River Severn at Montford, Shropshire

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Highlights

The River Severn at Montford represents an excellent example of river-channel underfitness whereby the river-channel system still relates to a previous climatic condition of greater runoff. In this case the pool–riffle sequence and channel size have adjusted to existing flow conditions while the meander wavelength has not. The site therefore provides valuable information on former discharge events and subsequent channel adjustment to changing climatic conditions, and has been the location for several more recent studies of the pool–riffle sequence in gravel-bedded streams.

Introduction

This site on the river Severn near Shrewsbury is a classic example of an Osage-type underfit stream (Figure 6.4), and was the first to be overtly recognized in Britain as being of this type (Dury *et al.,* 1972). The river retains the meander wavelength of the valley with a much reduced pool–riffle spacing; it has failed on this reach to develop meanders harmonious with the existing discharge-runoff regime. Over two decades, research has led towards an explanation in terms of bank strength and sediment transport. The site has recently been studied in relation to the 'velocity-reversal hypothesis' over pool–riffle sequences (Carling, 1991).

From details of the section exposed on the reach at Preston Montford, and other regional evidence, M.D. Jones (1982) concluded that many of the anomalous channel reaches including this straight reach between Shrawardine and Montford appear to have been inherited from the period of deglacia-tion of the area, and were associated particularly with the formation of glacial lakes and the lower terrace suite of the Upper Severn.

River channel

Description

This part of the Severn cuts through the glacial and proglacial deposits of the Irish Sea Glacier, including outwash material, ablation till, moraines and lacustrine sediments (Shaw, 1972). Fluvial sediments include floodplain alluvium and the sands and gravels of undated postglacial terraces (Dury, 1983). Most of the stream banks are cut in till and/or alluvium and are rarely deformed; when this is the case, the banks slump at high angles. Part of the right bank of this section is cut in bedrock, in which pools have been excavated by the river. The slope of the valley long profile is low and is determined essentially by deposition rather than by fluvial erosion.

This stretch displays trains of valley meanders, whereas the existing headwater channels of the Severn display stream meanders. The latter are either very poorly developed or are absent downstream of the Vyrnwy confluence, until a short series of loops near Leighton, a short distance upstream of the Ironbridge Gorge.

Precipitation is seasonal, with monthly maxima in September (78 mm) and December (70 mm), and minima in February (40 mm), recorded between 1956 and 1968. At the Montford Bridge gauging station the channel has a width of 42 m, a mean depth of 4 m, and a maximum depth of 6.4 m. The channel is nearly rectangular in cross-section. Bankfull discharge is approximately 200 cumecs, maximum discharge 473 cumecs, the estimated Manning's n = 0.035, and the drainage area is 2025 km^2 upstream of Montford.

Interpretation

Recent research has examined the sensitivity of alluvial stream channels to climatic change, according to its effects on the characteristics of the drainage basin. Underfit streams are now generally regarded as responses of channels to climatically induced reduction in runoff (Duty, 1983). The Severn drainage was strongly affected by a major climatic change between 12 000 and 8 000 BP; the existing combination of plan, cross-section and profile geometries represents a combination of harmony and disharmony with the present climate (Duty *et al.,* 1972).

After a reduction in discharge, a stream adopts either a shorter wavelength within the long-wavelength valley meanders (manifestly underfit), or retains the wavelength of the valley with a much reduced pool–riffle distance (Osage-type underfit), which reflects the need for smaller channel dimensions. Underfit streams are widespread in central England, although by no means the only types of underfit represented. The Severn here is an Osage-type underfit, which combines a river channel significantly reduced from its former dimensions with a pool and riffle sequence adapted to the existing channel processes, but without stream meanders (Dury, 1966). The identification of these conditions has generated considerable discussion (Kennedy, 1972; Kirkby, 1972; Richards, 1972; Ferguson, 1973). The general question has been (Duty, 1983) stated as: Why should a stream with a discharge sufficiently diminished to have reduced its channel dimensions by a factor of 5–10, and remaining capable of deforming its bed profile, fail to generate stream meanders?

Both the existing and the former, larger, stream channel may be compared to the stereotype meandering stream (Duty, 1977), not only in relation to dimensional characteristics but also in relation to hydraulic characteristics. Duty *et al.* (1972) concluded that the pool–riffle sequence is adapted to the existing river channel width; harmonious with the existing discharge and runoff regime, but disharmonious with existing climate-discharge relationships, in that the meanders of the present channel are not appropriate for the present discharge regime. However, both the size and composition of the riffles seem to depend upon local sediment supply. Movement of gravel within the modern river channel is probably restricted. However, local outcrops of terrace sediment result in large gravel riffles, whereas riffles in the vicinity of loam alluvium tend to be poorly developed. This principle also applies to point bars, the composition of which depends upon sediment supply just upstream.

The conversion of a straight to a meandering channel begins with deformation of the bed, but this need not necessarily lead to deformation of the banks. Dury inferred that this is the case for this part of the Severn. Shrinkage of the stream has been accompanied by deformation of the bed, but by little or no deformation of the banks. A decade of measurements have been made, which allow a provisional explanation of why the former stream could meander, whereas the present stream cannot.

Dury's hypothesis was that the unduly low slope of the study reach so reduces stream power, shear stress and frictional shearing velocity on the banks that little bank deformation can occur. The observed slopes are about half of the stereotype slopes, although the observed velocities through the cross-sections closely resemble the stereotype values; the slope-dependent hydraulic characteristics of stream power, shear stress and frictional shearing velocity at the boundary as a whole are low on the present stream. Some contribution is also made by bank strength, but given the results of the hydraulic calculations, the main influence of bank strength could be thought to be the influence exerted on the channel form ratio. Two measurements have been taken to produce a third value: banktop width and water surface width give the width of batter. All three vary along the channel far more rapidly than would be expected from ran domness. Variation in bank strength appears to account for about half the variation in width between banktops.

Bank exposure

Description

The river terraces of the Severn valley between the Vyrnwy confluence and Ironbridge are divisible into three suites. The upper suite terraces (6, 5, 4) are limited to a 6 km valley section. The middle suite terraces (3, 2) extend the length of the valley from the Isle at Shrewsbury to Ironbridge, and are only exceeded in length by the low (1 + floodplain) suite. The lower terraces adopt a meandering course, the dimensions of which indicate a channel of medium sinuosity (1.32) about twice the size of the modern river.

Lake silts shown in the cliff section at Preston Montford, (Figure 6.5) can be traced through stream banks to west of Onslow Hall at 76 m OD. The section has a basal Welsh Ice till unit. Overlying this is a very poorly sorted unit of gravel and cobbles (up to 15 cm across), with a sand/fine gravel matrix. Stone orientation, sorted laminae of sand and openwork fine gravel indicate a general dip of the deposits to the south at 15–20°. The contact of the till with this gravel is obscured by scree, although the superimposition of one over the other is apparent.

Interpretation

M.D. Jones (1982) inferred that a general reduction in sediment input took place over time. The section (Figure 6.5) is thought to have resulted from the creation of an ice-dammed lake, into which a small 'delta-moraine' developed. Such lake silts cover much of the Severn valley floor. The orientation of the silts and gravels indicates an ice source to the WNW.

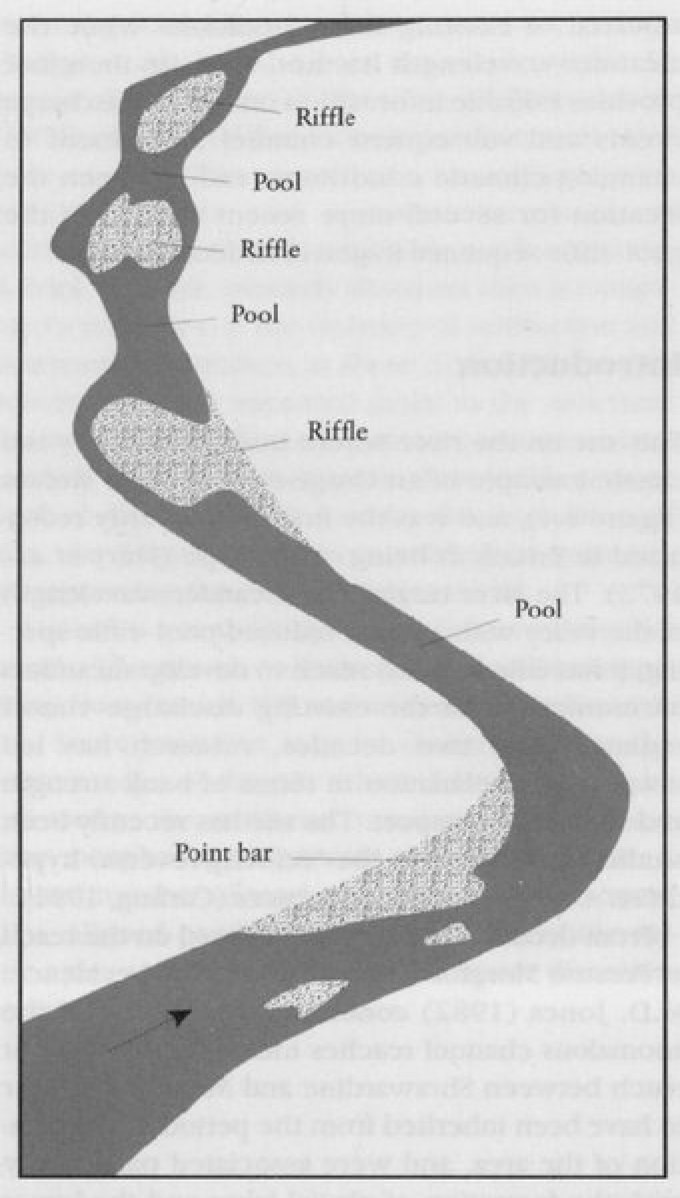
At the most, a span of 5000 years covers the deglaciation of the Shropshire Plain; the development of the stream traces now recorded in valley meanders; the ingrowing of these meanders and the concomitant formation of the terraces; and the diminution of the streams to underfitness.

Conclusion

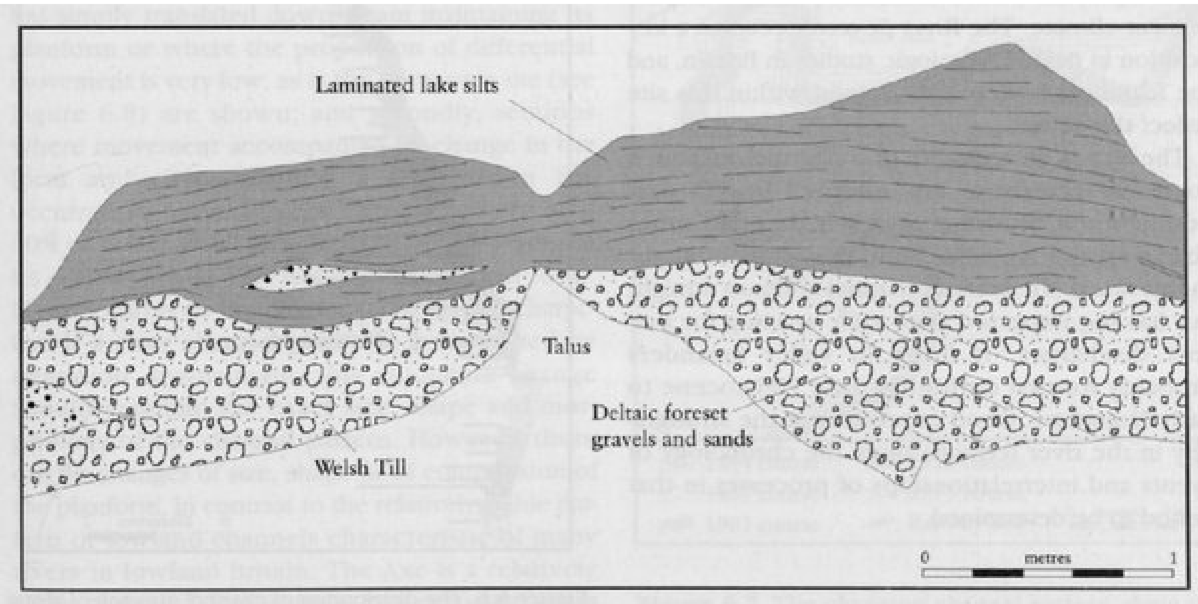
The River Severn at Montford is distinguished as part of the first British stream to be overtly recognized as of Osage-type underfitness. Detailed research has examined the discharge : channel form relationships of the existing and former Severn streams, and has contributed to the evidence explaining the development of underfitness in the deglaciation of the Shropshire Plain. These climatic events have impressed patterns upon the landscape that still survive, out of step with the present climate. The River Severn occupies a key position in palaeohydrologic studies in Britain, and the features of interest contained within this site reflect this status.

The site is an example of a channel in which some characteristics are inherited from a past period when discharges were higher and other characteristics are adjusted to present conditions. In this reach, the present channel is almost straight but has the expected pool–riffle spacing for present discharges. It flows in valley meanders probably formed during the Late Pleistocene to Early Holocene. Good exposures of the 'stratigra-phy in the river terraces allow the chronology of events and interrelationships of processes in that period to be determined.

References



(Figure 6.4) The pool-riffle sequence on valley bends of the Osage river, derived from aerial photographs. (After Duly, 1970.)



(Figure 6.5) A section of lake sediments at Preston Montford. (After Jones, 1982.)