The Natural Attractions of the Devil's Bridge Landscape

Answers to 10 Common Questions

A chan nerth ei ryferthwy

Gwna y llif y graig yn llwy

And through the force of its torrent

The deluge makes a spoon out of the rock

Daniel Evans, 1831

This brochure was prepared by Stephen Tooth, Hywel Griffiths and Sioned Llywelyn (Department of Geography and Earth Sciences, Aberystwyth University). Antony Smith is thanked for cartographic assistance. A Welsh language version of the brochure is available.

An accompanying audio trail is also available in both English and Welsh, and suggestions are made throughout the brochure as to where read each question

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derived from Greek

geomorphology

ge – 'earth'
morphe – 'form'
logos – 'discourse'

The study of rivers, waterfalls and potholes forms part of the subject of **geomorphology**, a science that studies the origin and development of landforms, and how those landforms combine to form landscapes.

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ADGD | DGES

BSG British Society for Geomorphology

PRIFYSGOL ABERYSTWYTH UNIVERSITY

10 questions commonly asked about Devil's Bridge

Introduction

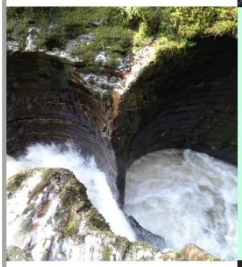
Some of the main natural attractions of the Devil's Bridge landscape are the spectacular potholes and waterfalls on the Mynach River, which translates as the Monk's River. The Mynach is a tributary of the larger Rheidol River, which runs in a deep, wooded valley towards Aberystwyth and the Cardigan Bay coastline. Technically, the waterfalls can be classified as a segmented or tiered falls. Five major drops and intervening cascades add up to a 91 m total drop, which is among the highest in Wales.

This brochure provides short answers to some of the questions that are commonly asked about the Devil's Bridge landscape. A 'Feature Spotting Challenge' is provided on page 2, and subsequent pages provide additional information. We hope that the information provides a little bit of insight into the origin and development of the key landforms that underpin the scenic splendour of the Devil's Bridge landscape, while also highlighting the many links with a long history of human activities.

Feature Spotting Challenge!

Mynach River

Points: ★

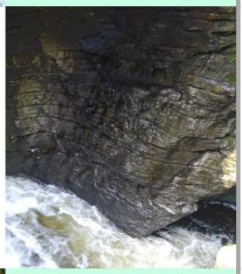


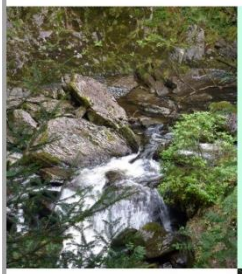
Pothole

Points: ★★

Rock outcrop with horizontal layers

Points: ★★★



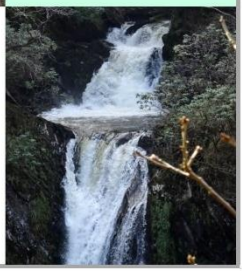


Fallen Rocks

Points: ★★★

Plunge Pool

Points: ★★



Rheidol River

Points: ★

Gorge

Points: ★★

Main waterfall

Points: ★★★

Rock outcrop with tilted layers

Points: ★★★★

Large woody debris

Points: ★★★★

Total points: _____/25 ★

1 How did the waterfalls form?

1. Erosion along the small tributary of the Mynach River has been unable to keep pace with erosion along the larger Rheidol River.
2. Waterfalls have been generated as flows along the Mynach cascade over exposed bedrock into the deeper Rheidol valley.

The development of the waterfalls on the Mynach is related to the development of the Rheidol valley. From its source on Plynlimon (the highest mountain in mid Wales, known as Pumlumon Fawr in Welsh), the Rheidol initially flows southwards, but near Devil's Bridge takes an abrupt westwards turn towards Aberystwyth and the coastline. The abrupt change of course has been attributed to severing and re-routing ('capture' or 'piracy') of the upper parts of the ancient north-south flowing proto-Teifi River by shorter rivers eroding aggressively inland from the coastline, namely the Ystwyth and the Rheidol (Figure 1).

QUESTIONS 1 & 2

Listen from outside the Hafod Hotel **or** when looking over the side of the road bridge near the turnstiles

Did you know?

The Rheidol is a very steep river, falling around 550 m (1880 ft) in its 39 km (24 mile) long course from its headwaters to the coast. The middle reaches upstream of Devil's Bridge are especially steep, and host at least one waterfall (the Gyfarllwyd Falls). At certain times of the year, this waterfall is visible when looking north from the viewpoint in front of the Hafod Hotel, as well as at other points on the longer walking trail.

Once capture of the upper proto-Teifi had taken place, the additional flow along the newly extended Rheidol enabled more rapid deepening of its valley. Small tributaries such as the Mynach were unable to keep pace with this rapid deepening, and waterfalls started to develop as flows along the Mynach cascaded over increasing amounts of

bedrock exposed at the junction with the Rheidol. Ongoing erosion has meant that, over time, the waterfalls have retreated slowly up the Mynach's course (see question 4), and they now stand more than one hundred metres upstream of the junction. As the waterfalls have retreated, steep-sided gorges have been left in their wake (Figure 2).

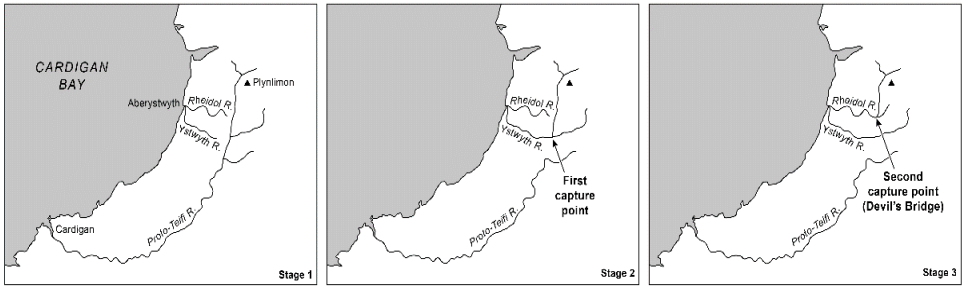


Figure 1. Illustration of the stages in the capture of the upper proto-Teifi River by the Ystwyth and Rheidol rivers (Source: adapted from Lewin, J. (1997), Fluvial landforms and processes in Wales. In Gregory, K.J. (Editor), *Fluvial Geomorphology of Great Britain*. Chapman & Hall).

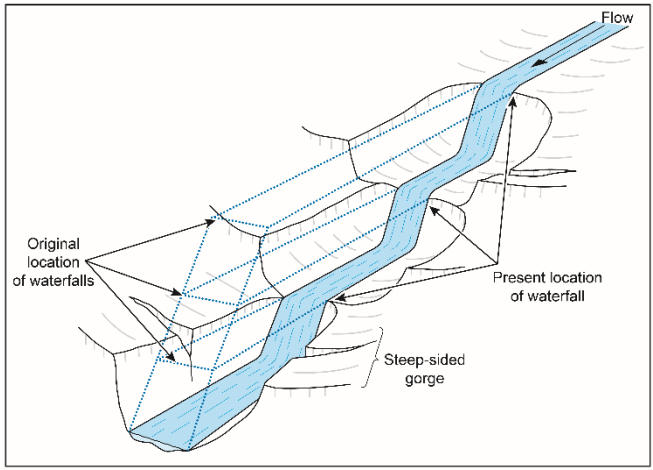


Figure 2. Illustration to show how upstream retreat of waterfalls can lead to cutting of steep-sided gorges.

2 How old are the waterfalls?

1. The waterfalls probably initially formed at least hundreds of thousands of years and quite possibly millions of years ago.
2. The waterfalls have persisted through many ice ages and are significantly older than any major human structures on Earth.

The Devil's Bridge landscape is underlain by sedimentary rocks (principally shales, slates, siltstones and sandstones) that formed during the Silurian period (roughly 444-419 million years ago). The development of the valleys, waterfalls and potholes occurred much later in Earth history. Nonetheless, although the sequence of events leading to waterfall formation can be outlined (see question 1), their precise age is hard to establish with any certainty. The processes of erosion that have contributed to deepening of the Rheidol valley and the upstream retreat of the waterfalls on the Mynach (Figure 2) tend to remove many of the river landforms and deposits that otherwise might provide clues as to the age of capture of the proto-Teifi and the initial formation of the waterfalls.

But as is explained under questions 5 and 10, the very slow rates of change to the waterfalls suggest a very great age for their initial formation, at least hundreds of thousands of years and quite possibly millions of years. This means that the waterfalls will have survived through many or all of the numerous ice ages that have occurred in the northern hemisphere in the recent geological past. It also means that the waterfalls are

Did you know?

In contrast to the Rheidol and many other Welsh rivers, the Mynach River remains undammed, and so flow over the waterfalls at Devil's Bridge varies naturally. Flow tends to higher in autumn and winter, especially following heavy rainfall, and lower in spring and summer.

significantly older than any major human structures on Earth, as even the earliest known Egyptian pyramids are no more than 5000 years old. Indeed the waterfalls are likely older than the origins of our own species, *Homo sapiens*, which most estimates suggest occurred only within the last 200 000 years.

3 How have the potholes formed?

1. Potholes at places like the Devil's Punchbowl have formed by bedrock erosion that occurs as sediment is swirled about in turbulent river flow.
2. Over time, potholes tend to widen and deepen and may eventually join together to carve a gorge through bedrock.

QUESTIONS 3 & 4

Listen on the shorter walking trail when descending the steps to Devil's Punchbowl

Potholes are typically circular to oval depressions that can form in bedrock exposed in a river bed. Their formation is related to the grinding action of sediment (mainly sand and gravel) that is swirled around in small bedrock depressions by turbulent eddies in fast-flowing water. Particularly large potholes can be seen in the bed of the Mynach River at the Devil's Punchbowl (Figure 3), which is located above the waterfalls close to the ancient bridge from which Devil's Bridge takes its name. Other potholes are present at many other points along the river bed, especially near the base of the waterfalls. Although many may be under water, can you spot other examples of potholes as you walk around the trails?

Potholes tend to form best in moderately to highly resistant rocks where lines of weakness (joints, cracks, layers in the rock) are limited. The impact of swirling sediment leads to grain-by-grain removal and smoothing of the walls

and floor of the developing pothole, similar to a sandpapering effect. If too many lines of weaknesses are present, developing potholes tend to be eroded partially or completely by the erosion of larger fragments or blocks of rock.

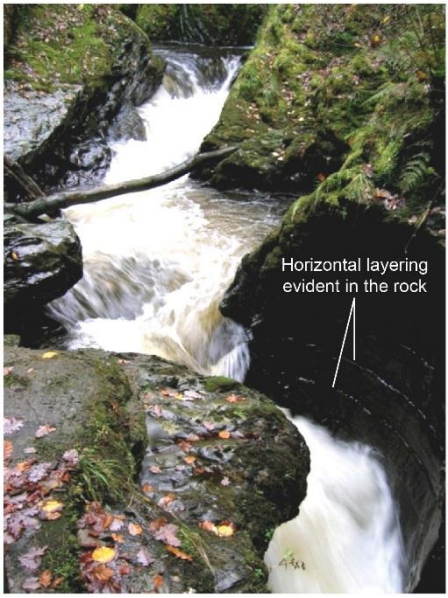


Figure 3. Photograph illustrating part of one of the large potholes at the Devil's Punchbowl on the Mynach River. At this location, the few layers present in the sedimentary bedrock are horizontal, so rock resistance is maximised and potholes can slowly enlarge over time without being destroyed by the erosion of larger fragments or blocks of rock.

Over time, the slow but continual grinding action of sediment means that potholes tend to grow in size, both by widening and deepening. Neighbouring potholes grow and eventually join together, and by doing so contribute to the carving of a gorge through the resistant rock. Indeed, from the Punchbowl viewing platform, a glance at the sides of the Mynach gorge will reveal many smooth, curved faces on the rock. Do you think these faces represent the traces of former potholes that have contributed to formation of the gorge?

4 How do potholes contribute to waterfall development?

1. Potholes can form above the lip and near the base of waterfalls, and over time may lead to waterfalls increasing in height, decreasing in height, or maintaining their height.
2. Above and below the Devil's Bridge waterfalls, pothole and wider bedrock erosion rates are roughly in balance, and waterfall height is most likely being maintained.

Potholes can form both near the base of waterfalls and above the lip of waterfalls. Near the base of a waterfall, pothole development and the erosion of larger blocks of rocks can contribute to the development of a larger feature known as a plunge pool. Over time, as a plunge pool grows in size by widening and deepening, buttressing support for the near-vertical face forming the waterfall is weakened. This weakening of support can lead to periodic collapse of the waterfall face, thereby contributing to a slow, punctuated, upstream retreat. Above the lip of a waterfall, such as at the Devil's Punchbowl (Figure 3), pothole growth can lead to weakening of the rock in the river bed and may also contribute to carving of a gorge (see question 3).

Potholes and associated plunge pools forming at the base of waterfalls help to deepen the river bed and therefore increase waterfall height. Potholes forming above the lip also help to deepen the river bed but by doing so, they tend to decrease waterfall height. Whether a waterfall increases in height, decreases in height or maintains its height with time, therefore depends on the relative rates of erosion below and above the falls (Figure 4). At Devil's Bridge, the very slow rates of change to the waterfalls (see questions 5 and 10) suggest that present-day erosion rates are roughly in balance and that waterfall height is most likely being maintained.

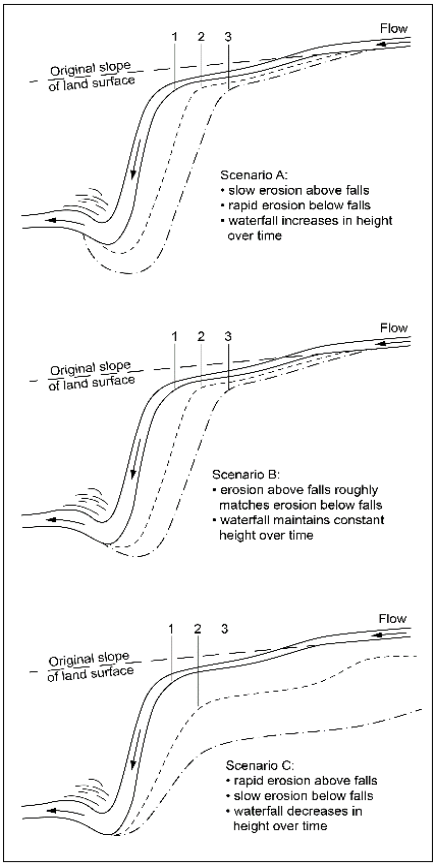


Figure 4. Illustration to show how a waterfall may either a) increase in height, b) maintain a roughly constant height, or c) decrease in height depending on the relative rates of erosion below and above the waterfall face. In all cases, the waterfall face may also retreat upstream over time.

Did you know?

After periods of heavy rainfall, high flow and heavy spray mean that the waterfalls are at their most spectacular. Such conditions, however, tend to obscure some of the other landscape features such as the potholes, plunge pools and riverside rock layers and in fact may restrict access to the viewing platform at the Devil's Punchbowl. So even if visiting at times of lower flow, there is still plenty to see and do.

5 How quickly are the natural attractions developing?

1. With an average retreat rate of 1 cm every year, it would take a waterfall around 1000 years to retreat just 10 m, and with a rate of 1 mm every year, it would take 10 000 years.
2. At Devil's Bridge, the rate of change to the waterfalls is probably towards the lower end of this range, and essentially is undetectable on a human timescale.

QUESTIONS 5 & 6

Listen on the longer walking trail and stop at the viewpoint of the three bridges

At Devil's Bridge, the age of waterfall formation (see question 2) and the rate of pothole formation and waterfall retreat (question 4) is not well known. Limited evidence from other settings worldwide reveal that waterfall retreat rates in relatively weak rocks may range from centimetres to a few metres a year, but long-term average retreat rates in more resistant rocks commonly tend to be less than a few millimetres a year. With an average retreat rate of 1 cm every year, it would take a waterfall around 1000 years to retreat just 10 m, and with a rate of 1 mm every year, it would take 10 000 years. Modern observations and historical evidence (see question 10) for little significant change to the waterfalls, even during major floods, suggest that the rate of any change is probably towards the lower end of this range. Given these likely slow rates, do you think that any changes would be detectable on a human timescale?

Did you know?

The slow rate of change to the Devil's Bridge waterfalls contrasts with the more rapid changes occurring elsewhere in the Welsh landscape, particularly in estuaries and along other parts of the coastline. Nonetheless, maintenance of the waterfalls as a visitor attraction depends on raising awareness and appreciation of these landforms and their wider landscape setting.

6 How will the natural attractions be affected by future climate change?

1. Bedrock landforms such as waterfalls and potholes have a high degree of resilience to climate change.
2. Greater future extremes of floods and droughts, however, may influence the volumes of water cascading over the waterfalls, with impacts on the ecology of the wider landscape.

The waterfalls, potholes, gorges and valleys that characterise the Devil's Bridge landscape have gradually developed over long periods of time during which major climatic changes have repeatedly occurred, most notably the onset and ending of ice ages. The long-term persistence of these dominantly bedrock landforms, despite major climatic upheavals, suggests that they have a high degree of resilience to climate change. Even in the current era of rapid global climatic change, when there is increasing concern both within the UK and farther afield over rapid, possibly detrimental, changes to landscapes that may result from warmer global temperatures and rising sea levels, the landforms at Devil's Bridge will continue to persist.

Projected future climatic changes that lead to greater extremes of floods and droughts, however, may influence the volumes of water cascading over the waterfalls, so the wider landscape may still be impacted. In particular, what do you think the implications of possible increases or decreases in flow volumes might be for the plants and animals living within the rivers and their gorges and valleys?

7 How have the natural attractions shaped human use of the landscape?

1. At Devil's Bridge, the rivers, gorges and valleys have presented obstacles to the movement of people and goods but have long attracted tourists from far and wide.
2. The water cascading down the waterfalls gave rise to an early hydroelectric power scheme.

The natural attractions at Devil's Bridge have shaped human use in various ways. Most prominently, the rivers, gorges and valleys have presented obstacles to the movement of people and goods, with the construction of the original

QUESTIONS 7 & 8
Descend the longer walking trail and listen when you reach the gazebo

medieval bridge across the Mynach gorge being associated with the legend of Devil's Bridge itself. The natural attractions have long attracted visitors from far and wide, including those undertaking various leisure or artistic pursuits (see question 8), and still form the basis for the modern tourism industry. The need for electricity in the area before the days of public supply gave rise to an early attempt to capture the hydroelectric power (HEP) generated by the water cascading down the waterfalls. Although this HEP scheme has fallen into disuse, the remains of the cast-iron pipework can be seen adjacent to the falls below the Hafod Hotel. The Rheidol River is today part of a larger HEP scheme, one that exploits the large elevation drop that occurs over a short distance between the upper and lower reaches of the river, itself a legacy of the ancient capture of the upper proto-Teifi by the eroding Rheidol River (see question 1).

Did you know?

The steep fall along the Rheidol is part of the reason why the river was selected for development of a hydroelectric power scheme. This scheme involved the construction of interconnected dams, reservoirs, pipelines, aqueducts and power stations, and was completed in the early 1960s. Consequently, the flow along the Rheidol is now heavily regulated.

8 In what ways have the natural attractions inspired cultural responses?

1. The natural attractions at Devil's Bridge have long inspired painters, poets, writers and photographers.
2. The television crime drama *Hinterland* has recently made use of the scenery and atmosphere provided by the site.

The natural attractions at Devil's Bridge have long inspired a variety of cultural responses, including from painters, poets, writers and photographers. Particularly notable early examples include those from the poet William Wordsworth who penned *To the Torrent at the Devil's Bridge, North Wales*

(1824), the travel writer George Borrow who commented on the site at length in *Wild Wales: Its People, Language and Scenery* (1862), and the pioneering photographer Francis Bedford who made black-and-white images of the waterfalls in the late 1800s (see question 10). These and other cultural pursuits continue to the present day. Recently, the television crime drama *Hinterland* has made use of the scenery and sometimes brooding atmosphere provided by the site, with some of the waterfalls and plunge pools providing the location for filming.

9 Why have artists in particular been attracted to the Devil's Bridge site?

1. Particularly from the 19th century onwards, Devil's Bridge provided many artists with the challenge of representing the awe-inspiring scenery and atmosphere.
2. Many people continue to be attracted and inspired artistically by the landscape.

QUESTIONS 9 & 10
Descend the steep part of the longer walking trail, cross the river on the metal footbridge and listen part way back up the trail

By the 17th century, many painters, poets, writers and musicians had become concerned with the search for 'the sublime', a term which has been used to mean aspects of nature, art, buildings, language, style, or other cultural artefacts that were raised aloft, even exalted. Particularly from the 19th century onwards, the scenery and atmosphere at Devil's Bridge provided many artists with the challenge of representing the sublime in a landscape context, and attempts were made to provoke the sensation that people experience when they are overawed, terrified or lost for words. For example, some of the lines in Wordsworth's 1824 poem can be seen as attempts to evoke the sublime: "*... There I seem to stand, // As in life's morn; permitted to behold, // From the dread chasm, woods climbing above woods …*". For those undertaking modern-day cultural activities at Devil's Bridge, the search for

the sublime may be less of a conscious desire, but there is little doubt that many people continue to be attracted and inspired artistically by the landscape. What particular elements do you think might have contributed to perceptions of the sublime nature of the Devil's Bridge landscape? Is there anything about the landscape that particularly inspires you?

10 What can past cultural activities tell us about landscape experiences and change?

1. Activities such as painting, poetry and writing can provide insights into how human responses to landscapes have changed over time.
2. Photography can provide a historical snapshot of the landscape at different points in time, in some instances informing scientific understanding of the characteristic rates of waterfall development.

Examples of past cultural activities are valuable not only because they provide insights into how human responses to landscapes have changed over time, but also because they can provide a historical archive that records snapshots of the landscape at different points in time. For instance, comparisons can be made between George Borrow's mid-19th century descriptions and the present-day conditions at the site ("*Below you now is a frightful cavity, at the bottom of which the waters of the Monk's [Mynach] River, … whirl, boil and hiss in a horrid pot or cauldron, … in a manner truly tremendous*"), or between sequences of photographs taken through time.

In particular, early photographs of the waterfalls can inform our scientific understanding of the characteristic rates of waterfall development (Figure 5), in this case supporting other lines of evidence indicating that significant changes are taking place only slowly.

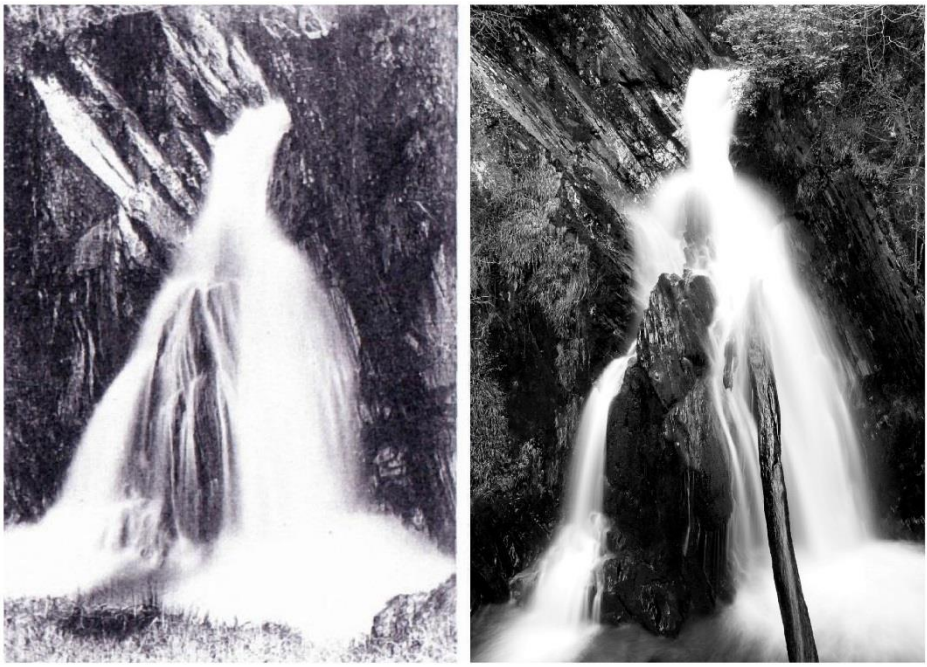


Figure 5. Comparisons of photographs to illustrate the very slow changes occurring on one of the waterfalls at Devil's Bridge. The photograph on the left was taken by Francis Bedford at some point between 1860 and 1890. The photograph on the right was taken by Stephen Tooth in January 2008. Perspective, lighting, and water levels are slightly different in the two photographs, and the later photograph includes some flood-transported woody debris, but otherwise much of the bedrock exposed in and around the waterfall appears largely unchanged. When standing near this part of the waterfall, can you identify whether any significant changes have occurred since January 2008?

Further Information

Additional resources that explain the essential basis of geomorphology include:

Goudie, A.S. and Viles, H.A. (2010) *Landscapes and Geomorphology: A Very Short Introduction*. Oxford University Press, 144 pp.

Tooth, S. and Viles, H.A. (2014) *10 Reasons Why Geomorphology Is Important*, Promotional brochure produced on behalf of the British Society for Geomorphology, available at: http://www.geomorphology.org.uk/what-geomorphology

Yarham, R. (2010) *How to Read the Landscape: A Crash Course in Interpreting the Great Outdoors*. Herbert Press, 256 pp.

Blog posts that highlight 10 reasons why the geomorphology of Wales is important are available at:
https://stephentooth.wordpress.com/category/10-reasons-why-10-rheswm-pam/

Although focusing mainly on North America with relatively little information specific to Wales, the following is a very useful resource for learning more about waterfalls in general:
World Waterfall Database, available at: http://www.worldwaterfalldatabase.com/