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New thoughts on the Origins of Downton Gorge

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FRANCIS, K. (2009). New thoughts on the Origins of Downton Gorge. *Proceedings of the Shropshire Geological Society*, **14**, 30–41. With access to the latest Ordnance Survey height data and using *Global Mapper* to produce profiles, new evidence has been found which suggests a pre-glacial period of drainage reversal in the vicinity of Downton Gorge. The overflow point for Glacial Lake Wigmore is shown to have been further east than previously thought, and actually within the area now containing the gorge.

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INTRODUCTION

The late Dr Peter Cross's work on the Wigmore Vale was a *tour de force* of geomorphology (Cross, 1968; Cross & Hodgson, 1975); an area of great beauty was given an exciting history stretching back through the Devensian ice age. This inspired the current study, part of a project to identify the location of the overflow point of Glacial Lake Wigmore.

Cross's study was based on Ordnance Survey (OS) contour maps at 1:10,560 scale, portraying contour lines at 100 foot (30.48 m) intervals. Interpolation was achieved by section drawing assisted by surveying at critical locations using an Abney Level and staff (Cross, 1971). Accuracy would have been of the order of +/- 3 m overall. The new analysis has also been based on a study of OS elevation data but in digital form, provided to a resolution of one metre and an accuracy of +/- 0.5 m on a 10 m square grid, sourced by EDiNA *Digimap*. The software used to perform the analysis was *Global Mapper* (www.GlobalMapper.com), capable of handling large quantities of elevation data, rendering 3D landscapes and producing vertical surface profiles.

Figure 1 is a 3D image which prompted the work leading to the present paper. The height data is shaded in proportion to slope angle, i.e. it is "lit" vertically. At first glance, the widening of the valley to the south and the geometry of the tributaries are all suggestive of a southward-flowing stream. Yet this is the southern end of Downton Gorge which currently hosts the River Teme, flowing *northwards*. Was there once a south-flowing drainage for this area, before pro-glacial Lake Wigmore formed? And, if there was, where was the lake's breaching point?

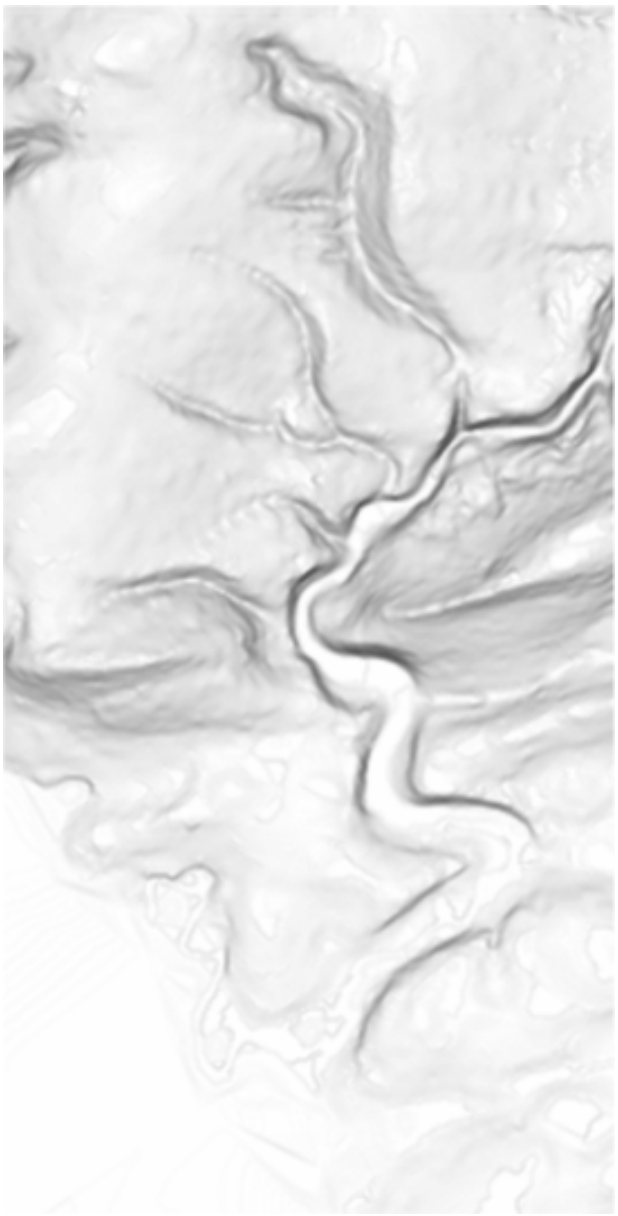

Figure 1. Vertically-lit image produced by Global Mapper showing elevation in the vicinity of Downton Gorge (centre and right). This reveals a southward-widening valley, suggestive of erosion by a southward flowing stream. The present-day drainage by the River Teme flows in the opposite direction through the Gorge: northwards.

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Considering the formation of Downton Gorge, nature has not been the only architect; Man has exerted an influence too, as shown by the following timeline summarising current knowledge of the Wigmore area:

- After the Devensian ice retreat around 10,000 years ago, Man colonised the area which led, until the end of the Iron Age some 2,000 years ago, to construction of extensive earthworks ("hill forts") on some of the ridges (Twigger & Haslam, 1991).
- Travel was predominantly E-W, as shown by development of a major trading route: the Clun-Clee Ridgeway (Chitty & Lily, 1963).
- Almost 2,000 years ago the Roman administration began, responsible for constructing a new N-S road across the Wigmore marshes and establishing a large fortified site at Leintwardine at its intersection with the Clun-Clee Ridgeway.
- Between 900 and 150 years ago Ludlow owed much of its wealth to sheep farming and processing the fleeces using energy gained from the Teme via mills. Downton Gorge itself houses 4 weirs, some associated with the early iron industry. These weirs have been responsible for deposition of alluvial flats within the Gorge.
- Over the last 350 years, Wigmore Vale has been progressively drained as farmers dug drainage channels.
- Between 350 and 150 years ago clay pipe making at Pipe Aston created a demand for white clay, possibly partly sourced locally by varved lacustrine deposits within the Vale; other possible sources include Clee Hill which, at that time, was being used to source the ironstone for local smelting.
- In the last 110 years there have been two major excavations across the area associated with installation of the large diameter pipes for carrying water underground from the Elan Valley to Birmingham. During excavations, contractors' trams have been used to carry out spoil, creating terraced dumps that have since blended into the landscape.

GEOLOGICAL SETTING

The published geological map for the region (Sheet 181: BGS, 2000) shows the geology of the area and the latest stratigraphic nomenclature. However, rather more detail of the exposures together with a clearer portrayal of strata dip angles and faulting is given by the older 1:25,000 geological map based on field studies by the Ludlow Research Group (IGS, 1973; Schofield, 2008), in particular for the Downton Gorge area the mapping undertaken by "Mac" Whitaker (1962). The larger scale maps show a syncline trending SW-NE through the present line of the River Teme within Downton Gorge, and several faults. Two major normal faults within Downton Gorge appear critical to understanding its geomorphological evolution (Figure 2).

The first normal fault runs N-S along the path of the Teme where it cuts the Aymestry Limestone ridge downstream from Downton Bridge [SO 427 730]. It is downthrown to the west by up to one hundred metres and so must have created a significant zone of fracturing through the ridge at this point. The second strikes NW-SE, downstream at Castle Bridge [SO 443 744], downthrown to the northeast by a similar magnitude thereby bringing the younger, weaker Ledbury Formation mudstones (now considered part of the Raglan Mudstone Formation) to the surface. In effect, these two faults have created a horst block uplifting the Whitcliffe Beds along what is now Downton Gorge.

The 3D map of the area shown in Figure 1 has had the geology draped over it in order to clarify the positions of these two normal faults, highlighted in yellow (Figure 2).

The two blue dashed lines mark the position of terrace profiles taken on the NW side of the Gorge, 200 m and 400 m away from the River Teme. The current river profile together with these two terrace profiles are shown in Figure 3. This shows a composite longitudinal profile of the current river level with both terrace profiles behind. These three profiles have been stretched to the same width, and the horizontal scale is that of the river channel.

Note the impact of the four weirs within the Gorge: flattening the longitudinal profile with alluvial splays. The stepped profiles are a consequence of handling digital elevation data to one metre resolution within *Global Mapper*. Furthermore, since the height data and OS topographic map were not contemporaneous, tracing the mapped meanders occasionally creates anomalies of the order of 1-2 m with regard to the elevation data.

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The two red dotted lines on Figure 3 indicate potential river profiles. The stream which runs NE towards Ludlow, draining the area that now contains the Gorge, is henceforth known as the "Pre-Teme". It was a mature stream draining a relatively small basin contained within the syncline. The terrace profiles suggest there may have been a nick point somewhere near Castle Bridge, where the stronger calcareous siltstones of the Whitcliffe Formation give way to the younger, weaker Ledbury Formation mudstones.

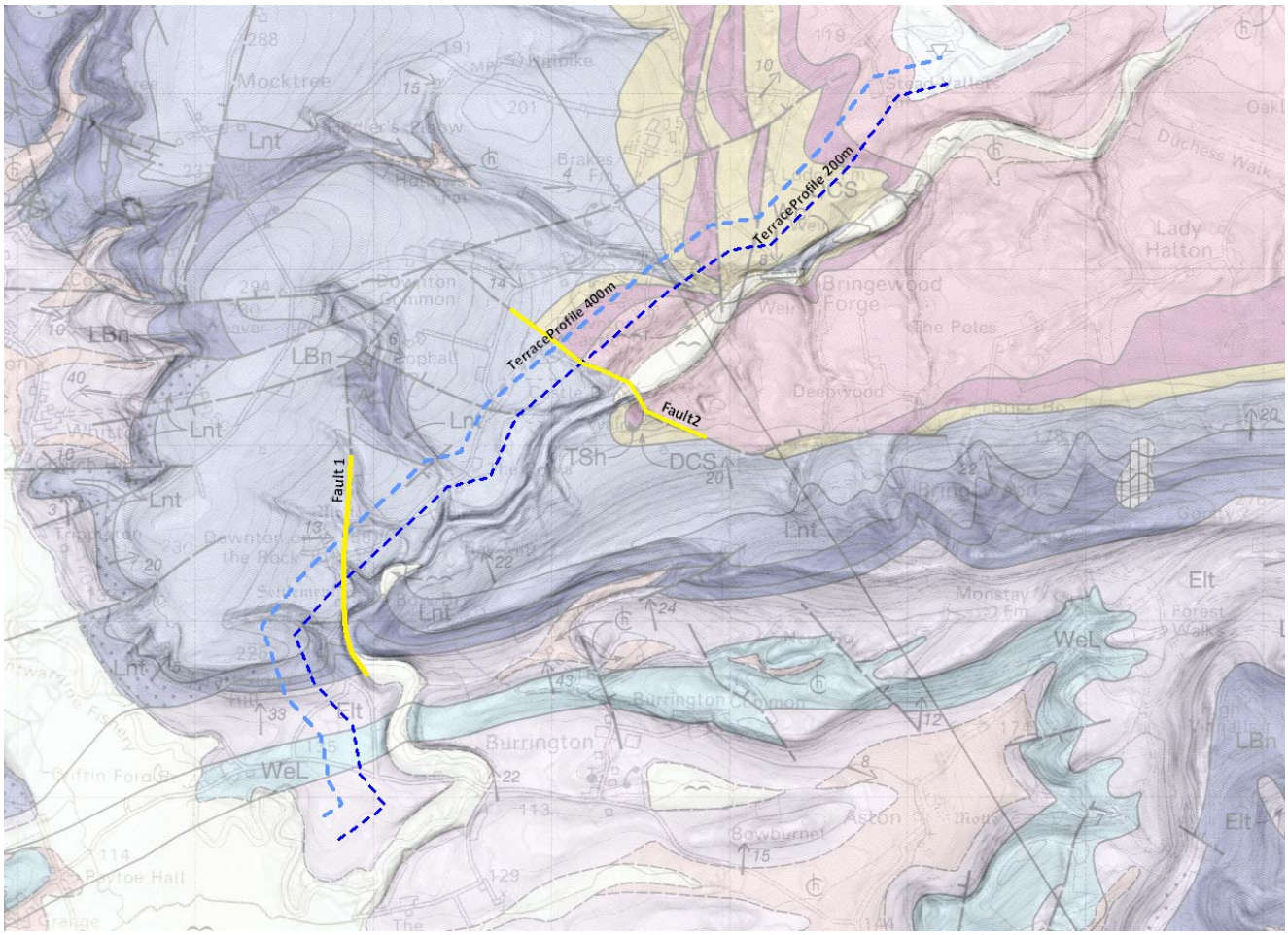

Figure 2. 3D image of Downton Gorge prepared by superimposing the geological map onto the topography prepared for Figure 1. Lines of the two normal faults referred to in the text and locations of profiles are also shown.

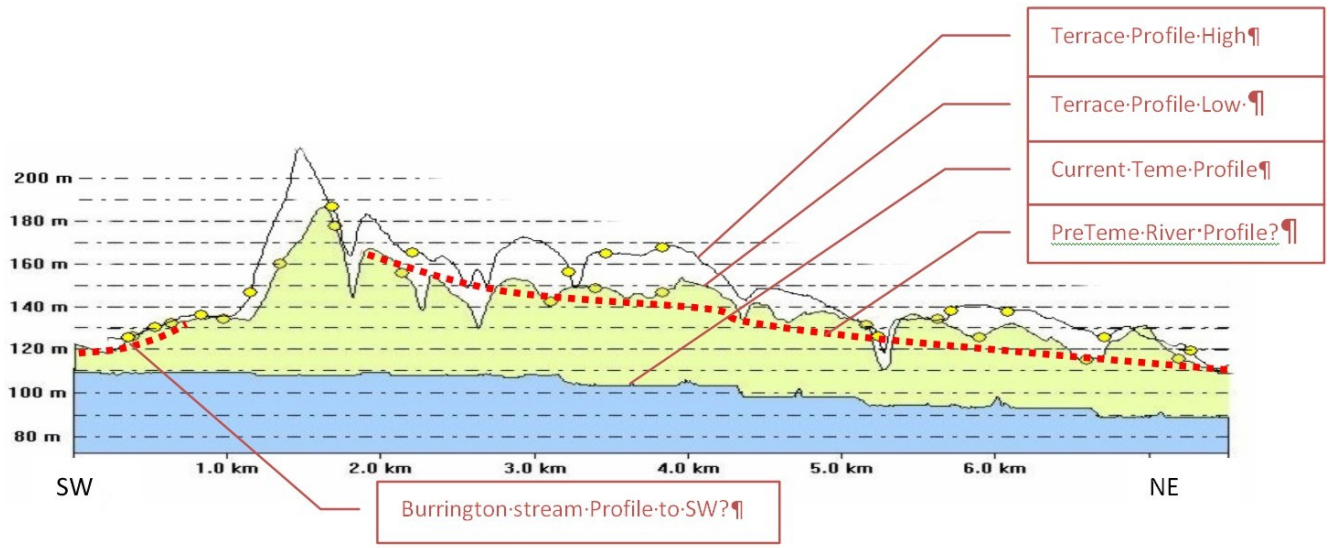

Figure 3. Composite profile along the River Teme, showing current river profile, two terrace profiles 200 m and 400 m to the NW of the gorge, and suggested profiles for the initial drainage within this landscape.

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GEOMORPHOLOGY OF DOWNTON GORGE

The geomorphological evolution of Downton Gorge can now be considered using the digital elevation data, which enables the possible origins of the Gorge to be evaluated.

The stream draining the SW of the ridge now containing Downton Gorge is to be called here the "Burrington Stream" since it would have joined the Teme near Burrington. From there, the Teme would have originally flowed south out of the Wigmore Vale through the gap at Aymestrey.

This is referred to as the "Phase 1" drainage pattern.

As for the drainage of the Burrington Stream to the SW from Downton Bridge, no reliable evidence can be extracted from either the longitudinal or cross profiles. During this time, the Teme flowed out of the Vale through the Aymestrey gap.

Only one piece of direct evidence for the pre-Devensian level of the Teme through the Vale could be found. Clive Gurney (who farms Abbey Court Farm which lies in the lowest parts of the Vale of Wigmore, just north of Wigmore village) has two ponds (arguably kettle holes, since there is peat nearby) on his land at 110 m elevation with respect to Ordnance Datum (OD). These act as natural sumps which have to be pumped out constantly (see Annex for further details). When cleaning out one of these sumps, clay and peat were still being excavated at a depth of 10 m below ground level. This could imply that the Teme was at least 10 m lower than it is now in its current course at Burrington.

Four kilometres to the south, the present elevation of the River Lugg at Aymestrey, which flows from there south towards Leominster, is at about 100 m OD. This may be compared with a ground level of 110 m OD at the depression by Abbey Court Farm. If the current profile of the River Lugg is extrapolated backwards into the Wigmore Vale, it would follow a gentle, uniform gradient, consistent with the concept of a river 10 m lower than at present within the Vale. On the other hand, it could instead indicate slight over-deepening of the Vale due to ice and nevee collecting on the north eastern flanks of Wigmore Rolls, to the west, possibly around stagnant ice (i.e. forming a kettle hole).

It is of relevance to note that Cross (1968) described a deposit of sand and gravel within the Aymestrey gap which appears to have been deposited as a delta by meltwater from an ice sheet flowing from further south. Deposition was northwards into a body of water, quite probably the proglacial lake now known as Glacial Lake Wigmore. The top of the delta (since quarried away) was at a maximum elevation of 131 m OD, dropping northwards to about 128 m OD. The delta was in excess of 22 m in thickness and so the ground level prior to deposition must have been a little below 106 m OD, which would be consistent with a location near the banks of a pre-glacial river hereabouts, comparable to the present day Lugg.

Global Mapper was used to create many cross profiles of the valley along the whole length of Downton Gorge. Only a small number are presented here in evidence, chosen as being representative. The remainder are considered within a related, but unpublished, report (Francis, 2009).

The stages and evidence for the evolution of the river system through Downton Gorge will now be considered.

Figures 4, 5 and 6 show stages in the proposed drainage reversal as a series of vertical longitudinal sections along the line of Downton Gorge, perpendicular to bedding.

The Burrington Stream has the advantage of attacking the synclinal axis and the fault zone at Downton Bridge. The Pre-Teme's ability to erode its upper course above Castle Bridge is hampered by the comparatively strong calcareous siltstone of the Whitcliffe Beds that outcrops there, which may have created a nick point, flattening the upper profile.

Figure 6 shows the greatest extent of Phase 2 drainage with a one kilometre long col (once part of the upper Pre-Teme's course) between The Pools and Castle Bridge, acting as a watershed.

DISCUSSION

The geomorphological evolution of Downton Gorge has been considered by previous writers in terms of glacial lake overflow (Cross, 1971) and subglacial river erosion (Rosenbaum, 2007).

Consideration of the field evidence can now be refined using the digital elevation data available to

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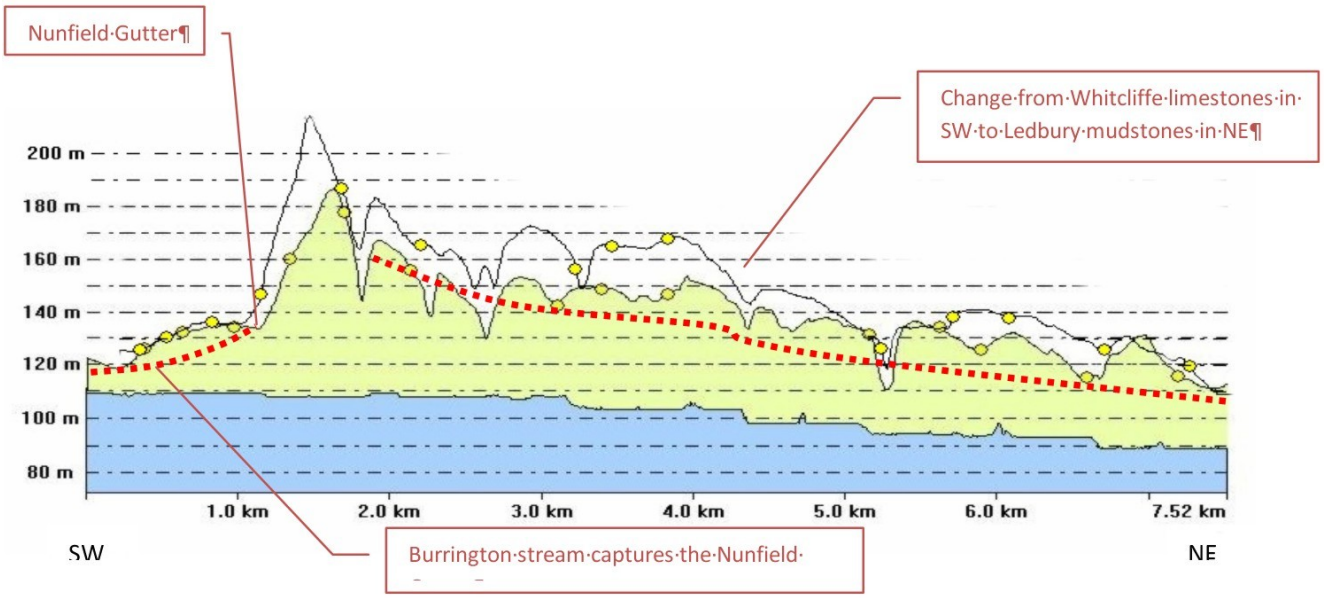

Figure 4. The dip slope with Burrington stream capturing the larger Nunfield Gutter.

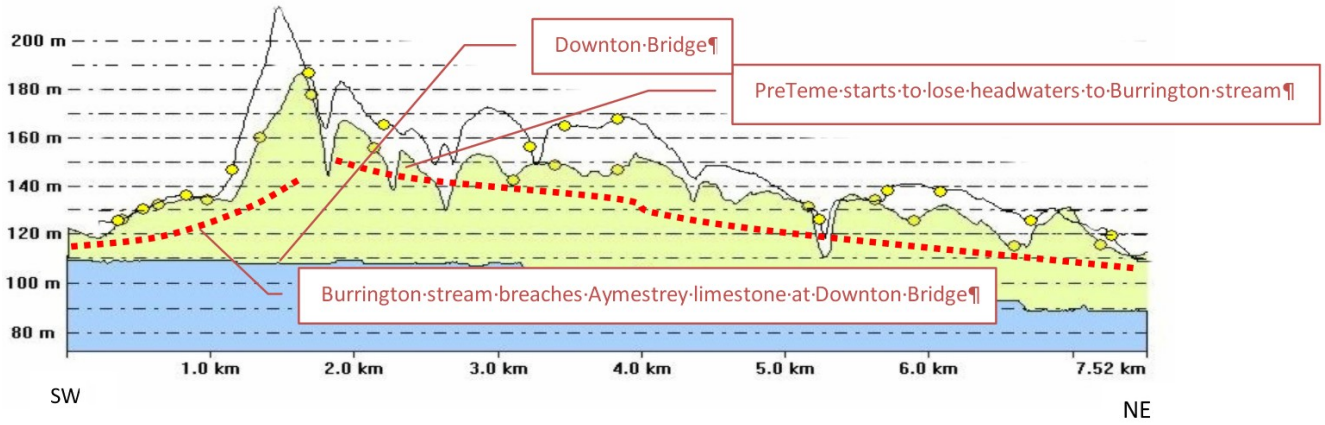

Figure 5. The capture of the Nunfield Gutter at the base of the faulted ridge, leading to aggressive erosion which breaches the original watershed.

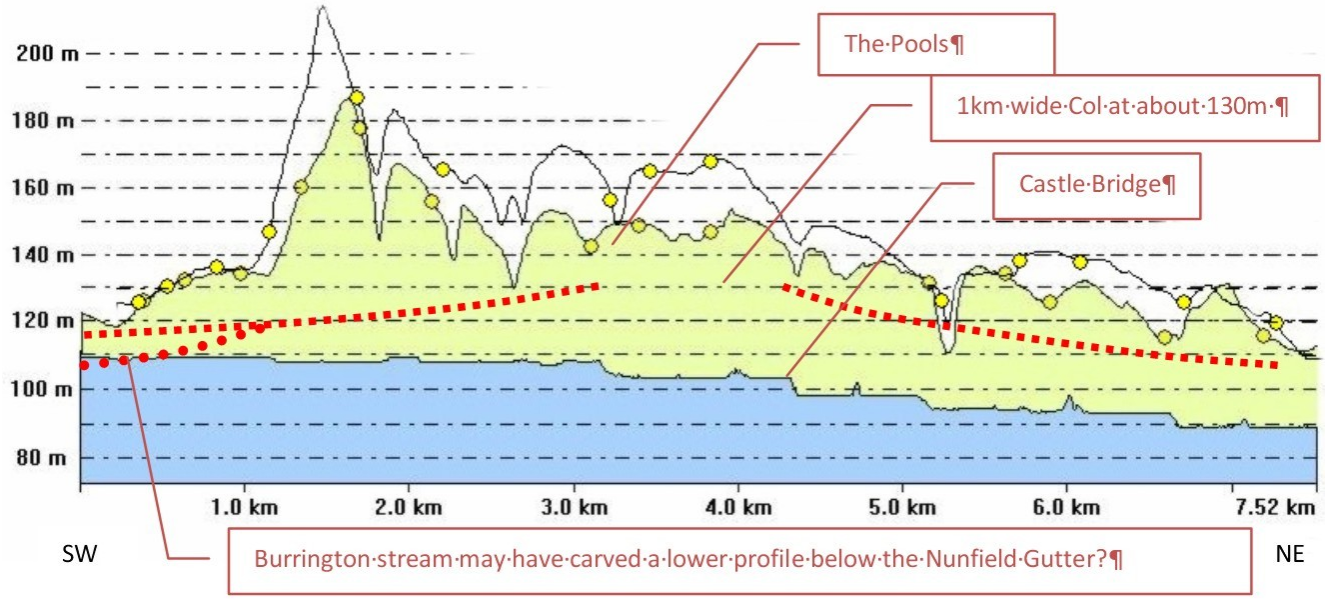

Figure 6. The Burrington stream aggressively cuts back, capturing the Pre-Teme's headwaters as far as the area of The Pools. In addition, the Teme may have flowed up to 10 m lower than at present around Burrington, and caused a steeper profile in the lower Burrington stream.

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the author, which enables the possible origins of the Gorge to be reconsidered.

In his 1971 PhD thesis, Cross proposed that the Pre-Teme had eroded back southwards through the Aymestry Limestone ridge and had captured the waters of the Nunfield Gutter, leaving the Wenlock Limestone ridge as the watershed between it and the Teme. During the Devensian, when the Aymestrey gap was blocked by ice and Glacial Lake Wigmore was formed, this became Cross's breaching point for the subsequent Lake Wigmore. Cross presented a cross section of the valley here and proposed a 130 m OD col from evidence of terrace deposits (Figure 8). *Global Mapper* was used to create many cross profiles of the valley along its whole length, one of which faithfully reproduced Cross's original section.

The geometry of the lower sections of the three streams north of Downton Bridge does not support Cross's theory for the breach. It is therefore suggested that there was another phase of drainage, before the Devensian glaciation, which saw the Burrington Stream erode back north and east, along the line of the N-S fault and then the axis of the SW-NE trending syncline mapped by Whitaker (1962), and thereafter capture much of the headwaters of the Pre-Teme. The sequence is summarised in Figures 9 to 13.

The breaching point for Glacial Lake Wigmore is now considered to have been the newly identified watershed between the Pre-Teme and Burrington Stream: a one kilometre long col near The Pools at 130 m elevation OD containing the remnants of the Pre-Teme's drainage channel. The current gorge is thus considered not so much to be a fluvio-glacial overflow channel as a series of purely fluvial gorges cut back through this col and the downstream Pre-Teme valley.

In addition if, immediately pre-Devensian, the Teme flowed around 10 m lower than it does now around Burrington, the wide flat-floored valley between Burrington and Downton Bridge would have been the site of incised meanders cut by the southwest-flowing Burrington Stream; these have subsequently silted up. Drainage in this valley is now reversed, explaining why this part of the valley apparently widens upstream. Alternatively, this may simply be the result of the Teme undercutting its banks.

When the Devensian glaciation began and permafrost became widespread, stronger rocks such as the Whitcliffe Beds would have been frozen and thus less permeable, enabling fluvial erosion to become more effective. This would have not only rapidly increased overland flow processes but would have also encouraged freeze-thaw weathering to take place, affecting the fractured rock of the fault zones in particular.

Once the Wye glacial ice sheet had blocked the Aymestrey gap, impounding Glacial Lake Wigmore, the valley filled up and the lake eventually breached the col at Downton. Figure 7 shows the situation after breaching. This marks the start of the current Phase 3 drainage system.

It should be noted at this juncture that the Burrington Stream's course would have been drowned by the proglacial Lake Wigmore. Thereafter it would be expected that lacustrine silt would be deposited and thereby protect the geomorphology of the Phase 2 drainage.

Secondly, the Pre-Teme channel at the breach and beyond would have had to cope with a volume of water from a basin of at least 400 km^2, 100 times larger than its maximum during Phase 1. The erosional power of this water, especially in the periglacial conditions of that time, would have been enormous on the weak mudstones of the Ledbury Beds northeast of Castle Bridge. Any nick points would travel upstream relatively rapidly until their progress was slowed by the stronger Whitcliffe Beds, where they would accumulate to form a significant waterfall. It is suggested that the gorge between Castle Bridge and The Pools was cut by such fluvial processes. Furthermore, the gorge would have to be cut along its full length before there could be any significant lowering of Glacial Lake Wigmore. Perhaps the gorge was cut in more than one go, but there is no

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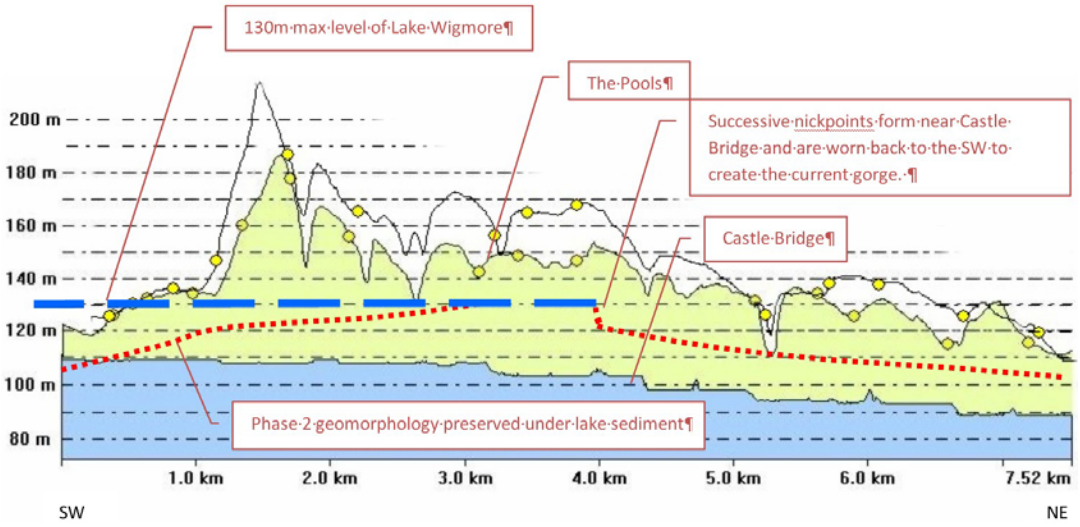

Figure 7. Glacial Lake Wigmore floods the Burrington stream valley burying, and thereby protecting, some of its features with sediment. The lake's breaching point is near Castle Bridge. The increased flow causes a gorge to cut back from that point. The lake level cannot significantly drop until that gorge reaches The Pools.

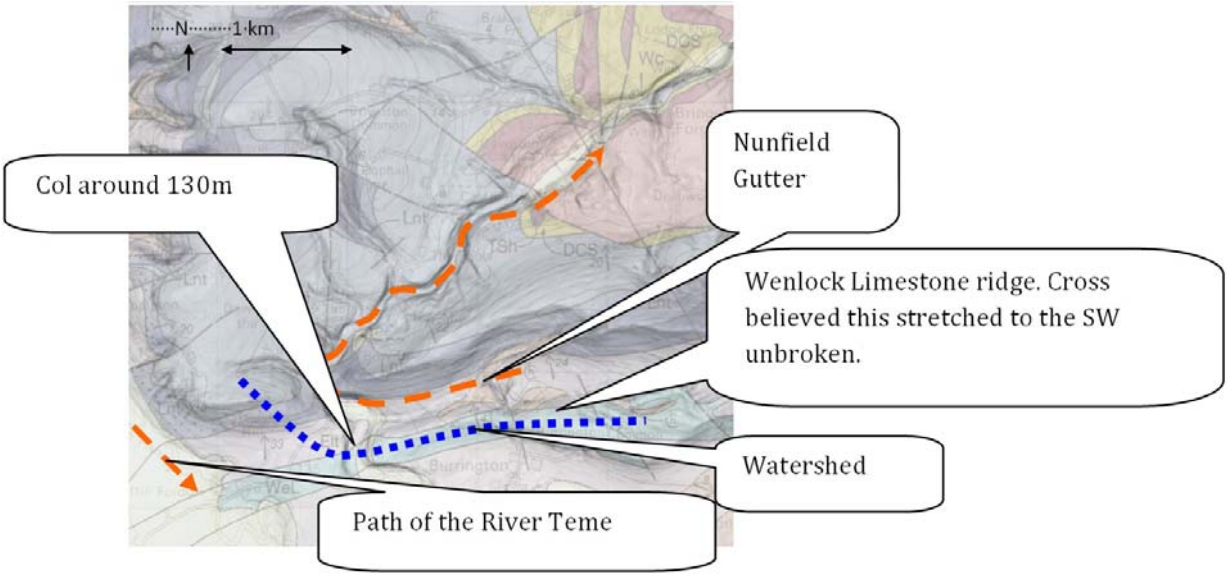

Figure 8. The breaching of Glacial Lake Wigmore according to Cross (1971).

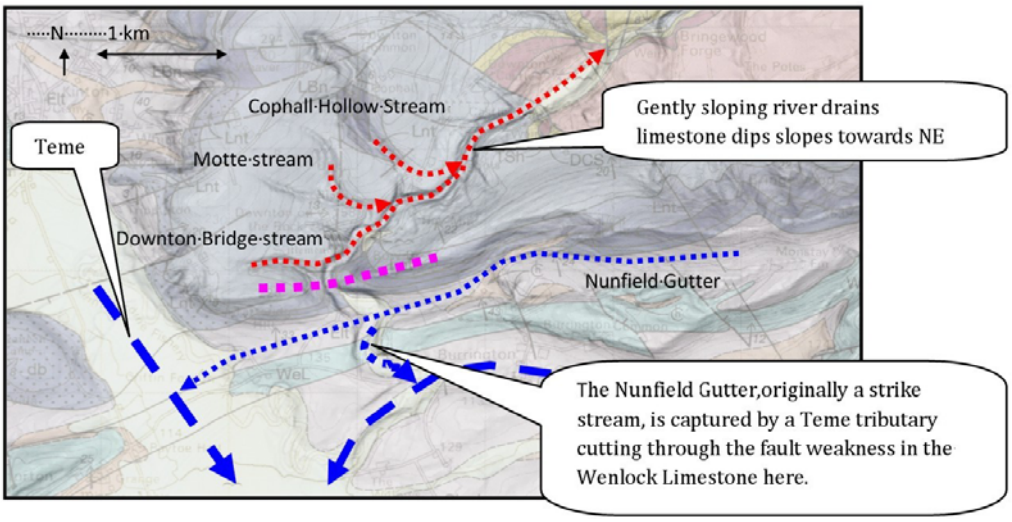

Figure 9. Proposed Phase 1 development of drainage within Downton Gorge.

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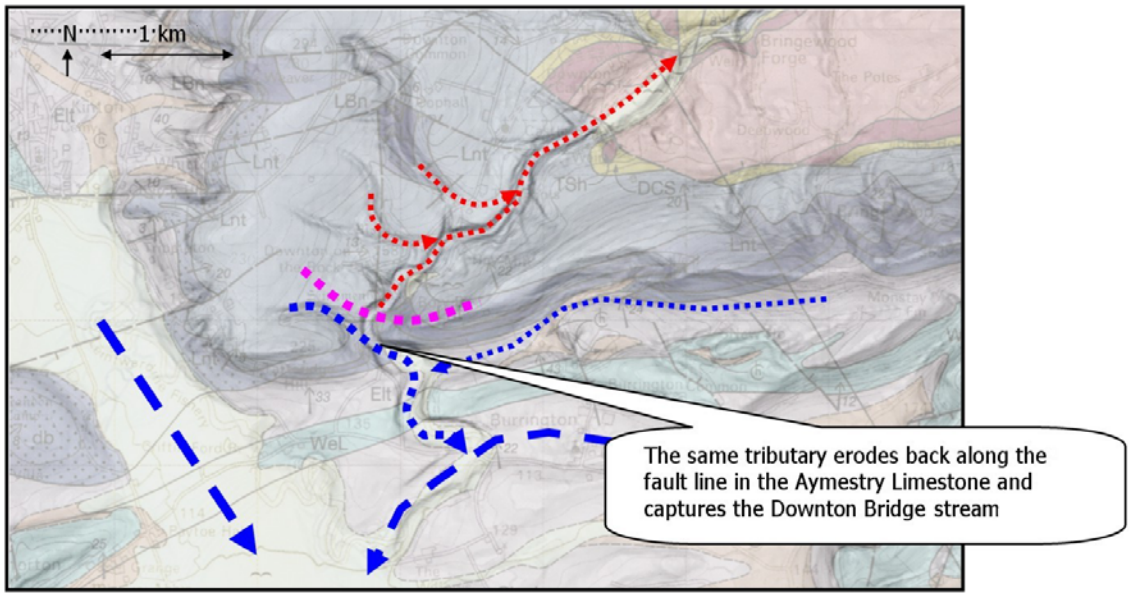

Figure 10. Proposed Phase 2a development of drainage within Downton Gorge. Blue stream cuts back to capture Downton Bridge stream.

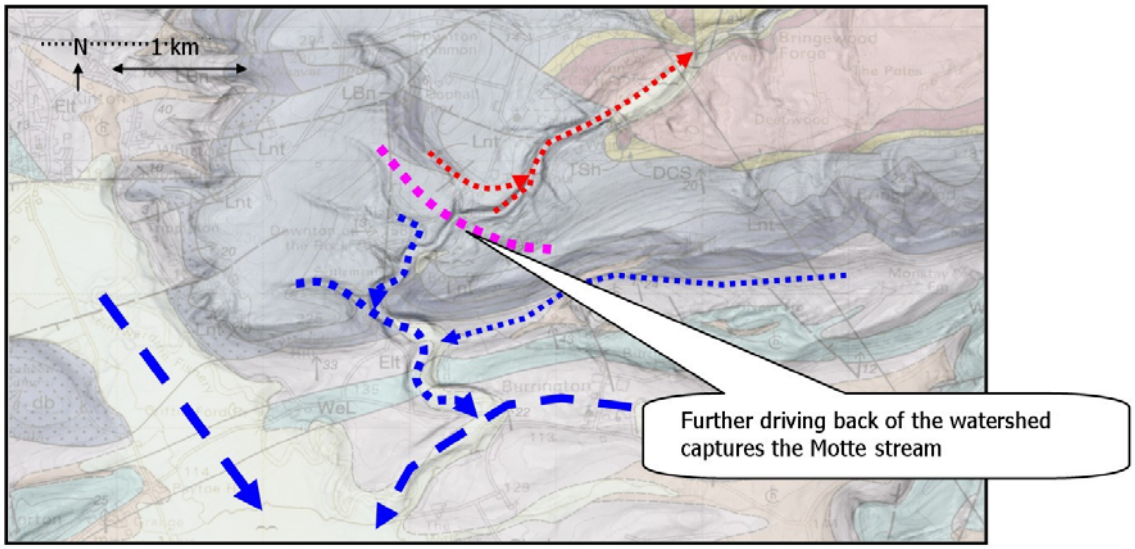

Figure 11. Proposed Phase 2b development of drainage. Blue stream cuts back further to capture the Motte Stream.

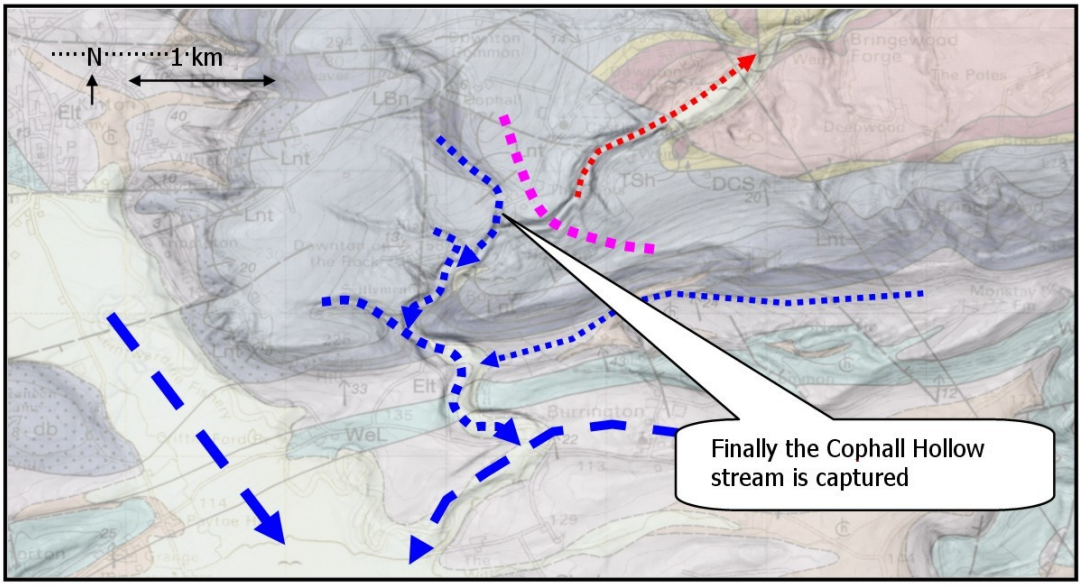

Figure 12. Proposed Phase 2c development of drainage. The blue stream captures the Cophall Hollow Stream.

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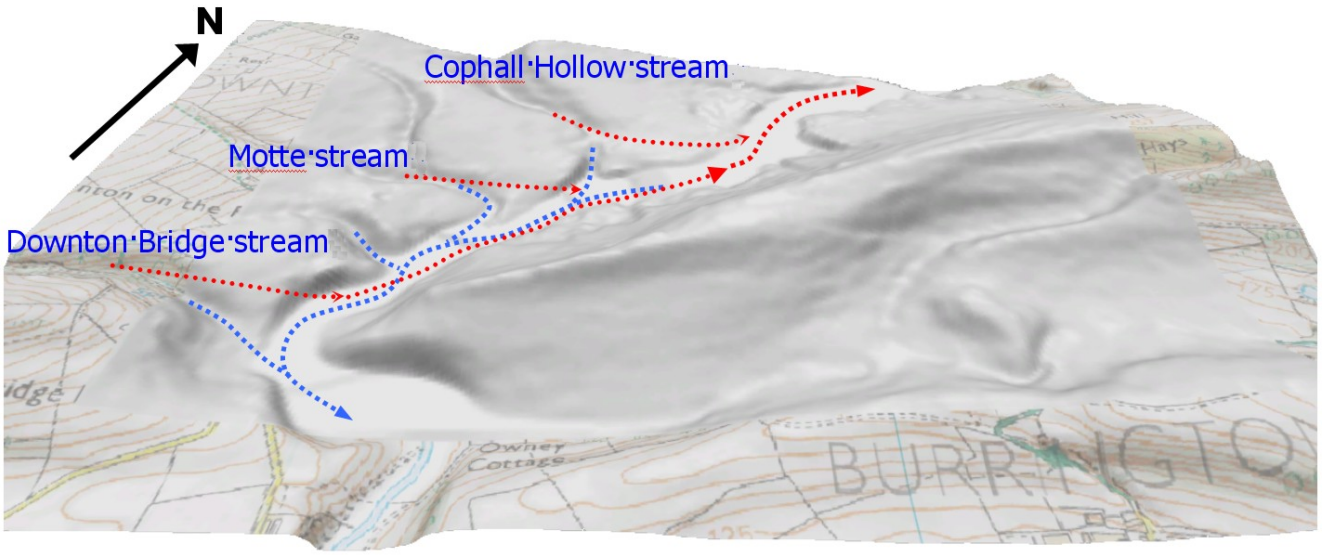

Figure 13. 3D model of Phase 1 (red) to Phase 2(blue) transition for development of drainage within Downton Gorge.

evidence within the Vale to suggest a second shoreline (Figure 14).

The inference is, therefore, that Glacial Lake Wigmore maintained its level of around 130 m OD while a one kilometre long by 20 m deep gorge was eroded into the relatively strong calcareous siltstone of the Whitcliffe Beds. Indeed, Cross (1968) suggested the Lake level was stable long enough to create shorelines in the Vale, citing examples at Leinthall Starkes which are at an elevation of 131 m OD.

The second inference is that the lake level would have fallen relatively quickly once the gorge reached the old Burrington Stream channel at The Pools, with the flow rates suddenly augmented by the lake's accumulated water. If the lake's surface covered of the order of 20 km^2, (based on the assumption of a top water level of 130 m OD and the current profile for the Vale of Wigmore (Figure 15) then the extra flow would have amounted initially to more than 2,000 million litres per 0.1 m drop in lake level. The rate of erosion was thus so fast that Phase 2 tributaries were left stranded as hanging valleys while the gorge was cut deeper in front of them (Figures 16 and 17).

CONCLUSIONS

Compelling evidence for Phase 2 drainage reversal comes from the drainage channel geomorphology between Downton Bridge and The Pools. Three tributaries of the River Teme are presented as evidence. From West to East they are: the Downton Bridge stream (which joins the Teme at Downton Bridge), the "Motte" stream to the NE of Downton-on-the-Rock, and the Cophall Hollow stream near The Pools.

If the new drainage reversal theory is correct, then Glacial Lake Wigmore would have maintained its maximum level of 131 m OD for many years as a gorge was eroded across the one kilometre long col at The Pools. This would have been sufficient for strand lines to have developed around the lake margins, as seen at Leinthall Starkes. Only once the whole length of the gorge was cut could the lake level drop. It is believed that the enhanced flow due to the lake drainage which followed the breach would have been capable of eroding the steep sided gorge through the Whitcliffe Beds. In contrast, Cross's theory of breaching would have led to a comparatively rapid fall in lake level as the narrow col of Wenlock Limestone was eroded away, for which no evidence has been identified in the present study.

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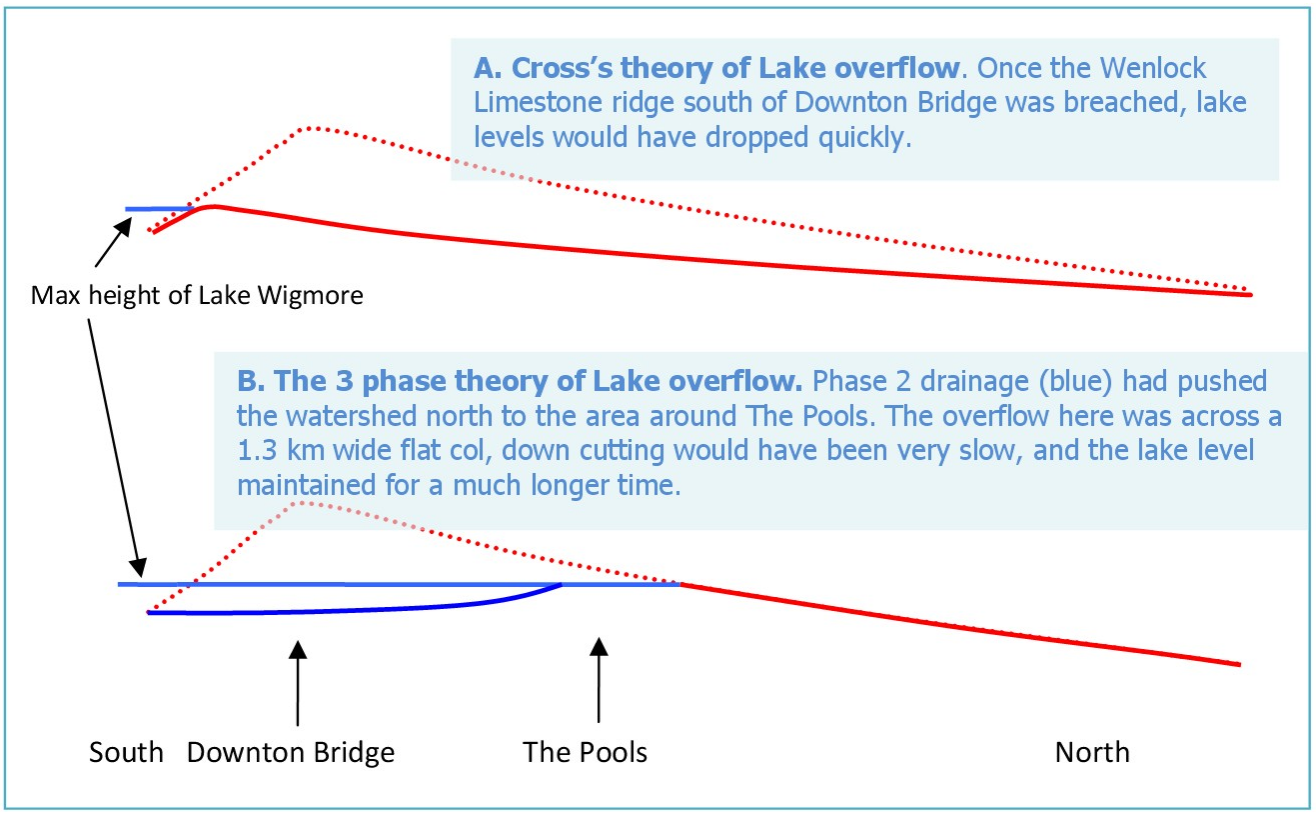

Figure 14. Two alternative hypotheses for draining Glacial Lake Wigmore.

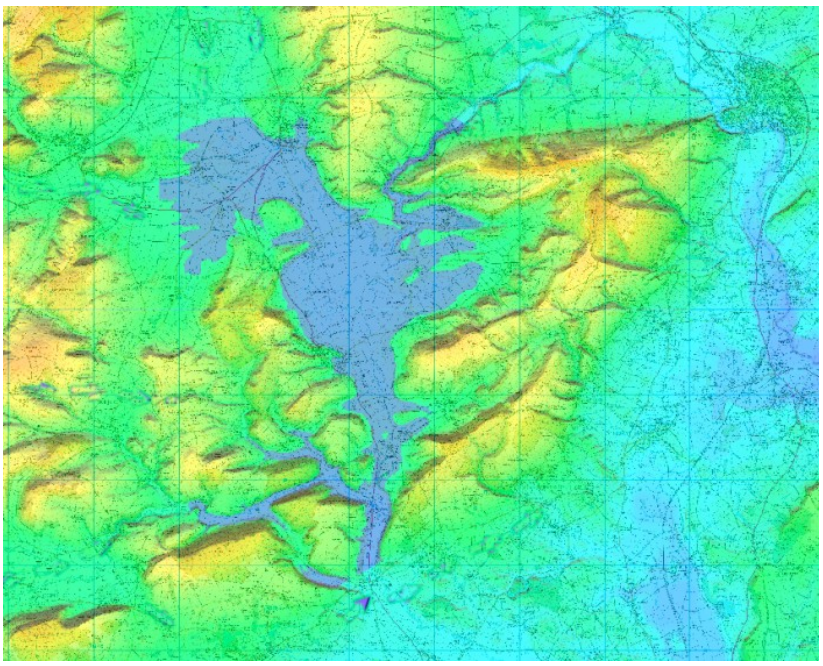

Figure 15. The extent of Glacial Lake Wigmore with a top water level of 130 m OD. Downton Gorge is located in the centre towards the top; the small arrow centre bottom marks the Aymestrey Gap; Ludlow is in the top right.

Figure 16. Whitcliffe Beds Formation exposed in the north face of Downton Gorge, 500 metres downstream of Bow Bridge by the red arrow in Figure 17. The valley above this cliff has been left hanging above the level of the Teme beneath.

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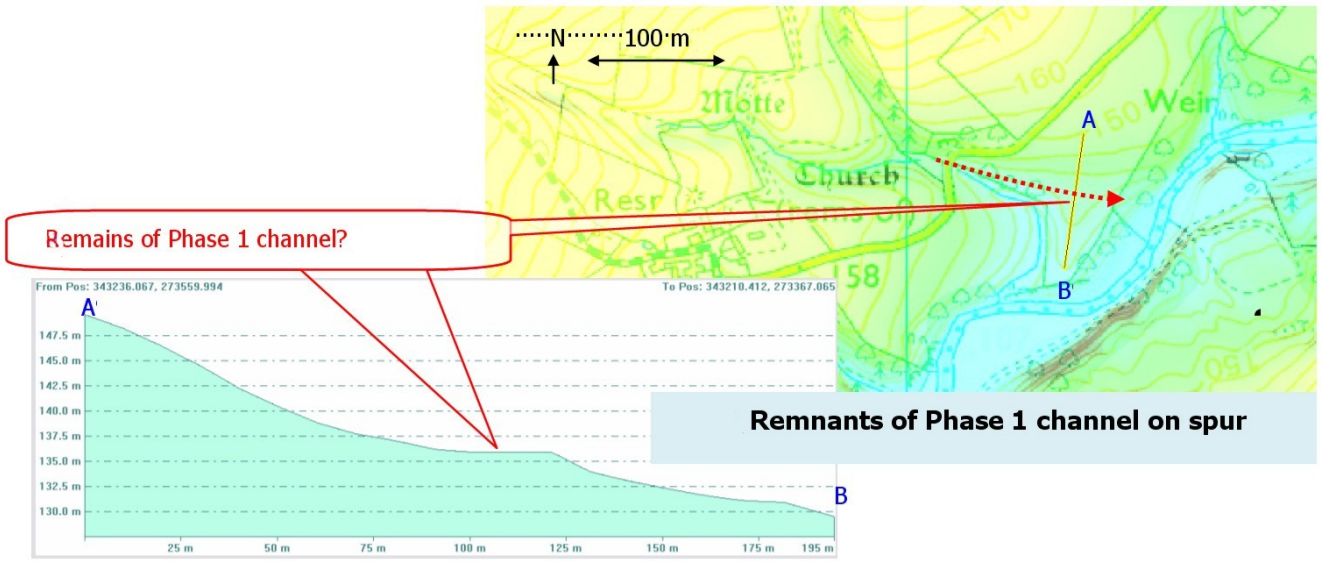

Figure 17. The flattening of slope profiles entering the gorge just north of Downton-on-the Rock parish church. See Figure 16 for a picture of the topography at the position of the red arrow, right of section A-B.

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The author would like to thank her father, David Francis, for his enthusiasm and support during the fieldwork and data analysis phases for this study. The work was undertaken as a part of an A-Level Geography project whilst studying at Hereford Sixth Form College under the excellent guidance of Alan Inkersole and Tony Murgatroyd to whom the author is grateful.

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Particular thanks are due to Clive Gurney, owner of Abbey Court Farm, who shared his extensive knowledge of the area, both geological and cultural. Details of his interview are summarised in the Annex.

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ANNEX: Interview with Clive Gurney, owner of Abbey Court Farm *[authors notes in italics]*

Clive Gurney, owner of Abbey Court Farm, has extensive knowledge of the Wigmore area, both geological and cultural, which he shared with the author during an extended interview.

The rich soil has proven good for dairy farming. He described how "the Dutch" *[notably Cornelius Vermuyden]* were employed to drain the fens from 1620 onwards. Ever since, drainage channels have progressively been cut across the Vale from the lowest parts of the lake bed around Wigmore to the Teme, the other side of the valley.

Since Clive's arrival, many of the smaller ditches and channels, though still shown on the OS maps, have been replaced by underground pipes. There have obviously been immense changes to the soil structure over the last 300 years, extending down to a deep level.

Clive's own aerial photos studied using MS Virtual Earth show clear signs of old river meanders extending just west of the Roman road of Watling Street. *[Is the age of these meander shadows pre-glacial or post-glacial? The Roman road was built around 50 AD http://www.smr.herefordshire.gov.uk/roman/rom_hrfds.htm and it is not obvious from aerial photos which came first: road or meander.]*

There were two ponds on Abbey Court Farm. Clive gave permission to auger near one of them. This lies at the lowest point of the valley [SO 416 700] and is a natural sump. The pond is at least 10 metres deep and contains peat on the southern side. Unless water is continuously pumped away it overflows, flooding surrounding fields. Local folklore believes this pond was dug to provide an additional water source for Wigmore, its supply depleted after the lake was drained. *[Other local people have said this depression may be a kettle hole, which would be consistent with the presence of peat. The fact that the peat is no longer infilling much of the depression may also add weight to the story that it had been dug out.]*

Clive described how he would quite often come across "white streaks", usually in layers, in the soil excavated by mechanical diggers. These could be interpreted as evidence of varves (Figure 18).

Figure 18. Smeared sediment recovered by auger from one metres depth within the depression at Abbey Court Farm; possibly varved lacustrine sediment.

Dr Allan Peacey, an expert on the clay pipe industry at nearby Pipe Aston, has been investigating pipe kilns that date between 1630 and *ca*. 1830 [www.pipeastonproject.co.uk/main.html]. Thus far, no local source of clay suitable for firing white pipes has been positively identified. The previous owners of Abbey Court Farm understood that their predecessors had sold white clays to the pipe makers centuries before. *[Is it coincidence that Clive talks of "the Dutch" draining the lake in the 1600s and, contemporaneously, the introduction of clay pipe making, for which the Dutch were also pioneers?]*

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