner; Llanfair Hill; Pen Offa; Rushock Hill

Introduction

This article presents preliminary results from drone photography along Offa's Dyke's central sections in Shropshire and Powys (historic Radnorshire) by Julian Ravest (JR). It identifies key sets of observations that augment existing identifications and interpretations regarding its design and placement. The results are presented via case studies that show the adjusted-segmented design of the monument, possible pre-existing features the Dyke traversed, and possible gateways in the monument, as well as further aspects of the monument's construction and use. This work illustrates new insights into aspects of the Dyke's placement, building and function. This in turn reveals the successes of avocational investigators in providing fresh insights into ancient monuments often considered well-known, as well as identifying the potential for further high-quality investigations of linear earthworks using drone photography in future.

Background

JR has had a broad and varied career. He was trained as a physicist and, after undertaking research in electrical engineering, he studied history and philosophy at Oxford University. After teaching and being a museum curator (which included running a planetarium), JR became a management consultant, working in major accountancy companies. This was followed by becoming an independent senior consultant on major projects to both the Arts Council of England and the Heritage Lottery Fund. During this latter period, he was also an agent for Russian artists.

On retirement to Wales, JR became actively involved with archaeology. This had been stimulated as a child by books in Abergavenny Library, however, it had remained an

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armchair interest until retiring to Wales. The crossover of JR's interests in archaeology, photography, computing and hill walking led to an appreciation of drone photography and photogrammetry as a useful tool to explore the historic environment in detail.

The output from the photographic survey consists of 'simple' oblique photographs, photomosaic maps and photogrammetric digital surface models. The photomosaic maps consist of numerous photographs 'stitched' together to form a geo-referenced image covering a large area with high resolution. The photogrammetry imagery is based on the same multiple overlapping photographs to create what is effectively a three-dimensional digital model of the visible land surface which can be manipulated to produce visualisations, (images), to reveal particular features. Details of the process used and the consequent results are given later in this article.

Working between 2016 and the present, JR has amassed a collection of some 60,000 aerial photographs, including around 7,000 images of Offa's Dyke. In total, these have contributed to over four hundred HER site records and has created many new ones. JR produced around 450 photogrammetric digital models, of which seventy-two are of Offa's Dyke.

Besides the Dyke, other significant projects have included the medieval Cistercian monastic sites of Strata Florida and Abbey Cwmhir with their surrounding landscapes and land holdings, upland surveys, and the mapping of a medieval field system on Penybont Common. The Strata Florida photography was initiated as part of the Sacred Landscapes Project and is an ongoing project with Professor David Austin. The Abbey Cwmhir work has been under the auspices of the Abbey Cwmhir Heritage Trust and is also ongoing. All other work has been self-motivated and self-funded (see Ravest 2019, 2021a, 2021b, 2021c, 2022a, 2022b, 2023; Bezant *et al.* 2021; Austin and Ravest 2022).

JR is also a keen advocate of encouraging wider awareness of archaeological sites and their importance. In this context, JR has presented numerous talks to local groups in mid-Wales as well as to professionals and students. JR has also published videos on YouTube as a means of widening the appreciation of significant sites, cited in videos list at the end of this (Ravest, 2021a, 2021b and 2021c). Unless people are aware of such sites they cannot be expected to value and preserve them. In this, JR shared the rationale of the Offa's Dyke Collaboratory to encourage responsible and sustained avocational engagement with the monument (Williams and Delaney 2019; see also Ray *et al.* 2021). To this end, JR's images have been used by the Collaboratory in its promotional material and in various contributions to *Offa's Dyke Journal* volume 1 (A. Williams 2019). The images also contributed to the re-display of heritage interpretation led by Professor Keith Ray for the Offa's Dyke Centre in Knighton, Powys (see H. Williams 2021a; 2025). Yet, to date, JR has not articulated his project and its preliminary results in print elsewhere.

Most field observations of Offa's Dyke have been conducted from ground level and via existing Ordnance Survey maps and/or bespoke maps (Fox 1955; Noble 1981, 1983). Aerial

photographs have been utilised to record Offa's Dyke systematically in order to monitor the monument on behalf of Cadw (Musson 1994: 142–143; 2013: 50–51) but they have had a fairly limited, and a supplementary at best role in identifying and interpreting the monument (Hill and Worthington 2003; Worthington Hill 2019; Williams 2023). This matches the restricted use of detailed topographical survey to date in investigating Offa's Dyke (Ray and Bapty 2016: 194–198). The only exception is the detailed analysis of the monument by Ray and Bapty (2016) who incorporated not only twenty aerial photographs of Offa's Dyke in their careful discussion of the monument's form and placement, but also a few low-level aerial photographs taken by drone as well as a single Lidar image. When considering the study, mapping and illustration of the monument, Keith Ray (2021) explicitly notes the potential of modern digital recording methods including aerial survey, explicitly noting the value of drone photography. However, to date, although innovative uses of ground survey and Lidar technologies have developed important new insights into the monument's character, placement and course (Delaney 2021; Humphreys 2021; Ray *et al.* 2021), drone photography has yet to be systematically deployed in investigating the monument. Set against this backdrop, the article builds on a talk given to the Offa's Dyke Collaboratory conference in June 2024 (Ravest 2024; reviewed by Williams 2025).

Aims and methods

The article aims to present preliminary results from an avocational high-quality survey of central sections of Offa's Dyke conducted to support Welsh and borderlands archaeology. JR targeted a particularly well-photographed and studied section of Offa's Dyke sporting generally good survival in south Shropshire and East Radnorshire. This area of the monument was first systematically surveyed from the ground by Sir Cyril Fox (1955: 125–172) who defined it as the 'Mountain Zone' between the Vale of Montgomery and the Severn to the north, and the Herefordshire plain to the south. Referred to by Noble (1983: 40) as the 'central border' zone, it contains particularly well-preserved sections from Hergan Corner in the Clun Forest (SO 261 854) south through Knighton to Rushock Hill (SO 301 596) at which point the precise line of the Dyke becomes more difficult to track east and south (but see now Delaney 2021: 88–90). This article provides a photographic portrait of four lengths of Offa's Dyke in this zone which are presented in geographical order from north to south: Hergan Corner and Llanfair Hill (both in Shropshire), Pen Offa and Rushock Hill (both in Powys, formerly Radnorshire).

The aim for each section is to elucidate the potential contribution of drone photography to study Offa's Dyke. Specific objectives linked to this aim were fivefold:

1. heritage conservation, management and interpretation: to attempt to capture the character of the monument for heritage conservation, management and interpretation for the public today and in the future;
2. empirical: to provide a detailed record of a some 20km of the Dyke as a reference survey for future research and teaching;

3. methodological: to demonstrate the application of drone technology to an archaeological site.
4. interpretative: to provide new data for interpretations of the function and significance of Offa's Dyke in early medieval Britain.
5. educational: the case studies include iconic, easily recognised sections of the Dyke which may provide fresh insights into the Dyke and its context to both the specialist and non-specialist reader.

This article provides an overview of the project and shows results of selected sections of the Dyke. The four sections chosen as case studies were selected as they are well known and have been extensively discussed in the literature. As such the results of the drone imagery can be readily compared to recognised features and interpretations provided using other remote sensing means, notably and briefly:

Aerial photography from aircraft remain an invaluable research tool by efficiently covering large areas. Still, they are limited in resolution and ability to frame low level oblique images. The resulting images cannot be used as the source of photogrammetry.

Lidar: This is an extraordinarily powerful technique overcoming the limitations of visible light photography by being able to cut through vegetation cover (see Davis 2011, Delaney 2021). It is now available for the whole of Wales at a resolution of 1m per pixel. The drone photography used in this survey has a typical ground resolution of around 2–3cm per pixel. Colour is preserved which is important in photographing parch marks. Higher resolutions are obtained by flying lower. Drone photography is restricted by weather and vegetation.

The drone photography survey is based on aerial photographs taken using a DJI Phantom 4 drone with its built-in 12Mp camera. The images used in this article are a small selection from a collection of over six thousand which were taken of the Dyke during periods of fine weather between 2018 and 2021. Some hand-held camera photographs were also taken but are not shown here.

Two types of photographs were taken: oblique and vertical. For oblique photographs the drone simply acted as a tripod in the sky enabling views to be framed. The oblique photographs have immediate appeal and can be informative in showing the Dyke and its landscape context.

Overlapping vertical photographs were taken by the drone flying on a pre-programmed flight grid. Flight plans used in this survey were created using Drone Deploy software. Once uploaded to the drone a series of photographs were automatically taken to cover the area of interest. For this vertical photography the drone was usually flown at approximately

Figure 1 (next page): Orthomosaic of Hergan Corner, Clun Forest, Shropshire (Photograph: Julian Ravest, 2019)


0
100 m

75m above ground surface to give a photographic ground resolution of 2–3cm per pixel. All aerial photographs were geo-referenced using the drone's built-in GPS system. The collection of all aerial photographs were managed using Adobe Lightroom.

The overlapping photographs were used by mapsmadeeasy.com software to create photomosaics and a range of point clouds in different formats. The point clouds were uploaded to Relief Visualisation Toolbox, (RVT), a service provided by the Institute of Anthropological and Spatial Studies, Slovenia, or to Planlauf/TERRAIN which is available from Planlauf GmbH, Germany. These programmes provide customisable visualisations to reveal characteristics of the landscape. RVT is now available as a plug-in for QGIS.

For the purposes of this project the Dyke was divided into fifty-five sections, each with its own photogrammetric survey and oblique photographs. This case study illustrates the range of imagery and the information available for each of the fifty-five sections. Together, these cover an almost continuous ribbon of Offa's Dyke.

Case study 1: Hergan Corner (SO 262 856)

Fox described the survival of the Dyke here as 'remarkable' in scale but took the 'right angle' as 'awkward and incomplete; the builders were apparently indifferent, and made no attempt to disguise it' (Fox 1955: 130). He notes it was one of a series of angles at clearly defined geographical locations, others being at Cwmsanaham Hill and Rushock Hill. Yet, at Hergan, Fox argued the angle was the result of a disjointed construction caused by different work gangs failing to adequately liaise with each other (Fox 1955: 153). Frank Noble concurred that the shift of alignment at the Hergan Corner col was the result of a 'lack of co-ordination' which resulted in over a mile of the Dyke to the north of Hergan Corner having 'no command of the ground nor any view to the west'. Noble also noted this arrangement resulted from the need to 'cross small head-stream valleys and boggy springheads draining eastwards' (Noble 1983: 67). Hill and Worthington (2003: 53) made a point of disagreement with Fox and Noble, seeking a logic in the positioning of Offa's Dyke here resulting from a desire to avoid the Dyke crossing wet and boggy ground: 'The line is in fact very carefully chosen with great regard for the local topography whilst keeping the long-distance objective in view; it is economical of build and minimise both the effects of the dead ground in one section and the number of streams crossed'. Therefore, the placement suggests the builders were 'extremely sensitive to local topography' (Hill and Worthington 2003: 53; see also

Figure 2 (next page, above): Oblique view looking south along the line of Offa's Dyke towards Hergan Corner with Hergan Hill in the background (Photograph: Julian Ravest, 2019)

Figure 3 (next page, below): Vertical view detailing the Hergan Corner section of Offa's Dyke with two clear breaches: one is a modern farm track and a second, arguably original gateway and associated trackway (Photograph: Julian Ravest, 2019)

Figure 4: Viewed from the east (behind) Offa's Dyke looking west, this oblique view of the Hergan Corner gateway seems designed to impress those approaching overshadowed by the bank, ditch and counterscarp bank to their right and upslope (Photograph: Julian Ravest, 2019)

Williams 2013: 156). Ray and Bapty (2016: 237) dismiss these earlier explanations in favour of regarding the logic of Hergan Corner resulting from the need for it providing one of a series of 'surveillance facilities at key points along the Dyke and also providing a striking impression when approached from the west'. To inform this debate, Hergan Corner was selected as an important case study with which to apply drone photography.

We begin with an orthomosaic of Hergan Corner where the bank from the north has been deflected to meet the southern bank, which at this point is bivallate (bank and counterscarp bank), to create an obtuse angled corner at an angle of approximately 110 degrees (Figure 1). This configuration is clearly intentional and integral to the original design; there are no topographical reasons for this deflection and no indications of any prior straight section which had been subsequently modified to create the corner. An oblique view along the straight section approaching Hergan Corner from the north of the Dyke, looking south, clearly illustrates this purposeful deflection to form an 'angled turn' far more effectively than previous ground-level photographs (e.g. Ray and Bapty 2016: 238) (Figure 2). Focusing in on the angle turn itself, the 'corner' is breached in two places. One is a modern-era farm track whilst the other is likely to be far older and perhaps the original raison d'être of the corner; a gateway through which a track passes (Figure 3).

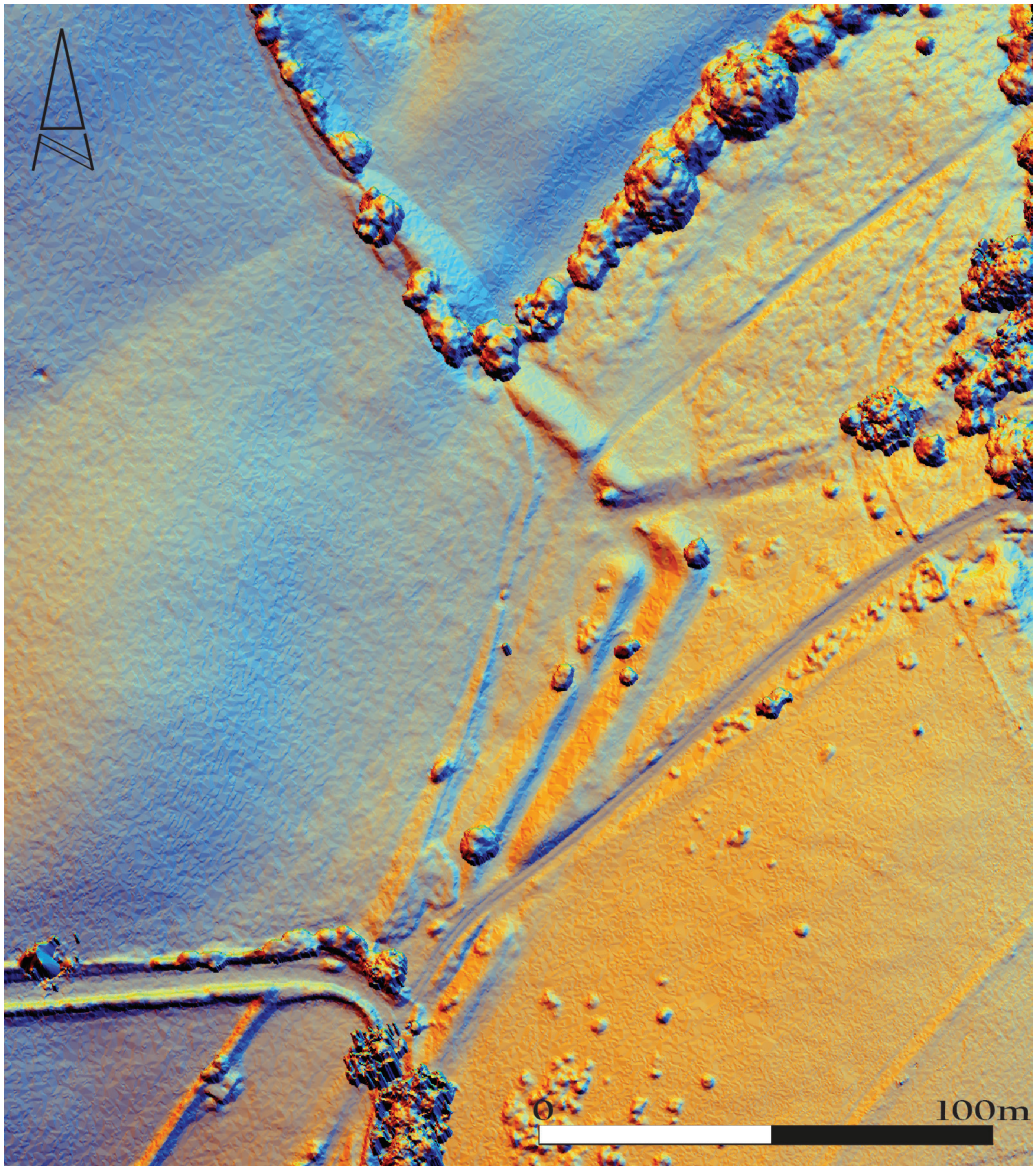


Figure 5: Hergan Corner viewed as a 3D surface model with north-east facing slopes coloured orange and south-east facing slopes coloured blue emphasising how the angle turn is located at the lowest part of a shallow valley (col) (Photograph: Julian Ravest, 2019)

This earlier gateway through the Dyke, viewed from the north-east looking south-west along the slopes of Hergan Hill (Figure 4), is designed to impress those approaching from the west (as argued by Ray and Bapty 2016: 239). Those approaching the corner would first have passed beneath the single vallate set in the hillside above, before facing a large bank immediately in front of them with the impressive bivallate section to their right. The corner is thus a distinctive confluence of routes from the west and perhaps an ideal place for observing and controlling the movement of people and their animals wishing to pass east of the Dyke.

Figure 6: Oblique view of the wider course of Offa's Dyke showing how the scale of the earthwork reduces away from the particularly monumental earthworks at Hergan Corner (Photograph: Julian Ravest, 2019)

Hergan Corner is further revealed by a 3D surface model with north-east-facing slopes coloured orange and south-east facing slopes in blue (Figure 5). The counterscarp bank is clearly visible to the south of Hergan Corner (see Ray and Bapty 2016: 209–211). This emphasises how the corner sits in the lowest part of a shallow valley. The track on the eastern side of the gateway also shows up before it enters trees. No trace of the track towards the west is now visible. Looking northwards from Hergan Corner, the Dyke arcs over the landscape crossing multiple valleys before descending into the Vale of Montgomery. Moreover, away from the Corner, the scale of the large bank reduces in scale as the Dyke traverses the landscape northwards (Figure 6). In summary, the drone photographs reveal the behaviour of Offa's Dyke at Hergan Corner and its relationship to a possible historic crossing point of the monument in more precise detail than existing published photographic records have been able to achieve to date (see Ray and Bapty 2016: figure 6.10). This bolsters the argument of Ray and Bapty (2016) regarding this being a likely historic gateway allowing control and surveillance of those approaching the monument from the west rather than a mishap of poor co-ordination or else exclusively concerned with avoiding wetland and water courses.

Figure 7: Oblique view looking north-west over Springhead Farm and the northern edge of Llanfair Hill (Photograph: Julian Ravest, 2019)

Case study 2: Llanfair Hill (SO 251 797)

This is an iconic section of Offa's Dyke where it straddles the western slopes of Llanfair Hill (Fox 1955: 134–135; Hill and Worthington 2003: 8, 51). Here, Noble (1983: 62) described it as '... one of the most impressive stretches of the Dyke'. Ray and Bapty described the Dyke in this location as surviving in their 'monumental construction mode' (Ray and Bapty 2016: 169) across 'sweeping uplands' (Ray and Bapty 2016: figure 6.4) where the monument's 'adjusted-segmented construction' that they have identified and characterised is clearly visible (Ray and Bapty 2016: 203). Another distinctive aspect of this stretch is that a counterscarp bank can be readily discerned as a continuous feature of the monument (Ray and Bapty 2016: 210, figure 5.37). This is also one of a series of locations where dry-stone wall revetments were incorporated into the west-facing bank of the Dyke (Ray and Bapty 2016: 212). Here also, quarry pits are visible (not to be confused as an eastern ditch) to the east of the bank (Ray and Bapty 2016: 188–192, 219).

The drone photography elucidates some of these features far more clearly than high-level or ground-level images. For instance, an oblique view looking north-west over the Dyke shows clearly its curving path around the contours before it drops down off Llanfair Hill before crossing a stream and heading in a relatively straight section towards Springhill Farm and

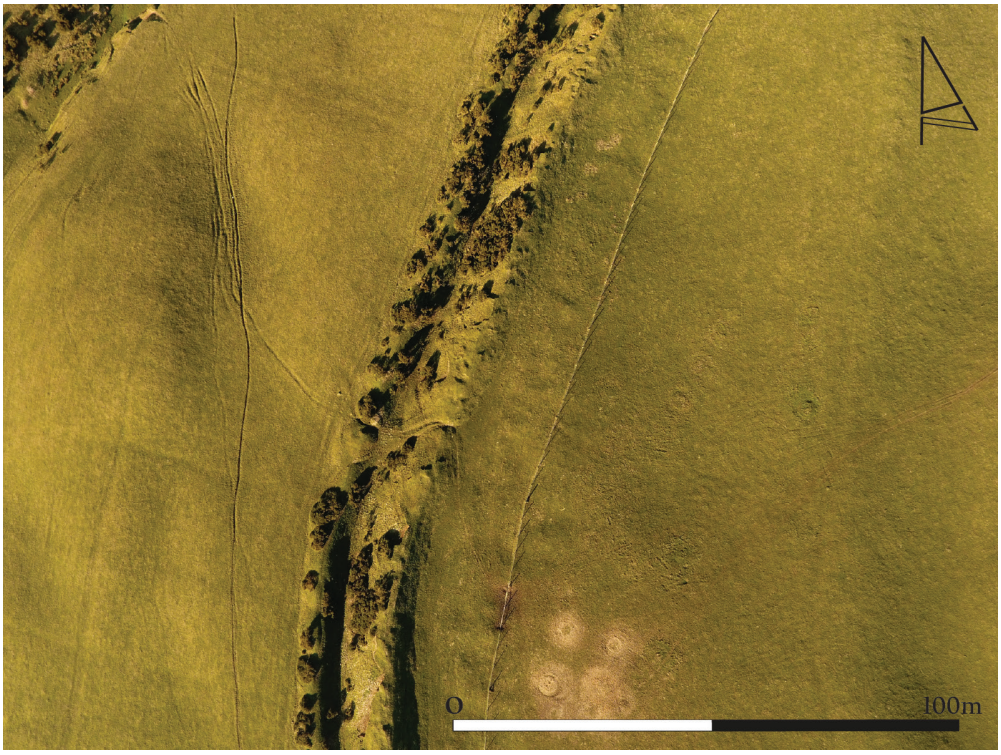
Figure 8: Example of a georeferenced orthomosaic image of Offa's Dyke has it traverses west of the summit of Llanfair Hill (Photograph: Julian Ravest, 2019)

from thence to Spoad Farm in the Clun Valley (Williams 2023: figure 24). Springhill Cottage is in the trees near the centre of the image. Few features are visible in the surrounding 'improved' enclosure fields through which the Dyke passes but the quarry pits can be readily distinguished to the east (near-side in this photograph) of the monument (Figure 7).

To further introduce this stretch, an example of a georeferenced orthomosaic image maps a composite of eighty-eight photographs superimposed on a satellite image to demonstrate how such images, created from drone photographs with GPS metadata, can be applied

Figure 9 (next page, above): One of the eighty-eight overlapping vertical photographs that make up the photomosaic Figure 8 (Photograph: Julian Ravest, 2019)

Figure 10 (next page, below): Illustration fo the detail of the Figure 9 orthomosaic photographs (Photograph, Julian Ravest, 2019).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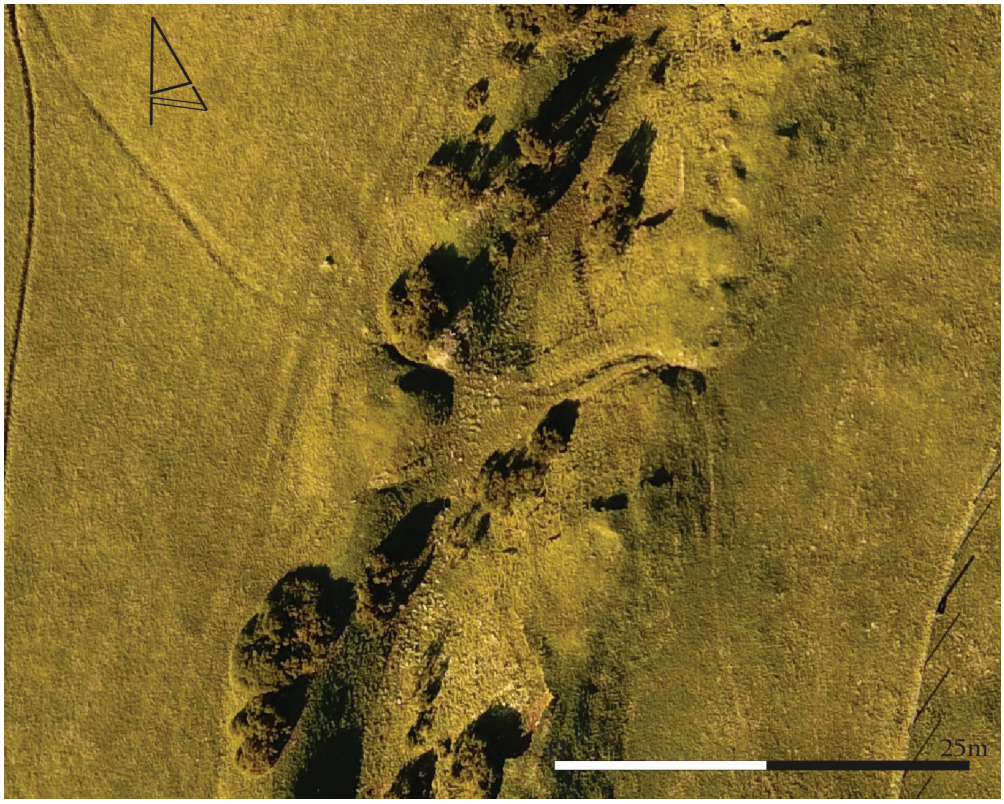
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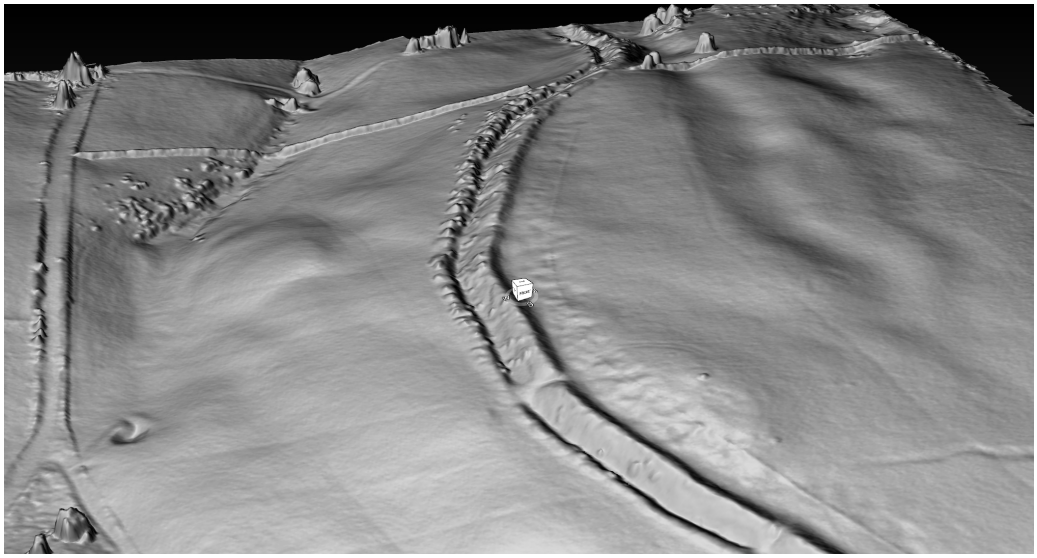


Figure 11: Oblique view of part of 3D digital surface model with vertical elevation exaggerated by factor of 1.5 revealing quarrying on the eastern side of the bank and the counterscarp bank (Photograph: Julian Ravest, 2019)

Figure 12: Oblique view south along Offa's Dyke at Llanfair Hill (Photograph: Julian Ravest, 2019)

Figure 13: A lower oblique view south along Offa's Dyke Dyke illustrating the adjusted-segmented structure and a braided relict route seemingly passing under the monument (Photograph: Julian Ravest, 2019)

to Geographical Image Systems (GIS) (Figures 8–9). Details of the quarry ditches to the east and counterscarp bank to the west are readily identified with a definition hitherto unmatched (see Ray and Bapty 2016: 209–211). Details of such high-resolution vertical photographs afford a precise recording of the state of the monument at the time it was taken and thus can be invaluable for heritage conservation, management and interpretation as well as education and research in the future, such as by assessing erosion over time (Figure 10). Specific features can be discerned through further scrutiny of the images. For example, by adopting an oblique view of part of 3D digital surface model with vertical elevation exaggerated by factor of 1.5, the aforementioned quarry pits on the eastern side of the bank are revealed, as are the straight sections of the adjusted-segmented design of the Dyke (Figure 11). Parameters such as angle of 'digital' lighting, angle of view, exaggerated vertical dimension can be varied to reveal subtle features which may otherwise pass unnoticed.

Further oblique drone photographs reveal this section of the Dyke's careful navigation of the topography to the west of the summit of Llanfair Hill. The Dyke itself is well formed and in good condition and generally free of agricultural damage apart from some crossing farm tracks (Figures 12–14). The overall relationship of the Dyke to the ridge

Figure 14: Oblique view looking south over the braided track in relation to Offa's Dyke on Llanfair Hill (Photograph: Julian Ravest, 2019)

can be seen (Figure 12), but from a lower viewpoint the line of the Dyke can be seen to 'wiggle', not because of differential erosion but because of its original, deliberate adjusted-segmented design comprised of straight lengths 'bolted' together (Ray and Bapty 2016: 192–208). These photographs thus show far more precise and discernible evidence than the ground-level photographs hitherto presented in support of the existence of this design feature on Llanfair Hill (Ray and Bapty 2016: figure 5.30). This design is reminiscent of the subtle changes of direction one can discern in a ridgeway over open countryside which can sometimes constitute a locally agreed boundary. Notably the Dyke is on a westward facing slope in the foreground section while in the distance the Dyke is on an eastern slope, illustrating how the monument navigates through the topography to optimise its role in blocking, controlling and surveilling movement in the landscape between the watersheds (see also Noble 1983: 62). A sunken braided track can be seen passing under the Dyke in this and the following photograph (Figure 13), possibly enhanced by recent farming activity but perhaps revealing a longer-term ridgeway route used to traverse the landscape from before the Dyke's construction. This braided track rises from the valley below and follows the line of the ridge (Figure 14).

The drone photographic survey revealed a further, hitherto unrecognised earthwork feature associated with Offa's Dyke. In glancing light, at the point where the modern

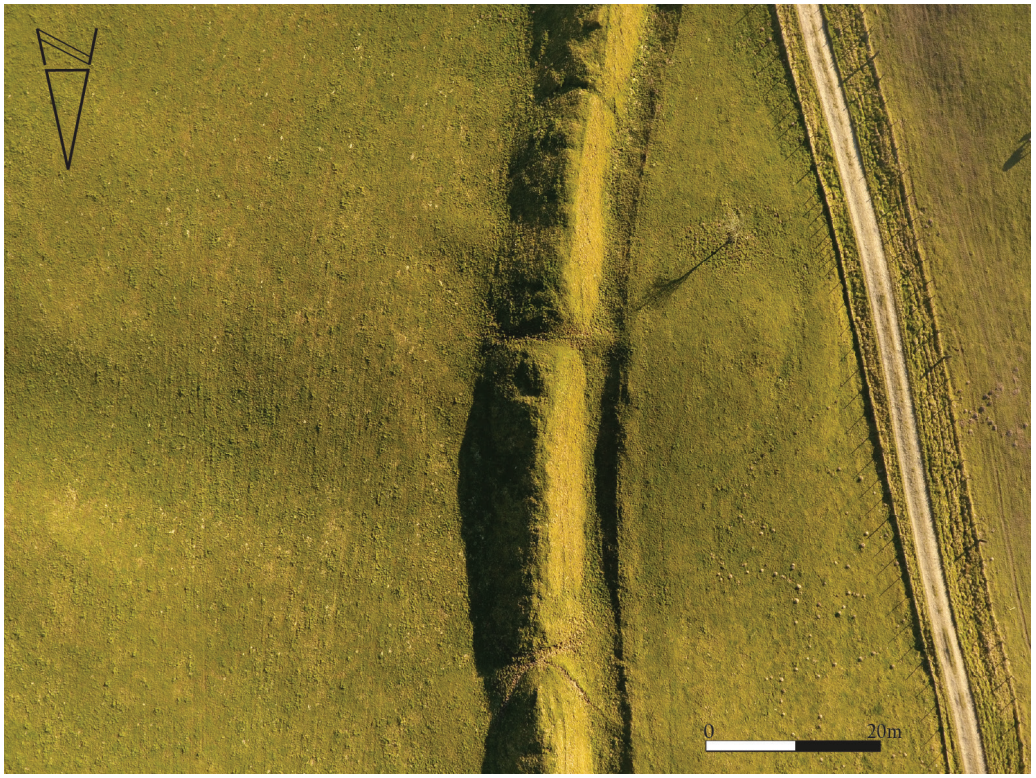


Figure 15: In oblique light, this vertical view reveals a previously unrecorded earthwork underlying Offa's Dyke (Photograph: Julian Ravest, 2019)

farm track and the Dyke converge is the hint of a previously unrecorded rectangular earthwork, approximately 40m x 25m, (SO 2528 7897) (Figure 15). A photogrammetric view of the earthwork highlights this subtle feature the vertical scale when it has been magnified by a factor of ten (Figure 16).

A different type of visualisation of the same 3D digital model shows more clearly the rectangular enclosure on top of a raised platform that is beneath, and hence older than, the Dyke. Some processing artefacts are present at some edges of the visualisation where there are insufficient overlapping photographs to provide a 3D analysis (Figure 17).

No conclusive interpretation of the earthwork is possible without further parallels or investigation. One option is that it has prehistoric origins as a control point along as the postulated (above) north–south ridgeway passed through a ridge-top choke point. A second suggestion is that this might be a Roman fortlet: a form of monument which takes varied forms in northern Britain from the first to the early fifth century AD, but has far fewer parallels in western Britain beyond the first century (see Symonds 2018: 197–208, 214–218; White 2022). Still, aerial reconnaissance, geophysical survey and earthwork survey have together begun to reveal more examples of varying date-range, size and likely function

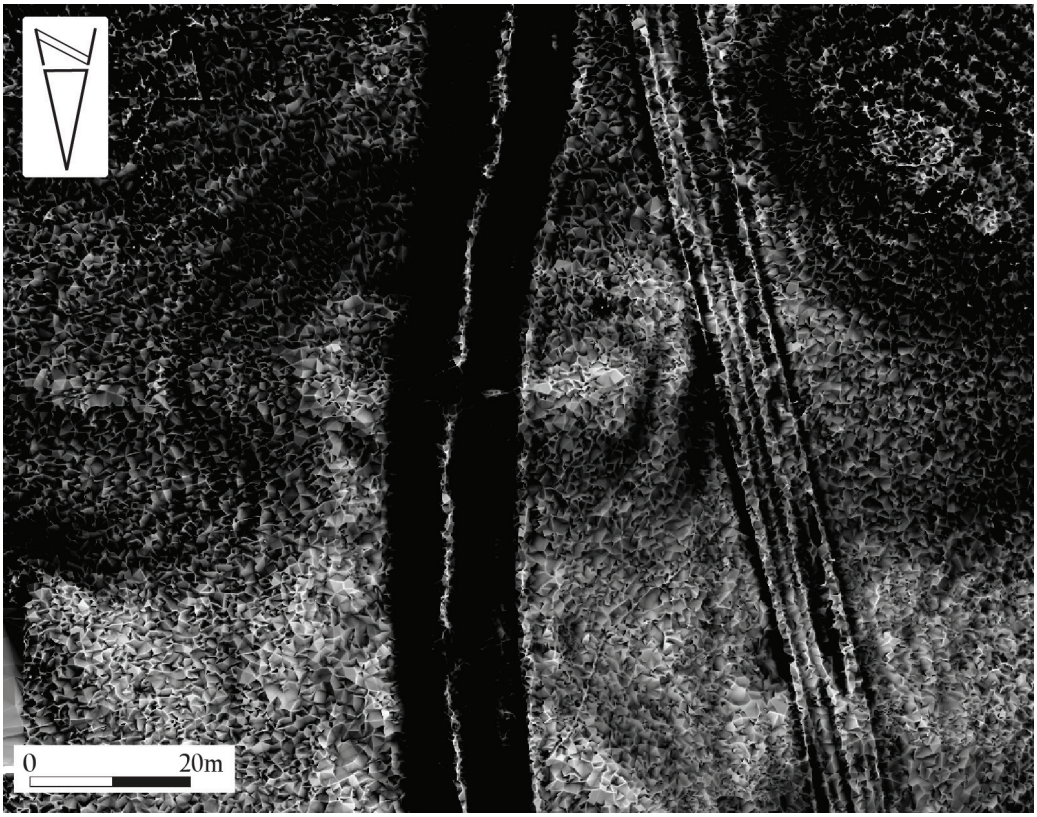


Figure 16: Photogrammetric view of the earthwork hinted at in Figure 15 magnified by a factor of ten on the vertical scale in order to highlight this subtle feature (Photograph: Julian Ravest, 2019)

(Burnham and Davies 2010: 67–68, 71, 291–301: Driver *et al.* 2020). At c. 40m x 25m, the Llanfair Hill earthwork is not dissimilar in proportions from Pen y Crocbren, measuring 23.5m x 20m (Putnam 2010: 297; see also Frere and St Joseph 1983: 139–140), Waun-ddu (Y Pigwyn III) c. 38m x 35m (Murphy 2010: 298–299), Penmincae sized at 42m x 30m (Frere 2010: 296), and Period 1 of Erglodd at 49m x 32m (Davies 2010: 292–295). More examples of these fortlets are likely to come to light with further aerial investigations: a notable recent example in the Anglo-Welsh borderlands is the Harpton signal station in proximity to a series of Roman first-century marching camps and associated structures and activity in the Walton Basin (Britnell and Jones 2019: 60, 74, 91).

For Llanfair Hill, the nearest Roman forts are Brompton/Pentrehyling (White 2010) and the longer-lasting Forden Gaer slightly farther away still (Jones 2010: 243–245; see also Jones and Mattingly 1990: 103, map 4:34, 103–105, maps 4:34–4:38). Yet, a precise Roman context to activities in the Clun Forest has not been established, although it is plausible this postulated fortlet might have served as part of a chain of communications between Roman military installations during the first-century invasion phase or later various attempts to control and communicate across the province. Thus, it might be

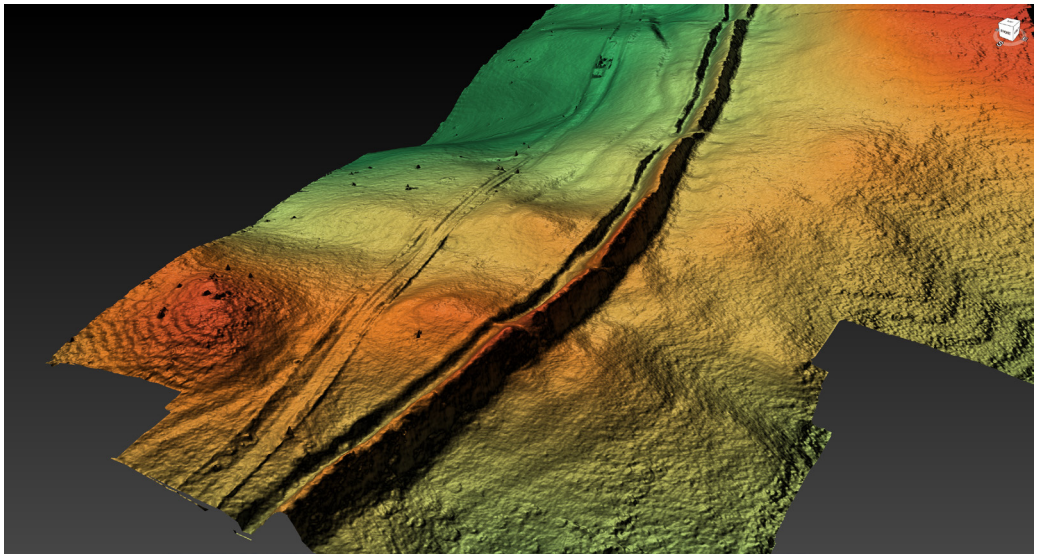


Figure 17: An alternative visualisation of the same 3D digital model as Figure 16 (Photograph: Julian Ravest, 2019)

no coincidence that Offa's Dyke incorporated this ruinous site into its line. However, without further investigations, a precise logic and context to a Roman fortification at this precise location cannot be determined.

A further alternative explanation for the earthwork is that it may relate to the actual construction of the Dyke: perhaps a small garrison was installed here to protect workers or to act as their base, a suggestion hitherto not considered but which might equally apply to enclosures and fortifications adjacent to or under the Dyke, including possible repurposed prehistoric sites (cf. Ray and Bapty 2016: 244–250). Whatever its date and function, any beacon on this specific site would be visible for long distances to the east and its position gives it extensive views to the west. As such, its incorporation into the line of Offa's Dyke certainly speaks to the careful positioning of the Mercian monument in the landscape.

Case Study 3: Pen Offa (Castle Ring) Crossing (SO 269 638)

Our third case study explores a gap in the Dyke at Pen Offa near Castle Ring which coincides with a slight change of direction of the Dyke of some 20 degrees, creating an obtuse corner. This feature was completely missing from Fox's commentary on the course of the monument (Fox 1955: 145–146) but identified by him as an 'opening' where the bank is 'slightly reflected', the gap being 5–6m in breadth. A deep trackway leads to the opening from the north-west but is not discernible on the east side of the monument which he regarded as the line of a 'hill-way' from Radnor Forest (Fox 1955: 158). Frank Noble also considered this a possible gap and noted a trend for this happening where traffic from the Welsh side would have to pass below one flank of

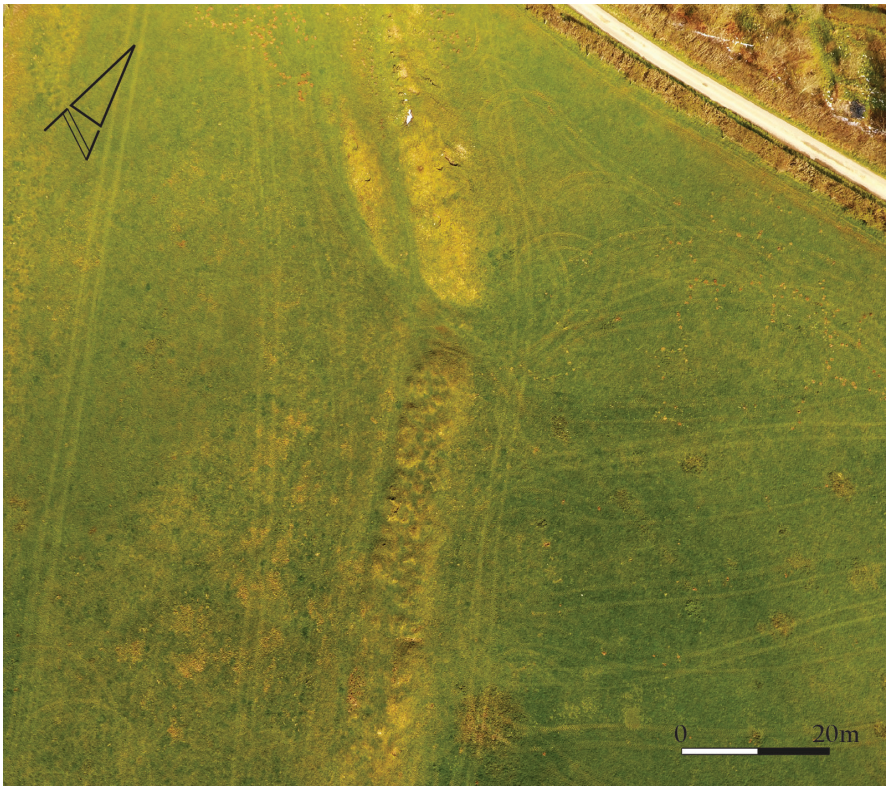


Figure 18: Vertical view of the gap at Pen Offa (Photograph: Julian Ravest, 2019)

Figure 19: An oblique view of the Pen Offa gap looking south (Photograph: Julian Ravest, 2019)

Figure 20: Offa's Dyke at Pen Offa viewed from the west showing the bank after the second gap with a third gap visible beyond (to the south) (Photograph: Julian Ravest, 2019)

Dyke when approaching the monument (Noble 1983: 44). He considered it a 'very important crossing-place on the upland between the Lugg and the Teme valleys' (Noble 1983: 45). Hill and Worthington (1983: 53) conducted excavations (their site 62) which they describe as 'limited' and argue that the gap is the result of being crossed by 'post-medieval drainage' and not original. Ray and Bapty (2015: 229–232) explicitly countered Hill and Worthington's scepticism and excavation results (noting the limited records of the excavation, and how the trench was unlocated). They questioned whether the small ditch uncovered was the continuation of the Dyke's ditch. Utilising drone photography by Adam Stanford of Aerial-Cam to support their arguments, Ray and Bapty show how the Dyke approaching the gap from both directions, north and south, shifted its alignment eastwards and that the gap exists at the point where the alignment is angled. Following Fox's observations of a trackway approaching from the north-west, the Dyke is here seen as diverting an earlier route towards the gap. They find this evidence 'compelling' regarding this being an original gateway, and add the observation that the place-name of the cottage to the north-east of the gap by only 100m 'Bwlch' means 'gap, pass, or notch' (Ray and Bapty 2016: 231–232).

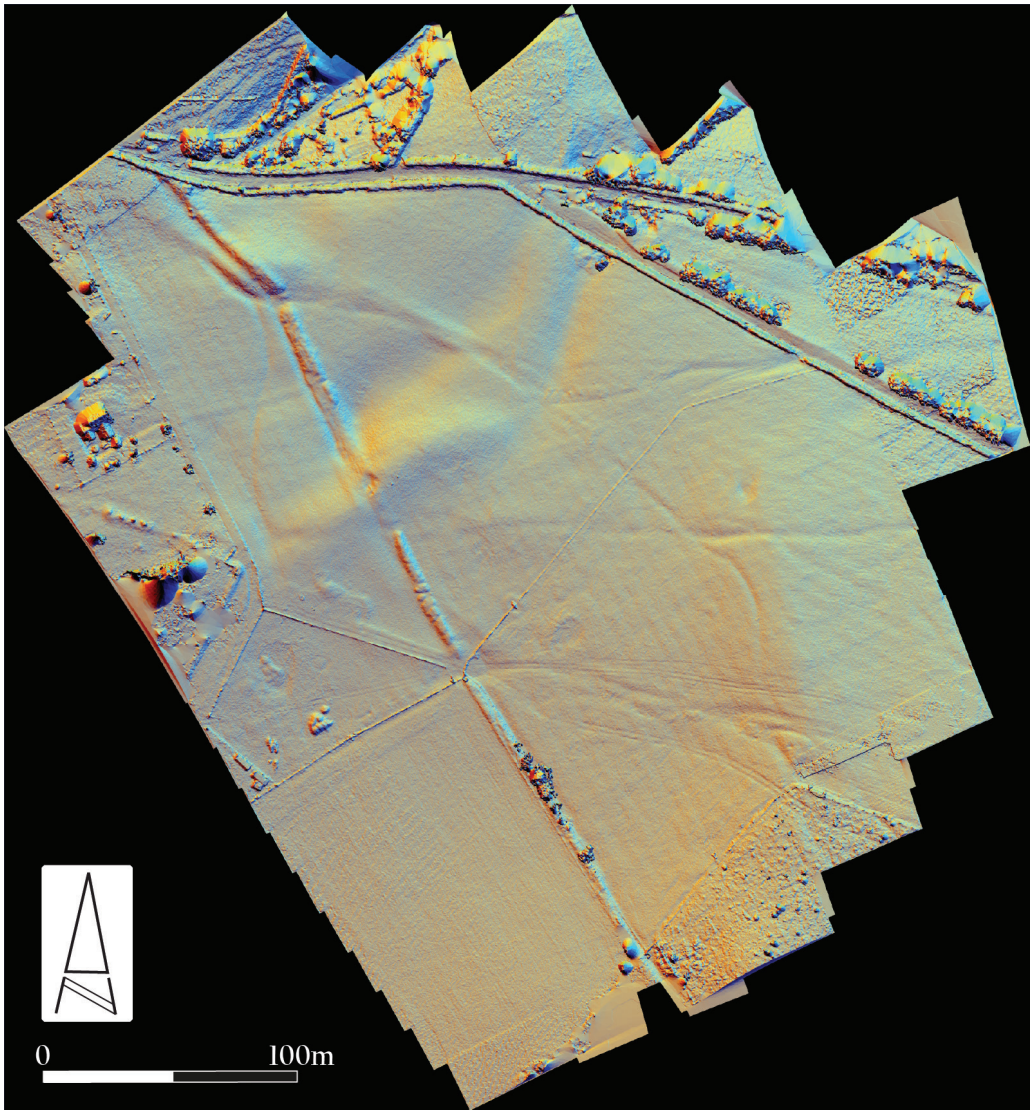


Figure 21: Multi-directional vertical 3D visualisation of the three crossings of the Dyke near Pen Offa with associated tracks (Photograph: Julian Ravest, 2019)

The new drone photographs conducted by this survey reveal a short counterscarp bank lies parallel to the Dyke to the northern side of the gap and there is a vestigial, possibly much eroded, counterscarp bank also visible on the southern side of the gap (Figure 18). The significance of the crossing point would have been enhanced if this part of the Dyke had been bivallate, supporting the arguments of Fox, reiterated by Ray and Bapty, that the section either side of the gateway was particularly monumental. As noted by Ray and Bapty (2016: 230), a sunken east-west, braided, track crosses the Dyke at this point and this may have been a precursor of the modern road along the valley (Figures 19–21). The modern road, B4372, crosses the Dyke some 70m to the north of the postulated gateway

(Figure 20) and two other sunken tracks cross the Dyke in this section (Figures 20 and 21). In summary, this high-resolution drone photography, oblique and vertical, supports and enhances prior observations regarding the potential for this having been an original gateway in Offa's Dyke.

Case study 4: Rushock Hill (SO 289 595)

The Rushock Hill section of the Dyke is the most southerly area photographed in this survey and represents a critical node in the monument's major 'stances': To the north of Rushock Hill the monument follows a broadly north–south alignment, to the south of Rushock Hill it heads north-west/south-east to join the Wye west of Hereford (Ray and Bapty 2016: 128). The abrupt change of direction , 'angle turn', of the Dyke at this key node of some 65 degrees, is a significant and much debated feature in this section between Herrock Hill and Rushock Hill (Fox 1955: 148–150; Noble 1983: 40; Hill and Worthington 2003: 132–134, 143).

We begin this final case study with an orthomosaic view of Rushock Corner that provides a clear impression of the angle-turn of the monument, supporting the argument that this was a feature that enhanced the visual impact and use of the monument in controlling movement along and across its line (Ray and Bapty 2016: 234–240). No 'hidden' features are revealed by photogrammetric techniques in the adjacent improved

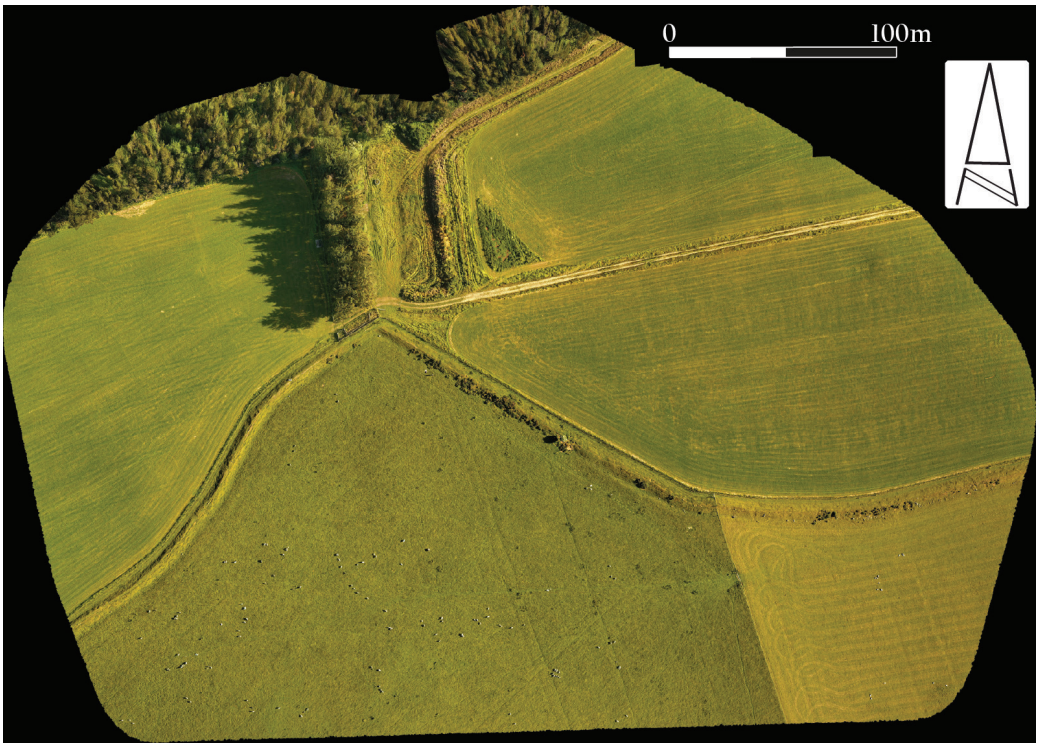


Figure 22: Orthomosaic view of Offa's Dyke's angle turn on Rushock Hill (Photograph: Julian Ravest, 2019)

fields with no gap in the Dyke. The actual corner shows no sign of discontinuity where the two branches meet. The adjusted-segmentation of the monument is evident in this and subsequent images (Figure 22). Indeed, it is demonstrable in a fashion that has not been adequately mapped or visualised before (cf. Ray and Bapty 2016: 206).

At this point the Dyke appears to make a deliberate and purposeful detour off the more obvious ridge line (Figure 23). While no track has penetrated the Dyke near the corner, a possible sunken track can be seen directed towards the Dyke but peters out before reaching it. This is possibly a cross-ridge track that would have predated the Dyke and may have been a reason for this particular location of the corner.

A second cross ridge sunken track can be discerned passing through the Dyke further to the east (Figure 24). It does not appear to be part of the Dyke design but is a later break-through. Offa's Dyke Path follows this track across the Dyke. As on Llanfair Hill, the line of the Dyke is laid out in adjusted-segmentation along a ridge. A closer view looking east of the crossing shows where Offa's Dyke Path meets the Dyke. This is the only location on Rushock Hill where a significant number of exposed stones rest in the ditch perhaps formerly elements of the monument's bank (Figure 25) (see also Ray and Bapty 2016: 212–213).

An oblique photograph looking north-east shows Offa's Dyke dropping off Rushock Hill ridge into Kennel Wood via a series of adjusted segments (see also Ray and Bapty 2016; contra Hill and Worthington 2003: 50). Furthermore, a georeferenced photogrammetric visualisation/map shows the adjusted segments of the Dyke before it crosses diagonally down a steep slope which is now wooded (Figures 26 and 27). One consideration might have been the creation of an obtuse corner where there is a gap in the Dyke; now a crossing point by the Mortimer Trail (SO 2982 5952). Part of the Dyke is severely eroded in this section. This firmly supports Ray and Bapty's (2016) and Delaney's (2021) determinations that Offa's Dyke continued into Kennel Wood and did not, as Hill and Worthington (2003: 143) argue, stop on the hilltop.

Discussion

This study has presented case studies from an avocational high-quality survey to support Welsh and borderlands archaeology. The twenty-seven images in the case studies presented in this article are but a small fraction of the information contained in the complete survey database and are indicative of the contribution that drone photography can make in the mapping and analysis of Offa's Dyke. In particular, this project complements the strengths and weaknesses of other remote sensing tools available to archaeologists (e.g. Davis 2011;

Figure 23 (next page, above): Oblique view east over Offa's Dyke on Rushock Hill (Photograph: Julian Ravest, 2019)

Figure 24 (next page, below): Oblique view looking east over Offa's Dyke on Rushock Hill showing a second cross-ridge sunken track passes over the earthwork (Photograph: Julian Ravest, 2019)

Delaney 2021; see also Ray *et al.* 2021). Its overall benefit is to detail archaeological features at high resolution and at low level in their landscape context. Its main weakness is that, unlike Lidar, it cannot penetrate vegetation cover.

Two uses that are not covered in this survey are its use in recording, in 3D modelling via photogrammetry, of archaeological excavations and in surveying parch or crop marks. However, the case studies included are sufficient to justify the ongoing and sustained use of drone photography alongside other aerial reconnaissance methods to benefit our understanding and appreciation of the historic landscape of the Anglo-Welsh borderlands, including its linear earthworks. Certainly, the potential remains to widen the scope of this survey, not only to other areas of Offa's Dyke, but to other linear monuments in the region. These include the 'short dykes' of western Britain (e.g. Hankinson 2024) and Wat's Dyke (Williams 2021b) as well as other linear monuments of postulated early medieval date (e.g. Vyner 2021). Such work might deploy drone photography in targeting specific features and sections which might resolve questions regarding the presence, character, function and significance of linear earthworks.

This initial report of a drone survey of the Dyke has contributed fresh insights and clarity into understanding the selected features, and in so doing has provided evidence to determine some long-standing uncertainties and controversies.

Topographic position

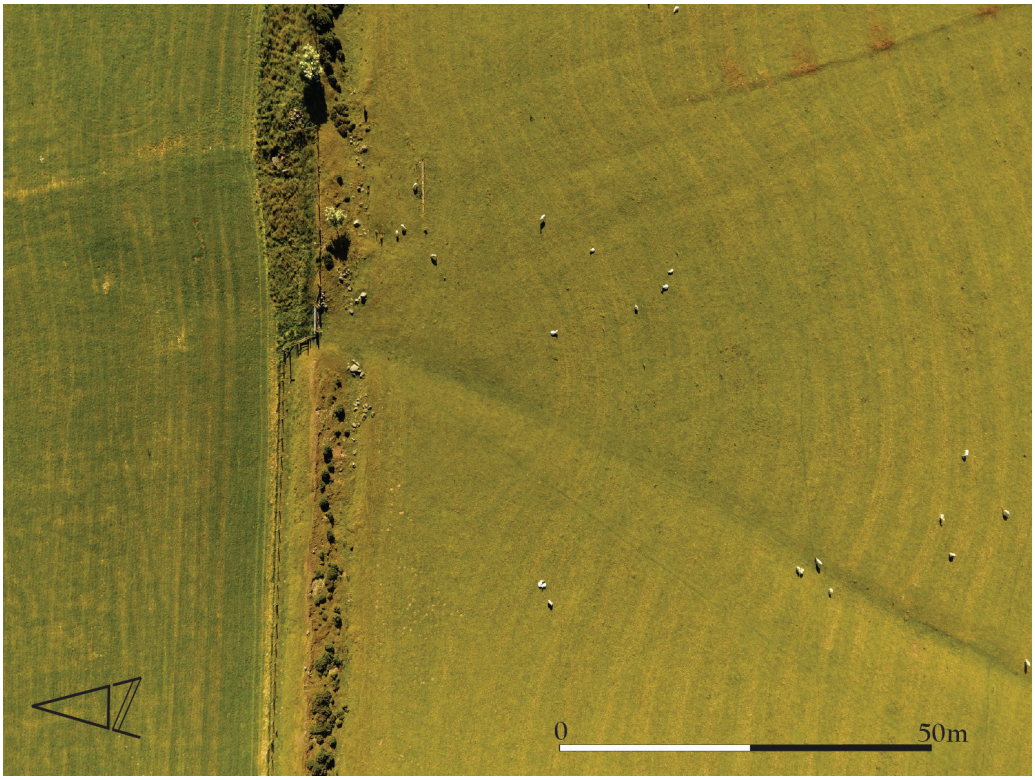
The course of the Dyke through the landscape is clearly shown in each of the four case studies. It does not hog the western slope so as to dominate the west. Often it is seen to follow ridges, or even on occasions eastern slopes, where visibility from the west would be limited. The placement appears deliberate in all sections considered as it navigates complex topography along, across water courses and other routes of movement in the landscape (see also Ray and Bapty 2016; Williams 2023).

Relationship with earlier trackways

An aspect of the survey is its ability to show trackways not readily apparent from ground level. Such trackways, at Hergan Corner, Llanfair Hill, Pen Offa and Rushock Hill, may cross the Dyke and in some instances might suggest cross traffic prior to the construction of the Dyke. Other tracks run parallel to the Dyke or cross under it as noted on Llanfair Hill. Such tracks may have been used to mark earlier, pre-existing boundaries which have been reinforced by the Dyke.

Figure 25 (next page, above): Vertical view of the crossing showing exposed stones on and around Offa's Dyke (Photograph: Julian Ravest, 2019)

Figure 26 (next page, below): Oblique view looking east-north-east showing Offa's Dyke dropping off Rushock Hill ridge into Kennel Woods (Photograph: Julian Ravest, 2019)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50m

Design of gateways

The gateways considered at Hergan Corner and Pen Offa both appear to have been part of the original design of the Dyke, confirming and enhancing arguments presented by Ray and Bapty (2016). There is no evidence of extant alignment of the dyke being prefigured by earlier banks. Rather, the banks adjoining gateways have been planned to make concave corners, even if slight, towards western approaches. In the case of Hergan Corner the placing of the gateway with banks, including bivallate construction (bank and counterscarp bank), is designed to impress those approaching from the west. However, an acute corner does not necessarily indicate a gateway in all instances, and there seems not to be one at the Rushock Hill angle turn.

Construction modes and methods

The mode of construction of the Dyke has been revealed with counterscarp, ditch and bank, particularly on Llanfair Hill. Meanwhile, quarrying on the eastern side of the Dyke in the Llanfair Hill section has been depicted in detail. All these features are revealed far clearer via drone photography than available to previous investigators. Whether the material was used in the initial construction, or used later for 'maintenance', cannot be determined from the photography. However, at a practical level, it is plausible that after the ditch and bank were constructed, excavating from the deep ditch would have become more difficult. The mode of construction of Offa's Dyke in adjusted segments by Ray and Bapty (2016) is confirmed and extended in each of the four sections investigated and show careful installation of the bank and ditch in regards to seeing out from its line and being seen by those approaching the monument.

Discovery of a new monument

The discovery of a previously unrecorded rectangular earthwork under the line of Offa's Dyke is notable, particularly as this section of the Dyke has been studied by generations of archaeologists. Further visual/photographic studies are unlikely to determine its date or function is required. This instance illustrates a key limitation of drone surveys which are necessarily concerned with the visible ground surface.

Conclusions

Early medieval sites and monuments in western Britain are investigated using a range of methods and techniques, in which aerial photography (often alongside geophysical survey and excavation) has been long-established as valuable technique for both identification and interpretation (e.g. Jones *et al.* 2018). However, to date, the potential for drone photography for further investigations of early medieval linear earthworks has yet to be fully realised. The application of aerial photography and photogrammetry using drones to archaeology has been made possible by technologies and software developed in recent years for more commercial endeavours. Its increasingly affordable pricing

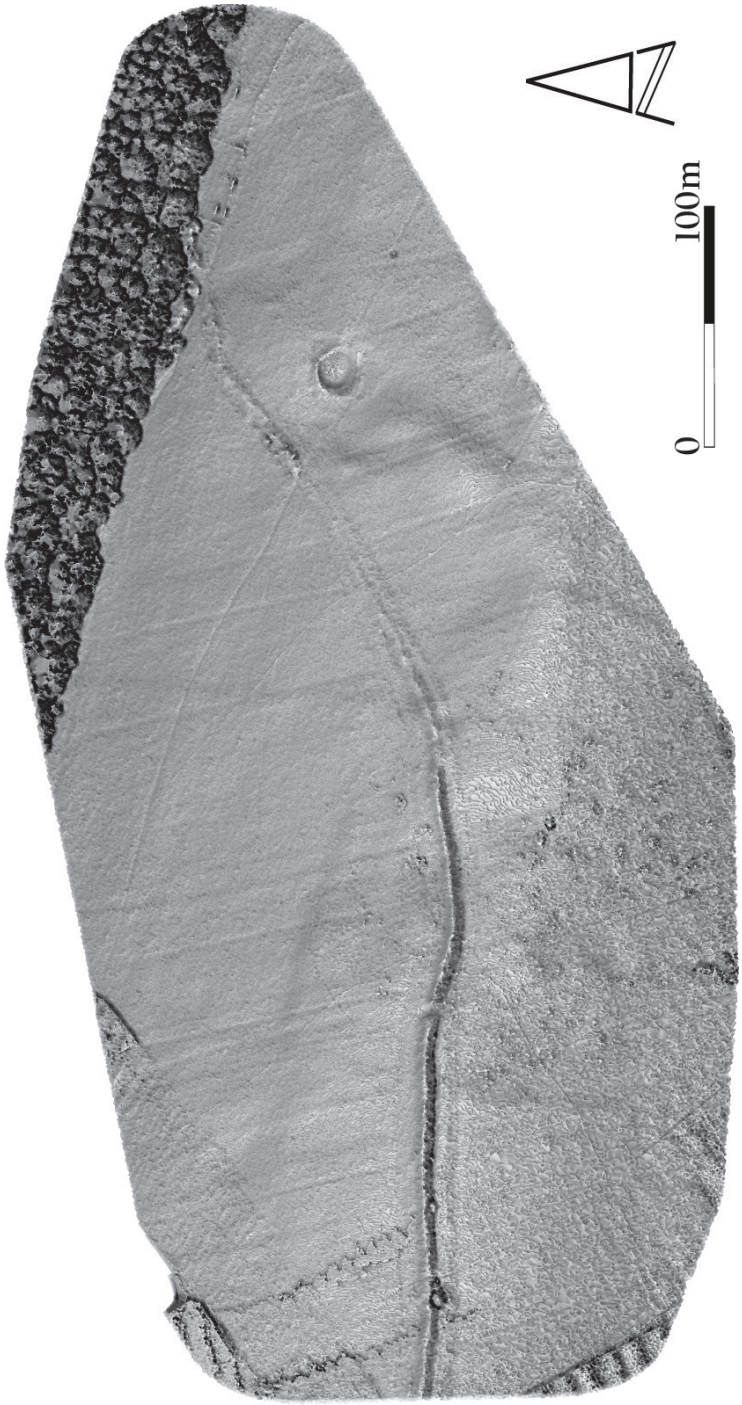

Figure 27: A georeferenced photogrammetric visualisation/map showing the adjusted-segmentation of the monument and its course into Kennel Wood (Photograph: Julian Ravest, 2019)

enables non-professional, (avocational or amateur) archaeologists to contribute to the sum of archaeological knowledge in new non-invasive ways. It is a tool for recording, for discovery, for research and for increasing awareness to the general public.

Postscript: availability of imagery

JR took all photographs and created photogrammetric visualisations in this article. All photographs and visualisations in the complete Offa's Dyke collection are available by contacting JR or Heneb-CPAT as are all my other aerial photographs.

In the context of this article, by making the images of this survey freely available, it is hoped they may be used by others to augment their researches into the Dyke and be used to promote it responsibly to the widest possible audience. It can also be used in the management of the Dyke as it records the Dyke, in detail, at one point in time and therefore might be of valuable for examining its future condition in comparative terms.

Acknowledgements

The early encouragement of the Offa's Dyke Association, in particular its current chair, Dave McGlade, was important in motivating this project. The drone photography and investigation was conducted by Julian Ravest. Subsequently, Howard Williams worked in liaison with Julian to select the four case studies to show-case his project, contributing to this article by providing the context of past research approaches and interpretations, identifying parallel sites and monuments, and considering the project in relation to current archaeological research theory, methods and techniques.

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Reply to Ravest and Willams

Lena Delaney

Offa's Dyke has a long tradition of scholarly investigations, many of these based upon observations of how the surviving monument uses the landscape (Fox 1955; Noble 1981; Hill and Worthington 1983; Ray and Bapty 2016; Delaney 2021; Williams 2023). Although these investigations have brought great insights, the process of interpretation is difficult due to the vast scale of the Dyke and the many factors affecting how, where and to what extent it survives. Multiple excavations of the Dyke remain the more desired intervention for future research in order to address the many remaining unanswered questions about its date, form, function and significance. Still, there is a lot of potential in studying the landscape archaeology of the monument remotely. Fine-grained and accurate accounts and mapping of Offa's Dyke's landscape context is essential for interpretation, as Julian Ravest's drone photography ably demonstrates here.

The use of a drone to capture bespoke, targeted, high-resolution photographs provides new perspectives on Offa's Dyke. Whilst aerial photography is not a new technique for archaeological prospection, due to a relative paucity of published interventions and surveys, the low-level photography taken from drones is a relatively new undertaking for Offa's Dyke. This article serves to illustrate and encourage the many potential applications of drone photography.

The article discusses possible readings of the monument based on its surviving form in the landscape in four stretches. It identifies possible gateways at Hergen Corner and Castle Ring, a probable earthwork feature underlying the Dyke on Llanfair Hill, and confirmation of the earthwork continuing beyond Rushock Hill into Herefordshire.

In the first stretch of Offa's Dyke investigated, Hergen Corner, the study provides a reading of the terrain which hopes to explain the usual behaviour noted by previous scholarship. The proposal that the unusual behavior denotes a type of bottleneck gateway is worthy of consideration. Still, the wider view of the landscape should not be forgotten when looking at curious behaviour of the Dyke, offered by Hill and Worthington (1983) and lidar surveys (Delaney forthcoming). That is to say, the proposed gateway is not firmly demonstrated and the right-angled turn at this location might instead suggest the course of the monument is a product of both avoiding less favourable ground but also sacrificing efficiency in the route to utilise the north-west ridge of Hergen Hill to enhance its visibility towards the west.

The photographs from Castle Ring seem to show that traces of previous access routes were cut off by the construction of the Dyke. Here, the landscape provides an insight into how

the Dyke affected movement through the region. This is consistent with other discoveries that the Dyke did block existing routeways (Ray *et al.* 2021) rather than created gated access. Similar to Hergen Corner, the seemingly impractical shifts in the alignment of the Dyke at Castle Ring appear to position the monument to best utlilise the entire north-west slope of Granner Wood, thus enhancing its visibly towards Castle Ring to the north-west. Again, this might relate less to a gate through the monument in this specific location and more to the negotiation of complex topography by the Dyke in relation to its desire to exploit western facing slopes on a broader (roughly) north-to-south alignment.

The existence of a possible earthwork enclosure cut by the Dyke at Llanfair Hill gives insight into a broader pattern I have observed regarding how the Dyke treats previously existing monuments along the route. My own work along the entire length of the monument shows that at no point where the Dyke cuts through an existing (prehistoric) monument is the Dyke utilising existing earthworks, e.g. Lancaut (Gloucestershire), Redhill (Herefordshire), Burfa Bank (Powys), Llanymynech Hill (Shropshire) (Delaney forthcoming). This gives us a valuable insight into the construction practices of the Dyke builders. The lack of reutilisation reveals a policy of overwriting existing features by the Mercians, possibly as a demonstration of their physical domination over the landscape, although this power makes compromises in its course to avoid other monuments.

Both Llanfair Hill and Castle Ring show the importance of the act of construction to the builders. They did not take shortcuts by using existing banks of monuments. Instead, the process of shaping the landscape by constructing the Dyke was more important to them than using opportunistic lengths of existing earthwork. Cutting off routeways, like at Castle Ring, made the Dyke overall more impractical, but its presence was more important than any practical management of the frontier. As demonstrated with the shifts in alignment at Selattyn Hill (Shropshire), Llynclys Hill (Powys), Cwm-Sanaham (Shropshire), Rushock Hill (Herefordshire) and Lower Meend (Gloucestershire). These locations involve the Dyke making movements in the landscape that are less efficient in terms of construction but lead to more favourable visible landscape or even avoiding, probable, contested land (Delaney forthcoming).

The confirmation that the Dyke continues east then south beyond Rushock Hill outlined by this article supports my own research into the Dyke in Herefordshire (Delaney 2021). Together, this promotes a more accurate view of the completed Dyke between the Severn and the Wye (see also Ray *et al.* 2021). This is part of my ongoing doctoral research focused on using lidar data to analyse Offa's Dyke, looking into landscape use and the monument's agency to affect the experience and movement of people in the early medieval landscape. Lidar has obvious benefits in rapid data collection and mapping landscapes without vegetation cover, and it has allowed me to conduct a far larger scale investigation into Offa's Dyke's interaction with the landscape. However, it comes with limitations. In relation to drone photography, the resolution of that data is often not able to match the high resolution of the drone photography Ravest's survey allows.

This means that detail can be lost when producing models for analysis. Therefore, the use of Ravest's drone photography is an excellent extension to this wider lidar survey and enables a continuation of scholarship. In fact, undertaking more high-level surveys and modeling on specific parts of the Dyke, will undoubtedly improve upon the current understanding of the monument. This type of collaboration is vital for researchers to capitalise on opportunities to build upon insights.

In summary, in this work, Ravest and Williams target critical sections of Offa's Dyke for drone photography and produces high-resolution data for further analysis. This type of work will be an important data source for the future, enabling researchers to see and research features previously unseen by the available lidar data. This complements my ongoing work which is demonstrating that Offa's Dyke cut off existing routeways, was continuous in the landscape (and particularly through Herefordshire), and did not reuse existing pre-existing earthworks (Delaney forthcoming). The modelling Ravest shows here offers some evidence to support those positions, and new avenues of study. I am excited to see more of it in tandem with other work. Whilst my work has not supported the existence of gateways along the route of the Dyke as proposed here, the possibility continues to be a fascinating topic worthy of further research. Certainly, there is a lot more to unravel with the morphology of Offa's Dyke.

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