Glaciation and drainage evolution in the southern Welsh Borderland

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RICHARDS, A.E. (2008). Glaciation and drainage evolution in the southern Welsh Borderland. Proceedings of the Shropshire Geological Society, 13, 92–99. An introduction to the complex causes of changes in river behaviour, looking particularly at the longer term development of fluvial landscapes using the response of river systems in Herefordshire and the surrounding area to environmental change during the Quaternary. This draws attention to the need for more research in this aspect of the landscape, necessary for a full appreciation of the recent geological history of the Welsh Borderland.

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BACKGROUND

The Welsh Borderland has been subject to at least two phases of widespread glaciation and significant river system development over the last half million years. River system development has received very little attention over the past few decades. This paper investigates the response of river systems in Herefordshire and the surrounding area to environmental change during the Quaternary. It provides an introduction to the complex causes of changes in river behaviour, looking particularly at the longer term development of fluvial landscapes in the region.

DEVELOPMENT DURING THE TERTIARY AND EARLY QUATERNARY

Five hundred thousand years ago the British landscape was somewhat different from today. The earlier up-doming of the Irish Sea Basin and NW Britain prior to plate divergence and the opening of the North Atlantic had controlled river evolution across the British Isles throughout the Tertiary (Cope, 1994). This is essentially the reason why so much of the high ground of central Wales seems to be a plateau dissected by deep valleys. To the east, across England, the general flow of the rivers, as with the dip of the rock beds beneath, was consequently towards the ESE, away from the up-domed region.

However, in detail many of the major rivers we know today either did not exist, as for example the River Avon in Warwickshire, or flowed along a quite different course, as for example the Severn. There were also rivers that have since disappeared. The painstaking work of reconstructing this lost landscape has been carried out by the research of several geologists and other specialists, notably Professor Fred Shotton, Head of the Geology Department at Birmingham University for many years, and John C.W. Cope, formerly at Cardiff University and now Honorary Research Fellow at the National Museums & Galleries of Wales.

These ancient river systems were either obliterated or fundamentally altered by the severest glaciation known in British geological history, the Anglian glaciation. Around 478,000 years ago its ice sheets flowed down from the northwest covering most of Britain as far south as London. This cold period lasted for almost fifty thousand years. The Anglian glaciation is just one – if a very severe example – of a number of fluctuating climatic events that are known collectively as the Pleistocene (Ice Age).

However, little is known about the early glaciations in the Welsh Borderland since any deposits have been destroyed by the Anglian, itself largely swept away by the glacial processes associated with the more recent Devensian glacial advances. However, there is limited evidence for a superimposed E-W drainage, of unknown (but Pre-Anglian) age, for instance the col near Alton where the Teme changes direction at Knightwick.

The Pleistocene in fact comprises a number of cold stages, known as glacial, and warm stages, known as interglacials, with many more minor climatic variations in between. Since the Anglian glaciation there have been globally been eleven glacial and interglacial cycles, evidence for which comes from cores recovered from (undisturbed) regions in the Antarctic and the deep sea (Figure 1).
LANDSCAPES IN THE WELSH BORDERLAND

An important phase in the study of landscapes in the Welsh Borderland was led in the 1950s by Eric Brown, based on analysis of the topography and the near surface deposits on high ground (Figure 2). Brown (1960) recognised the importance of:

- Passive/active tectonic controls
- Phases of marine incursion

Brown (1960) thereby deduced (Figures 3–5) that the ‘original’ drainage patterns owed their development to:

- Uplift of a domed structure
- Rivers radiating from a focus in Snowdonia
  - Fresh rock cover
  - Uplift
  - Some superimposition
- Marine incursions

Drainage patterns on the High Plateau exhibit:

- Phases of endogenic and eustatic change
- High cols with early weathered profiles
- Structurally-driven modifications of consequents

Drainage developed during the Middle Peneplain Stage showed further expansion of the network under structural influence.

The Lower Peneplain Stage saw the development of the modern rivers Severn, Wye (above Glasbury), Teme and Lugg as discordant routes (Figure 6).

The effects of the glacial/interglacial cycles on Britain’s rivers formed the valley landscape we know today. Fast-flowing rivers transported sand and gravel, which were deposited to a depth of several metres in the valley bottoms. During the glacial/interglacial cycles the rivers cut down through earlier deposits and laid down fresh deposits of sand and gravel. This process has resulted in creation of a series of terraces along the river valleys, with the highest terrace being the most ancient and the lowest the most recent. Much geological research and controversy surrounds the interpretation of these terraces and their correlation with specific glacial events.
Figure 3. Rivers radiating from a focus in Snowdonia, from Brown (1960) © Copyright University of Wales Press.

Figure 4. The succeeding High Plateau Phase, from Brown (1960) © Copyright University of Wales Press.

Figure 5. The Middle Peneplain Stage, from Brown (1960) © Copyright University of Wales Press.

Figure 6. The succeeding Lower Peneplain Stage, from Brown (1960) © Copyright University of Wales Press.

GENERAL CONSIDERATIONS

The river-transported deposits of sand and gravel now form a valuable resource, extensively exploited in this area, as elsewhere, on behalf of
the construction industry. Such deposits also contain valuable evidence of past environments in the form of fossilised remains of plants and animals as well as evidence of early human activity in the form of stone implements and settlements (e.g. burnt ground around food preparation sites).

The most recent major cold event, which peaked around 18,000 years ago, saw the last major advance of ice sheets across the country. This was the Devensian glaciation, which came as far south as Birmingham and covered much of Herefordshire. The current warm phase (the Holocene) began about ten thousand years ago.

General considerations for research attempting to identify the various influences on drainage development can be considered under the following categories:

- **Endogenic**
  - Volcanism
  - Seismicity
  - Tectonics

- **Eustacy**

- **Exogenic**
  - Geomorphological processes
  - Glaciation

The major processes influencing river system development in Wales in terms of relief and drainage need to recognise the dominating importance of the role of glaciation (Figures 7a & 7b). In order to develop a robust model for pre-Quaternary drainage system, the processes need to be sensitive to the:

- Dominant N-S/ NW-SE grain
- Structural influence of major basins
- Tranverse drainage

### PLEISTOCENE PALAEOGEOGRAPHY

The river drainage network of the Welsh Borderland can be set in its broader palaeogeographic framework by the work of Gibbard (1988), developed on the tectonic fabric of the country identified by Gibbard & Lewin (1993) (Figures 8 to 13).

Small outcrops of superficial deposits have yielded dateable evidence, for instance on the Bromyard Plateau where Pre-Anglian or Early Anglian (cold stage, but not glacial) gravels occur between Tenbury and Bromyard. Similar deposits outcrop in the Cradley Valley gravels. Consideration of their (high) altitude argues for their relatively old age.

The Humber Formation comprising high level gravels at about 110 m elevation from early tributaries of the River Lugg is overlain by glacial deposits of Anglian age. The Humber Formation comprises locally derived clasts indicating derivation from the North (Bunter, coal, Longmyndian, Uriconian; even rolled flints which might either be natural or the remains from activities of early Man). The North to South flow predates the Teme.

Of similar age is the Mathon Formation, just west of the Malverns. The Mathon River is possibly a precursor of the Severn, or even the Thames (Gibbard & Lewin, 1993). This area is now geomorphologically stagnant and thus materials have been accumulating over long periods and have good archive potential.

Superimposition of drainage systems over the earlier landforms may explain the common occurrence of transverse drainage patterns in the Welsh Borderland.


The evolution of the river drainage network of the Welsh Borderland can now be considered within this wider palaeogeographic framework, building on the work of Richards (1998) (Figures 14 to 19). These developments are effectively demonstrated by the evolution of the River Lugg in the vicinity of Eaton Hill, south of Leominster (Figure 20). The Lugg was a much larger river in the Mid-Pleistocene than it is today; the other main river at the time was the Mathon River.


Figure 17. Pre-Devensian drainage patterns in the Welsh Borderland, after Cross & Hodgson (1975) and Lewis & Richards (2005) © Copyright Logaston Press.
Figure 18. Late-Devensian drainage patterns in the Welsh Borderland, after Lewis & Richards (2005) © Copyright Logaston Press.

Figure 19. Post-Devensian drainage patterns in the Welsh Borderland, after Lewis & Richards (2005) © Copyright Logaston Press.

Figure 20. The evolution of the River Lugg in the vicinity of Eaton Hill, south of Leominster, after Lewis & Richards (2005) © Copyright Logaston Press.

The following stages are represented:
A. Pre-Older Drift
B. Post-Older Drift–Pre-Newer Drift
C. Maximum extent of Newer Drift ice margin
D. Early regressive stage of Newer Drift ice margin
E. Present

Stretford Brook is also referred to as Cheaton Brook

Abbreviations:
LR Leominster railway station
SP Stoke Prior church
FB Ford Bridge
RC Risbury Cross
SB Steen’s Bridge

Meltwater channel
Outwash fan
Maximum extent of Devensian ice
Older Drift filling channels
CONCLUSIONS

The modern landscape of the Marches has developed as a consequence of the:

- Structural framework providing first a N-S and then a W-E structural influence on drainage patterns
- Mathon Formation providing evidence of a N-S drainage pattern and tributaries in the Middle Pleistocene
- Lugg, Wye, Teme and Severn Valley Formations providing a wealth of information for Post-Anglian/Pre-Late Devensian developments
- Glaciations throughout the Pleistocene having a direct influence by:
  - diverting river courses
  - promoting lines of transverse drainage
  - excavating structural basins and expanding the drainage network

Opportunities for future research concerning the landscape of the Welsh Borderland and its river system development include:

- More detailed examination of passive and active tectonic controls on local river development
- Study of high level gravel remnants in both Herefordshire and Shropshire
- At least four discrete terrace aggradations in the Wye, Lugg and Teme Valleys
- Palaeoecology
- Dating by correlation with marine sequences (which have very high resolution)

There is thus plenty of scope for more research into these aspects of the landscape, necessary for a full appreciation of the recent geological history of this fascinating region.

ACKNOWLEDGEMENTS

This paper has been compiled by Michael Rosenbaum and checked by the author from notes taken at his lecture in Ludlow on 13th September, 2007, as a part of the Marches Festival of Geology.

REFERENCES