<u>Shedding *light* on the age of ancient field systems</u>

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Introduction

Archaeologists are used to dating artefacts or specific and spatially defined sites. But, what if you are interested in the wider history of landscapes, how people have cultivated them in the past and how that has shaped their present-day character? Identifying and understanding the chronological relations between ancient landscape features like field boundary banks, lynchets and terraces has often proved very challenging. The innovative application of optically stimulated luminescence profiling and dating (OSL-PD) to earthworks can help solve this puzzle in a practical and cost-effective way.

Challenges in dating field boundaries

The boundary features which divide Britain's landscape into fields provide some of its most characteristic elements. In many lowland regions the hedges, walls and lanes are associated with earth banks, whilst on moors and mountains the earthworks themselves often provide the boundaries. Dating earthworks has been a major challenge for archaeologists and the true age of these boundaries remains a mystery in many parts of the country.

Earthworks are typically part of long histories of landscape exploitation. It is rarely clear when they were first created or how they have developed with time. Historic maps and written archives usually only take the story back a few hundred years – and rarely beyond the early eighteenth century. To understand earlier periods, landscape researchers have had to make interpretations based on the morphology of the boundaries or the relationships between boundaries and other features. For example, it is sometimes possible to establish the approximate age of earthworks through association with independently dated sites like settlements. Related features like ditches may contain fills which can be dated scientifically, though the complexities of interpreting formation processes make this difficult – ditches, for example, could have been cleared out regularly in the past. By painstakingly examining the stratigraphic relationships between features, analytical surveys based on fieldwork, aerial photography and lidar data can be used to create narratives of landscape change. This has been done most successfully in the uplands, for example on the prehistoric field systems of Dartmoor and Salisbury Plain. Nevertheless, in other parts of the country attempts to date patterns like the 'co-axial' fields of East Anglia by retrogressive analysis continue to provoke controversy. Even in clear-cut cases, these techniques generally produce broad narratives by period which lack chronological detail.

Archaeological excavations of agricultural earthworks in rural areas rarely yield more than a few indeterminate finds. Even when artefacts can be dated with confidence, it is almost impossible to know whether they are in primary or secondary contexts. Scientific dating of ecofacts and soils using radiocarbon methods suffers from similar problems to artefact studies: it is generally not possible to tell whether samples have been redeposited from another location or disturbed by post-depositional processes, so that any dates produced may not relate to the original construction of the feature. Researchers have tried to mitigate the impact of animal and root disturbance using bulk soil samples, but this tends to produce overestimates of the age because much older carbon fractions are present in the environment.

Optically Stimulated Luminescence or OSL can be used as an alternative method to date sediments found in archaeological settings. It provides a direct age estimate of the last time quartz or feldspar minerals in the sediment were exposed to enough light to reduce a previous luminescence signal to zero and effectively reset the OSL dating clock. Luminescence results from the exposure of the minerals to naturally occurring ionizing radiation from radioisotopes in the sample and the surrounding sediment, and through incoming cosmic radiation. Once the sediment is buried and protected from light, the radiation causes electrons to slowly accumulate in defects in the crystal lattice of the minerals. Subsequent exposure to light causes the trapped electrons to be released very quickly and to emit a photon of light in the process. The intensity of this luminescence signal is directly proportional to the radiation dose the minerals received each year since they were last exposed to sunlight, also known as the annual dose rate. This means that depositional events like the burial of an old ground surface or the construction of an earthwork can be dated directly from the sediment itself. The OSL age is determined by dividing the apparent or burial dose by the annual dose rate. The typical age range for luminescence dating is from zero (completely bleached) to ca. 200,000 years, making it well suited not just for dating events with timescales of thousands of years, but also recent phenomena with event resolutions of several tens of years. Like radiocarbon dating, OSL dating comes with the limitation that a date relates only to the specific location in the soil profile that is being sampled. Time and cost constraints typically limit the number of dating samples to just one or two per profile, which increases the risk of unreliable dates from redeposited sediment or material unrelated to the construction or use of the earthwork.

OSL profiling and dating

Combining conventional OSL dating in the laboratory with practical field profiling methods can offer a solution here. Our research uses portable OSL equipment, which allows the luminescence signals from small soil samples, collected through the entire profile of the investigated earthworks, to be measured on site in real-time. The OSL profiling and dating (OSL-PD) method is fast and minimally intrusive, because it only requires cutting a small trench into the earthwork, wide enough to fit a person and deep enough to reach the natural substrate underneath. Once the sediment stratigraphy is exposed it is immediately covered under an opaque black tarpaulin, to prevent exposing the samples to sunlight and zeroing their luminescence signal. The covered section is then cleaned and small quantities of soil (5-10g) are removed at regular intervals (normally <10cm) down the profile for immediate interrogation with the portable OSL reader. That information is used in the field to construct luminescence-depth profiles for the entire stratigraphy of the earthwork. The insights this provides into the relative chronology of the feature inform the subsequent sampling strategy for the larger dating samples. These are collected from those stratigraphic horizons which are deemed most significant to securely date the construction of the feature, maximizing the effectiveness of the fieldwork. Both the profiling and dating samples are subsequently analysed in the laboratory. Examining the luminescence behavior of the whole stratigraphic profile also means the dating samples are not isolated and sediment ages can be contextualized, which provides tighter chronological control on the age of the earthworks. It also makes it possible to produce highly-detailed accounts of the earthwork's history, from its construction date to its use and modification over time. One can see for example if the feature was built in a single event or in multiple phases, if it cuts into older layers or was constructed on top of them, and whether a stratigraphic horizon constitutes a single anthropogenic fill, deposited at once, or is the result of gradual sedimentation. In this way, OSL-PD can be invaluable for understanding the earthwork's stratigraphic sequence and correctly defining archaeological contexts.

Having successfully used OSL-PD in the past to demonstrate the medieval date of terraced field systems in Spain, Turkey and Greece, our team from the McCord Centre for Landscape at Newcastle University and the School of Earth and Environmental Sciences at the University of St Andrews applied the methodology in the UK in 2018. Historic field boundaries in two rural case study areas were investigated. The first was the National Trust's Wallington estate in central Northumberland, the second was the National Trust's Bosigran farming estate in western Cornwall. Both showed extensive evidence of earlier agricultural practices and shrunken and deserted settlements.

Wallington

The landscape of the Wallington estate, which surrounds a late-seventeenth century country house, has been heavily shaped by estate management practices and improvements in the eighteenth and nineteenth centuries. Today's field systems reflect the orderly layout of planned enclosure, with rectangular fields divided up by long and straight stone-faced banks. In medieval and early modern times, the outlook of the landscape is thought to have been quite different, with more irregular fields and large swathes of still unenclosed countryside, farmed under a collective open-field system. This can best be seen on an estate map of 1728 kept in the Wallington Hall archives which still shows the remnants of this earlier system, before it was subjected to agricultural improvement. Unfortunately, we are less well informed about the earlier development and origins of these post-medieval field systems, and this is the case for most of Northumberland. The extent to which the remains of prehistoric, Roman and early medieval landscapes have influenced those of later periods is open to question, because reliable dating evidence is largely lacking. Investigating the possible long-term continuity of boundaries, dykes, lynchets, and other elements of Northumbrian field systems is therefore of particular importance for the region.

For the Wallington estate, retrogressive landscape analysis was used to identify and inventory historic earthwork boundaries still present in the current landscape. This led to the selection of five earthworks for further archaeological investigation and OSL-PD sampling. All are depicted on the 1728 estate map, so they were definitely in existence by the early eighteenth century and presumably originated at different stages in the enclosure of the local open-field systems. This turned out to be the case. One boundary was found to have been created in the early modern period, more specifically the mid-sixteenth century, consistent with a general pattern of piecemeal enclosure which is well-documented across the North East. Perhaps surprisingly, the majority of the investigated boundaries was found to be older, most likely constructed during the Middle Ages. Three earthworks span dates from the fourteenth to the eleventh centuries, while one was probably already constructed in the first millennium A.D., most likely in the sixth or seventh centuries. The research demonstrates that medieval farmers were working the area well before local settlements were first recorded in documents and shows that early field patterns continued to influence the organization of the landscape in the area despite subsequent episodes of reorganisation.

Bosigran

The second case study area was the Bosigran farming estate on the northwestern coast of Cornwall, in West Penwith. The region has rich archaeology from all periods and its rural landscapes have long been regarded as especially beautiful and unusually ancient. Impressive granite-and-earth boundaries form small irregular fields, dubbed the 'work of giants' by pioneering landscape archaeologist O.G.S. Crawford in an *Antiquity* article of 1936. In the 1980s West Penwith's field systems came under increasing threat from modern farming practices, particularly the removal of field boundaries to create larger units. To be able to protect the landscape, the Cornwall Committee for Rescue Archaeology, supported by English Heritage and the National Trust, initiated the West Penwith Survey, which recorded the field patterns of the region in detail and established relative chronologies through analysis of the physical, functional and systemic relationships between boundaries and other features. Periods of origin for the field types were suggested based on their association with independently dated features, such as houses. In this way, a relative chronological framework was also established for six different types of field boundaries identified at Bosigran, from a coaxial field system probably dating to the Middle Bronze Age, through a regular and irregular field system presumed to have Iron Age origins, to medieval strip fields and cliff-dividing boundaries constructed in post—medieval times. Still lacking though was absolute dating evidence to back up or question this intricate landscape narrative.

OSL-PD was used to obtain sediment chronologies for five key field boundaries at Bosigran, representing different types of enclosure. One of them formed a main axis of the surviving coaxial field system in Halldrine Croft, a broad strip of rough land on the western edge of Bosigran. The field system here consists of roughly rectangular fields delineated by low stony banks, which do not appear to have been reused as boundaries in later field systems. A second-millennium BC origin was proposed for the coaxial fields, based on Cornish comparators and through association with four roundhouses. The OSL-PD research was able to confirm this chronology, placing the construction date of the stone core of the bank between the seventeenth and twelfth centuries BC, most probably around 1300-1400 BC. Apart from the addition on top of the bank of a shallow layer of agricultural soils, in use over the last 2000 years, no true structural alterations had been made to the Bronze Age earthwork over time.

A second earthwork which was investigated in detail was a substantial, 1.7m high stone-faced lynchet. It forms one of several concentric curving lines in a regular field system, thought to be of late prehistoric origin and still functioning today. The fields were dated relatively by their association with a small hamlet of Iron Age stone-built roundhouses, later transformed into Romano-British courtyard houses, which are located along the investigated lynchet. A narrow trench was excavated through the boundary to collect profiling and dating samples from its entire stratigraphy. This confirmed that the stony bank forming the core of the feature was constructed in the Middle Iron Age, as suggested by the West Penwith Survey. The OSL-PD however offered important new insights into its diachronic development, demonstrating that the bank was constructed by cutting into Bronze Age soil and remained fairly low until early medieval times. It was only during the Middle Ages that the boundary was substantially enlarged in different phases and the prominent lynchet that currently stands at the site developed. This must have coincided with a change in agricultural management practices as the Romano-British courtyard houses were abandoned and an early medieval settlement was established at a new location, where Bosigran farm currently stands.

Future applications of OSL-PD

The research at Bosigran and Wallington, two sites located on different geologies and geomorphological settings at opposite ends of England, shows that OSL-PD has the potential to provide chronological definition for earth boundaries that can otherwise be difficult to date precisely. Whilst the results from Bosigran confirmed and developed the interpretations made by earlier archaeological survey, the Wallington study provided a new chronological framework for the development of the historic landscape which was hitherto completely unknown.

The team's work elsewhere in Europe and the Middle East has shown that OSL-PD can also be used to date other types of earthworks, notably the Mediterranean's highly characteristic agricultural terraces. For example, case studies in Spain, Greece and on the southern and western coasts of Turkey have all identified the later Middle Ages as the key period for construction of terraces. The method has the potential to unlock the history of terraces and other earthworks all over the world.

The ability to date soil profiles in detail also opens up possibilities to integrate study of landscape development with a suite of multi-proxy geoarchaeological analyses, including sediment micromorphology, analysis of plant macro- and microfossils (pollen and other remains), geochemistry and soil organic biomarkers. By using these approaches, it will be possible to write detailed histories of land use and farming directly from the soil itself, rather than having to rely only on patchy documentary or archaeological sources.

Finally, studies like the one at Bosigran show that the results of OSL-PD analyses can be linked to other types of landscape archaeology such as analytical survey or historic landscape characterization. This makes it possible to examine the creation and development of field systems on a much broader scale, helping to highlight the broader significance of the landscape heritage which surrounds us.

Figures

1. Soil samples collected under a dark cover from a field boundary near Gallows Hill Farm on the Wallington estate are immediately analysed using the portable OSL reader *(photograph by Soetkin Vervust)*
2. Core of an earth bank after sampling *(photograph by Soetkin Vervust)*
3. Hypothetical luminescence-depth profiles associated with the construction of agricultural terraces (*Kinnaird et al. (2017) Journal of Archaeological Science 78: 66-77*)
4. Wallington Hall surrounded by parkland, with the village of Cambo in the background (looking north-east) *(©National Trust)*
5. View north from Cambo on the Wallington estate *(©National Trust)*
6. Fields on the Wallington estate on the modern 1:25,000 OS map and an estate map of 1728 *(figure by Soetkin Vervust)*
7. Fieldwork on an earth bank near Fairnley Farm on the Wallington estate (looking south) *(photograph by Soetkin Vervust)*
8. A stone-faced earth bank near Newhouses Farm on the Wallington estate (looking south) *(photograph by Soetkin Vervust)*
9. The Zennor coastal plateau from the west, with Bosigran Farm and its field systems in the foreground *(Cornwall and Scilly Historic Environment Record, F88/033, 2008; ©Cornwall Council)*
10. Bosigran Farm and its fields from the south-east *(Cornwall and Scilly Historic Environment Record, F88/059, 2008; ©Cornwall Council)*
11. Map of Bosigran with six types of field systems identified by the West Penwith Survey and five field boundary sites studied using OSL-PD *(figure by Soetkin Vervust)*
12. Fieldwork on the low stony bank at Bosigran site 1 (looking south) *(photograph by Soetkin Vervust)*
13. The stone-faced lynchet at Bosigran site 3 (looking west) *(photograph by Soetkin Vervust)*
14. Section drawing of Bosigran site 3 showing an interpolation of the apparent doses measured for the profiling samples (white dots) and dating samples (black squares) *(figure by Soetkin Vervust)*