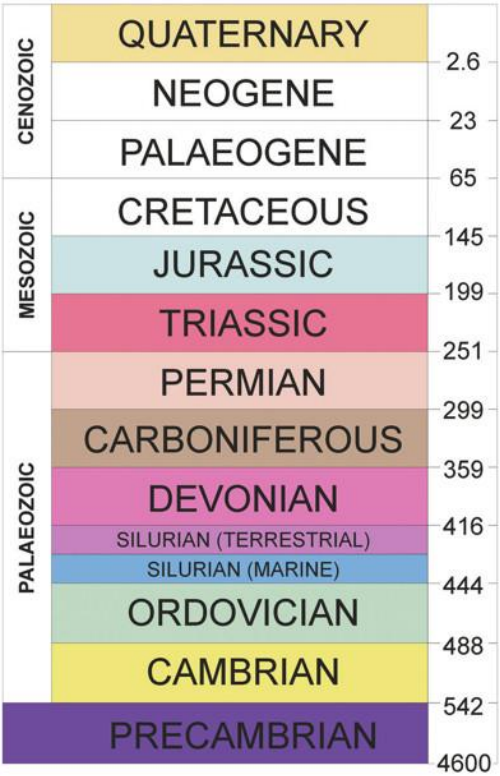
Malvern Hills

Dingle, Westminster Bank, Gardiners and Tank Quarries

Community Earth Heritage
CHAMPIONS
project



GEOLOGICAL TIMESCALE IN MILLIONS OF YEARS

The coloured boxes show the ages of the rocks and deposits that are found in the counties of Herefordshire and Worcestershire

Cover Images:

Main photograph:
The northern Malvern Hills
Courtesy of John Payne

Small photographs:
1. **Malverns Complex rock**
Courtesy of John Stocks
2. **Pyx Granite company machinery in a quarry at the northern end of the Malvern Hills circa 1920**
Courtesy of the Malvern Hills Conservators
3. **A Spear Thistle near Gardiners Quarry**

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Herefordshire & Worcestershire
EARTH HERITAGE TRUST


Gardiners Quary

Contents

The Malvern Hills

Forming a natural boundary between the counties of Herefordshire and Worcestershire, the Malvern Hills dramatically rise out of the landscape. There are some twenty named hills along the 14km (9 miles) long north-south range, the highest point being Worcestershire Beacon at 425m. The Hills are a defining feature of both the Malvern Hills Area of Outstanding Natural Beauty and the Abberley and Malvern Hills Geopark.

The earliest settlements on the Hills date back to the Late Bronze Age and Iron Age; the Hill Forts of Midsummer Hill and British Camp (Herefordshire Beacon).

Malvern Water, that issues from the numerous springs on the Hills, has long been famous for its healing properties. Yet it was in the 19th century that Malvern Water brought significant change to the Malverns with the arrival of Dr Wilson and his 'water cure'; this attracted an influx of Victorian gentry to 'take the waters' resulting in the development of Malvern into a Spa resort.

Fact File:

Distance to the Wyche Cutting, Malvern Hills: 9.5 miles south-west of Worcester / 21.5 miles east of Hereford
Grid reference: (Wyche Cutting) SO769437
Car parks: £3 per day
Local train stations (distance to the Hills from the station): Colwall station (0.6 miles), Great Malvern station (0.7 miles), Malvern Link station (0.9 miles)
Local bus services: 675 service from Malvern to Ledbury (Monday - Saturday)

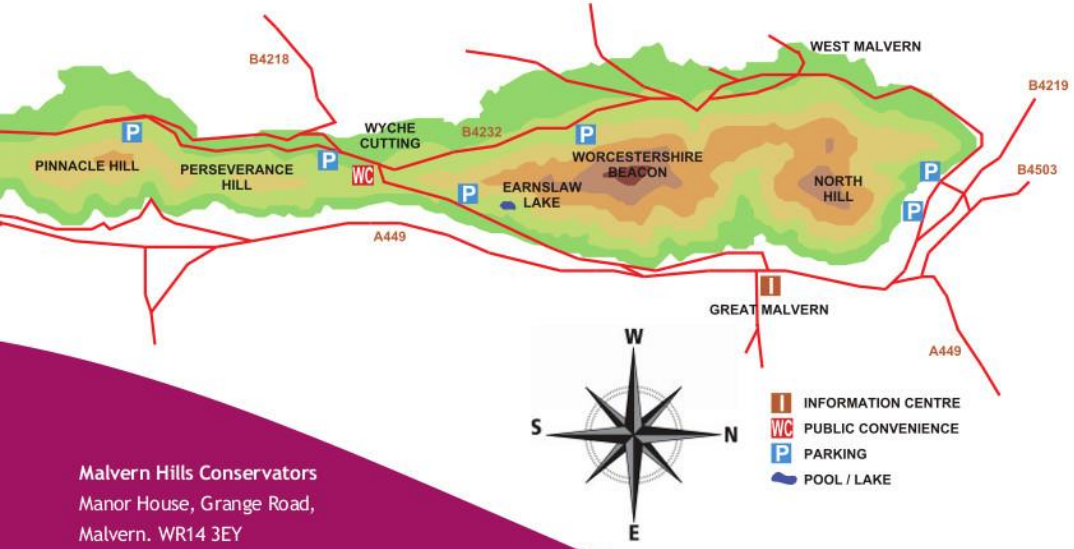
Location of the Malvern Hills

The Malvern Hills can be found on the border of the counties of Herefordshire and Worcestershire, with the southernmost hill lying in Gloucestershire. The principal roads around the Hills are the A449 and B4232. Roads cutting across the Hills are the B4218 and the A438.

The Malvern Hills have long been a location for those interested in geology. The amateur and professional alike can view igneous, metamorphic and sedimentary rocks of many ages within a relatively small area. Such variety and interest help to make the area special. There are twenty-two Local Geological Sites on the Malvern Hills, which are also ranked as a Site of Special Scientific Interest (SSSI) for both their geology and their botany.

Today the Malvern Hills are a popular destination for recreational pursuits, most commonly walking and mountain biking. The more adventurous local organisations and clubs hang glide, abseil, climb and dive on the Hills.

The Malvern Hills Conservators own, or have under their jurisdiction, most of the Malvern Hills and Commons (a total area of 1200 hectares, or 3000 acres) and manage them to preserve their unique ecology and natural beauty, and for public recreation. Set up under the Malvern Hills Act of 1884, the Malvern Hills Conservators are one of Britain's oldest conservation charities.



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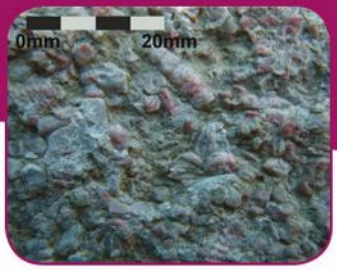
www.malvernhills.org.uk

What is Geology?



Fossil-rich limestone

Geology is the study of rocks, minerals and fossils; how they were formed; and how they have influenced landscapes over millions of years. Planet Earth is some 4600 million years old, and trapped within each and every rock there is a geological story just waiting to be read: how and where they came into existence and how they end up where they are today. By closely looking at what a rock is made up of, together with its relationship to the surrounding landscape, then, bit by bit a story begins to reveal itself; and it's a long story covering millions of years of geological history!

Rocks underpin the natural world in which we all live. They shape our landscapes, influence soil types, and consequently affect biodiversity and land-use.

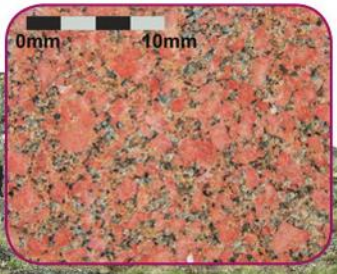
An introduction to rocks

Rocks can be divided into three main groups:

Igneous rocks are formed when magma (molten rock) cools and solidifies. They can either be intrusive: formed beneath the Earth's surface, or extrusive: when the molten material comes to the surface and forms a volcano for example. Examples of igneous rocks are granite, rhyolite and basalt.

Sedimentary rocks are made up of particles deposited in layers. They usually form on the sea floor, in lakes and rivers, or in deserts. The layers of sediment are compacted and consolidated by the weight of overlying material. The particles within the layers can also be cemented together by minerals (e.g. iron compounds) carried by water percolating through the sediments. Eventually, over millions of years, the compressed sediments become rock. Sedimentary rocks today are being formed over much of the Earth's surface. Examples of sedimentary rocks are sandstone, limestone and mudstone.

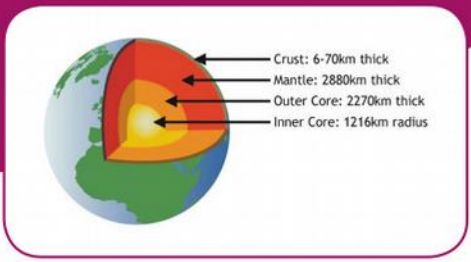
Metamorphic rocks are rocks that have been altered (metamorphosed) by heat and/or pressure. The original rocks can either be sedimentary or igneous rocks, squeezed deep within the Earth due to the movement of tectonic plates, or heated due to the presence of molten rock (magma). Examples of metamorphic rocks are slate, schist and marble.



Granite

Studying the geology of the Malvern Hills

Trilobite fossil



Structure of Planet Earth

Fossils

Fossils are the remains of plants and animals. Fossils usually represent the harder parts of organisms, since these are the most resistant to erosion e.g. shells, bones, exoskeletons and wood. The majority of fossils are aquatic animals or plants because conditions for preservation are usually better in water than on land. Other types of fossils include trace fossils such as burrow holes, walking tracks and fossilised animal droppings (coprolites). To be a fossil you need to be at least 10,000 years old. This is not very old in geological terms when you consider that the oldest fossil ever found is a 3500 million year old pond-slime-like bacteria.

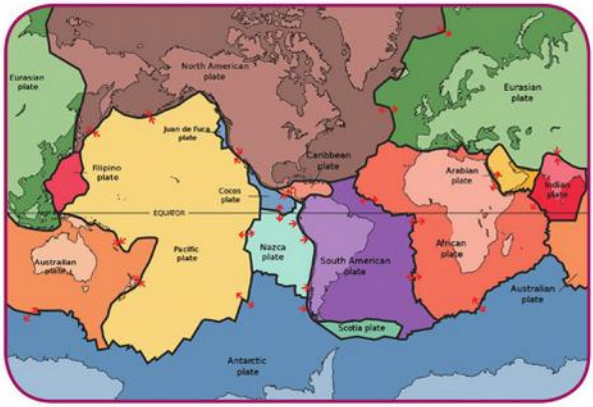
Structure of the Earth and its powerful forces

Planet Earth has a diameter of 12,735km. As you move from the surface of the Earth to its centre you pass through four distinct layers; the **Crust**, the **Mantle**, the **Outer Core** and the **Inner Core**.

Scientific calculations indicate that the temperature at the centre of the Earth is over 3000° Celsius and that the inner core is composed of a high-density ($13.5 g.cm^{-3}$) solid iron-nickel alloy.

From the moment the surface of the Earth began to cool, solid rock coalesced to form a continuous crust. This crust has always been subject to immense forces operating beneath it in the mantle, where slow, ongoing movements have caused the fracturing of the crust above. This has resulted in the creation of large portions of the crust, known as plates, which are constantly moving against or away from each other at an average rate that varies between two and seven centimetres a year. Mountains, volcanoes, earthquakes, ocean trenches and mid-ocean ridges are all results of this plate movement, as is the migration, over millions of years, of these plates over the Earth's surface (plate tectonics).

Trace fossil; dinosaur footprint



Current position of tectonic plates.
Courtesy of the US Geological Survey

Geological History Of Herefordshire & Worcestershire

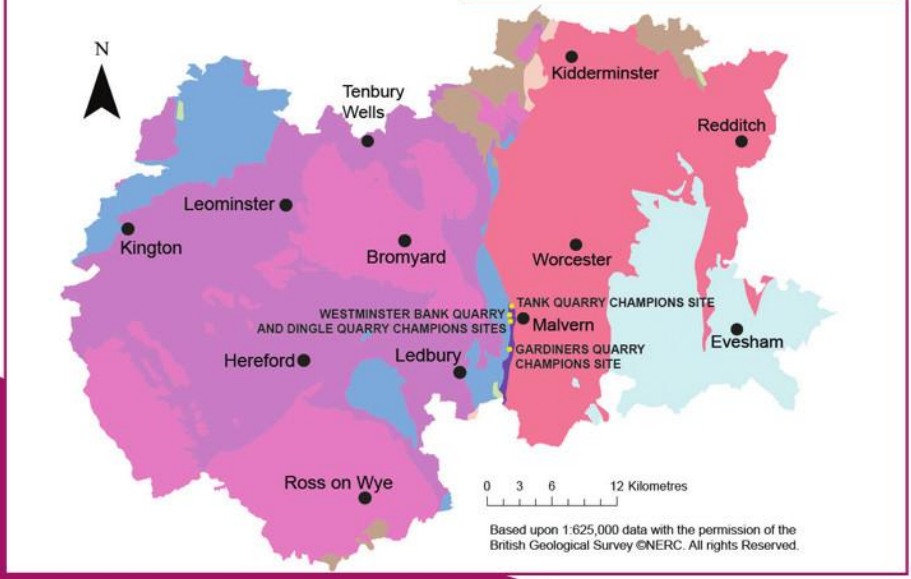
▲ The Olchon Valley in west Herefordshire

Natural breaks in the geological record allow for the vastness of geological time to be divided into smaller units. The last 542 million years are split into twelve geological periods (as illustrated by the geological timescale on the inside front cover). Time before 542 million years ago is referred to as the Precambrian. In addition to the Precambrian, nine geological periods are represented in the rock units of Herefordshire and Worcestershire.

Key to Geological Map

Quaternary (2.6 million years ago to recent)	
Neogene (23 million years ago to 2.6 million years ago)	
Palaeogene (66 million years ago to 23 million years ago)	
Cretaceous (145 million years ago to 66 million years ago)	
Jurassic (199 million years ago to 145 million years ago)	
Triassic (251 million years ago to 199 million years ago)	
Permian (299 million years ago to 251 million years ago)	
Carboniferous (359 million years ago to 299 million years ago)	
Devonian (416 million years ago to 359 million years ago)	
Silurian (444 million years ago to 416 million years ago)	**Pridoli stage** (419 million years ago to 416 million years ago)
	Llandovery, Wenlock and Ludlow stages (444 million years ago to 419 million years ago)
Ordovician (488 million years ago to 444 million years ago)	
Cambrian (542 million years ago to 488 million years ago)	
Precambrian (4600 million years ago to 542 million years ago)	

Geological Map of Herefordshire & Worcestershire

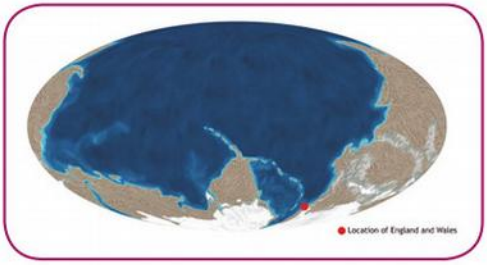


Travelling back 700 million years ago, what we know now as England was positioned 60° south of the equator near the South Pole. Since then we have slowly crept our way northwards on an epic journey to our current latitude of 52° north (plate tectonics - refer to final paragraph on page 5).

Precambrian (4600 million years ago to 542 million years ago)
- Igneous and metamorphic rocks make up the Malvern Hills and three small areas to the north. Here they are approximately 680 million years old, and amongst the oldest in England.

1. Cambrian (542 million years ago to 488 million years ago)
- Quartzite, sandstone and shale formed as the sea level began to rise - as found in small areas adjacent to the Malvern Hills and in Martley (Worcestershire).

2. Ordovician (488 million years ago to 444 million years ago)
- Volcanic material was erupted and then deposited in water during the opening stages of this period, followed by sand deposited in a warm, shallow sea which formed into quartzites. Rocks of this age are found in the Lickey Hills, Worcestershire. Further west in Herefordshire, near Pedwardine and west of the Malvern Hills, shales that were deposited within a deep ocean environment can be found, as well as igneous intrusions seen near Eastnor.



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A globe showing the location and shape of the continents in Precambrian times: 600 million years ago.
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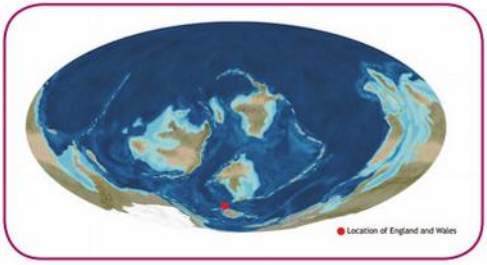

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A globe showing the location and shape of the continents in early Ordovician times: 470 million years ago.
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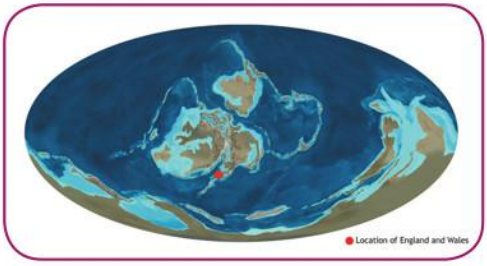
View south from Abberley Hill, Worcestershire

3. Silurian (444 million years ago to 416 million years ago)
a. Llandovery, Wenlock and Ludlow stages (between 444 million years ago and 419 million years ago)
- At the start of the period, sandstones and conglomerates (sediments containing rounded pebbles) formed from the material brought down into a shallow sea during flash flood events. Then limestones and shales formed as the sea level rose. These limestones form prominent hills in both Herefordshire and Worcestershire counties, for example, the Woolhope Dome and the Abberley Hills respectively.

b. Pridoli stage (between 419 million years ago and 416 million years ago)
- Mudstones, sandstones and calcretes (calcium-rich fossilised soil) deposited within a flat, arid landscape, near the coast and crossed by seasonal streams. These rocks are found in west Worcestershire and across much of Herefordshire county.

4. Devonian (416 million years ago to 359 million years ago)
- Sandstones, deposited by streams in an otherwise flat and arid landscape. These rocks are found in west Worcestershire around Tenbury Wells and across much of Herefordshire county.

5. Carboniferous (359 million years ago to 299 million years ago)
- Thick beds of limestone, which formed in a shallow sea, can be found on the south-eastern margin of Herefordshire. Later on during the Carboniferous, clays, coals, shales and sandstones formed in a flat, swampy delta. These Coal Measure rocks are found around the Wyre Forest Coalfield area of Worcestershire and in a very small area around Howle Hill in Herefordshire. There are also igneous intrusions of this same age found in the Teme Valley and also near Kidderminster.



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A globe showing the location and shape of the continents in mid-Silurian times: 430 million years ago.
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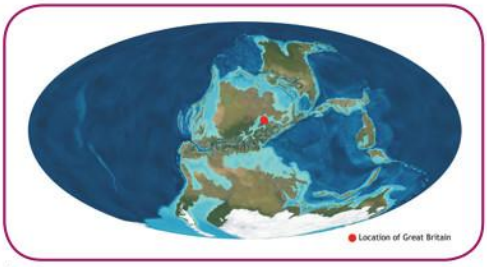

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A globe showing the location and shape of the continents in late Carboniferous times: 300 million years ago.
© Ron Blakey and Colorado Plateau Geosystems, Inc.

Artist's impression of a Carboniferous swamp
Image created by John Watson

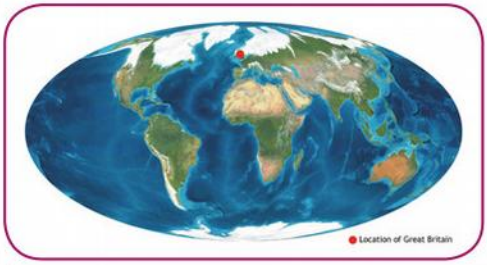
6. Permian (299 million years ago to 251 million years ago)
- At the start of the period, breccias (sediments containing angular fragments) formed during catastrophic events such as flash floods or earthquakes. Red desert sandstones are found in small areas in the north and west of Worcestershire, and south of Ledbury in Herefordshire. There is also a small igneous intrusion of this age near Bartestree.

7. Triassic (251 million years ago to 199 million years ago)
- Sandstones, conglomerates, evaporites (salts), breccias and mudstones - all representing a change in environment; first into a flat, arid landscape covered in rivers and lakes, and later into oceanic conditions. These rocks predominate in Worcestershire.

8. Jurassic (199 million years ago to 145 million years ago)
- Limestones and mudstones deposited in a warm, shallow sea. These rocks are found mainly in the south-east of Worcestershire towards the Cotswold Hills. There are no rocks of Jurassic age in Herefordshire.

9. Quaternary (2.6 million years ago to recent)
- Glacial deposits, river sands, gravels and alluvium, plus chemical deposits such as tufa, overlying the hard rocks (not shown on the geological map).

▲ **A globe showing the location and shape of the continents in mid-Triassic times: 220 million years ago.**
© Ron Blakey and Colorado Plateau Geosystems, Inc.



▲ **A globe showing the location and shape of the continents 12,000 years ago.**
© Ron Blakey and Colorado Plateau Geosystems, Inc.

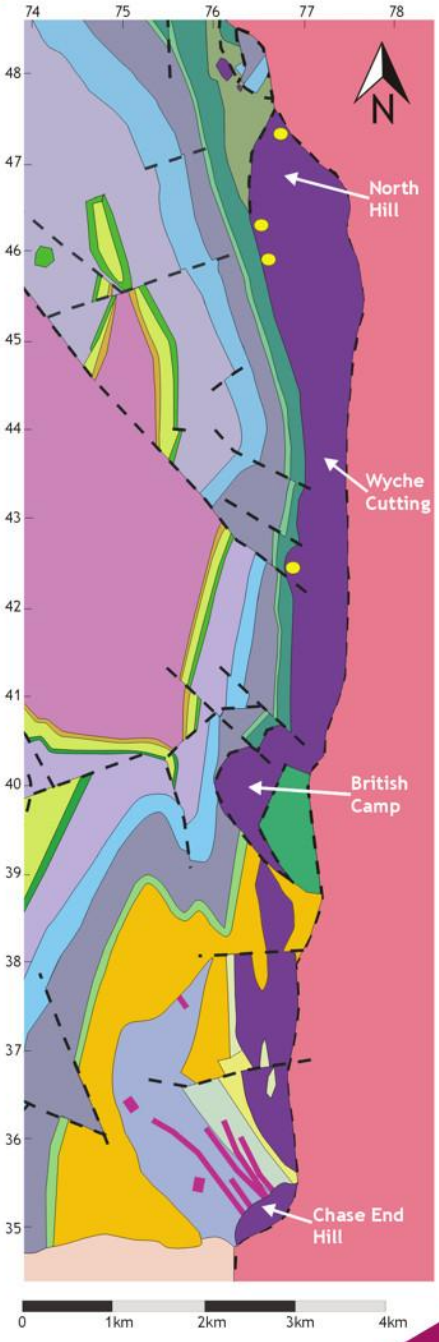
◀ **Woolly Mammoths roamed Britain during the last Ice Age. The youngest and most complete British specimen, found in Shropshire, was dated at 12,800 years old.**
© Worcestershire Historic Environment and Archaeology Service

Geological History of the Malvern Hills & the Immediate Area

The rocks of the Malvern Hills and the immediate area range in age from around 680 million years to around 251 million years old. The Precambrian together with six geological periods are represented in the local rocks. The rocks of each of these periods of geological time are further subdivided into ever-smaller units of rock - Stages, Groups and Formations - generally representing different conditions of rock formation. Superficial material (clays, silts, sands, gravels, pebbles and boulders) deposited during the last Ice Age represent the seventh geological period present in this area, known as the Quaternary Period.

Era	Period	Depositional environment	Age
Cenozoic	Quaternary	Cold climatic conditions with intervening temperate conditions.	2.6
	Neogene	Not represented in the Malvern Hills.	23
	Palaeogene	Not represented in the Malvern Hills.	65
Mesozoic	Cretaceous	Not represented in the Malvern Hills. Removed by erosion following Palaeogene and Neogene earth movements.	145
	Jurassic	Not represented in the Malvern Hills. Removed by erosion following Palaeogene and Neogene earth movements.	199
	Triassic	Arid desert dissected by large braided streams. Shallow playa (salt) lakes covered large parts of the Worcester Basin.	251
Palaeozoic	Permian	Arid rocky desert, alluvial fan deposits and aeolian deposition (sand dunes).	299
	Carboniferous	Not represented in the Malvern Hills due to a period of uplift associated with the formation of the large supercontinent Pangaea.	359
	Devonian	Arid conditions. Land surface was exposed for a long period of time allowing soil formation.	416
	Silurian	Rising sea levels. The Malvern Hills were located at the edge of a warm shallow sea. Towards the end of the Silurian, the conditions changed to continental deposition and sinuous streams migrated over a semi-arid alluvial plain.	444
	Ordovician	Marine deposition initially, later mostly eroded away following a depression of sea level caused by a major Ice Age. Renewed igneous activity resulted in the intrusion of a series of dykes and sills towards the southern end of the Malvern Hills.	488
	Cambrian	Shallow seas gradually covered the old Precambrian land surface.	542
Precambrian		Ocean floor volcanic eruptions. Plutonic igneous activity associated with subduction of tectonic plates.	

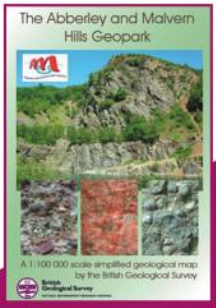
▲ The geological history of the Malvern Hills. Age shown in million of years



Sketch map depicting the geology of the Malvern Hills and the immediate area. *Adapted from Groom 1900. On the Geological Structure of Portions of the Malvern and Abberley Hills.*

KEY

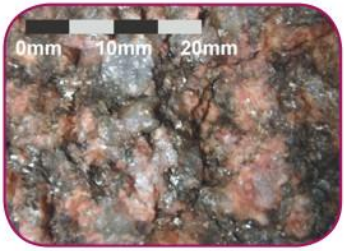
- Sandstones and mudstones (Triassic)
- Sandstones and conglomerates (Permian)
- Raglan Mudstone Formation (Silurian)
- Downton Castle Sandstone Formation (Silurian)
- Upper Ludlow Shales (Silurian)
- Aymestry Limestone Formation (Silurian)
- Lower Ludlow Shales (Silurian)
- Much Wenlock Limestone Formation (Silurian)
- Coalbrookdale Formation (Silurian)
- Woolhope Limestone Formation (Silurian)
- Wyche Formation (Silurian)
- Cowleigh Park Formation (Silurian)
- May Hill Sandstone Group (Silurian)
- Igneous Intrusions (Ordovician)
- Bronsil Shale Formation (Ordovician)
- White-leaved Oak Shale Formation (Cambrian)
- Hollybush Sandstone Formation (Cambrian)
- Malvern Quartzite Formation (Cambrian)
- Warren House Formation (Precambrian)
- Malverns Complex (Precambrian)
- Geological fault
- Community Earth Heritage Champions Site



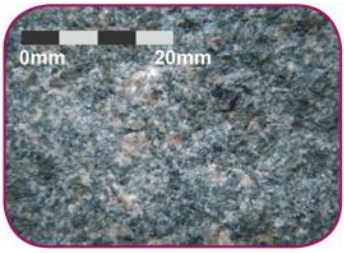
Reference maps:
British Geological Survey Sheet 199 Worcester
British Geological Survey Map of the Abberley and Malvern Hills Geopark

Malverns Complex (Precambrian in age)
The rocks of the Malvern Hills consist of igneous and metamorphic rocks collectively referred to as the Malverns Complex. They formed about 680 million years ago. Travel back in time to the Precambrian and the position and shape of the continents was completely different from today. This area was located some 60° south of the equator on the northern edge of an ancient supercontinent called Gondwana. The collision of two tectonic plates at the edge of this landmass resulted in one of the plates sliding under the other along a line known as a **subduction zone.** The intense heat and pressure caused by the movement of the slowly descending plate led to the formation of most of the igneous and metamorphic rocks seen on the Malvern Hills today.

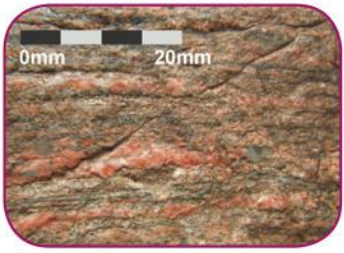
The dominant igneous rocks on the Malvern Hills are dark green-speckled **diorite**; made up mainly of feldspar and the ferro-magnesian minerals biotite and hornblende, and plutonic pink **granite**; its components of quartz and feldspar giving the rock a pink colour. Later episodes of plate tectonic activity led to further bodies of magma forming, which were forced into cracks in the pre-existing Malvern rock. This magma then cooled and solidified, forming bodies (sills, dykes and veins) of dark-coloured igneous rocks called **microdiorite** and pink-coloured igneous rocks called **pegmatite**. In addition, the Malverns Complex suite of rocks include minor amounts of **amphibolite** (a dark green ultrabasic rock consisting entirely of hornblende) and the metamorphic rocks gneiss and schist. **Gneiss** is formed by extreme heat and pressure acting on pre-existing rocks. The minerals within gneiss are arranged in light and dark bands. **Schist** readily splits into flakes or slabs often with the mineral mica present.



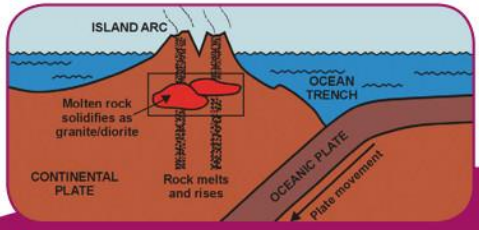
▲ Granite



▲ Diorite



▲ Gneiss



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A diagram of a subduction zone. Here, tectonic plates (part of the Earth's crust) collide and one plate is dragged under another along a subduction zone. Intense heat and friction cause melting to form magma in the overlying rocks. Some of the magma reaches the surface to form volcanoes but if it solidifies deep within the crust, as with the Malvern rocks, it forms intrusive igneous rocks such as granite and diorite. The surface layers, and therefore the evidence of volcanoes, have subsequently been eroded away, leaving just the rocks seen in the boxed area of the diagram to form the Malvern Hills we see today.

Warren House Formation (Precambrian in age)
Also found in the Malverns Hills are some ancient volcanic rocks known as the Warren House Formation. They comprise a suite of spilitic basalts (lava), rhyolites (lava) and ignimbrites (pyroclastic rocks). The eruption of these lavas has been dated at 566 million years ago, 100 million years after the formation of the Malverns Complex. The presence of 'pyroclastic' rocks (meaning 'fire' and 'broken') shows that these volcanic eruptions were extremely violent. These rocks can be seen on Tinker's Hill, Broad Down and on Hangman's Hill.

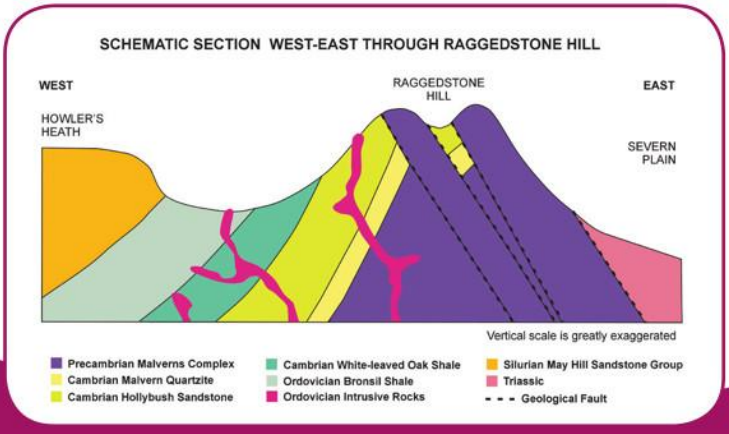
Malvern Quartzite Formation (Cambrian in age)
During the Cambrian period sea levels rose as global warming melted a southern hemisphere ice sheet. Sands and pebbles deposited into this shallow sea over millions of years turned into pale grey, hard, quartz-cemented sandstone and quartz pebble conglomerates. These rocks can be seen on Midsummer Hill.

Hollybush Sandstone Formation (Cambrian in age)
A flaggy, micaceous (containing the mineral mica) and distinctively dark green sandstone. The green colouring is due to the presence of the minerals chlorite and glauconite. The presence of glauconite is indicative of the sandstone being laid down in shallow marine waters with temperatures of 10 to 15°C. There is further evidence for the marine setting seen within these sediments including ripple marks which have preserved the shape of the wave movement on the sediment. This sandstone is seen in Hollybush road cutting.

White-leaved Oak Shale Formation (Cambrian in age)
A dark grey, fissile shale containing trilobite and brachiopod fossils. The shales were deposited in a deep, stagnant, oxygen deficient marine environment. There are a handful of shale pits in the hamlet of Whiteleaved Oak.

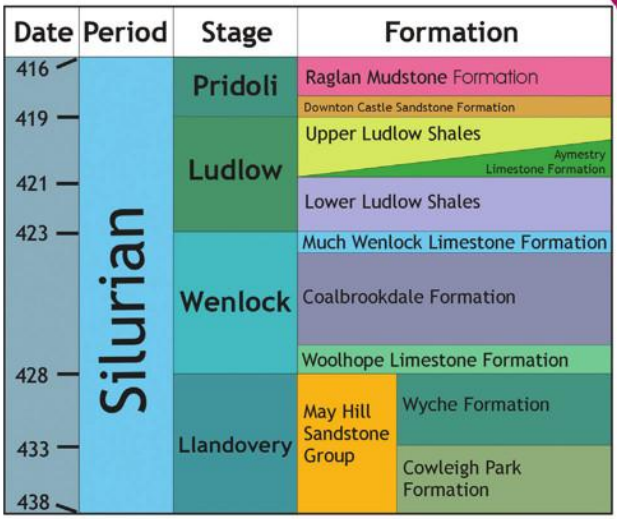
Bronsil Shale Formation (Ordovician in age)
A pale grey shale containing brachiopod, trilobite and graptolite fossils. The paler colour of these rocks, in comparison to the Cambrian-aged shales, suggests that they were deposited in oxygenated waters. Previously they were thought to be Cambrian in age too. However, fossil evidence indicates they were deposited during the early stages of the Ordovician period. At the end of the Ordovician period there was a significant drop in global sea level (roughly 100m) due to a major glaciation.

Igneous intrusions (Ordovician in age)
Igneous activity during Ordovician times injected a series of igneous rocks into the local Cambrian-aged rocks and Bronsil Shale. These intrusions, dykes and sills, form the ridges seen in the relatively low land between Whiteleaved Oak and Eastnor Park.



◀ This cross section through Raggedstone Hill shows that the Ordovician-aged igneous material has been forced through the surrounding rocks. Geologists are able to tell the relative age of the igneous material as it occurs within the sedimentary rocks of the Ordovician period, but not the Silurian-aged rocks.

May Hill Sandstone Group (Silurian in age)
At the beginning of Silurian times sea levels rose with the melting of ice at the end of the Ordovician Ice Age. During early Silurian times the Malverns formed the eastern shoreline of the Welsh Sea. Some of the material eroded from the landmass to the east (the Midlands Platform) was transported west by streams to the nearby shore. This sediment over millions of years turned into siltstones, sandstones, breccias and conglomerates. Rocks of this age can be found in Gullet Quarry. Hard sandstones and conglomerates lie immediately west of the Malvern Hills along much of their length.

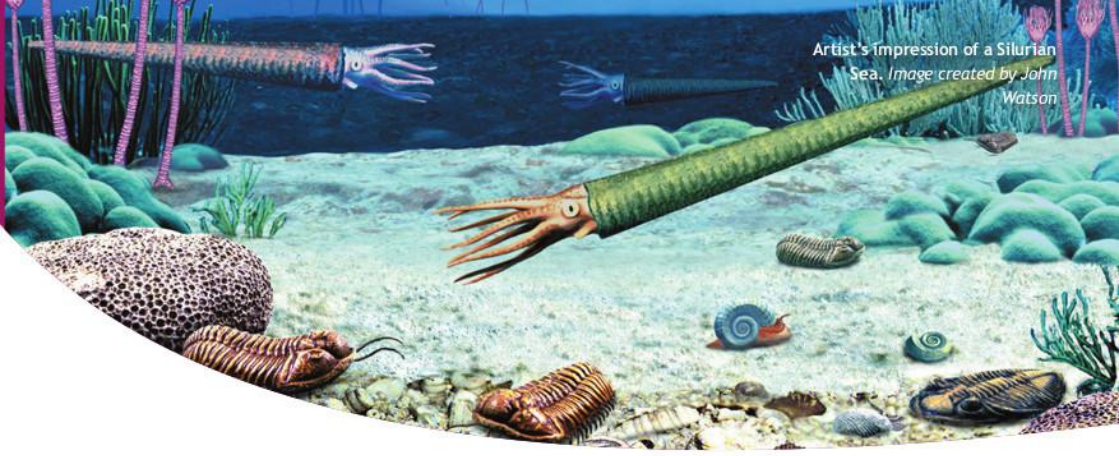


▲ Geological timescale showing the sequence of Silurian rocks found in the Malvern Hills area. Age shown in millions of years

The Wenlock and Ludlow Stages (Silurian in age)
The Welsh Sea had now covered the land in this area. Factors such as fluctuations in sea depth and the nature of the sediment being laid down in this sea dictated the subsequent rock types that formed. Shallow warm tropical seas favoured the growth of coral reefs; the resultant rock type is fossiliferous limestone. Deep waters led to the deposition of mud particles which would later form into the Coalbrookdale Formation (shale). There are numerous exposures of Silurian limestone and shale in the hills and valleys to the west of the Malvern Hills including Park Wood and the Purlieu, Upper Colwall.

Downton Castle Sandstone Formation (Silurian in age)
The end of the Silurian period was marked by dramatic events as the continents on either side of the Welsh Sea converged. This high energy, stormy environment resulted in the deposition of a coastal sandstone. This buff-brown-coloured micaceous sandstone can be seen in Brockhill Quarry in the Purlieu, Upper Colwall.

Raglan Mudstone Formation (Silurian in age)
The impact of the two colliding continents generated a range of high mountains comprising what is now North Wales, the Lake District and Scotland. Material eroded from these mountains was transported south by streams and rivers to the lowlands where mud, silt and sand were deposited onto the semi-arid plains. These sediments over time turned into the red 'Raglan Mudstone' which is closest to the Malvern Hills at Colwall train station.



Artist's impression of a Silurian Sea. *Image created by John Watson*

The Silurian seas teemed with life. The wide variety of weird and wonderful creatures that inhabited this environment can be found today, as fossils in the Silurian limestone and shale that make up the hills and valleys to the west of the Malvern Hills. Some of the fossils that can be found include:

Brachiopods are a type of shellfish. They are filter feeders. They are the most common type of fossil found in Silurian limestones. They still exist in the sea today but they are much rarer than in Silurian times.

Trilobites were a group of early marine invertebrates. They are now extinct but were an extremely successful group of animals, existing for 300 million years. They are related to crustaceans such as lobsters and crabs.

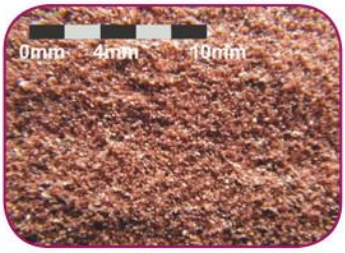
Corals are simple animals, closely related to sea anemones and jellyfish. Although solitary forms do exist, they often live in colonies of many genetically identical individuals (polyps). They secrete a hard skeleton of calcium carbonate, which can sometimes form large reef structures. Whilst they are different to modern day corals, Silurian corals were important reef builders.

Crinoids are commonly known as 'sea lilies' or 'feather-stars'. They were much more abundant and diverse in the past than they are today.

Fossiliferous limestone of the Much Wenlock Limestone Formation ▼

Haffield Formation (Permian in age)
Following a major period of earth movements and uplift (see page 17) the land to the east of the Hills began to subside (see page 19). Rapid erosion of the newly formed mountains led to locally derived alluvial fans consisting of angular fragments of mainly local Precambrian and Silurian pebbles. By now this area had travelled to 10° north of the equator and was experiencing a desert-like climate, hence these rocks are stained red. Haffield Breccia can be seen in Bromsberrow Lane just south-west of the southern tip of the Malvern Hills.

Bridgnorth Sandstone Formation (Permian in age)
Desert sediments formed on the flat desert plain by the action of wind blowing the sand into dunes. These red, coarse-grained sandstones can be seen in Bromsberrow Lane just south-west of the southern tip of the Malvern Hills.



▲ Bridgnorth Sandstone

Bromsgrove Sandstone Formation (Triassic in age)
By around 251 million years ago this area had drifted northwards into the semi-arid regions of 31° north of the equator. Thick layers of sandstone were being deposited in the Worcester Basin east of the Hills (see page 19). A braided river, the 'Budleighensis River', with its origins in what is now France, criss-crossed the basin floor depositing vast amounts of material. Some of this material, over time, consolidated into red sandstone. A small amount of this Bromsgrove Sandstone lies to the east of the northern Malvern Hills, in Malvern town centre.

Mercia Mudstone Group (Triassic in age)
As the Worcester Basin filled, fine-grained silts and muds were deposited in the mudflats, playa lakes and sabkha environments that ensued. These red mudstones and siltstones, with green reduction spots, lie adjacent to much of the eastern edge of the Malvern Hills.

Superficial Deposits (Quaternary in age)
Over the last 500,000 years there have been three episodes of glaciation in Britain: the Anglian (between 480,000 and 416,000 years ago), the Wolstonian (380,000 to 130,000 years ago) and the Devensian (120,000 to 10,000 years ago). They were separated by interglacial periods when the climate was somewhat warmer than today. We now live in an interglacial that started around 10,000 years ago. The Quaternary deposits around the Malvern Hills include sand and gravel deposits from the former Mathon River (west of the Hills) deposited during the early Anglian, and till deposits in Coddington that indicate that the Anglian ice sheet reached the Malvern Hills. During later cold spells ice never reached the Malvern Hills but arctic conditions prevailed, thus freezing the ground, which then thawed in the spring and summer months. These freeze-thaw conditions produced 'head' deposits of shattered Precambrian rocks which cover a large proportion of the lower slopes of the Hills.


▲ Shattered Precambrian Head deposits

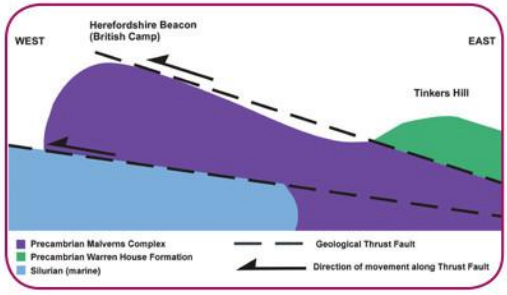
The East Malvern Fault & The Grand Upheaval

The reason for such a variety of rocks types of differing ages being in close proximity to each other in the Malvern Hills area is due to the presence of a deep-seated and ancient line of weakness in the Earth's crust. This line of weakness, which can be traced all the way from Bristol through Malvern and to the north of Kidderminster, is a dividing line between ancient and modern Britain, geologically speaking that is! It is known locally as the East Malvern Fault. To the west of this fault lie Palaeozoic rocks, whilst to the east lie the younger Mesozoic rocks. The term Palaeozoic means 'ancient life' whereas Mesozoic indicates 'middle life'.

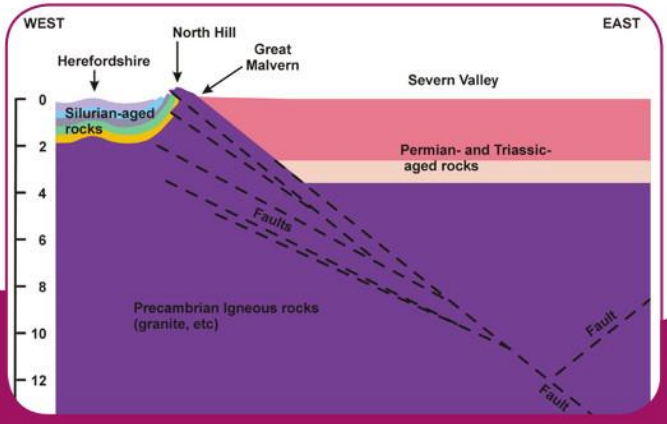
Around 300 million years ago, major earth movement occurred when the ancient continents of Gondwana and Laurussia were colliding together. This collision produced the major mountain building episode of the Variscan orogeny. This welded together the continents of Gondwana and Laurussia creating the supercontinent of Pangaea and a massive mountain belt, extending from Russia, through Western Europe, to North America.

The cross-section at the bottom of the page shows the results of this earth movement on the Precambrian rocks that make up the Malvern Hills. The compressive forces exerted on the rocks led to a mass of the basement rock (the Precambrian Malverns Complex) being raised above the surface along a fault plane.

During this period of uplift compression in the crust led to the development of a series of thrust faults which displaced sections of the Malvern Axis westwards. The Herefordshire Beacon represents a thrust mass of Malverns Complex; it has been offset west of the main ridge line by around 500m.



▲ A sketch cross-section through Herefordshire Beacon illustrating the thrust fault movement



A sketch cross-section through the Malvern Hills illustrating how the basement Precambrian rocks were raised to the surface along geological faults. Rocks deposited later, to the east of the Malvern Hills after the grand upheaval, are also shown. Scale in kilometres.

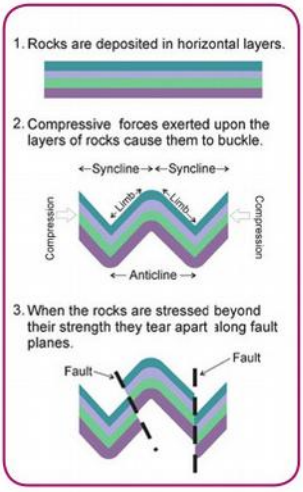
◀

West of the Malvern Hills

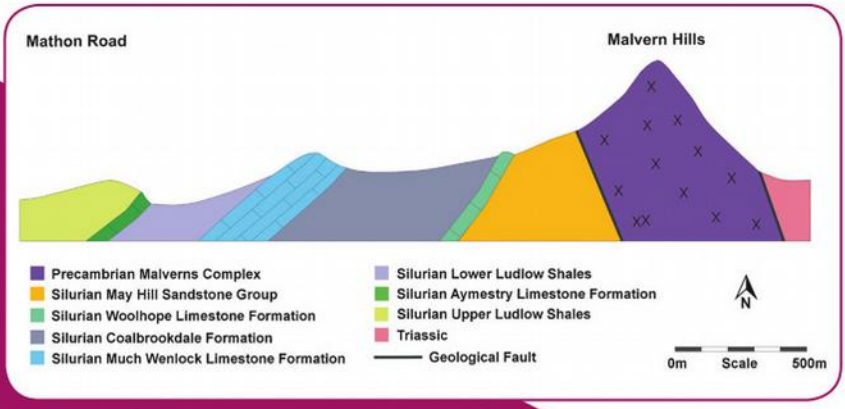
▲ Ridge and Vale landscape to the west of the Malvern Hills

The landscape immediately west of the Malvern Hills displays a sequence of gently rolling hills and valleys. This is known as ridge and vale topography. It results from the sequence of rocks that formed some 425 million years ago during Silurian times. Fluctuating sea levels during the Silurian led to the formation of horizontal layers of the sedimentary rocks - sandstones, limestones and shales. Around 300 million years ago, as a consequence of the earth movements of the Variscan Orogeny (see page 17), these sedimentary rocks were compressed, tilting the layers of rock to the west. These tilted layers of rock have since been ravaged by erosion. The harder limestones and sandstones have fared relatively well and stand proud as hill ridgelines; the softer shales have worn away to a greater extent to form sculpted vales (see diagram below).

The intense pressures exerted on the rocks that caused them to tilt, in places resulted in the rocks buckling and folding (see diagram to the right). If the pressure exerted on the rocks when they were being folded reached breaking point, the rocks tore apart along lines of weakness, forming geological faults. The extensive nature of the faulting in the Silurian Hills, particularly those south of the Wyche Cutting/Upper Colwall, breaks up the simple order you would expect to find in a folded sequence of rocks (see diagram below). However, this complicated geology does make for stunning scenery.



◀ Diagrammatic representation of folding and faulting



▲ A cross-section illustrating the tilted Silurian sequence of rocks between the Malvern Hills and Mathon Road

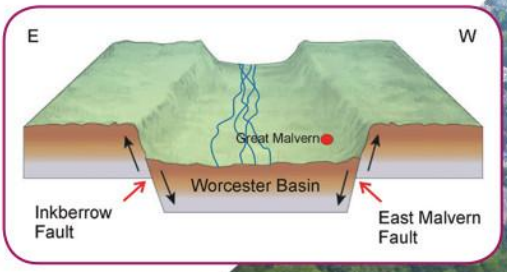
East of the Malvern Hills

The crustal compression experienced during the Variscan orogeny (page 17) was followed by phases of crustal extension in the newly formed supercontinent of Pangaea. Initiated during the Permian period (299-251 million years ago), this extension locally reactivated movement along the East Malvern Fault. Such activity was being mirrored to the east by another similar deep-seated fracture, the Inkberrow Fault in east Worcestershire. The resultant landscape structure between these two fault lines was a flat-topped prism of rock. This prism slowly subsided by about 3000m to form a great rift valley, the Worcester Basin (see diagram below).

By the Triassic period (251-199 million years ago) Pangaea had moved to 31° north of the equator. Throughout the Triassic, the Worcester Basin gradually filled with vast quantities of sediment deposited in alluvial fans, lakes, mudflats and from the mighty 'Budleighensis River' that flowed across it. These sediments were later covered by younger material and they eventually turned into sedimentary rocks. Much of this younger material has subsequently been removed through erosion. As a result, the present day landscape comprises a swathe of flat plains underlain by Triassic-aged mudstones and siltstones, occasionally interrupted by gentle hills composed of sandstone. Over the course of the last two million years, water and ice have passed over these rocks depositing patches of sand and gravel.

A braided river in the mountain regions of Kyrgzstan; a similar environment to the Triassic Worcester Basin, although there was less vegetation as the first land plants were only just developing. *© Marli Miller*

A diagram representing the Worcester Basin

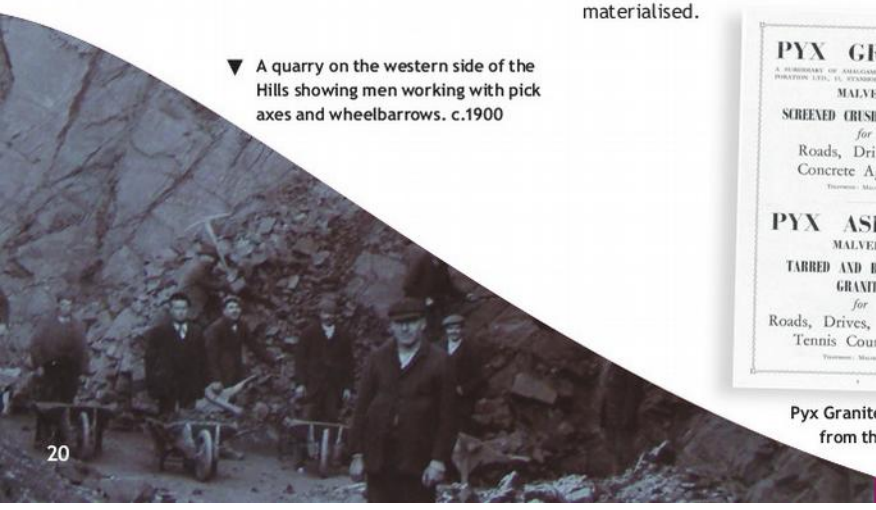


The flat plain of the Worcester Basin as viewed from the Malvern Hills

Industrial Archaeology of the Malvern Hills

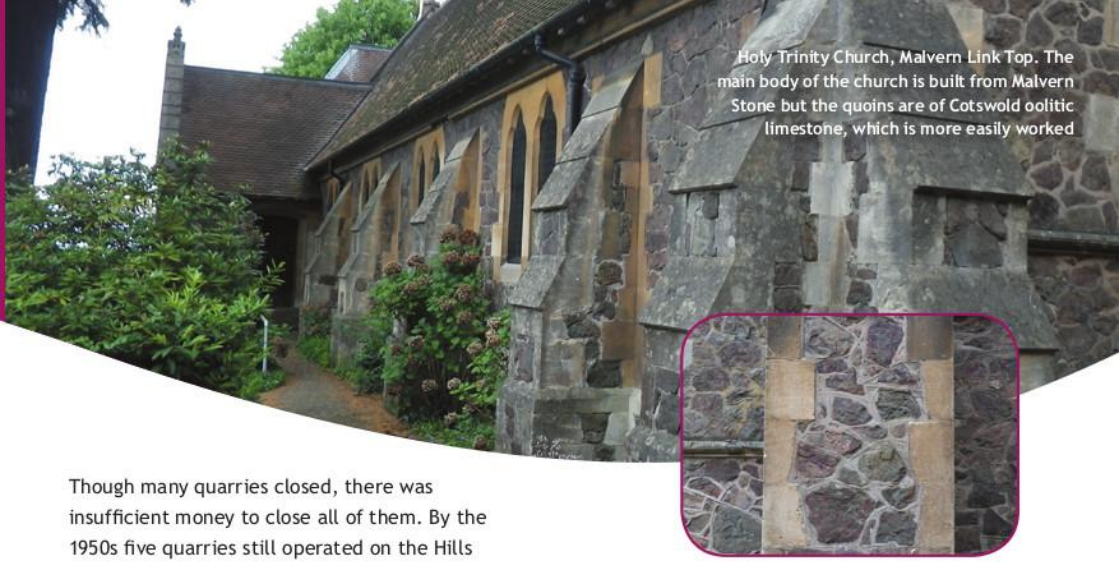
The hard nature of the rocks that make up the Malvern Hills lends itself very well for use as crushed stone for road aggregate. It was during the 20th century, with the coming of British motorways that demand for 'Malvern Rock' soared. Large commercial scale quarrying operations started up across the Hills to serve this demand.

Quarrying on the Hills had begun many centuries before the birth of the motorways. Manorial Lords with their rights to 'dig stone' extracted Malvern Rock for use as building stone and crushed rock. Extraction was done by hand using picks and hammers. These traditional rights to extract stone never really caught the public eye, even with the growing size of the quarries at the northern end of the Hills that supplied crushed rock for local roads in the late 19th century. However, during the early 20th century when some landowners, realising they were sitting on valuable stone quarrying rights, began to lease out their rights to commercial companies, opposition to the industry began to be vocalised. There was plenty to oppose; commercial quarrying brought with it noise from blasting, dust, cranes and stone crushers, unsightly spoil heaps and degradation of the natural beauty of the Hills, along with the danger faced by the general public of falling rocks and damaged roads. Public petitions were signed and many spoke out about the industry including Professor William Knight, a pioneer member of the National Trust. This disapproval was typically channelled towards the Malvern Hills Conservators, who people were looking towards to put a stop to the commercial scale quarrying. The Malvern Hills Conservators proposed a Bill to parliament to curtail the quarrying but it was not until 1924, when the third Malvern Hills Act was passed through parliament, that the Malvern Hills Conservators were able to buy land, manorial rights and mineral rights even if the owners objected. Compensation levels to owners were high, the costs being covered through an increase in local rates. There was a proposal to provide compensation to the quarrymen who lost their livelihoods through the closures but this never materialised.



▼ A quarry on the western side of the Hills showing men working with pick axes and wheelbarrows. c.1900

Pyx Granite advert from the 1960s ▲



Holy Trinity Church, Malvern Link Top. The main body of the church is built from Malvern Stone but the quoins are of Cotswold oolitic limestone, which is more easily worked

Though many quarries closed, there was insufficient money to close all of them. By the 1950s five quarries still operated on the Hills - Hollybush Quarry, Tank Quarry (Pyx Granite Company), North Quarry (Pyx Granite Company), Earnslaw Quarry (Malvern Granite Company) and Gullet Quarry. Collectively they extracted stone at a rate of 200,000 tons a year and employed 250 workers. By 1977 all quarrying activity had ceased on the Malvern Hills.

Building Stones

As well as being used as crushed rock, Malvern Stone was also used as a building stone, with many Malvern Victorian buildings being constructed of the material. The nature of the rock meant that uniform blocks could not be cut. The irregular shapes and sizes of the building stones used led to a locally distinctive style of heavy mortar use being developed (see photograph above right). Quoins, door and window lintels tended to be made of brick or a more workable stone.

By the end of the 19th century brick was the chosen material for building, with Malvern Stone now reserved only for use in foundations and basements and in stone walls. The builders didn't need to travel far from the Malvern Hills for these new preferred materials; clay pits and lime kilns could be found in the surrounding parishes, with Malvern Link being a centre for brick making in the mid-20th century, having five brick works in operation.

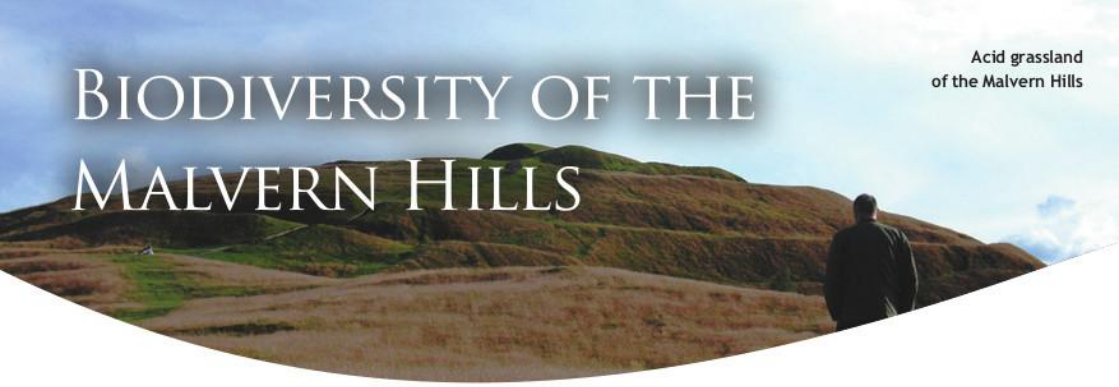
Malvern Pottery

Pieces of pottery dating back as far as the Iron Age and Roman times contain fragments of Malverns Complex rock. It has been concluded that this pottery was made in the Malverns area, and distributed throughout Worcestershire and over considerable distances to the Marches, South Wales, and Gloucestershire. The inclusion of fragments of Malverns Complex rock into the clay would no doubt have strengthened the pottery. It may even have been used for decoration, but did it also serve as a signature of provenance?

Late Iron Age/early Roman Malvernian ware tubby cooking pot.

Since extraction ceased, the Malvern Hills Conservators have rehabilitated many of the quarries under their jurisdiction through landscaping and planting schemes. Several quarries have since become filled with spring water, creating habitats that without quarrying would not exist on the Malvern Hills.

Biodiversity of the Malvern Hills



Acid grassland of the Malvern Hills

The Malvern Hills provide a mosaic of habitats and are home to a diverse flora and fauna including some of Britain's rarest animals, birds, insects and plants. The Malvern Hills have been designated a Site of Special Scientific Interest because of their national importance as a wildlife habitat.

The upper slopes and open, acid grassland hilltops bear swathes of heathers and grasses. The lower slopes and valleys support bracken, gorse and scrub, together with recent and ancient woodland. The quarries on the Hills provide unique habitats that would not have existed on the Hills prior to extraction, e.g. high cliff ledges and lakes.

◀ Gorse

◀ Thistle

The route of the Malvern Hills Champions Trail (pages 23-42) crosses a number of the key habitats seen on the Malvern Hills.

▲ **Twenty-five species of butterflies have been recorded on the Hills, including the high brown fritillary (above) and green hairstreak butterfly.** *Image © Roger Wasley*

▲ **There are thought to be nine main adder populations on the Malverns. The adders live in areas of rough grassland and low scrub with scattered groups of trees where they can hunt for their prey.** *Image © Peter Preece*