Primary coversand and loess deposits on the summit of Bredon Hill, Worcestershire, England.

Paul F. Whitehead
Moor Leys, Little Comberton, Pershore, Worcestershire, WR10 3EH. Email: paul@thewhiteheads.eu

Introduction

On 16 March 2016 whilst researching on the summit of Bredon Hill I observed that a bed of sand was visible on land forming part of the Overbury Estate in Kemerton civil parish. The sand was traceable over a wide area of the summit plateau. Subsequent observations during August 2016 confirmed that these and related sediments comprised a range of particle sizes and that deep beds of loess, not mapped by Jefferson, Smalley and Northmore (2003) also occurred.

Discussion

The published geological record of Bredon Hill, the largest of the English midland Cotswold Hill outliers, is detailed, especially through the work of Linsdall Richardson (Richardson, 1905; 1924) and Alfred Whittaker (Whittaker, 1967; Whittaker & Ivimey-Cook, 1972). A feature of the Inferior Oolitic Limestone plateau is marked cambering and gulling (Whittaker & Ivimey-Cook, 1972) (01). Gulls form on hill slopes where jointed strata are unsupported when underlying soft sediments descend those slopes; the lack of support for Bredon Hill limestone is plain to see along its southern perimeter with large fragmentation blocks visible at Westmancote and Conderton.

01. Cambering and gulling of Inferior Oolitic Limestone, Bredon Hill summit, Kemerton Parish SO9539, 23 August 2016. Geomorphology due to displacement of underlying Jurassic clays in periglacial climates.

Sand deposits first observed at SO9540 on 16 March 2016 were > 40 cms thick and composed of quartz grains in a finer silty matrix (02). Further work during August 2016 showed accumulations of loess in the gulls. In attempting to reach a bumble bee's nest a badger *Meles meles* (L., 1758) sectioned this loess to a depth of some 50 cms (03). This sediment is so fine that it creates an imperceptibly abrasive sometimes silky stain on the wet finger.

02. Aeolian coversand, Bredon Hill summit 16 August 2016. Sediments not bottomed.

03. Loess bed in limestone gull, Bredon Hill summit 16 August 2016. 50 cms deep not bottomed.

04. Aeolian coversand in loessic matrix, sheared angular quartz grains, Bredon Hill summit SO9540 16 August 2016 (sample from near base of (02).

In discussing these superficial sediments a number of matters require to be considered *viz.*, why is there no previous published record of them; what is their age; how did they arrive there and what ecological significance might they have?

The occurrence of quartzose sand in the Cotswold Hills area has been recognised for more than 160 years; earlier explanations for its origin were somewhat fanciful. Richardson (1929) proposed an aeolian origin for sand in the Cheltenham Sands which are by no means exclusively sand (Whitehead, 1990). More recently Briggs, Coope and Gilbertson (1975) and Briggs (1984) confirmed that both the Cheltenham Sands and Carrant Brook Main Terrace sands were likely to have been blown from Quaternary fluvial sand deposits in the Severn valley *i.e.* from the north-west. This process would have swept sand across the denuded midland landscape until it encountered the physical obstacle of Bredon Hill on and around which it came to rest. The scale of this must have been very significant over time and no doubt such sand was also swept against the primary Cotswold escarpment. The oldest finite radiocarbon date from the Carrant Main Terrace is *ca*32000BP (Birm-505) and the youngest is *ca*26000BP (Birm-382) *i.e.* mid-last ice age. Blown sand must therefore have been available to the Carrant Brook catchment prior to 32000BP and also episodically after that. In this periglacial climate there is evidence that very fine loess was redistributed during river terrace formation to create conditions suitable for some distinctive invertebrate assemblages, especially molluscs (Whitehead, 1988). Equally Aeolian sand would have been recycled by fluvial processes over many tens of thousands of years.

The coversands from the summit of Bredon Hill differ from all these fluvially sorted sands in one critically important regard: their sand grains are angular and shattered in most cases. Under the microscope individual grains show shear-faces and sharp edge angles (04); a typical grain size is 0.15 mm diameter rarely up to 0.5 mm diameter. This means that they cannot have been subject to fluvial transportation and they cannot have been far transported, for they show little or no trace of wind-smoothing. The coversands must be in a primary context.

If the Bredon Hill coversand is to be perceived as Quaternary in origin, i.e. <2.6 million years old, the remote possibility that it may be part of the regional Jurassic geology requires to be ruled out. The Jurassic Harford Member of the Inferior Oolite group includes the Harford Sand (Cox & Sumbler, 2002, p. 191). According to Goudie & Parker (1996) these are brown sands up to 3 m thick now visible in only a few places between Winchcombe and Broad Camden on the primary Jurassic escarpment. In this discussion we are helped considerably by published section and borehole records. In a limestone quarry face just 690 m south of the Bredon Hill summit Whittaker (1972, p. 25) observed: "0.46 m of **earthy soil with no limestone debris**, overlying angular disoriented limestone rubble." It is perhaps remarkable that this soil was never investigated in detail because it must surely relate to the aeolian sediments described here and its context provides some evidence not simply for a post-Jurassic age but for a recent one. The 'earthy soil' is a Brown Rendzina developed on bedrock and representing soil subgroup 3.43 of the Sherborne Series (Cranfield University 2016. *The Soils Guide.* Available: www.landis.org.uk. Cranfield University, UK. Accessed 08/11/2016). If it is accepted that cambering and gulling and fragmentation of the limestone surface were enhanced by last ice age processes (Whittaker, 1972) then the cover sediments described here could well be younger but not necessarily greatly. Their angular facetted grains demonstrate that they cannot share a common history with the Carrant Brook and Cotswold Sands sand which comprise exclusively rounded to subrounded grains.

Self (1995) demonstrated that speleothems, mineral deposits, developed in 'gull caves' under jointed gulls in Oolitic Limestone on the Cotswold Hills near Bath, were in the age range 78000BP-350000BP. If limestone cambering and gulling on Bredon Hill is that old a Rendzina could not have remained *in situ* on it for so long. According to Jefferson, Smalley and Northmore (2003) primary loess beds are unlikely to survive intact for >10000 years. I therefore conclude that the Bredon Hill cover sediments are of more recent emplacement almost certainly during late Last Glacial (Devensian) time.

The glaciers of the last glacial maximum reached as far south as Bridgnorth and Wolverhampton in the English midlands and from Wales to within 25 kms of the Malvern Hills. The climate ameliorated rapidly after 14000 BP but deteriorated again for a millennium or so at about 11000 BP. It is contended therefore that sometime after 18000 BP an arid treeless landscape south of Bridgnorth was swept by cold dry winds that carried shattered sand grains of glacigenic origin a distance of some 65 kms south to Bredon Hill where they were swept up its northern escarpment. These sands settled differentially in the hillcrest lee with the finest loessic material accumulating in the limestone gulls. It is a presumption that shattered quartz sand grains moving by saltation over 65 kms is a distance insufficient for them to be rounded but that distance may have been less.

As a diversion it may be observed that the Banbury Stone, a well-known feature of the Bredon Hill summit, could be explained elegantly by the extended chronology provided by Self (1995) and that rumours of a cave there (e.g. Anon., 1915) would be confirmed. The Banbury Stone on the edge of the northern escarpment represents the contents of that gull cave exposed originally by gravitational tectonics such as the downslope descent of limestone originally cambered against the dip. The fragmented limestone thus exposed was removed for building over a long time period the site being serviced by the probably medieval hollow way on Woollas Hill.

Ecological implications of Bredon Hill coversand

The ecological implications of this finding are considerable both in terms of the historical development of the invertebrate fauna of Bredon Hill and wider communities of all species. The overall extent of coversand on the hill is presently unknown but modern agriculture needs to be aware of it due to its extreme fragility. In the summit area and downslope any ancient unploughed pasture or headlands, pockets of grassland or scrub or sediments under woodland cover should be safeguarded.

The development of lithomorphic Rendzina soils would have had implications for early organised human settlement; in fact there would probably have been competition for such a resource. This study also confirms that these sands are distributed thinly under permanent summit pasture to the north of the Iron Age hillfort and that the same sand was also incorporated into its ramparts during their construction.

05. Perforated surface pebble of Oolitic Limestone 47 mm transverse diameter containing two juxtaposed cells created by the vespid wasp *Ancistrocerus trifasciatus* from which wasps emerged on 24 and 25 May 2016. Arable headland, Bredon Hill summit, SO 9540, 16 March 2016.

The effect on invertebrates of these superficial sediments over limestone will be discussed in due course but reference is made here to a few matters of interest. On 16 March 2016 a completely perforated pebble of Oolitic Limestone was recovered in which each end of the perforation was plugged by silk and capped with compacted sand (05). This was the work of a vespid wasp *Ancistrocerus trifasciatus* (Müller, 1776) which used silk padding to divide the perforation into two cells, each of which produced a male and female wasp on 24 and 25 May 2016 respectively. This is an example of a species benefitting opportunistically from the availability of coversand and is a rare instance of pebble-nesting by that species. We have already seen that the thick loess beds enable Bumble Bees *Bombus terrestris* (L., 1758) to nest so deeply that they are able to partially resist the attempts of badgers to access them. The sediments are also attractive to fossorial mammals. Finally, it is these coversands which provide the correct rationale for understanding the existence of gorse scrub developed on limestone at the hill summit.

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Images

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02. Aeolian coversand, Bredon Hill summit 16 August 2016.

03. Loess bed in limestone gull, Bredon Hill summit 16 August 2016.

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