A Geological Trail in front of the last glacier in South Shropshire

By

Michael Rosenbaum

Figure 1. General view looking north from Mortimer Forest towards Onibury (centre top), across the sandur (fluvioglacial outwash plain) created by the melting of glaciers that came from Wales, eastwards over Clun Forest. One glacial lobe is believed to have come eastwards through the col by Downton Castle (to the left of the above view) and perhaps terminated in the centre of the field of view. Another lobe reached Craven Arms and perhaps then turned southwards towards Onibury (in the centre distance). This landscape has also been modified by erosion as the River Teme, diverted eastwards from Aymestry by a major glacier coming from the Wye Valley to the south, rejuvenated erosion and transportation of weathered material from the Silurian mudstones that underlie the lower ground in the field of view. These alluvial processes were significantly assisted by periglacial weathering, especially solifluction, leaving behind an intricate pattern of small curved steep-sided valleys.

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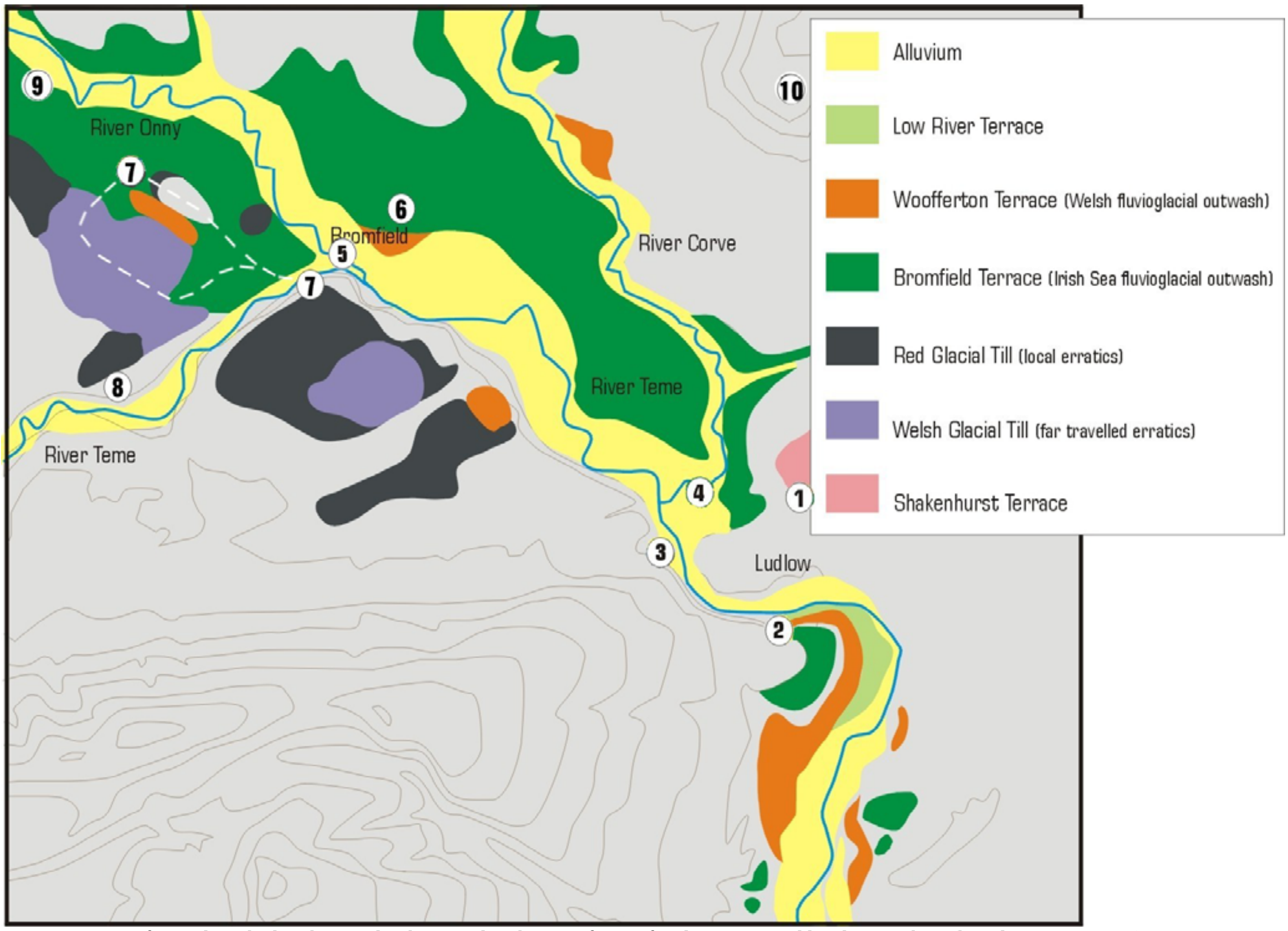

Figure 2. Map of sites described in this Guide, showing distribution of Superficial Deposits and locality numbers (based on Cross, 1971).

INTRODUCTION

Glaciations have taken place a number of times during the past 2–2.5 million years. The last to affect the Welsh Marches was 120,000 to 11,000 yrs BP, called the Devensian; its coldest phase ended some 18,000 yrs BP.

During the Devensian the low ground hereabouts, west of the Clee Hills, was the meeting point of glaciers (1) from the north (Irish Sea, with one lobe through Church Stretton, a second down Ape Dale which occasionally spilt across Wenlock Edge into Corve Dale, and a third to Morville, just beyond the present-day head of Corve Dale), (2) from the west (through the Clun Valley) and (3) from the south (from the Wye Valley, the northern lobe flowing across the low ground between Leominster and Mortimer's Cross). The river valleys responded to the onset of a colder climate and consequent drop in base level (since sea level dropped by many tens of metres as water worldwide became locked within the glacial ice) and to the influx of meltwater loaded with sediment from the glaciers.

A complex network of river channels and terrace deposits resulted, and some river capture and relocation took place. Evidence comes from the direction in slope of the higher river terrace deposits of the Rivers Teme and Lugg a little to the south and east, across the borders into Herefordshire and Worcestershire, and some detailed clast orientation studies of the gravels at Bromfield surveyed by Peter Cross.

The Guide follows public roads and footpaths. The use of a large scale Ordnance Survey map is strongly recommended, such as the Explorer Series Sheet 203 (1:25,000 scale). Ordnance Survey grid references are included to assist location. A compass and hand lens will be found useful but visitors should refrain from using hammers since the exposures are few in number and small in size; fragments can generally be found in the vicinity. Visitors should also follow both the Countryside Code (Anon., 2006) and the Geological Fieldwork Code (Geologists' Association, 2006).

The numbers within squared brackets in the text that follow refer to grid references for the stopping points ('Localities') shown on the accompanying sketch map. 6-figure grid references locate the feature to the nearest 100 m; 8-figure grid references to the nearest 10 m.

Much of the geology described in this guide is revealed by subtle variations in topography and in the soil 'float'. These are more obvious at those times of the year when soils are slightly damp and the vegetation low. Visitors are advised to wear appropriate footwear for ground that can in places be rough and muddy.

LOCALITY 1: East Hamlet, Ludlow [515 754]

Gravel Hill is the road that now leads northeast out of Ludlow up towards the hospital and the suburb of East Hamlet. This road used to be called "The road to the sand pits", recalling not only that industry but also the nature of the superficial deposits that lie above the 115 m contour. This outcrop of sand with subordinate gravel is fluvial, deposited by the River Corve before it was captured by the diverted Teme and erosion lowered the valley floor by some 40 m (see also Figure 9).

These granular deposits are permeable which creates problems for house basements along the contact with the underlying (impermeable) Raglan Mudstone. On the other hand, this water also feeds the spring in Livesey Road (St Julian's Well [5185 7505], Figure 3) which was a vital source of water for Ludlow during medieval times. From here a lead conduit led to a public pump in the Bull Ring near the town centre. The well house is still extant, from which a magnificent chestnut tree now grows.

The East Hamlet outcrop lines up with the river terrace outcropping above the Ledwyche Brook to the southeast, which is clearly a misfit. The two were probably once linked by a single river, somewhat larger in size, draining Corve Dale. This would be consistent with the Devonian provenance of the constituent gravel recorded by Curley during his excavations for the town drains during Victorian times (Curley, 1863).

Figure 3. St Julian's Well, Livesey Road, Ludlow. The stone structure protects the well that supplied the public water pump in the Bull Ring during medieval times. It lies at the base of the high level sands that were formerly excavated in the Sandpits area just to the north. The clear break of slope above this point reflects the different rate of erosion of the sands above compared with the Raglan Mudstone Formation beneath. Similar breaks in slope, springs and groundwater issues are found at about the same elevation all around East Hamlet.

Go to the south of Ludlow, crossing the river by Ludford Bridge and immediately turning left into the village. This is a 'no through road'; car parking is discouraged and it may be easier to leave transport on Whitcliffe Common by turning right instead of left from the bridge, parking in the lay-by on the right after 300 m.

LOCALITY 2: Ludford [513 741]

By the side of the Remembrance Garden the large field clearly reveals two substantial terraces above the present River Teme. These are thought to have been deposited by meltwater flowing from the glaciers melting just to the north of Ludlow. The two separate terraces are the result of a change in drainage, with water initially flowing south towards Leominster (creating the higher terrace) and then draining east as the Teme broke through to the River Severn, the result of its passage being dammed by a glacier that had flowed up from the Wye Valley to the south and west.

A good view of the lower terrace can be seen from the public viewing platform by the Casemill Weir on Temeside [5185 7430] (Figure 4).

Figure 4. River cliff profile on private land opposite the Casemill on the River Teme. Green-grey mottled red-brown mudstone from the Raglan Mudstone Formation is seen to be overlain by the fluvioglacial terrace sand and gravel. This section can be viewed in the distance by looking left from the public platform overlooking the Casemill Weir on Temeside, Ludlow. The contact is at approximately the same elevation as the platform. Imbrication indicates flow to the east (left), in the same direction as the present day river.

River valleys responded to the changing regimes too, in response to the drop in base level (since sea level dropped by many tens of metres as the water worldwide became locked within the glacial ice) and to the influx of meltwater loaded with sediment from the glaciers. A complex network of river channels and terrace deposits resulted, and some river capture and relocation took place.

A local example is provided by the River Teme, which now flows east to the Severn (Figures 5 and 6). Formerly the Teme flowed south towards the Wye, and within part of the present valley around Tenbury flowed *west*, in the opposite direction to today. Evidence comes from the direction in slope of the higher river terrace deposits. Indeed, it is possible that the local rivers may have flowed predominantly towards the southeast as part of an early course of the River Thames, which is known to have existed since the beginning of the Tertiary and thought to have drained this region.

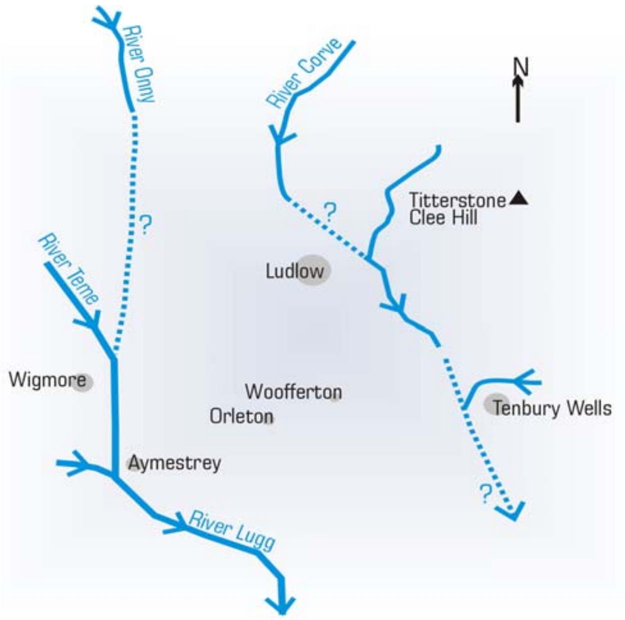

Figure 5. Likely drainage pattern prior to the-advance of the last (Devensian) glaciation, possibly instigated during the previous (Anglian) glaciation.

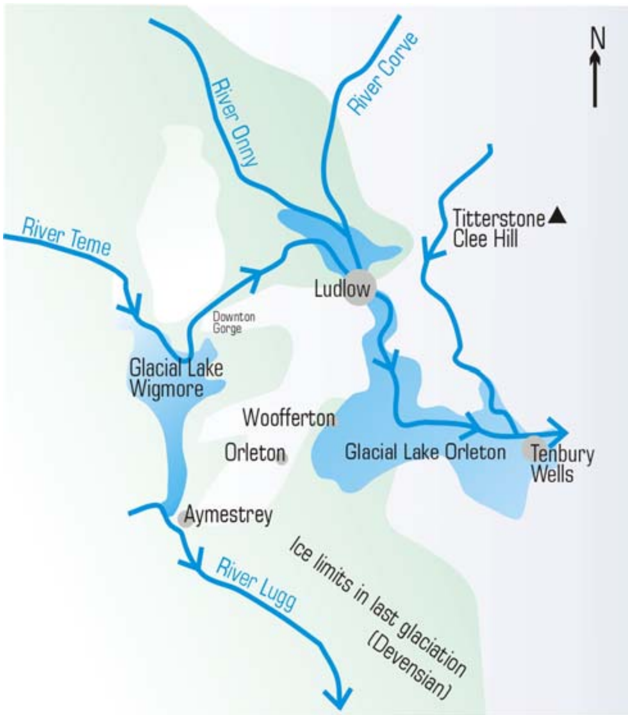

Figure 6. River diversions caused by glacial advance during the last (Devensian) glaciation.

Go through Whitcliffe Common past the lay-by from where there is a fine view of the town, and take the minor road to the north. There is parking for 3 cars on north side of hairpin bend, by junction with Lower Wood Road.

LOCALITY 3: Lower Wood Road, Whitcliffe North [503 745]

Standing on the Silurian siltstone of the north flank of the Mortimer Forest anticline, looking north over the lower ground underlain by the younger Raglan Mudstone Formation, note the hummocky terrain in the near few hundred metres (Figure 7). This is not typical of the Raglan Mudstone and is rather more likely to have been developed as the result of processes operating during the 'Ice Age', i.e. the Quaternary.

However, there was not one single glaciation during the last two million or so years but several. Across the UK there is clear evidence of at least two major glaciations. The most extensive, covering virtually the whole of our region, was the Anglian, some 350,000 yrs BP. The second was the Devensian, which lasted from 120,000 to 11,000 yrs BP; its coldest phase ended some 18,000 yrs BP. The Devensian glaciers obliterated virtually all the evidence of the earlier Anglian glaciation, leaving just a few tantalising fragments (e.g. on the south side of the Longmynd and to the southeast of Leominster).

What may well have happened in the Ludlow area is that the basic landforms had been shaped by the Anglian ice and, together with its associated fluvioglacial deposits (laid down by meltwater from the thawing ice) instigated an important phase of river capture and diversion (Figure 5). However, since this was 350,000 yrs BP, several tens of metres of downward erosion of the softer parts of the landscape are likely to have taken place during the interim. As a consequence, rivers such as the Corve, Onny and Teme would have significantly lowered the elevation of their valley floors by effectively transporting away debris being weathered from the banks and valley sides, but the smaller tributaries would need significantly more time to catch up and reduce their profiles to the same level.

The erosion processes associated with rivers would have been particularly effective during the permafrost conditions which prevail when the climate is so cold that the groundwater is frozen for much of the year, as during the glacial advances of the Anglian and Devensian. The hummocky landscape seen here (Figure 7) may well be the consequence of drainage over the weak Raglan Mudstone not being capable of reducing the level of the landscape sufficiently rapidly to keep pace with the downcutting facilitated by the River Teme. Indeed, the smooth curves of the valley sides on the Raglan Mudstone outcrop are very reminiscent of landforms created by solifluction, the process of seasonal mudflow activity which is so effective during periglacial climatic conditions.

Figure 7. Hummocky terrain ("rock drumlins"), probably eroded since the Devensian as streams cut down to the lower base level created by the River Teme, and modified by periglacial solifluction. The Teme had been diverted by glacial action in the Wigmore area to the west. Lower Wood Road, Whitcliffe North.

Another possibility is that the hummocky topography is a direct effect of glacial ice. Thus glacial ice flowing over this landscape deposited its debris ("glacial till") as mounds ("ground moraine"), or eroded the landscape into streamlined shapes ("rock drumlins") (Jansson & Glasser, 2005). Whether such glacial ice dated back to the Anglian (which almost certainly flowed over this area) or originated more recently in the Irish Sea or the uplands of Wales during the Devensian some 30,000 years ago, is not known. The evidence to confirm the glacial history has yet to be discovered. There is no firm evidence of Anglian glaciers in Ludlow, and indeed the subsequent erosion and transport by rivers would be expected to have destroyed much of it, at least in the valley floors. Clear evidence for the Devensian glaciers is also lacking within Ludlow, although the meltwater deposits are clearly in evidence (as seen at Ludford and Bromfield, visited at other localities in this guide), but it is several kilometres to the nearest clear moraines (Craven Arms to the north and Orleton to the south).

Did the Devensian glaciers actually reach Ludlow? We still do not know. The most recent published summary of our knowledge concerning this matter in Shropshire is in Toghill (2006), and more broadly in Lewis & Richards (2005) (Figure 8). Since then, detailed analysis of the terrain topography is revealing a series of broad ridges trending northwest-southeast, particularly west of Bromfield. These suggest that glacial ice spilt eastwards from Wigmore towards Ludlow, reaching thepresent-day A49. Glacial till has also been reported from a trial pit at Stanton Lacy, a little further east, and thus the glacier may have actually reached this far east (Toghill, *pers. comm.*).

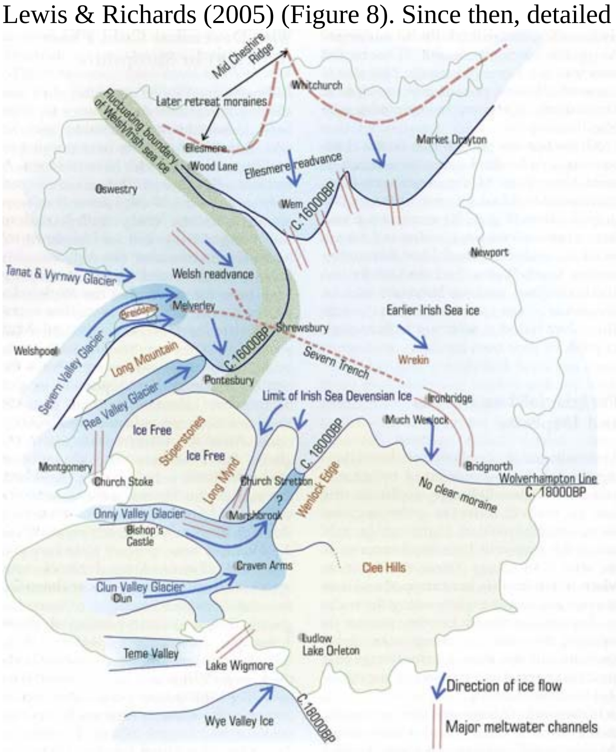

Figure 8. Overview of the Devensian glaciations within Shropshire (Figure 176 in Toghill, 2006).

Adding to the list of possible theories, it is also just possible that the hummocks may have been modified by meltwater flow as Glacial Lake Wigmore drained, but until their composition is known there will continue to be conjecture.

Note the rapid narrowing of the valley though which the present day River Teme flows. This gorge has only been in existence a relatively short period of time. The water flow in the river here is very rapid, indicating that the river bed has a profile out of equilibrium with the landscape (hence the rapids and coarse alluvium hereabouts). It is thought that the River Teme's passage through Ludlow could have been developed either by a subglacial river at the margins of the Anglian glacier or created more recently by the sudden influx of meltwater as the glaciers to the north melted away, and Glacial Lake Wigmore drained. The sand and gravel deposited on the banks of the meltwater create the terraces seen around northern Ludlow today, and on which the Bromfield Sand & Gravel pit is situated. These are in marked contrast to the finer grained (and gentler conditions) represented by the silt and sand of the relatively small present day River Teme, and the much earlier river whose deposits are known to exist around the Sandpits area of East Hamlet to the northeast of the town centre, now left stranded some 40 m above the present day river level. The contrasting valley profiles are well brought out by Curley's early section (Fig. 2 in Curley, 1863) (Figure 9).

It is the presence of such alluvial deposits on what is now higher ground which provides the main indication of where valley floors were once situated, now left stranded by subsequent erosion of the surrounding ground. However, such deposits need to be dated if they are to provide unambiguous evidence for the evolution of this landscape. Much research remains to be done.

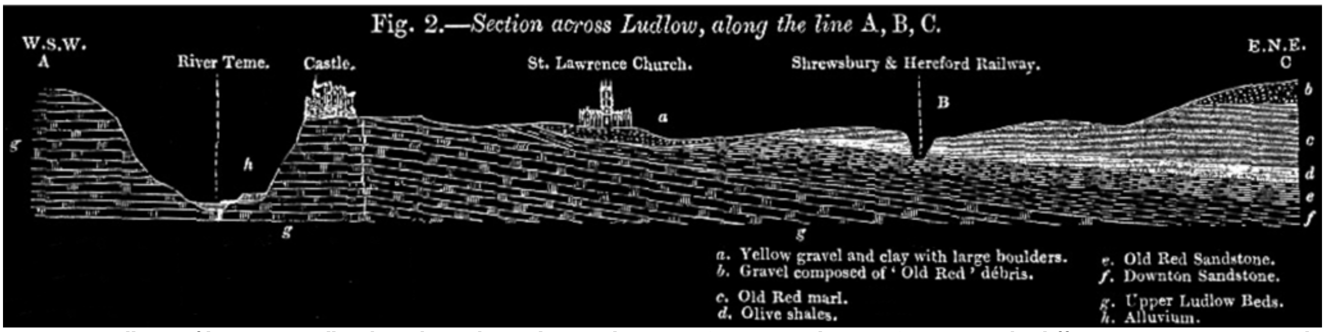

Figure 9. Valley profiles across Ludlow brought out by Curley's early section (Fig.2 in Curley, 1863). A is on Whitcliffe Common; C is East Hamlet (floor of the main pre-Devensian valley through the area)

Continue downhill and cross Dinham Bridge, turning first left below the Castle into Linney.

LOCALITY 4: Linney [510 751]

Going north along Linney, the low ground to the left is the modern floodplain of the Rivers Corve and Teme, and is floored with alluvium. To the right of the road, the ground rises sharply onto the Bromfield Terrace of fluvioglacial meltwater sands and gravels deposited by the glacier melting just to the north (Figure 10). St Leonard's churchyard is located on this terrace, and the gravels were worked just across the road in the early 20th Century.

Groundwater still flows in considerable volume through the terrace deposits, partly accounting for the standing water frequently observed during winter months on the recreation ground immediately north of Ludlow Castle. This is also responsible for maintaining the vigorous discharge from the spring called Boiling Well [5085 7520], beside the footpath just beyond the footbridge over the River Corve (Figure 11).

Go northwest for 2 km to Bromfield, turning left off the A49 just past the Clive Restaurant (refreshments), and immediately left again into the lane. There is parking by the lytch gate to the church.

LOCALITY 5: Bromfield Church [482 768]

Around Bromfield note the relatively wide, flat expanse of low ground, dipping gently southwards (Figure 12). This is a lobe of fluvioglacial (river-deposited) sand and gravel, initially deposited in a delta within a glacial-dammed lake (Glacial Lake Orleton, named after the village south of Ludlow where the glacier responsible terminated). As the lake drained so the meltwater developed a major braided river flowing south from here towards Ludlow.

Figure 10. Looking south towards the centre of Ludlow, Castle to the right, from a viewpoint near the football ground close to the junction of the old Shrewsbury road with the modern bypass (A49). In the lower left of this painting can be seen the Bromfield Terrace; Linney lies just beyond the woodland in the centre; the hill just to the left of the Castle may be artistic licence, and could represent the hummocky ground which is actually further to the right, visited at Locality 3; from a painting ca. 1810 (artist unknown).

Figure 11. The spring known as the Boiling Well. The fluvioglacial Bromfield Terrace rises beyond, above the present-day alluvial plain; looking north towards the houses on Burway.

Figure 12. Fluvioglacial sand and gravel being exposed on private land along the north bank of the River Onny due to erosion by the (smaller) modern river; viewed from Bromfield churchyard.

This is a convenient place to park the car if intending to visit Localities 6 and 7. Pedestrians may cross the A49 by the underpass next to the river.

Turn north (left) along the A49 for 400 m, to where the rising ground begins to level off, just before the lay-by. The gate on the right provides a vantage point over the Bromfield Sand & Gravel workings.

Note the low cutting for the main road; this was excavated through a hummock of glacial till in the 1970's. This till is evidence of the passage of a glacier.

LOCALITY 6: Bromfield Sand & Gravel [478 771]

The working pit exposes a thick sequence of fluvioglacial sediments which are being actively extracted for building materials and construction aggregates. The bedrock geology is the Raglan Mudstone Formation (the Downtonian of the Pridoli Stage at the top of the Silurian), and is hundreds of metres in thickness. The Pleistocene superficial geology comprises well-bedded sandy gravels with occasional thin beds of sand (Figure 13). There appears to be very little silt or clay except at the base, where some 0.1 m of red-brown laminated silty clay occurs (Figure 14).

The sandy gravels have the appearance of having been deposited by moving water, probably a braided river. The laminated silty clay appears to have been deposited within still water, possibly on a lake bed. The likelihood is that these deposits have been transported by glacial ice and then washed out by meltwater to be laid down by braided rivers; the earliest (lowest) part of the sequence might have been sedimented as a deltaic deposit within a temporary glacial lake (the thin clay at the base may represent a lake-bed mud).

Some very large boulders have been encountered at the bottom of the fluvioglacial sequence at Bromfield, for which the name "tobogganite" has been suggested, with the implication of rafting across compacted snow.

Figure 13. Vertical face at the northern boundary of the Bromfield Sand & Gravel pit, close to the railway, looking north north east, exposing Late Devensian fluvioglacial sandy gravel. Bedding exhibits imbrication, indicating flow towards the right (east south east); note the degree of sorting, and the varied lithologies of the gravel component. The length of the scale rule is 150 mm.

Figure 14. Fragment from the floor of the working pit with, at the bottom, green-grey mottled red-brown mudstone from the Raglan Mudstone Formation and, at the top, red-brown laminated silty clay, possibly glacio-lacustrine.

Visits to Bromfield Sand & Gravel always require the prior agreement of the Site Manager, tel. 01584 856 258

LOCALITY 7: Cookeridge [458 775]

A walk of approximately 5 km provides an opportunity to cross the front of the last glacier to reach this area.

From Bromfield Church (Locality 5) take the footpath west along the bank of the River Teme, accessed by a stile next to the bridge. The lower part of the meadow is on the alluvial flood plain of the present-day river. A prominent bank uphill marks the edge of a terrace composed of fluvioglacial sands and gravels belonging to the Bromfield Terrace, similar in character to the deposits being worked at Bromfield (Figure 15).

Figure 15. The edge of the Bromfield Terrace, composed of fluvioglacial sands and gravels.

After 500 m take the footpath heading northwest towards the road (A4113), crossing it and continuing in the same direction. The first 500 m crosses the flat low ground of the fluvioglacial Bromfield Terrace, similar in character to the deposits being worked at Bromfield. To either side the ground rises as low ridges, formed of glacial till that is characteristic of deposition by melting of a glacier (Figure 16). It was probably only a relatively small lobe that reached Bromfield; here it stagnated and melted.

Figure 16. Low ridges, formed of glacial till that is characteristic of deposition by melting of a glacier, rising from the Bromfield Terrace composed of fluvioglacial sands and gravels.

The moraine predominantly comprises remoulded reddish brown Raglan Mudstone but it also contains erratics derived from Wales, some of which might be visible in the field "float" (Figure 17).

The source of this particular glacier is still a matter of debate. It may have flowed southeast through the valley now occupied by the (small) River Onny between Stokesay and Onibury. Alternatively it may have flowed from the west, just managing to penetrate the high ground of what is now Downton Gorge, behind which the major part of the parent ice sheet lay. It has already been noted that detailed analysis of the terrain topography is revealing a series of broad ridges trending northwest-southeast, west of Bromfield, reminiscent of a glacial terminal moraine (Figure 18). These suggest that glacial ice spilt eastwards from Wigmore towards Ludlow, and reached the present-day A49 (Figure 19). However, there is also a striking similarity to the 'Rogen moraines' of Sweden, formed by subglacial water flow. Careful and detailed description and analysis of the geomorphology and the composition and fabric of the superficial deposits are required to elucidate their origin.

The edge of the Bromfield Terrace is reached by the side of Cookeridge Wood, just after two right-angle bends in the footpath (Figure 20). The Wood is underlain by glacial till.

From Cookeridge Farm [458 775] walk west-southwest towards Cookeridge Cottages, then east-southeast past Stead Vallets Farm, turning east towards Stocking Nursery and thence back to Bromfield, all across similar glacial moraine.

A good view of the chaotic hummocky terrain so characteristic of a waning glacier may be appreciated from vantage points to the west and south of Cookeridge Farm (Figure 21). Also note the enclosed topographic hollows with poor drainage hereabouts, the result of moraine deposition by ice when there was insufficient time for a new river drainage system to become established.

Note the similar terrain all along the Teme Valley towards Downton Gorge, seen to advantage where the footpaths diverge south of Stead Vallets Farm [460 757], lending support to the hypothesis that the glacier responsible flowed through the hills above Downton Castle (Figure 22).

It should also be remembered, as noted at Locality 3, that this landscape may have experienced rejuvenation following the rapid lowering of base level when the River Teme cut through Whitcliffe, and that the valley sides on the Silurian mudstone outcrop are very likely to have been subsequently modified by solifluction.

Figure 17. Glacial till containing erratics, some of which are sedimentary rocks derived from Wales; Cookeridge Wood.

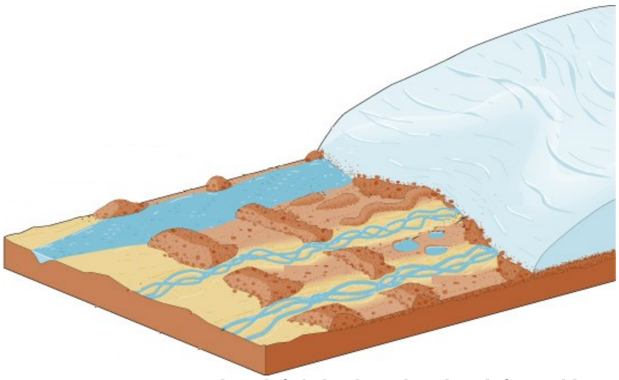

Figure 18. Moraine ridges left behind as the glacial front ablates. Image is Fig.1228 from Plummer *Physical Geography* © McGraw Hill.

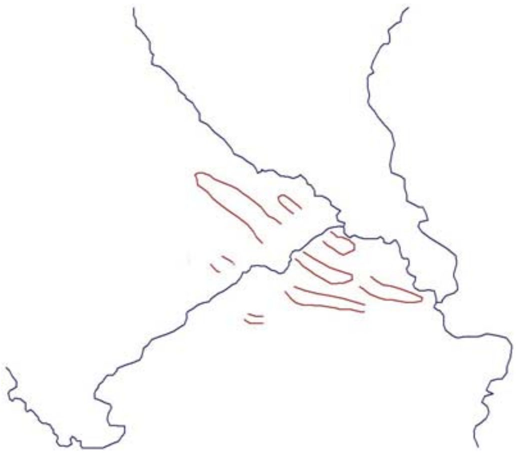

Figure 19. Broad ridges trending northwest-southeast, particularly south and west of Bromfield, identified from digital terrain topography analysis. These may have been formed by glacial deposition as ice spilt eastwards from Wigmore (lower left) towards Bromfield (centre) and thence towards Ludlow (lower right); however, there are other possible theories too (see text)! Map is ca. 12 km across and shows the River Teme (flowing in at lower left and out at lower right) and the Rivers Onny and Corve which join it.

Figure 20. Patches of dark organic rich soil in a freshly ploughed field reveal the locations of kettle holes where stagnant ice slowly melted, surrounded by glacial till; Cookeridge Wood, looking north from the Leintwardine road (A4113).

Figure 21. Chaotic hummocky terrain characteristic of a waning glacier may be appreciated to the west and south of Cookeridge Farm.

Figure 22. Hummocky ground (right) due to glacial moraine along the northern side of the Teme Valley below Downton Castle, looking west towards where the glacier responsible is believed to have flowed. Silurian bedrock underlies the high ground of Mortimer Forest, rising to the south (left). Viewpoint south of Stead Vallets Farm.

Continue west along the A4113 for 2 km through the hummocky terrain of glacial moraine and at the pronounced right-hand bend, as the road begins to rise up the dip slope of Silurian bedrock, take the minor road southwest for 1 km.

LOCALITY 8: Downton Gorge [445 742]

The Downton Castle Estate is private but is crossed by a public footpath. Walk from The Brakes [449 752] to where the public footpath crosses the River Teme [445 742].

As noted at Cookeridge, here is one possible route that might have been taken by a lobe of glacial ice flowing east through the high ground hereabouts. Any moraine has since largely been eroded by the subsequent flow of a major river which followed the same route, swollen by the melting of the main glacier to the west; patches of reddish-brown clay that might be till are known to exist within the private land of the estate.

Glacial ice on occasion also dammed river valleys such as this to create temporary lakes. One example of such a blockage by glacial ice interrupted the former southward passage of the Teme to the south of Wigmore, impounding the large Glacial Lake Wigmore (Thornhill, 2001). It has been argued that such impounded water could subsequently overflow, eroding a new channel through the high ground just to the west of Downton thereby permanently diverting the Teme from its original southward path through Aymestry, thence to flow east to Ludlow. The erosive forces needed to create a gorge as large as this are enormous, and it may perhaps be more plausible that erosion of the gorge began as a subglacial meltwater channel, eroded *beneath* the glacier, when water erosion would have been concentrated and the ground weakened by frost action (Figure 23).

Figure 23. A modern example from western Norway of a subglacial meltwater channel.

Figure 24. A modern example from western Norway of the deposition of fluvioglacial sediment in front of a glacier.

Figure 25. Slight bulge in the valley floor at Downton Gorge seen from the public footpath (Downton Castle to the left). This is likely to be a bedform of fluvioglacial sand and gravel that was rapidly deposited by the meltwater disgorging through Downton Gorge after it had been breached by the overtopping of Glacial Lake Wigmore (behind the photographer).

Subsequent glacial melting and distribution of sediment by the swollen river distributed a wide expanse of fluvioglacial sand and gravel across the lower ground downstream (Figures 24 and 25).

Travel north to Onibury, either by returning to Bromfield and turning north on the A49 or by taking the minor road through Duxmoor. Before reaching the river bridge and level crossing, take the minor road heading due north towards View Edge. Just beyond the entrance gates to Stokesay Court, the road bends left by Stepaside Farm. There is limited roadside parking just beyond.

LOCALITY 9: Onibury [445 742]

A walk of approximately 2 km provides an opportunity to view the narrow valley through which the River Onny now flows, and which is probably the path taken by the meltwater from the glacial lobe that reached Craven Arms from Clun Forest to the west.

Take the footpath heading north across the meadows from the road at Stepaside [453 790], immediately west of the sharp turn in the road and some 250 m due west of Onibury Bridge. Note the wide flat expanse of the meadows, periodically flooded by the present-day river and floored with silt alluvium. Nevertheless bedrock (Silurian mudstones) is exposed in the river bed along the eastern side indicative of the (shallow) prevailing base level for erosion. In addition, the fields hereabouts are strewn with cobbles and gravel, well rounded and indicative of transportation by glacial ice, or at least by rivers fed by meltwater from that ice.

After a kilometre, the footpath crosses the railway and then the River Onny [446 801]. The underlying Superficial deposits are exposed in the banks of the river and seen to consist predominantly of sands and gravels with cobbles; these belong to the fluvioglacial outwash of the glacier that flowed down to Craven Arms and was melting just to the north of here. To either side of the valley, particularly clear to the west, are a series of raised terraces. These reflect the progressive erosion and downcutting of the valley floor under the vigorous energy of the meltwater as it flowed south into Glacial Lake Orleton where it built up the deposits seen at Bromfield.

It is possible, but by no means certain, that the glacier actually managed to penetrate this valley southwards, at least at the northern (Craven Arms) end. If glacial till that is characteristic of deposition by melting of a glacier was ever deposited here, it has since been removed by erosion or at least covered by later sediments and not yet discovered. There is also no sign of any hummocky terrain in the valley floor, so characteristic of a waning glacier, or of enclosed topographic hollows with poor drainage that might have been the result of moraine deposition by ice. However, particularly in the northwestern part of the valley, there is hummocky ground on the valley side strongly reminiscent of kame terracing, emphasised by the break between open pasture below and woodland above. This could well indicate the top of the glacier at a time when glacial-marginal meltwater rivers were flowing (Figure 26).

Figure 26. Looking northwest across the Onibury valley from the River Onny. Fluvioglacial gravels outcrop in the river bed (centre right). On the far side of the valley hummocky ground in the open pasture passes up into woodland, suggestive of kame terraces that could have been deposited by a river fed by meltwater flowing alongside a glacier partially filling the northern end of this valley in late Devensian times.

The erosive forces needed to create a valley as large as that at Onibury are enormous, and the present River Onny is far too small to have done so in the form that it is today. It is indeed plausible that the erosion of the valley may have begun as a subglacial meltwater channel, eroded *beneath* a glacier, when the water erosion would have been concentrated and the ground weakened by frost action. Subsequent glacial melting and distribution of sediment by the swollen river could then have distributed a wide expanse of fluvioglacial sand and gravel across the lower ground downstream.

Instead of retracing your steps along the valley bottom footpath, take the footpath heading west, re-crossing the railway line and join the Shropshire Way above the fluvioglacial terrace at the foot of the wood [441 802]. Walk(*) south-south-east along the eastern flank of View Edge, noting the splendid views over the sandur of Bromfield (Figure 1), and thence back to the starting point.

**Alternatively proceed northwards to visit some of the interesting sites south of Craven Arms. These include:*

Stokesay Castle [435 817] is an impressive moated manor house managed by English Heritage.

The Secret Hill Discovery Centre [435 825] lies 800 m further north, to the east of the main road (A49), where refreshments and a bookshop supplement both indoor and outdoor display areas; there is also a Rock Trail that can be followed around the meadows.

To the east sits Norton Camp [447 819], a large Bronze Age hill fort on top of the hill. Footpaths lead from here back to Onibury on the eastern flanks of the valley, so avoiding the necessity of walking along the main road or retracing the steps of the outward walk.

Return towards Ludlow and travel east from the town, taking the Kidderminster road (A4117). The Trail ends by ascending Titterstone Clee Hill, from which a splendid view of the glacial features may be gained. Convenient parking is in the old quarry beneath the summit.

LOCALITY 10: Titterstone Clee [592 780]

Above the level of the quarry, the ground is strewn with angular boulders of dolerite, the rock forming the summit. Such breakage was caused by the periglacial conditions that existed here during the Devensian. Following collapse of the rock blocks, transport then took place downhill, by creep, frost heave and solifluction to form the broad apron of debris below, now largely obscured by bracken.

During the Devensian the low ground that can be seen to the west was the meeting point of glaciers from the north (Irish Sea, through Church Stretton), west (through the Clun Valley) and south (from the Wye Valley).

During this period the high ground remained free of glacial ice, but experienced permafrost (periglacial) conditions during which the bulk of the groundwater remained frozen. Just the near surface few metres of ground could thaw each summer. Under such harsh cold conditions, the frost was able to effectively shatter the exposed rock, opening fractures (since ice occupies 10% more volume than liquid water) and enabling solifluction to occur (the downhill flow of water-saturated soil over frozen ground beneath); such movement can take place on slopes as gentle as 1°. Finer grained particles can be readily washed down and out of the soil in such conditions, leaving behind ground covered in a mantle of boulders (Figure 27).

Figure 27. Blocks of dolerite carried downhill by periglacial processes, Titterstone Clee Hill.

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