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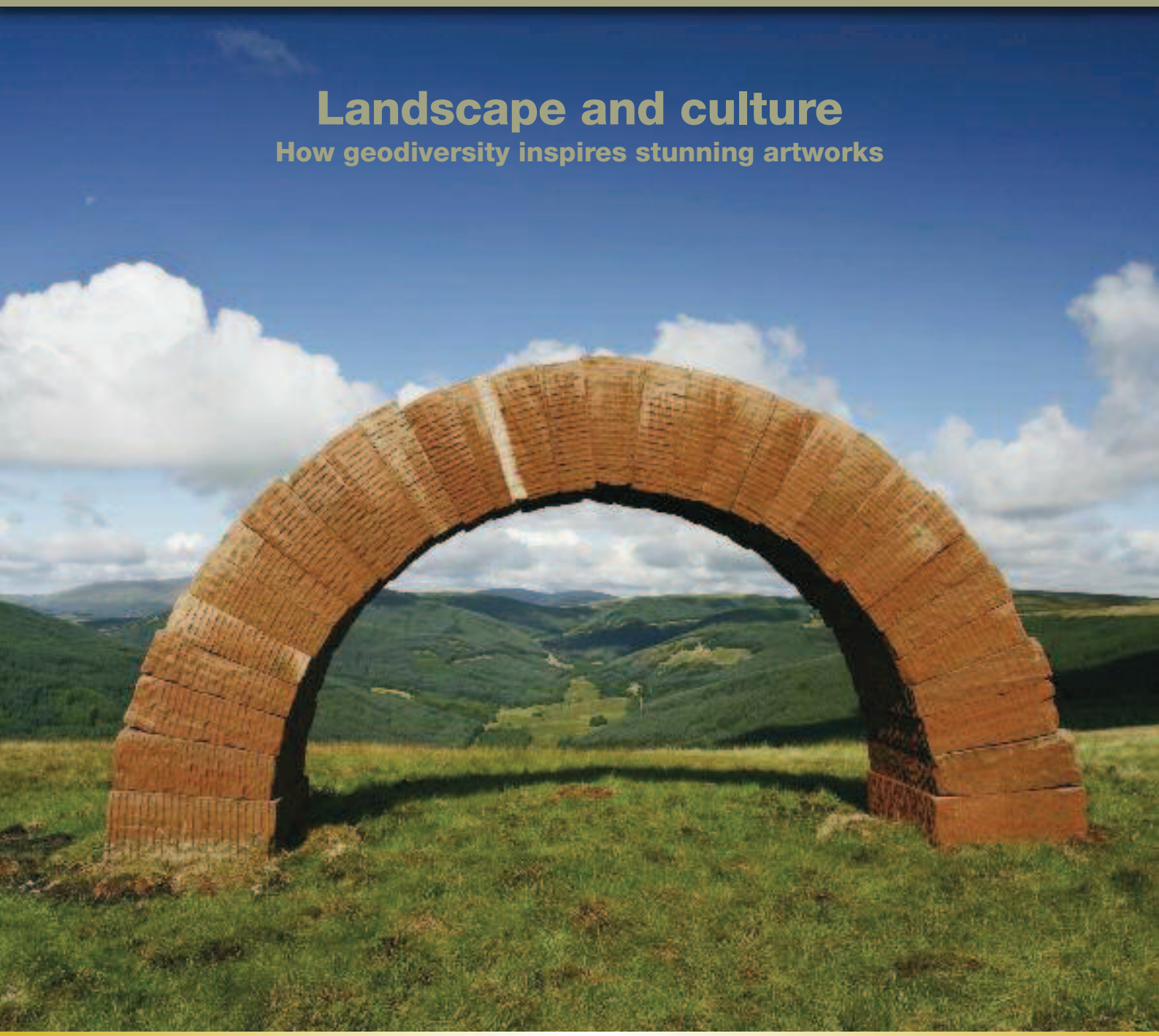

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OSL sheds new light on ka

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Have you ever wondered about the origin of the brownish, silty, soils that occur on the Carboniferous limestone of northern England? They partly, and sometimes completely, cover limestone pavements, and often fill the bottom of shallow dolines. Pedologists identify these well-drained soils as rendzinas but to leave the matter there would not do justice to an unfolding story that marks a paradigm shift in the way we should think about northern England's karst landscapes.

The silts, sometimes up to 1.5 m thick, cannot all have accumulated as a result of the solution of the limestone which frequently has less than 5 per cent insoluble residue. If this were so, then enormous amounts of post-glacial solution would have had to have taken place. Furthermore, we now know that the heavy mineral assemblages of the silts and the limestone are different. So what is the origin of the silt? In terms of its particle size and its high quartz content the silt is now recognised as loess winnowed from glacial outwash. Even without digging soil pits, the patches of well-drained loess are easy to recognise from the vegetation cover. The presence of the fern *Pterydium aquilinum* (bracken), whose rhizomes demand plenty of soil oxygen, and calcifuges such as *Calluna vulgaris* (ling), are often excellent clues.

Optically Stimulated Luminescence (OSL)

Recently, we have been able to date the loess deposits using a technique called Optically Stimulated Luminescence (OSL) and have made some fascinating discoveries. Not only is some of the loess much older than we had imagined but much of it has been colluviated (transported by gravity) from original airfall deposition sites down slope to topographically lower, more stable positions. **Colluviation** requires a break-up of any protective vegetation cover and the presence of water to lubricate the sediment flow. Water is, however, distinctly absent on the karst now. But what if the landscape was covered by lingering snow patches and **nivation** processes such as **gelifluction** were active?

Silt samples taken at regular intervals down the face of a soil pit for OSL dating indicated that the loessic silts became progressively older, thus representing different phases of colluviation and burial. So how old is the loess and how do we know it has been colluviated? In a **doline** above Arncliffe, loess samples at the bottom of a soil pit were found to be 27 ka BP old and were deposited prior to the area being overwhelmed by the Late Devensian ice cover.

Out of our sample of nearly 30 OSL dates of loessic silts from sites across north-west England we were surprised to find about 30 per cent of the results clustered at about 8 ka BP. We had detected colluviation during the Late Mesolithic which began about 9.5 ka BP and ended about 6 ka BP. Was it possible that Late Mesolithic hunter gatherers had triggered colluviation by burning vegetation and scrub to attract large herbivores? We rejected this idea on several grounds. First, we have not detected charcoal in our silt samples from this time. Second, our results cluster at about 8 ka BP rather than being spread throughout the Late Mesolithic. Third our evidence shows that colluviation at this time was a region-wide event. So if not hunter gatherers, what had triggered the colluviation? It turns out that nivation associated with the so-called 8.2 ka BP event fits the bill precisely and recent research in Sweden has shown that this was a period of accelerated geomorphic activity associated with increased snow fall.

OSL dating

Optically Stimulated Luminescence (OSL) has revolutionised Quaternary science because it enables much more accurate dating of sediments through directing a light beam at electrons in some minerals to identify absorbed radiation. From the data gathered, the age of the mineral can be calculated to within 10% accuracy.

In OSL, the interaction of ionizing radiation, produced by uranium and thorium with grains of quartz and feldspar, strips some electrons from the outer shells of the mineral atoms. The electrons then become trapped temporally within the crystal lattice defects.

The amount of trapped electrons is related to both the duration and intensity of radiation exposure. Trapped electrons can be 'freed' when the mineral grain is illuminated in the laboratory and the amount of light emitted by the illuminated mineral grain is proportional to the total absorbed radiation dose (D_e).

When mineral grains are exposed to natural daylight, individual crystals may be exposed and their trapped electrons are 'freed' thus 'bleaching' the signal – sometimes called 'resetting the clock'. On subsequent re-burial, the mineral grains once again start to accumulate trapped electrons.

In the field, the background radiation rate, the 'dose rate' can be measured by a γ spectrometer. The estimated age is thus:
Age (years) = D_e (Gy) / dose rate (Gy per year).

OSL dating has a range from a few hundred years to about four hundred thousand with an error of about 10 per cent.

arst loess

Small doline on the sloping pavements of Farlton Knott, Cumbria (SD 545 800), filled with loess and marked out by a patch of bracken.

Likely cause of climate event

The most likely cause of the 8.2 ka BP climatic event was the disruption of the Meridional Overturning Circulation in the North Atlantic. This was due to freshwater input from the final collapse of the North American ice-sheet and correlates with the catastrophic drainage of the proglacial lakes Ojibway and Agassiz. It is thought that for several centuries stormy, cloudy, conditions prevailed in the North Atlantic and air temperatures may have been depressed by as much as 5°C. In the Pennine uplands, deep snow patches probably lingered for much of the year, killing off herbaceous vegetation by denying it sunlight. Meltwater from the snow patches would have saturated the ground, pumping up the pore water pressure in the loess and reducing the frictional component of its already-low shear strength. All in all, ideal conditions for the colluviation of loessic silts, even on the most shallow of slopes.

Loessic silt trapped in hollows

Our data indicate that much loessic silt dating to this period is now trapped in hollows marginal to the glacio-karstic limestone pavements. It is known that the pavements were once buried by silts (and some peat) since their surfaces are festooned with rounded **rundkarren**.

The evidence now suggests that the exposure of many limestone pavements was related to climatic deterioration some 8 ka BP.

The silts are still episodically on the move and catastrophic rainfall and rare overland flow continue to denude the karst uplands of northern England of their loessic cover. ■

Background radiation being measured by a spectrometer, New Close, Malham, North Yorkshire (SD 911 645)

Technical terms

Colluviation:	**build-up of rock and mineral deposits at the base of a slope or cliff**
Nivation:	**processes taking place under the snow**
Gelifluction:	**the freeze-thaw cycle that can start material moving down a slope**
Rundkarren:	**branching systems of rounded grooves and ridges developed on limestone pavements**
Ka BP:	**thousands of years before present**
Doline:	**closed depression draining underground in a karst area**

Photos © Craven Research Group

Dowkabottom, Arncliffe, North Yorkshire (SD 954 690). Site of pre-Late Devensian loess

** **Earth Heritage*** regrets to announce that since writing this article, Peter Vincent, the lead author, has passed away. Peter was an innovative researcher whose considerable insights made this particular work possible. He had a deep and passionate interest in the loess deposits and karst landscapes of northern Britain and published numerous papers detailing their origins and significance. His co-authors wish to acknowledge the enthusiasm of their friend and colleague for Quaternary research and his stimulating company during the course of many field days.