The Welsh Borderland

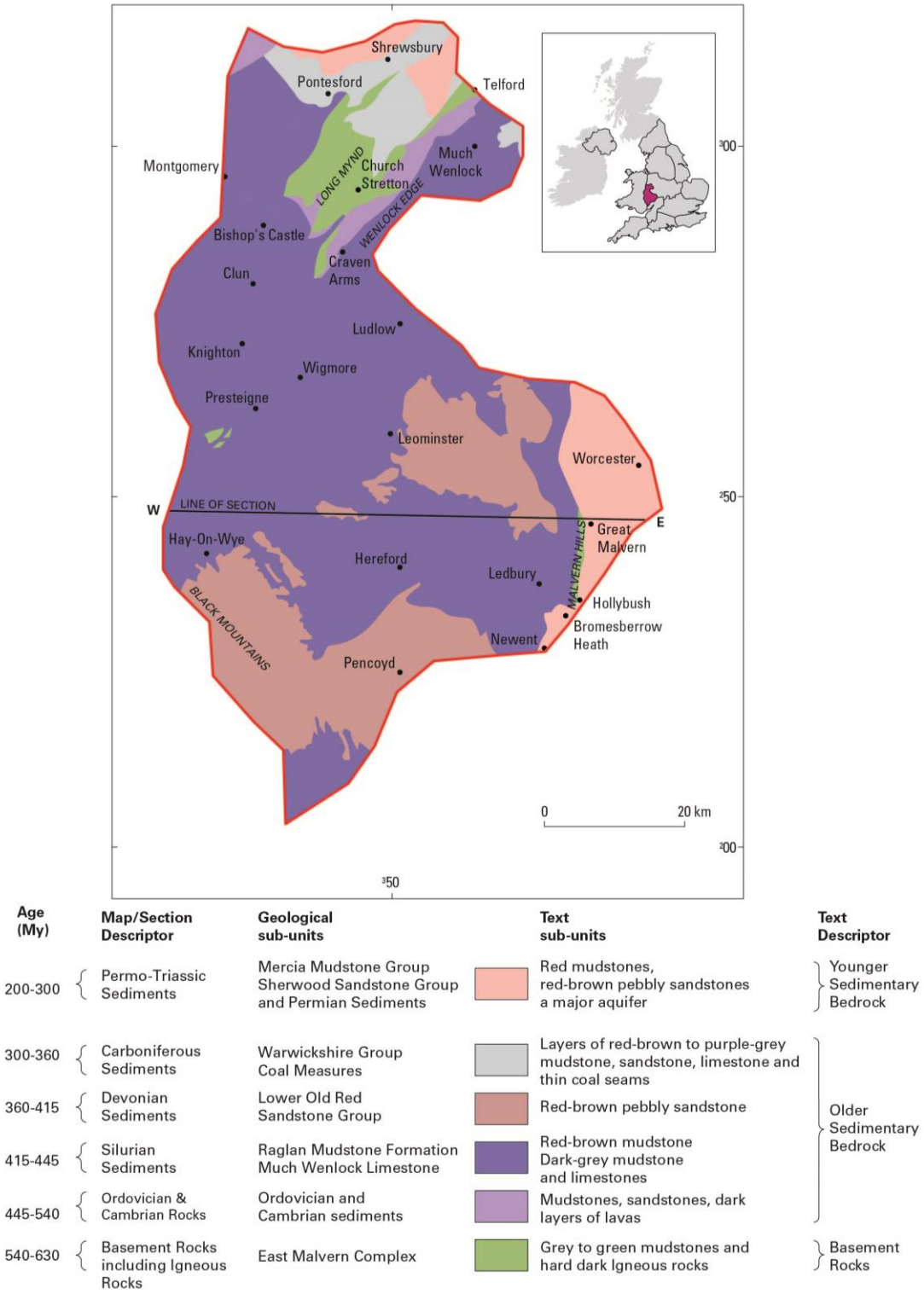
This account provides a broad perspective of the geology of the Welsh Borderland region which comprises the southeast of Powys, southern Shropshire, northern Gwent, the western half of Hereford and Worcester and a very small part of northern Gloucestershire. Figure 1 provides a geological sketch map of this region showing the rock types occurring in relation to the major towns and cities. This account outlines the geology to a depth of at least a kilometre and summarises the current and historical use of the geological resources in the area.

The Welsh Borders region contains a broad range of rock types and ages, exposing some of the oldest rocks in England and Wales. However, the geology of the region at depth is generally poorly understood due to a lack of deep drilled boreholes and seismic exploration survey data. Despite this uncertainty at depth, the geology at the surface is well understood, due to a reasonable number and spread of shallower boreholes, and local quarrying.

The landscape in the region is variable, from broad rolling hills to more pronounced steep ridges and valleys. This landscape has exposed a variety of different rock types and these are especially well exposed in the areas with steeper slopes. The northeast margin of the region towards Telford (outside of the region) has been quarried for coal. Information gained from quarrying activity has also provided valuable information to better understand the geology of this part of the region.

Geologically recent surface deposits

In the areas around Shrewsbury, Much Wenlock, Church Stretton, Leominster and Hereford there are locally widespread deposits of relatively recent origin formed over the past 2 to 3 million years and spanning the Ice Ages and Interglacial periods. These are known as superficial deposits, the most common of which were laid down by rivers and from glaciers. They typically comprise clays, silts, sands and gravels, which are soft and easily eroded as they have not been deeply buried and consolidated to form strong rocks, and only extend to depths of a few tens of metres.



Age (My)	Map/Section Descriptor	Geological sub-units	Text sub-units	Text Descriptor
200-300	Permo-Triassic Sediments	Mercia Mudstone Group Sherwood Sandstone Group and Permian Sediments	Red mudstones, red-brown pebbly sandstones a major aquifer	Younger Sedimentary Bedrock
300-360	Carboniferous Sediments	Warwickshire Group Coal Measures	Layers of red-brown to purple-grey mudstone, sandstone, limestone and thin coal seams	Older Sedimentary Bedrock
360-415	Devonian Sediments	Lower Old Red Sandstone Group	Red-brown pebbly sandstone	
415-445	Silurian Sediments	Raglan Mudstone Formation Much Wenlock Limestone	Red-brown mudstone Dark-grey mudstone and limestones	
445-540	Ordovician & Cambrian Rocks	Ordovician and Cambrian sediments	Mudstones, sandstones, dark layers of lavas	
540-630	Basement Rocks including Igneous Rocks	East Malvern Complex	Grey to green mudstones and hard dark Igneous rocks	Basement Rocks

Figure 1 *Geological map showing the range and distribution of different rock types in The Welsh Borderland, in relation to major towns and cities. The extent of the region is defined on the inset map of the United Kingdom.*

Geology at depth

Beneath the superficial deposits, or with just a cover of soil where such deposits are absent, are older rocks which geologists broadly split into two distinct types:

- The *sedimentary bedrock geology* is composed of quite hard rocks which were deposited between about 415 to 200 million years ago as layers of sediments in shallow seas, deserts and vast river systems in times when Britain lay closer to the Equator and the climate and landscape were very different from those of today.
- The *basement geology,* which underlies the bedrock, is over 415 years old and mainly comprises harder, denser rocks which have been strongly compacted and folded. They include both rocks originally deposited as sediments and others that are products of volcanic activity or formed from the solidification of molten rock below ancient volcanoes.

The sedimentary bedrock layers composed mainly of sandstones and mudstones are developed at the surface in the north of the region around Shrewsbury and also around Worcester. Elsewhere the basement rocks are exposed at the surface. Figure 2 provides a vertical section through the geology, referred to as a geological cross-section.

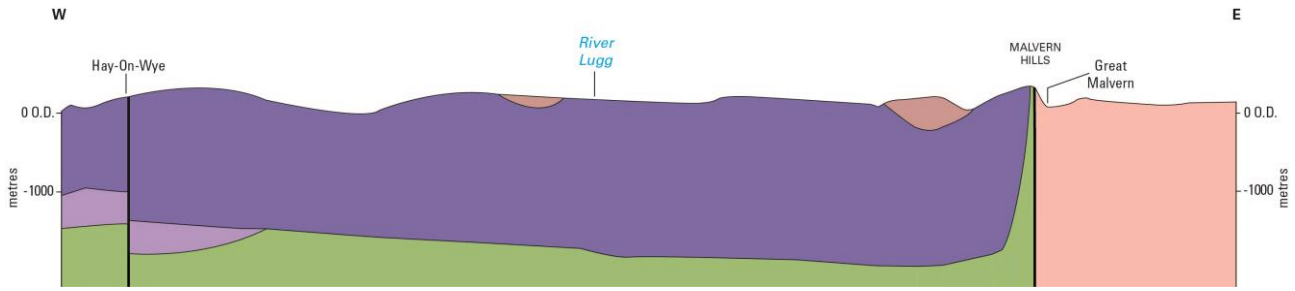


Figure 2 *Schematic cross-section of the geology of the Welsh Borderland. The alignment of the section and key are shown in Figure 1.*

Individual areas

For the ease of description the Welsh Borderland region has been divided into four areas each with markedly different geology. These are: Shrewsbury to the Long Mynd in the north; a large Central area that covers much of the region; the Worcester to Great Malvern area in the east, and the narrow north - south trending Malvern Hills that separate the Central and Worcester to Great Malvern areas.

Shrewsbury to the Long Mynd

Occupying the northern part of the region, this area extends from Shrewsbury to The Long Mynd and Church Stretton, and includes Telford and Montgomery at its margins. The geology here shows great variation in rock type and age. The landscape around the Long Mynd is characterised by steep sided hills with wide deep valleys at elevations higher than that of the adjacent area. This hill and valley landscape becomes increasingly less pronounced northwards towards Shrewsbury.

Sedimentary Bedrock

The youngest rocks, about 250 million years old, occur around Shrewsbury at the very limit of the region. The Sherwood Sandstone, comprises red-brown sandstones with layers rich in pebbles. It is present in small areas near Shrewsbury and is about 100 m thick. It was deposited after a period of tens of millions of years when the underlying rocks formed a land mass and were being eroded.

Beneath the Sherwood Sandstone and occurring at outcrop more extensively to the east and west of Shrewsbury are older red sandstones that extend to depths of about 200 m below the surface. These sandstones were deposited in an ancient desert approximately 280 million years ago. Beneath this lies about 500 m of reddened rocks known as the Warwickshire Group. In this area these rocks only contain thin coal seams and comprise red-brown to purple-grey mudstone, sandstone and thin layers of limestone. These rocks are present at the surface in central Shrewsbury and to the west and south of the town, where they underlie the younger higher layers in this area and descend to depths of about 1000 m below the surface. Coal Measures, restricted to the area around Telford, formed when vast quantities of sand and mud gradually built up to form large river deltas. When the tops of these deltas were exposed, massive swampy forests grew up and the vegetation from these forests was later buried and compressed to produce layers of coal. These sedimentary bedrock layers rest upon much older basement rocks.

Basement rocks

To the east of the Long Mynd lies Wenlock Edge, and the border of the region, and exposes the famous Much Wenlock Limestone. This limestone is about 425 million years old, only extending to depths of about 30 m below the surface at Wenlock Edge and occurring at the surface from Wenlock Edge to near the town of Ludlow. The Long Mynd, and other northeast-southwest trending ridges such as the Stiperstones, and the Wrekin are underlain by very old rocks that were formed over 450 million years ago. These rocks include mudstones, sandstones, limestones and volcanic tuffs - a rock formed from the compaction of erupted volcanic ash. In general, these rocks are particularly hard and this is the reason that the Long Mynd forms such a prominent upland area. The rocks on The Long Mynd are steeply inclined, very thick and are

thought to extend to depths greater than 1500 m below the surface. These rocks also host a number of small intrusions of molten magma which occur as sheets cutting through the basement rocks.

Central Welsh Borders

This area includes most of the Welsh Borders region west of the Malvern Hills and south of the Shrewsbury to The Long Mynd area. As such, this area includes the major towns of Bishop's Castle, Craven Arms, Clun, Ludlow, Knighton, Leominster, Hay-On-Wye and Hereford.

Sedimentary Bedrock

The area surrounding the Black Mountains and around Pencoyd have a red-brown pebbly sandstone at the surface, commonly known as the Old Red Sandstone. Deposited approximately 400 million years ago, this unit is only seen in the Welsh Borders region at these two locations. This sandstone can reach a thickness of 200 m.

Basement rocks

The basement rocks in this area are folded and faulted and are varied and all over 415 million years old. Extending beneath the Old Red Sandstone and occurring at surface across much of the southern parts of this central area the bedrock comprises red-brown mudstone called the Raglan Mudstone. These mudstones are up to 800 m thick but are generally absent around Knighton, Clun and to the northeast of Presteigne.

In such areas the underlying, slightly older rocks, occur at the surface. They comprise dark-grey Silurian mudstones with rare sandstone layers. These dark-grey mudstones near Knighton are up to 300 m thick but they thicken beneath the red-brown mudstones seen in the southern part of the region and can descend to depths of up to 1000 m below the surface.

Wherever the dark-grey mudstone is observed, either at the surface or underlying other rocks in the southern part of the region, it is underlain by series of limestones and muddy limestones (Figure 3). These limestones include the Much Wenlock Limestone that extends to around 550 m below the surface in the area around Knighton, Presteigne and Wigmore, and over 1200 m in the southern half of the region. Beneath the limestones exists a series of green to green-grey mudstones which date back to about 440 million years ago. In the area surrounding Knighton, Presteigne and Wigmore this mudstone is thought to extend up to 750 m below the surface. Underlying this is a series of rocks that date back to almost 500 million years ago. These rocks include a whole range of types including mudstones layered with dark

volcanic tuff, sandstones and pale and dark-coloured lavas. These layers are thought to extend to a depth of over 1200 m in the area of Knighton, Presteigne and Wigmore.

Figure 3 *Basement limestone and muddy limestone outcrop northeast of Ledbury.*

Worcester to Great Malvern

This area includes the low ground in the westernmost part of the region around Worcester and extending south to Great Malvern. It is bounded to the west by the ridge of the Malvern Hills.

Sedimentary Bedrock

The rocks in this area differ markedly in their nature and age from the rest of the Welsh Borderland region, lying east of a large geological fault (the Malvern Fault) which defines the eastern edge of the Malvern Hills. Movement on this fault uplifted the Malverns and produced an area of lowered topography to the east as today, within which sediments accumulated that were deposited by rivers and at times under desert conditions by the action of the wind.

The sedimentary bedrock layers at the surface are the youngest rocks in the region at 240 to 200 million years old. These mudstones, commonly referred to by geologists as Mercia Mudstone, are mostly red, and are tilted towards the southeast. These layers extend to a depth of about 100 m next to the Malvern Fault and lie progressively deeper to the east reaching a depth of about 400 m at the easternmost edge of the region. Underlying the red mudstone is a thick sequence of sandstones and pebbly sandstones, referred to

as the Sherwood Sandstone. This unit extends to a depth of about 2000 m below the surface directly east of the East Malvern Fault, and descends even deeper towards the eastern margin of the region. This thick sequence of sandstone was deposited in an ancient arid desert crossed by major rivers. As elsewhere in England and Wales the Sherwood Sandstone is an important aquifer used for drinking water supply with water flow occurring mainly between the individual sand grains that make up the rock and also within fractures in the sandstone.

Malvern Hills

The Malvern Hills area forms a north - south running ridge extending between the Central area and the Worcester-Great Malvern area (Figure 4). This ridge was uplifted in ancient times by movement on the Malvern Fault.

Sedimentary Bedrock

The youngest rocks in the Malvern Hills area are located to the south of Ledbury. These rocks are more extensively seen at depth within the Worcester-Great Malvern area to the east of the Malvern Fault. The bedrock geology at the surface comprises a sequence of soft, brick-red sandstones of the Sherwood Sandstone that are about 200 m thick. These are underlain by brown, red or grey sandstones which contain mudstone layers and pebble seams and are present at surface in a small area around Bromesberrow Heath, probably extending up to 700 m below the surface around Newent. These two sandstone layers together are 300 to 250 million years old. Underlying them is a sequence of Warwickshire Group comprising red and grey mudstone, sandstone, coal beds and the occasional thin layers of limestone. These rocks have not been exploited for coal in this area. This sequence was deposited approximately 320 million years ago and has a proven thickness of over 350 m in boreholes near Newent. In places within the Malvern Hills it is likely to reach to depths of at least 1000 m. These layers are tilted towards the south and rest upon the much older rocks that are observed at the surface in the northern part of this region.

Basement rocks

To the western side of the Malvern Fault the 5 km long Malvern Hills run north - south underlain by rocks that range in age from 1000 to 415 million years old. In the northern parts of the Malvern Hills the influence of the fault makes ascertaining the thickness and depth of the various rock layers uncertain. These rocks are tilted towards the west and so when traced eastwards from Ledbury to near Hollybush they get progressively older toward the Malvern Fault.

Figure 4 *The Malvern Hills, looking north from near Wynds Point, comprising hard igneous rocks of the Malvern Complex.*

The youngest rocks in this sequence are the same red-brown Raglan Mudstone (Silurian) that is seen across most of the Central part of the region. This unit is at the surface near Ledbury but thins from a maximum thickness of about 400 m in the west to nothing to the east. Underlying the red-brown mudstone are the same dark grey Silurian mudstones described previously in the Central area. This rock layer likely extends to depths of about 700 m near Ledbury. Underlying this are the well preserved fossil-rich limestones which are likely to be at depths of about 900 m below the surface; below this are the 440 million year old green-grey mudstones. These are likely to reach depths of over 1200 m based on their thickness observed elsewhere. Below this and reaching unknown depths is a sequence of grey to green finely layered mudstones. The oldest basement rocks, called the Malvern Complex, are visible at the surface north of Hollybush at Midsummer Hill.

In addition directly west of the Malvern Fault a number of slivers of hard, dark grey intrusive rocks formed from molten magma rising from very great depths are present at surface. These rocks are likely to be over 500 m wide and probably extend to depths of 2000 m.