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Loess on the Burren

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This paper reports, for the first time, relatively deep, widespread Late Glacial loessic silts on the karstic plateau of the Burren, Co. Clare, western Ireland. The nature and distribution of the loess is described and a model put forward for its development and preservation. A link between the widespread loessic cover and the archaeological record is suggested. The paper calls for a paradigm shift away from the traditional view that the karstic Burren has always been an inhospitable, 'rocky place'

I am not an archaeologist but a geomorphologist from the north-west of England interested in limestone landforms, soil development and the evolution of the landscapes of the British Isles since the wasting of the last Quaternary ice sheets. While leading several undergraduate field classes to Galway and the Burren I became fascinated by the presence of loess and the remarkable analogues the region has with similar environments in northern England where Carboniferous limestone outcrops, thin well-drained soils, and archaeological remains have an uncanny spatial correspondence.

I have found time and time again that colleagues are extremely reticent to identify the stone-free, buff-coloured silts overlying tills or resting directly on limestone pavements, as loess. They have in their mind images of the vast accumulations of loess found in northern China. But a moment's reflection and deduction is all that is needed to come to the conclusion that it can't really be anything else. Once the Rubicon is crossed loess is seen everywhere, even by the inexperienced. It is this paradigm shift in our thinking about the Burren, particularly in relation to soils and early man, that will be invoked in this paper.

What is loess?

Loess is a stone-free silt deposit with a grain size diameter ranging from 62 μm - 2 μm and is composed almost entirely of quartz. Individual grains are typically around 25 μm in diameter, and as seen with a scanning electron microscope are sub-angular and partially covered by very fine quartz debris. Loess is frequently buff-coloured, porous and, where thick enough, can form vertical cliff faces with a typical prismatic structure. Loess soils are well drained and easily worked but can be subject to severe erosion if left bare.

The origin of loessic silt has been much debated but it is now widely accepted that in the northern temperate zones of the world it owes it origin to glacial abrasion, as this appears to be the only widespread process capable of producing so much silt.[1] In temperate glaciers much eroded material is plastered onto the sub-glacial rock surface at the sole of the glacier as lodgement till but a good deal of abraded material is flushed out of the system by fluvioglacial meltwater as so-called rock flour. Beyond the glacier fluvioglacial deposits accumulate on outwash plains where the fine rock flour is winnowed by the wind and lifted into the atmosphere. The deflation of such outwash plains and the selective removal of silt is the most probable origin of much loess. Clays are not removed because

[1] A M. Assallay, C.D.F. Rogers, I.J. Smalley and I.F. Jefferson, 'Silt: 2-62 μm, 9 - 4?', *Earth-Science Review,* 45 (1998) pp 61-88.

there are generally very cohesive and, as aggregates, are too heavy for the wind to erode.

At the global scale loess is very widespread adjacent to areas which have been glaciated and accumulations are sometimes hundreds of feet thick, as in northern China. Thick loess deposits also occur in the Central Mississippi valley in the US and over much of central Europe.

Archaeologists have long known about the importance of loess for agriculture and brick making. Indeed, Assallay *et al.* go so far as to say that 'civilizations take root in silt'.[1] Edward Hyams[2] acknowledged this nearly half a century earlier in his classic text on the relationship between soils and civilization and wrote, perhaps rather a little deterministically, about 'a pastoral, patriarchal loess-soil people'. One can also cite Herodotus, writing in the fifth century BC, and his awareness of the critical importance of silt in the development and maintenance of the Egyptian civilization. In this case, though, the silts are alluvial not loessic. The Chinese civilization, the only one of the ancient civilizations to survive today, developed on the loess lands of northern China. In this region erosion of loess soils literally does make the rivers run yellow[3].

Loess doesn't only grow good crops; it makes good bricks, adobe bricks, which are known from many parts of the ancient world. In the not so ancient world the bricks of Buckingham Palace are made of brickearth (loess) from deposits in northern Kent.

Loess in the British Isles

In the British Isles, loess was hardly known about prior to the 1960s when systematic soil surveys by the now sadly defunct English Soil Survey identified high concentrations of silt particularly in the soils of southern England south of the last glaciation limits. Also about this time, there was an upsurge of interest in the Quaternary championed particularly by Professor Shotton (Birmingham, England) and Professor F. Mitchell (TCD, Ireland). One young Quaternary soil scientist who was strongly influenced by Shotton and Mitchell was John Catt, at the Rothampsted Experimental Station, who developed a particular interest in loessic soils. One of Catt's early discoveries was that the distribution of loess in England and Wales seemed to be associated with limestone and chalk outcrops and he concluded that the lack of overland flow in these areas was the prime reason for the preservation of loess[4].

Botanists, too, became interested in loess and pioneering work was done by Donald Pigott - then at Sheffield University - who researched vegetation growing on the silty soils developed on the Carboniferous limestones of the south Pennine Peak District[5]. At the time Piggott was writing, most authorities thought that the silt in soils developed on limestone was derived from simple weathering of the limestone itself, the impurities building up over a period of time to form a soil. Such a limestone soil is called an autochthonous rendzina. But Piggott was suspicious because the Carboniferous limestones of southern Derbyshire are extremely pure and hundreds of feet of limestone would have had to be weathered to produce even shallow rendzinas. He studied the heavy mineral component of the silt in the soil and compared it with that in the limestone. Not surprisingly, they were different. The evidence was quite clear. The silt had blown in, but from where? He then examined the mineral content in the glaciated gritstones in the north of the Peak District and found an exact match. Piggott had proved the loessic origin of the silts in soils over limestones.

A final line of evidence for the widespread distribution of loess over the Carboniferous limestones

2 ES Hyams, *Soils and Civilisation* (London 1952).

3 I. Smalley and C. Rogers, 'Loess: the yellow earth', *Geology Today,* (September-October, 1996) pp 186-92.

4 J. Catt, 'Loess and coversands', in: F.W. Shotton (ed.), *British Quaternary Studies: Recent Advances.* (Oxford 1977) pp 221-9.

5 D. Pigott, 'Soil formation and development on the Carboniferous limestone of Derbyshire, I: Parent materials', *Journal of Ecology* 50 (1962) pp 145-56.

of northern England comes from the observation that on many limestone pavements there are patches of *Calluna vulgaris* or ling (a heather). But most people know that *Calluna* is associated with acid soils and its presence on limestone pavements is therefore quite anomalous. In 1978 Martin Lee and myself noticed this anomaly on all the limestone uplands surrounding Morecambe Bay in northwest England and it was soon discovered that the *Calluna* was actually sitting on patches of loessic silt which had not been washed into the limestone pavement. A final piece of evidence which confirmed that the loess was not simply a weathering product was our discovery of glacial till under the loess in some karstic hollows thus precluding direct contact between the loess and the limestone [6].

Upland karst environments of the Burren - A Pennine analogue

To the informed eye there are striking resemblances between the Burren landscape and those of the Malham area of north Yorkshire. Both are glaciated limestone uplands, fringed with valleys filled with heavy glacial tills. Both areas have had a cover of loess and both have extensive archeological evidence for human habitation. Writing in 1947, Arthur Raistrick paints the following portrait of the invasion of the Malham area by Iron Age people but he might easily have been writing about the Burren:

> At the time at which the Iron Age people were penetrating this district and making their settlements on the (limestone) plateau, the lower ground of the valleys was still full of swampy woodland... And the thick woodland was the haunt of savage animals, wolves, wild boar and wild cattle. The limestones offered better-drained grassland with only thin woody scrub which was easily cleared, and which provided abundant open areas for pasture. [7]

In the Malham area, Iron Age peoples also grew a few cereals in small rectangular enclosures, but they were predominantly pastoralists[8]. From the point of view of the loess story, we should note that some of the small rectangular enclosures are on limestone pavements and one might well ask where has all the soil gone and how did it get there in the first place?

To understand the answers to these questions we must learn a little about karst geomorphology. Under a blanket of soil or peat, the limestone pavement surface is wet for much of the time and the soil water is acid and corrosive The acidity comes essentially from the carbon dioxide gas produced by the soil fauna, flora and plant roots. This acid water slowly seeps over the limestone pavement in shallow sub-soil runnels called by their German name, *rundkarren.* These round-shouldered runnels are in striking contrast to runnels formed on exposed limestone which have sharp profiles in cross-section. At more or less the same time as the rundkarren form, acid water also attacks the joints in the limestone which gradually open to capture both water from the karren and also the soil covering the pavement.

The soil material which slowly washes into the developing joints or grykes in the pavements then moves gradually down into the deeper karst system to be trapped in caves as cave earth. There is abundant evidence, both in Malham and also on the Burren pavements that a former soil cover existed because fossil rundkarren are abundant. And in the cave systems of both areas there is a good thickness of silty cave earth. Indeed the extent of the rundkarren on the pavements is indicative of widespread soil erosion most probably the result of disturbance when animals were first brought onto the pavements to graze.

[6] P. Vincent and M. Lee, 'Some observations on the loess around Morecambe Bay, North-West England', *Proceedings Yorkshire Geological Society* 43 (1977) pp 281-94.

[7] A. Raistrick, *Malham and Malham* Moor (Clapham 1947).

[8] M. Wheeler, 'The Stanwick Fortifications', *Society of Antiquaries Research Report* XVII (1954).

Distribution of loess on the Burren

The presence of possible loess deposits in the karst area of the Burren have been suggested been several researchers[9]. The most convincing case, hitherto, has been presented by Moles *et al.* who examined 12 very shallow soils samples in the area around Mullach Mór on the eastern edge of the Burren[10]. They concluded that their samples of stone-free drift differ from till and residual clays and soils. In particular, mineralogical investigations indicated that the stone-free drift incorporated a much larger component of material derived from granitic and metamorphic rocks than is present in the weathered glacial till of the area. They concluded that this foreign component has been brought into the area by wind. Although the work by Moles *et al.* is of much interest, it has remained hard to convince the non-specialist about the presence of loess in the Burren when based on such thin skeletal deposits. Indeed some of the samples investigated by these researchers were only 5 cm deep!

Had Man been present when the loess was blown on to the Burren he would have seen major dust storms. Dust would have repeatedly been deposited and eroded, especially from dry, exposed, snow-free, surfaces. This very obvious scenario provides an important hypothesis as to where to look for pockets of deep loess - not on the slopes of places like Mullach Mór or on any of the limestone pavements, which undoubtedly would have had loess deposited on them, but in the major dolines which pockmark the upland surface. The term doline is a very general term to describe a bowl-shaped hollow on a limestone surface. Dolines are often due to solution but sometimes they are collapsed features and form where the ceiling of a cave has given way. But we should not look in very small dolines since they might possibly have formed in the recent postglacial period after the loess forming events. Instead we should look for loess in the large dolines on the Burren some of which are so large that they are almost certainly pre-Quaternary in age. These large pits would have been natural collecting sites into which airborne loessic dust would have gently settled away from disturbance and turbulence on the plateau surface. Sweeting's study of the landforms of the Burren is accompanied by a map showing about 100 large dolines which she noted are drift filled and hence probably pre-date the last glaciation of the area.[11]

During an undergraduate field course to Galway in 1991, it was decided to test out these ideas and together with a small party of students I made for the very large doline called Poll an Bhalláin at the head of the Glen of Clab in the eastern Burren. This large doline is more than 80m. in diameter at its widest and its floor is, on average, 25m. below the plateau surface. It is a strange place, floored by a lush meadow in the centre of which are a number of circular stone mounds - perhaps burial mounds?

Soil augering in the floor of the doline revealed that it was lined with at least 150 cm. of homogeneous, buff-coloured loessic silt with no stones (Fig. 1). There was no reaction to dilute acid indicting that the silt was carbonate free. In some places the loess was too deep to bottom. On the edge of the doline floor the silt was found to be resting on white marl which we interpreted as a shallow Late Glacial lake deposit. This marl was examined for pollen by Prof. Michael O'Connell (The National University of Ireland, Galway) who found a few pollen grains of grasses and sedges suggesting that the lake might have formed very soon after the Burren was released from the grip of glaciers.

The silt from Poll an Bhalláin was examined in the laboratory using a Coulter Laser granulometer,

9 In the unpublished theses by: G. O'Donovan, 'An ecosystem study of grassland in the Burren National Park, Co. Clare', Ph.D. Trinity College, Dublin, 1987 and T. Travers, 'The origin of the soils of the Burren, Co. Clare', Undergraduate thesis, Department of Geography, Trinity College, Dublin, 1992.

10 N. Moles, R. Moles, R. and G. O'Donovan, 'Evidence for the presence of Quaternary loess-derived soils in the Burren karst area, western Ireland' *Irish Geography* 28 (1995) pp 48-63.

11 M. M. Sweeting, 'The landforms of north-west County Clare, Ireland', *Transactions, Institute of British Geographers* 21 (1955) pp 33-49.

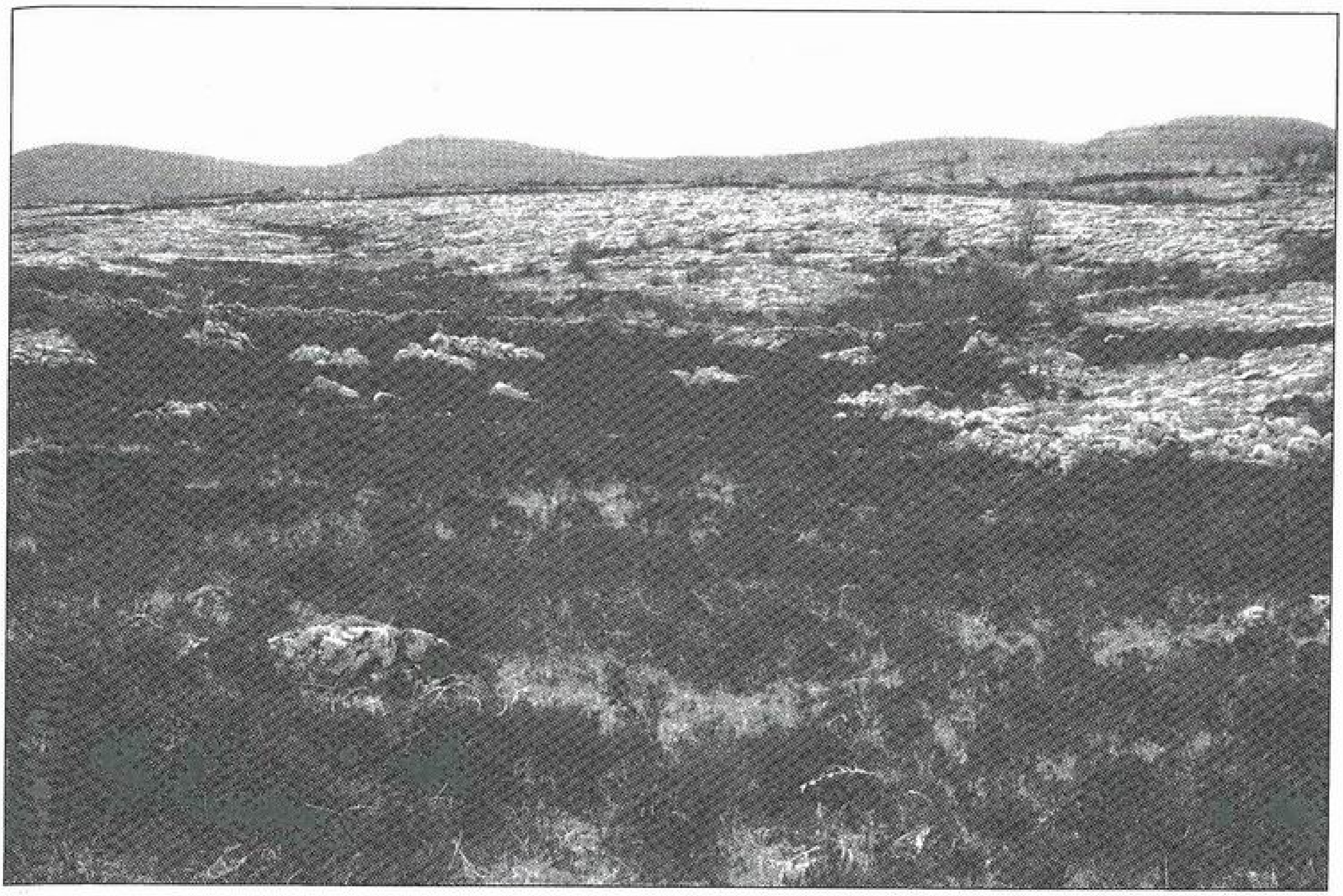

Fig. 1 Loess augered from the base of the Poll an Bhalláin doline.

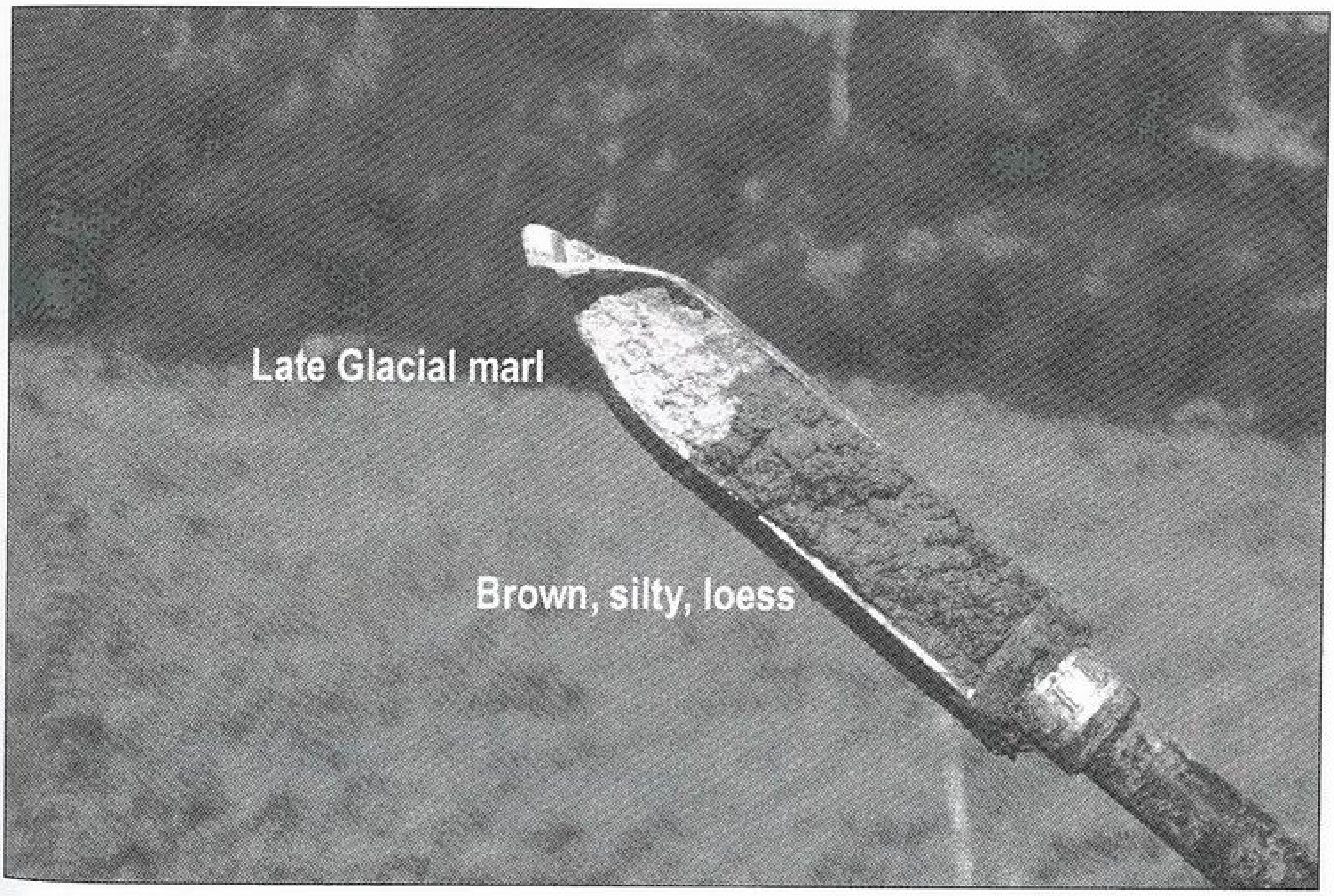

Fig. 2 Acid-loving heather growing on limestone pavements buffered by a blanket of loessic silt.

and the resulting measurements showed it to have a mean particle size of 30μm. X-ray diffraction indicated that quartz was the dominant mineral with small amounts of feldspar and mica. Scanning electron microscopy of individual grains revealed typical loessic shapes. All these data confirm the silt to be loess.

The whole length of the Glen of Clab was then examined. From the geomorphological evidence it is clear that this gorge-like valley was formed by the coalescence of a string of dolines, Poll an Bhalláin at the head of the valley being the last to remain intact. The whole valley floor is lined with loess, often more than 1m. deep and in places overlying a tenacious till.

Many other dolines were examined and all contained loessic silts indicating that loess deposits are at least as widespread in the Burren as is the distribution of dolines. On the surfaces overlooking the dolines the limestone pavements still have patches of loess and in many localities the obvious clue is the vegetation. Soil auger under any large patch of *Calluna* on the Burren and you will find a buff-coloured silt (Figure 2).

The origin and age of the Burren loess

The remarkable similarities between the Burren uplands and their karst equivalents in the north-western Pennines have already been pointed out above. This analogy can be developed even further with regard to the environmental conditions during the period of loess formation. The source of the loess on the limestone hills around Morecambe Bay, the large bay south of the Cumbrian Lake District, was an outwash plain that developed in a dry Morecambe Bay as ice wasted northwards into the English Lake District. A similar model holds true for Galway Bay.

At the time of the last glaciation eustatic sea-levels were as much as 100 m lower and practically all the continental shelf around the British Isles was dry land. We know from the distribution of Connemara granites that ice passed southwards over the Burren from sources to the north and northwest of Galway Bay.[12,13] At this time Galway Bay would have been dry with the open ocean many miles to the west where the continental shelf descends to the abyssal plains of the Atlantic Ocean. Some glaciers from local ice caps over Connemara and the Midlandian ice sheet[14] which developed over central Ireland poured vast quantities of fluvioglacial sediment onto the dry floor of Galway Bay and formed a large outwash plain rather similar to the sandur which can be found today in southern Iceland. Strong cold winds from the ice caps then winnowed the outwash plain of its silt and major dust storms conveyed this silt onto the Burren uplands. Of course, the silt was much more widespread than the Burren, but on wet sites it was easily washed into the river systems and it now forms a considerable component of many river terraces.

No precise dates such as those determined by thermoluminscence, are available for the Burren loess. It is known, however to overlie fresh Midlandian till in places and so must date from the very beginning of the Late Glacial and before tundra vegetation covered much of the landscape.

Discussion

In his study of the soils of the Burren, Finch concluded that, where soils exist at all on the limestone surfaces, they are dominantly rendzinas, 5-15cm. in depth. In hollows and in the valleys there are also patches of brown earth derived from calcareous glacial drift.[15] Finch makes no comments on the

[12] A. Farrington, 'The last glaciation of the Burren, Co. Clare', *Proceedings of the Royal Irish Academy* 64B (1965) pp 33-9.

[13] T.F. Finch has suggested that the higher parts of the Burren may have remained as nunataks during the last glaciation ('Slieve Elva, Co. Clare - a Nunatak', *Irish Naturalist Journal* 15 (1966) pp133-6). This is unlikely to be the case, however, given that limestone pavements are found on the summits of most of the limestone hills.

[14] F. Mitchell, *Reading the Irish Landscape* (London 1986).

[15] T. F. Finch, 'Soils of Co. Clare', *An Foras Talúntais Soil Survey of Ireland*, Bulletin 23 (1971).

origin of the silt component in the rendzina and all too often it has been taken for granted that the mineral component in such soils has been derived directly from solution of the underlying limestone. Some basic arithmetic might lead us to question this conclusion. Suppose, for the sake of argument, that the limestone is 95 per cent $CaCO_3$. This means that 100cm. of vertical solution would yield 5cm. of impurities, and it follows that a rendzina soil 15cm. thick would require about 300cm. of solution. Now even if these figures are wrong by an order of magnitude it seems unlikely that enough post glacial weathering has taken place to yield the mineral component of the rendzina, not withstanding the fact that the mineral component of the rendzina might also be foreign to the site. Rendzina soils developed on limestones should always be treated with suspicion, and in the case of the Burren it seems likely that at least some of the mineral component is loess.

That loess, or at least a silty soil, was probably once even more widespread can also be deduced from a careful investigation of the archaeological remains on the bare limestone pavements. For example, Drew describes rundkarren on the east-facing slab of the Poulnabrone dolmen indicating that the slab had at one time been under a soil cover.[16] Even more relevant to the loess story are Drew's accounts of the mineral soils under walls and wedge tombs. At Derrynavahagh, for example, augering has demonstrated that the soil beneath the wedge tomb is a calcareous silty loam similar to that found beneath ancient walls and from soil recovered from a depth of *c.*1m. in open joints on the surrounding area of limestone pavement.[17]

The history of vegetation and land use in the Burren is now reasonably well known[18]. The results of pollen analytical investigations indicate that, at least from 3200 B.P. the landscape was primarily open with some patches of hazel scrub. It is only in such open habitats that light demanding species, such as *Drias octopetala and Geniana verna* could have survived since the last glaciers left the uplands. The pollen diagrams also indicate small amounts of ash, oak and elm but pollen from these trees could also have blown up from drift filled valleys. Although there is no direct pollen analytical evidence, it is also thought that the Burren landscape has been open since at least the early Neolithic (*c.*5000 B.P.) and that there was a substantial human impact on the vegetation[19,20]

At least until the time when the loess was eroded into the developing karstic surfaces, the open landscape of the Burren described by palaeoecologists was one where rich herbaceous vegetation thrived on thin, warm, loessic soils. We know that these were widespread not only because of the omnipresence of rundkarren on all pavements but also because of deep loess in the major enclosed hollows of the Burren and the silts in the cave systems. It is also inconceivable that the fallout of loess now trapped in the large enclosed hollows of the Burren was not accompanied by a widespread blanketing of loess on the glaciated pavements.

Conclusions

Loess is much more widespread than is often supposed and the karstic uplands of the Burren are an ideal location for its preservation. The now bare limestone pavements were not always so bare and were once covered with a blanket of loess which has since been flushed into the joint systems of the evolving limestone pavements. In the deeper recesses of the dolines deep loess is still preserved.

[16] D. Drew, 'Geological note on Megaliths in the Burren', in M. O'Connell, *Irish Association for Quaternary Studies, Field Guide,* no.18, (1994) p. 24.

[17] D. Drew, 'Environmental archaeology and karstic terrains: the example of the Burren, Co. Clare, Ireland', in M. Bell and S. Limbrey (eds), *Archaeological Aspects of Woodland Ecology,* British Archaeological Reports, International Series 146 (1982) pp115-27.

[18] L. Jelicic and M. O'Connell, 'History of vegetation and land use from 3200 B.P. to the present in the north-west Burren, a karstic region of western Ireland', *Vegetation History and Archaeobotany* 1 (1992) pp 119-40.

[19] *Ibid.*, p.137.

[20] A. Lynch, 'Poulnabrone, - a stone in time...', *Archaeology Ireland* 2 (1988) pp 105-7.

Throughout Europe, the Middle East and China, loess is associated with ancient settlements and farming. The density of archaeological remains on the karstic Burren uplands points strongly to a similar association, the details of which need to be further investigated.

Acknowledgements

I should like particularly to thank those second year students from the Geography Department, Lancaster University who joined me to hunt for loess in the Burren karst during our Department's annual Galway field courses from 1991-96. I should also like to acknowledge conversations with Professor Ian Whyte (Lancaster) and Professor Ian Smalley (Loughborough). In 1996 I had the pleasure of convincing Dr. Cilian Roden and Gordon D'Arcy about the presence of loess in the Burren during a memorable fieldtrip: they were convinced! Lastly, I should like to thank Professor Etienne Rynne for encouraging me several times during the last few years to write this short paper for the Journal.