Historic England

Worcestershire

Building Stones of England

The Building Stones of England

England's rich architectural heritage owes much to the great variety of stones used in buildings and other structures. The building stones commonly reflect the local geology, imparting local distinctiveness to historic towns, villages and rural landscapes.

Historic England and the British Geological Survey (BGS), working with local geologists and historic buildings experts, have compiled the Building Stones Database for England to identify important building stones, where they came from and potential alternative sources for repairs and new construction.

Drawing on this research, plus BGS publications and fieldwork, guides like this one have been produced for each English county. The guides are aimed at mineral planners, building conservation advisers, architects and surveyors, and those assessing townscapes and countryside character. The guides will also be of interest if you want to find out more about local buildings, natural history, and landscapes.

This guide is based on original research and text by Peter Oliver.

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Front cover: Priory and Abbey Hotel, Great Malvern. Malvern Stone. © Stuart Black / Alamy Stock Photo.

How to Use this Guide

Each guide describes the local building stones in their geological timescale order, starting with the oldest layers through to the youngest. The guide ends with examples of other notable building stones from other parts of England and further afield.

Geological time periods, groups, formations and building stones

Each building stone is listed under the relevant geological timescale, group and formation. A formation may be divided into members and where relevant these are referenced in individual building stone sections.

Middle Jurassic
↑— geological time period

Inferior Oolite Group, Lincolnshire Limestone Formation
↑— geological group ↑— geological formation

Lincolnshire Limestone
↑— building stone (alternative or local name)

Bedrock geology map and stratigraphic table

To help you with the geology of the area, there is a bedrock geology map and a stratigraphic table which shows the layers of rocks and the associated building stones in this geological timescale, group, formation order.

Page numbers for each building stone are included in the stratigraphic table for ease of reference. The page numbers are inverted to correspond with the geological age order.

Contents list

If you click on the page number for a building stone in the Contents list, you will go straight to the relevant section in the guide.

Building stone sources and building examples

A companion spreadsheet to this guide provides:

- More examples of buildings. Information is included on building type, date, architectural style, building stone source, and listed/ scheduled status
- A list of known (active and ceased) building stone sources such as quarries, mines, pits and delphs
- Additional information on building stones including lithology, grain size, sedimentary structures, key identification features, and notes on failure/weathering, and use.

The Building Stone GIS map allows you to search the Building Stones Database for England for:

- A building stone type in an area
- Details on individual mapped buildings or stone sources
- Potential sources of building stone sources within a given proximity of a stone building or area
- Buildings or stone sources in individual mineral planning authority area.

Further Reading, Online Resources and Contacts

The guide includes geological and building stone references for the area. A separate guide is provided on general Further Reading, Online Resources and Contacts.

Glossary

The guides include many geological terms. A separate Glossary explaining these terms is provided to be used alongside the guides.

The guides use the BGS lexicon of named rock units.

Mineral and local planning authorities

This guide covers the Worcestershire County Council mineral planning authority area; and the local planning authority areas of Worcester, Malvern Hills, Wyre Forest, Bromsgrove, Redditch and Wychavon.

Contents

1 Introduction

No one can fail to be impressed by the natural scenic beauty of this county when seen from its hilltops. Much of this stunning scenery is a direct result of its varied underlying geological succession. The hills of Worcestershire rise on three sides, neatly enveloping the vale of the River Severn and its tributaries and leaving only the south as an opening to the Bristol Channel. In the west, the Malvern Hills form the border with Herefordshire. Stretching for 12km, they dominate the skyline and include some of the oldest rocks in England, consisting of granites and diorites of Precambrian age. This influential geological structure, known as the Malvern Axis, continues northwards as the tightly folded sedimentary Silurian limestones and shales of the Suckley and Abberley Hills, with their distinctive ridge and vale topography.

In the north of the county, there are younger rocks of the Wyre Forest Coalfield, comprising hard Carboniferous sandstones together with mudstones and thin coal seams. The high ground continues eastwards into the Clent and Lickey Hills, where Carboniferous and Triassic sandstones and mudstones and coarse Permian breccias crop out and, at Lickey, sit juxtaposed against hard resistant Ordovician quartzites. As the borders with Warwickshire are approached to the south of Redditch, the Arden Sandstone escarpment, a more resistant component within the Triassic mudstones that underlie much of central Worcestershire, forms a line of higher ground known as the Ridgeway, which is eventually masked by glacial deposits.

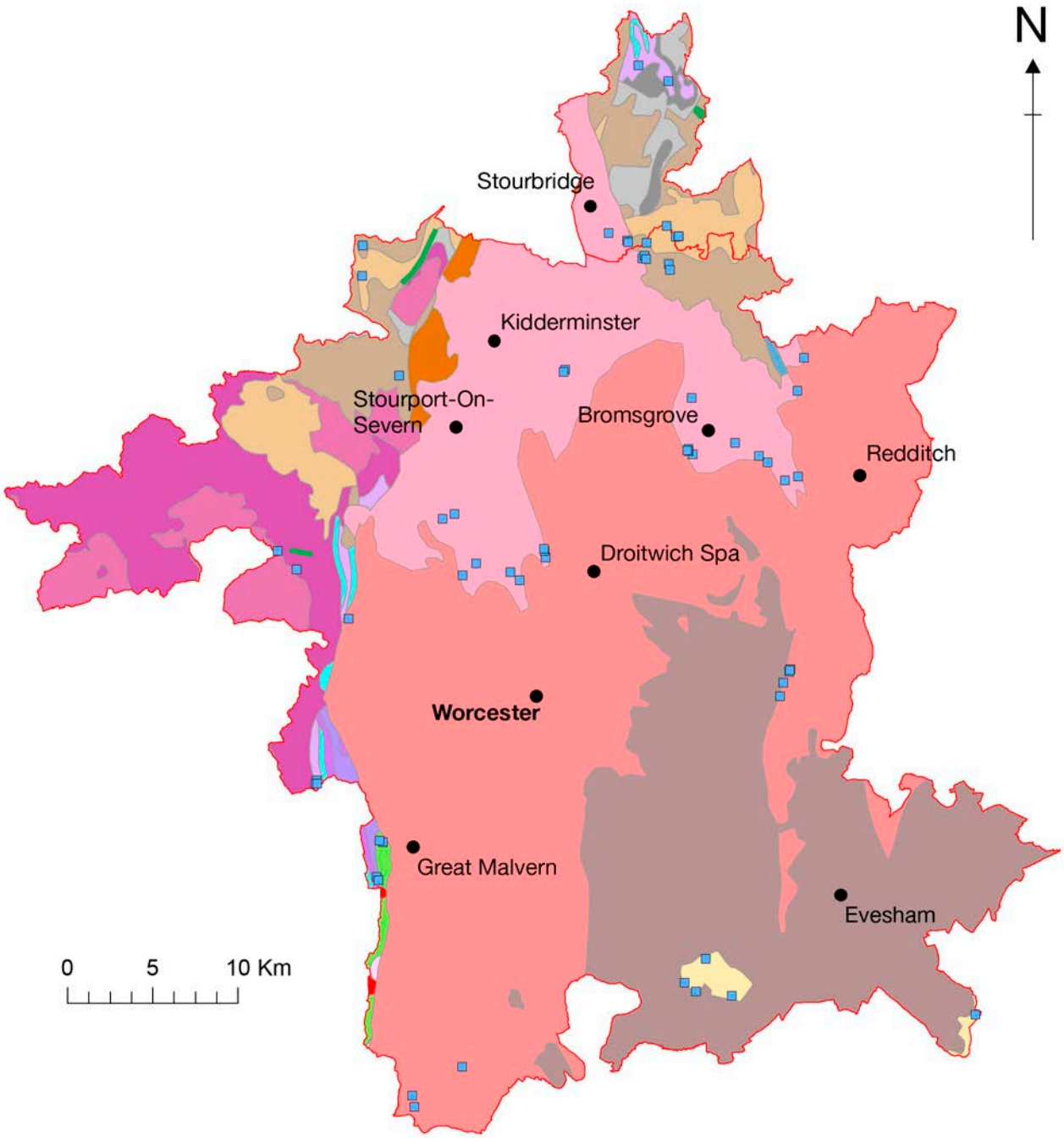
Figure 1: Broadway quarry. Cotswold Stone.

Finally, rising into Gloucestershire are the Jurassic limestones of the impressive Cotswold escarpment. Only a small part of the Cotswolds falls within Worcestershire, but the isolated Jurassic outlier of Bredon Hill, imposing and slab like, stands sentinel above the valley of the River Avon. Most of the lower ground in the northern part of the county is underlain by the distinctive red sandstones of Permian and Triassic age, some of which are resistant enough to form prominent ridges. To the south and east, these sandstones change to the mudstones of the Triassic and Jurassic periods. These are much softer and form the broad sweeping vale of the River Severn. Further small escarpments mark out the Arden Sandstone outcrop and the limestones of the Blue Lias, which all wind southwards to the Severn estuary. These are incorporated into the Worcester plain, which has been shaped by the Severn, Teme, Stour and Avon rivers as well as by the meltwaters from the vast Pleistocene ice sheets that poured from the north and west some 15,000 years ago.

This glacial legacy is evidenced across most of the lower ground of the county by the presence of till and outwash sand and gravel, mainly of Devensian age. The dominant features, however, are the great spreads of drift made up of fluvial sands, gravels and alluvium. These terraces rise step-like up the valley sides, with each rise taking us further back into periods of torrential meltwaters as the climate warmed. Locally, within this natural landscape, a very distinctive man-made vista of villages and farms has been added, in particular where the rocks have been the principal source of building stones.

Figure 2: Holy Trinity Church, Belbroughton. Bromsgrove Sandstone.

Bedrock Geology Map



Key

Building stone sources

Bedrock geology

Unnamed Igneous Intrusion, Carboniferous to Permian — mafic igneous rock

Inferior Oolite Group — limestone, sandstone, siltstone and mudstone

Lias Group — mudstone, siltstone, limestone and sandstone

Triassic Rocks (undifferentiated) — mudstone, siltstone and sandstone

Triassic Rocks (undifferentiated) — sandstone and conglomerate, interbedded

Permian Rocks (undifferentiated) — sandstone and conglomerate, interbedded

Warwickshire Group — mudstone, siltstone, sandstone, coal, ironstone and ferricrete

Warwickshire Group — siltstone and sandstone with subordinate mudstone

Pennine Middle Coal Measures Formation and South Wales Middle Coal Measures Formation (undifferentiated)

Pennine Lower Coal Measures Formation and South Wales Lower Coal Measures Formation (undifferentiated)

Unnamed Igneous Intrusion, Carboniferous to Permian — mafic igneous rock

Lower Devonian Rocks (undifferentiated) — mudstone, siltstone and sandstone

Pridoli Rocks (undifferentiated) — mudstone, siltstone and sandstone

Ludlow Rocks (undifferentiated) — mudstone, siltstone and sandstone

Wenlock Rocks (undifferentiated) — mudstone, siltstone and sandstone

Llandovery Rocks (undifferentiated) — mudstone, siltstone and sandstone

Silurian Rocks (undifferentiated) — limestone, mudstone and calcareous mudstone

Arenig Rocks (undifferentiated) — mudstone, siltstone and sandstone

Tremadoc Rocks (undifferentiated) — mudstone, siltstone and sandstone

Unnamed Extrusive Rocks, Neoproterozoic — mafic lava and mafic tuff — warren house formation

Unnamed Igneous Intrusion, Neoproterozoic — felsic rock, Malvern Complex

Unnamed Igneous Intrusion, Neoproterozoic — mafic igneous rock, Malvern Complex

Stratigraphic Table

Geological timescale	Group	Formation	Building stone	Page
Quaternary	various	various	Tufa, Quaternary pebbles	26
Middle Jurassic	Inferior Oolite Group	Birdlip Limestone Formation	Cotswold Stone	25
Lower Jurassic	Lias Group	Whitby Mudstone Formation		
		Marlstone Rock Formation	Marlstone (Marlstone Rock)	24
		Dyrham Formation		
		Charmouth Mudstone Formation		
		Blue Lias Formation	Cementstone, Blue Lias, Stock Green Limestone	23
Triassic	Penarth Group	various		
	Mercia Mudstone Group	Blue Anchor Formation		
		Branscombe Mudstone Formation		
		Arden Sandstone Formation	Arden Sandstone Inkberrow Stone Pendock Stone	21 21 21
		Sidmouth Mudstone Formation		
	Sherwood Sandstone Group	Bromsgrove Sandstone Formation (Helsby Sandstone Formation)	Bromsgrove Sandstone (Hadley Stone, Holt Stone, Ombersley Stone, Tardebigge Stone)	20
		Wildmoor Sandstone Formation	Wildmoor Sandstone	19
		Chester Formation (formerly Kidderminster Formation)	Kidderminster Conglomerate	19
Permian	not defined	Bridgnorth Sandstone Formation	Bridgnorth Sandstone	18
Upper Carboniferous	Warwickshire Group	Clent Formation	Clent Breccia (Haffield Breccia)	17
		Salop Formation	Alveley Stone (Hexton's Stone)	16
		Halesowen Formation	Highley Sandstone (Thick Sandstone)	13
		Etruria Formation	Etruria Formation Sandstones	11
	Pennine Coal Measures Group	various		
Devonian	Lower Old Red Sandstone group	St Maughans Formation	St Maughans Sandstone Bishop's Frome Limestone (Psammasteous Limestone)	9
Silurian		Raglan Mudstone Formation		
		Downton Castle Sandstone Formation		
	Upper and Lower Ludlow Shales groups	Whitcliffe Formation		
		Aymestry Limestone Formation		
		Lower Ludlow Shales		
	not defined	Much Wenlock Limestone Formation	Wenlock Limestone	8
		Coalbrookdale Formation		
		Wyche Formation		
	May Hill Sandstone Group	Cowleigh Park Formation	Cowleigh Park Sandstone	8
Ordovician	not defined	Lickey Quartzite Formation	Lickey Quartzite	8
Cambrian	not defined	Hollybush Sandstone Formation	Hollybush Sandstone	8
		Malvern Quartzite Formation	Malvern Quartzite	8
Precambrian	not defined	Warren House Formation	Warren House lavas	7
	Malverns Complex		Malvern Stone	6

Building stones in geological order from the oldest through to the youngest layers.

2 Local Building Stones

Precambrian

The Precambrian rocks of the Malvern Hills are divided into the Malverns Complex and the overlying Warren House Formation. The former is a suite of predominantly igneous rocks, mainly diorites, tonalites and granites, but with some ultra basic material and a variety of metamorphic rocks. It also includes dykes and veins of microdiorite and pegmatite. The Malvern Hills provide one of the largest exposures of Precambrian rocks in England.

Malverns Complex

Malvern Stone

These hard rocks were used locally as a building stone and were subsequently quarried predominantly as an aggregate for roadstone use. Quarrying ended in the area in the 1970s, but many of the large scars can still be seen and have become a paradise for the research geologist. Many houses, churches and walls in Great Malvern, Malvern Wells and West Malvern are constructed with pink, coarse-grained granite blocks, contrasting with finer grained, grey diorite blocks. These provide excellent examples of the use of Malvern Stone. The irregular natural jointing system within the rock means that the building stones are irregularly shaped, which gives a very distinctive polygonal pattern to the constructions. The Highley Sandstone drinking trough at Great Malvern railway station has an arch of Cotswold Stone and red Bromsgrove Sandstone, all set in a wall of Malvern Stone. The station itself is a fine example of the style and use of Malvern Stone.

The distinctive building stone style is ubiquitous in the area and provides a local character all of its own. This is also found in towns and villages a few miles away from the Malvern Hills, at Welland and Guarlford, for example, in buildings and boundary walls. Malvern Wells Church of England Primary School is an eclectic mix of styles, with rubble walls of Malvern Stone and Cotswold Stone dressings. Adjacent cottages are also of Malvern Stone.

Figure 3: Drinking trough, Great Malvern station. Highley Sandstone with arch of Cotswold Stone and red Bromsgrove Sandstone in a wall of Malvern Stone.

Figure 4: Malvern Wells Church of England Primary School. Malvern Stone rubble walls and Cotswold Stone dressings.

Group not defined, Warren House Formation

Warren House lavas

Seen on Broad Down and Hangman's Hill, this formation is composed of volcanic rocks that consist of lavas of basalt and rhyolite, interbedded with pyroclastic ash flows. Pillow lavas at nearby Clutter's Cave suggest submarine volcanic eruptions. Not much use has been made of the rocks of this formation as a building stone, except for incorporation into some local walls.

Cambrian

Group not defined, Malvern Quartzite Formation, Hollybush Sandstone Formation

Malvern Quartzite, Hollybush Sandstone

Sedimentary Cambrian strata are exposed in the southern parts of the Malvern Hills, where the Malvern Quartzite Formation and Hollybush Sandstone Formation can be seen in restricted exposures. Very little use has been made of the stones from these formations, except locally as aggregates and boundary walling.

Ordovician

Group unknown, Lickey Quartzite Formation

Lickey Quartzite

The only Ordovician rock to have been used as a building stone is the Lickey Quartzite: a sedimentary rock deposited in a high energy marine environment and showing variations in colour from purple to white. This hard siliceous rock was used in the north-eastern corner of the county, around Barnt Green and Lickey, for rough masonry and boundary walling. However, it was quarried predominantly as a source of aggregate.

Silurian

The restricted outcrops of Cambrian and Ordovician strata contrast significantly with the very extensive exposures of Silurian rocks. The latter stretch from the northern end of the Precambrian Malvern Hills into the Suckley Hills and northwards to the Abberley Hills. All four divisions of the Silurian are represented: the Llandovery, Wenlock, Ludlow and Pridoli Series.

Llandovery Series, May Hill Sandstone Group, Cowleigh Park Formation

Cowleigh Park Sandstone

The Llandovery Series has at its base the Cowleigh Park Formation, which was exploited on a small scale for its sandstone for building purposes in the Suckley area.

Wenlock Series, Group not defined, Much Wenlock Limestone Formation

Wenlock Limestone

A journey through the villages the Wenlock hills throws up examples of cottages built from the harder, purer, grey limestones of the Woolhope Formation, Much Wenlock Formation and Aymestry Formation. The stone was taken from a whole series of quarries, ranging in size from small pits to

the now disused major excavations of Penny Hill, Whitman's Hill, Woodbury (which ceased operations in 2000) and Shavers End. Careful investigation of walls in this area will reveal a wealth of fossils. Trilobites, corals, crinoids, brachiopods, gastropods and bryozoans are all there in abundance.

Of all the Silurian limestones, it is the Wenlock Limestone that was most commonly used as a building stone. Subsequently quarried largely as an aggregate and for lime burning, it was employed in earlier times in local cottages and as a walling stone. Where is has been used, it varies from calcareous mudstones and siltstones, which weather quite badly, to hard spar-cemented shelly limestones with more porcellanous beds.

It can be seen occasionally as a building stone in cottages, farm buildings and boundary walls along the Silurian outcrop, stretching from Alfrick to Abberley in the western part of the county. St Michael's church at Abberley boundary wall is made of Silurian limestones and siltstones.

Ludlow Series, Lower Old Red Sandstone Group, Downton Castle Sandstone Formation

This formation marks the top of the Ludlow Series. Although used as a building stone just over the border in Herefordshire, it does not have a significant outcrop in Worcestershire.

Pridoli Series, Lower Old Red Sandstone Group, Raglan Mudstone Formation

The upper part of the Silurian marks a change from marine to terrestrial conditions and comprises the fluvial deposits of the Raglan Mudstone Formation. With its chocolate red colour, this provides a great contrast to the grey and beige colouring of the underlying limestones and shales described above.

Silurian – Early Devonian

Lower Old Red Sandstone Group, St Maughans Formation

Bishop's Frome Limestone (Psammosteus Limestone), St Maughans Sandstone

The Raglan Mudstone Formation and the overlying St Maughans Formation surround the valley of the River Teme upstream from Knightwick to Tenbury Wells. The near horizontal strata make a significant scarp slope on the western banks of the River Teme. In the same locality, the junction between the Raglan Mudstone Formation and the St Maughans Formation is marked by the Bishop's Frome Limestone Member (Psammasteous Limestone). The latter is only a few metres thick at best and it was used for lime burning and as a roadstone. It was also used for fonts and decorative work. The building stone is seen in the churches along the valley and on the higher ground to the west, in particular.

This formation consists of red-brown, grey and greenish-grey sandstones, mudstones and conglomerates, and it underlies the extensive plateau at Bromyard to the west of the River Teme. All Saints Church at Shelsley Beauchamp is somewhat of a treasure trove because not only can the great variety of these sandstones be seen in the outside walls of the nave, but also the site is at the foot of the Abberley Hills and the boundary walls are built of grey fossiliferous Silurian limestones and siltstones. Many of the sandstones from the St Maughans Formation have been used as a building stone and they can be seen in their many colours in St Kenelm's Church and a number of cottages at Clifton-upon-Teme, as well as in surrounding villages.

Figure 5: All Saints Church, Shelsley Beauchamp. Lower Red Sandstone Group.

Figure 6: Cottage, Clifton upon Teme. St Maughans Formation sandstone rubble.

Figure 7: St Kenelm's Church, Clifton on Teme. St Maughans Formation sandstones. Tufa window surrounds.

Carboniferous

The higher horizons of the Carboniferous period can be seen in the Wyre Forest Coalfield, where the Coal Measures Group and the overlying Warwickshire Group crop out. It is predominantly the Etruria Formation, Halesowen Formation and Salop Formation of the Warwickshire Group, forming the southern portion of the coalfield, that are found in Worcestershire. The sandstones of the Halesowen and Salop formations have been used to great effect, and much evidence of their former extraction can still be seen in the old quarries of the coalfield and alongside the River Severn, especially near the county boundary with Shropshire.

Warwickshire Group, Etruria Formation

Eturia Formation Sandstones

In the area of north-west Bewdley and beyond, towards Cleobury Mortimer in Shropshire, many thin sandstones have been used for walls of local cottages and for boundary walls. The strata are typically red, purple, grey and mottled

clays, with frequent but impersistent thicker beds of brown sandstones. Sometimes, conglomerates and breccias are also present. All are significant building stones in the village of Far Forest and in the isolated cottages of the Wyre Forest.

The old school and schoolhouse in Far Forest have coursed random rubble walls of brown sandstone from the Etruria Formation of the Carboniferous. Holy Trinity Church at Far Forest shows coursed rubble walls and buttresses of Etruria Formation sandstones.

Figure 8: The old schoolhouse, Far Forest. Etruria Formation sandstones.

Figure 9: Holy Trinity Church, Far Forest. Etruria Formation sandstones.

Warwickshire Group, Halesowen Formation

Highley Sandstone (Thick Sandstone)

The best-known building stone from the Halesowen Formation is the massive light brown rock that reaches 30m thick in the Mamble and Abberley areas. Known as the Highley Sandstone or Thick Sandstone, it has been used in the building of the churches and cottages in Mamble, Bayton and Abberley. In these locations, the rock is massive and grey and brown in colour. It frequently displays iron oxide (geothite) staining on the joint surfaces and Liesegang banding within the rock.

Highley Sandstone has also been used in the construction of other churches along the Rivers Severn and Teme, such as the tower of St Anne's Church at Bewdley, and also for bridges, and country houses such as Abberley Hall and its clock tower folly. Highley Sandstone was are probably part of the original building stone used for three-arched stone bridge built by Thomas Pritchard in 1775. Other bridges across the river and the Severn Valley Railway are constructed of this stone.

The best known Highley Sandstone quarry is quarried alongside the River Severn just over the county boundary in Shropshire. This stone was used in considerable quantities in the construction of Worcester Cathedral. Although the thicker beds are hard at outcrop, the stone weathers poorly. Consequently, it is constantly being replaced at the cathedral by a much harder sandstone of similar colour, also of Carboniferous age, from the Forest of Dean. The Guildhall entrance in Bewdley is a good example of the use of Highley Sandstone and also shows its weathering characteristics.

Figure 10: Road bridge, Stourport-on-Severn. Highley Sandstone.

Figure 11: St Anne's Church tower, Bewdley. Highley Sandstone.

Figure 12: St Mary's Church, Abberley. Highley Sandstone.

Figure 13: Arley House and Gardens, Upper Arley. Local equivalent of Highley Sandstone.

Warwickshire Group, Salop Formation

Alveley Stone (Hexton's Stone)

In general, this is a fine-grained, well-sorted sandstone with common cross-bedding. For many centuries, Hexton's Quarry, just north of Arley, supplied red and grey sandstone to many locations along the River Severn, such as Hafren House, Arley.

Blocks of cut rock can still be seen abandoned alongside the remains of a wharf on the east bank of the river. The rock was transported down river and used in Worcester Cathedral. Indeed, it can also be seen to great effect in the village of Arley, in dwellings, boundary walls and the quayside. It is the principal stone used in St Peter's Church at Arley, All Saints' Church at Wribbenhall and St Martin's Church at Worcester.

Figure 14: Hafren House, Arley. Alveley Stone.

Figure 15: Blocks of cut rock. Alveley Stone.

Figure 16: Arley quayside. Alveley Stone.

Permo-Triassic

All the sedimentary rocks of the Permo-Triassic have a major impact on the topography and buildings of a vast swathe of the central and north-eastern parts of the county. These strata stretch from the Abberley and Malvern Hills in the west to the edge of the south Staffordshire coalfield, and to the Birmingham Plateau in the north and the Lickey and Clent Hills in the north-east. They pass eastwards into Warwickshire, where they continue to be significant, abut the lower Jurassic rocks and Cotswold Hills to the east and south-east, and then spread down the Severn Valley towards Gloucester.

Permian

The Permian rocks of the county are present as the Clent Formation (formerly Clent or Haffield Breccia) and the Bridgnorth Sandstone Formation (formerly Lower Mottled Sandstone).

Warwickshire Group, Clent Formation

Clent Breccia (Haffield Breccia)

The breccia is reddish coloured, with subangular fragments mainly of volcanic origin set in a mudstone matrix. Formed as alluvial fans at the base of the rising mountains created in Variscan orogeny 100 million years ago, the rock can be seen capping the Abberley Hills (where it is known as the Haffield Breccia), at Osebury Rock (a riverside cliff on the Teme) and in the type area of the Clent Hills.

Group not defined, Bridgnorth Sandstone Formation

Bridgnorth Sandstone

These dark red, dune-bedded sandstones crop out between Bewdley and Kidderminster and extend northwards into Staffordshire. The rock is generally quite soft and does not make a good building stone, but it has been used in boundary walls and doorsteps.

Good examples can be seen in Bewdley adjacent to the outcrop. In the town, the bridge carrying the Severn Valley Railway is partly constructed of steeply cross-bedded Bridgnorth Sandstone and cave dwellings are present in the sandstone in the nearby ancient river cliff of Blackstone Rock. The railway viaduct, also in Bewdley, is formed of large blocks of Bridgnorth Sandstone, probably quarried locally.

Figure 17: Wall, Bewdley. Bridgnorth Sandstone.

Figure 18: Railway viaduct, Bewdley. Bridgnorth Sandstone.

Triassic

Overlying the Permian rocks is a sequence of fluvial deposits that form the Sherwood Sandstone Group. The group comprises the Chester Formation (formerly known as the Kidderminster Formation or Bunter Pebble Beds), the Wildmoor Sandstone Formation (formerly Upper Mottled Sandstone) and the Bromsgrove Sandstone Formation (formerly Lower Keuper Sandstone), all consisting of red-brown sandstones and conglomerates. Cave dwellings exist in the Wildmoor Sandstone at Redstone Rock in Stourport-on-Severn and in the Chester Formation in Kidderminster.

Sherwood Sandstone Group, Chester Formation (formerly Kidderminster Formation)

Kidderminster Conglomerate

The conglomerates of the Chester Formation are resistant enough to form a significant ridge running through Kidderminster and the high ground north-east of Bromsgrove, rising further towards the Clent Hills. Occasional local use has been made of sandstones from this formation for buildings, but it is weakly cemented and has been employed predominantly as a source of sand and gravel. The large liver-coloured quartzite pebbles of the conglomerates have been reworked by the rivers flowing southwards at the end of the Pleistocene and today can be seen in some of the old street pavements across central Worcestershire.

Figure 19: Pebbles. Kidderminster Formation.

Wildmoor Sandstone Formation

Wildmoor Sandstone

This sandstone is generally weakly cemented and soft. Its main use has been, and still is, as a moulding sand. However, it does appear to have been used locally in boundary walls.

Bromsgrove Sandstone Formation (Helsby Sandstone Formation)

Bromsgrove Sandstone (Hadley Stone, Holt Stone, Ombersley Stone, Tardebigge Stone)

For building purposes, this is the most widely used stone quarried from the red Sherwood Sandstone Group. Although no quarries now operate, it has been used extensively for churches, public buildings, cottages and boundary walls. Some notable examples are the parish churches at Bromsgrove and Tardebigge, Hartlebury Castle and parts of Harvington Hall. Boundary walls in the Kidderminster and Bromsgrove areas are ubiquitous. Impressive use is also made of the stone in villages such as Belbroughton and Finstall. Some of the best quality Bromsgrove Sandstone came from quarries not only in Bromsgrove but also in the Ombersley area, where some beds provided hard, pink, cream and grey-white building stone, which was put to great use in many parts of the county. It was quarried alongside the River Severn at Ombersley and employed in the construction of Stourport Canal Basins and Worcester Cathedral.

Figure 20: All Saints' Church, Bromsgrove. Bromsgrove Sandstone.

Mercia Mudstone Group, Arden Sandstone Formation, Branscombe Mudstone Formation, Blue Anchor Formation

Pendock Stone, Inkberrow Stone, Arden Sandstone

For much of the latter part of the Triassic period, sedimentation was characterised by the deposition of the mudstone, siltstone, evaporite and occasional sandstone beds that form the Mercia Mudstone Group (formerly Keuper Marl). These beds represent the deposition of water and wind-borne materials laid down in the shallow low-energy sub-aqueous environments of an arid coastal plain. The salt deposits found in the group at Droitwich Spa provide further evidence of these arid environments. Within the Mercia Mudstone Group occurs the locally important building sandstone unit, the Arden Sandstone Formation.

This formation consists of mudstones, siltstones and grey-green to pale grey, fine to coarse-grained and cross-bedded sandstones. Large clasts of softer mudstone are occasionally present. The formation varies in thickness from less than a metre in the area to the east of Droitwich Spa to 5m just east of Worcester to 7m in the south-west of the county. None of the quarries for this rock in Worcestershire were very large because suitable beds of sandstone are thin and not laterally extensive. There is a long winding outcrop of the sandstone between Redditch and Worcester, with some notable examples of the use of the stone. St Peter's Church at Inkberrow is a fine building to inspect, and there are walls and cottages in the village built with the same rock. The outcrop continues as an escarpment to the Gloucestershire border and beyond. The unit reaches 7m thick in the Eldersfield area. The rock has been used in the south of Worcestershire, where it can be seen in the churches, village buildings and boundary walls at Eldersfield, Pendock and Longdon. Churches at Flyford Flavell, Grafton Flyford, Abbots Morton, Rous Lench, Stock Green, Bradley Green and Abberton are all built of Inkberrow Stone. In addition, churches at Feckenham, Dormston, Kingston and Cookhill have dressings of Inkberrow Stone.

Figure 21: St Peter's Church, Inkberrow. Inkberrow Stone.

Penarth Group, various formations

This thin unit, marking the Triassic–Jurassic boundary, represents a regional change from the arid continental environment of the Triassic to the shallow marine shelf seas that characterise the Jurassic.

The Penarth Group predominantly comprises grey fossiliferous mudstones, sandstones and limestones, which distinguish it from the earlier Triassic rocks. The boundary forms a prominent north–south escarpment east of the River Severn.

Jurassic

Jurassic strata are confined to the eastern and south-eastern parts of the county, and they are represented by the Lias and the Inferior Oolite groups. These sedimentary successions were deposited in a shallow marine environment and mark the beginning of a significant period of marine sedimentation.

The Lias Group is subdivided into five formations, with only the Blue Lias and Marlstone Rock formations with significant building stones. Within the county, the Inferior Oolite Group is dominated by typical Cotswold limestone lithologies. They have been quarried for building stone, walling stone, lime and aggregate and are also a source of many of the famous Cotswold fossils. The unit is thickest in the north Cotswolds and thins significantly towards the south. There is a variety of limestone lithologies within the unit, indicating that the nature of the marine environment changed repeatedly from current influenced shoals to lagoons and protected reefs. The higher strata of the Lias Group, together with part of the overlying Inferior Oolite Group, can be seen on Bredon Hill. The hill is a geological outlier and it is in the settlements here and in the nearby village of Broadway that the full glory of the yellow-brown ooidal limestones can be seen in nearly all the buildings.

There are many old quarries on Bredon Hill, most of them closely associated with a nearby settlement. Several of these quarries worked the thinner beds of limestone for roofing slate and boundary walling purposes. Examples of both these uses can be seen around Bredon Hill and along the adjacent Cotswold escarpment, as well as further westwards away from the source itself.

The Inferior Oolite Group is divided into the Birdlip Limestone Formation (Lower Inferior Oolite), the Aston Limestone Formation and the Salperton Limestone Formation. They are all represented at outcrop east of Broadway. The Birdlip Limestone includes one large building stone quarry just inside the county boundary on Fish Hill. It has now ceased operating.

Figure 22: Broadway village. Ooidal limestones.

Lower Jurassic

Lias Group, Blue Lias Formation

Stock Green Limestone, Blue Lias, Cementstone

The Blue Lias Formation has at its base the Wilmcote Limestone Member, which is up to 8m thick. It forms a small escarpment running from the Gloucestershire border in the south to Redditch in the north, where it is known as the Stock Green Limestone. Records show that it was much quarried for lime burning and as a building and paving stone. The thinly bedded grey and brown argillaceous limestones, frequently with thin shelly layers, have been used as building stones in villages near to the outcrop. It can be seen, in its many variations, to great effect in the buildings and grounds of Evesham Abbey. For example, the 14th-century Almonry in Evesham is constructed of coursed rubble Blue Lias and Cotswold limestones, with a Cotswold slate roof. The limestone is also seen in many villages, such as Cleeve Prior, Drakes Broughton, Broughton Hackett and Upton Snodsbury.

Figure 23: Cobbles, Evesham Abbey. Blue Lias.

The Rugby Limestone Member forms the upper part of the Blue Lias Formation. Often referred to as cement stone, it is a grey muddy limestone that again forms a small escarpment just east of the Wilmcote outcrop. There are many small old quarries, but there is little surviving evidence of the production of building stones.

Figure 24: Boundary wall, Worcester Crematorium. Blue Lias.

Figure 25: The Almonry, Evesham. Blue Lias and Cotswold limestones, Cotswold slate roof.

Marlstone Rock Formation

Marlstone (Marlstone Rock)

Lying near the top of the Lias Group is the Marlstone Rock Formation. This formation is up to 6m thick, and it is represented by a sequence of fossiliferous, grey and brown ferruginous limestones and grey sandy limestones. It forms a shelf on the western and northern sides of Bredon Hill and is present on the scarp slope at Broadway. It is often covered by landslip deposits. A few small quarries provided local building stone.

Middle Jurassic

Inferior Oolite Group, Birdlip Limestone Formation

Cotswold Stone

This limestone-dominated formation contains important ‘freestone’ beds, so called because they can easily be cut and shaped for building purposes. They are well-bedded, medium to coarse-grained ooidal and bioclastic limestones. The higher beds in the succession are of less massive, thinly bedded limestones and are typical of the rocks that have been used locally for drystone walling. Within Broadway Quarry, excellent exposures of the Cleeve Cloud Member and the Notgrove Member limestones are seen. These are the principal freestone beds within the quarry and in surrounding exposures that have contributed to the striking building stones vistas of the Cotswold villages.

These villages include Broadway, Bredon, Ashton under Hill and Overbury. However, the stone is also much used at some considerable distance from its source area and can be widely seen in buildings in Worcester, Evesham, Pershore, Malvern, Bewdley and many other towns and villages in the county. In Worcester, a few churches are constructed in Cotswold Stone and in the Malvern area some public buildings are also built of the limestone. Cotswold Stone is ubiquitous as quoins, gateposts, mullions and so forth throughout the county, where it has often been used in different locations alongside Malvern Stone, tufa, Triassic sandstones, Blue Lias and Arden Sandstone.

Figure 26: Tythe barn, Bredon. Cotswold Stone.

Figure 27: Almshouses, Bredon. Cotswold Stone.

Quaternary

Various groups, various formations

Tufa, Quaternary pebbles

The Quaternary deposits of the county range from Anglian to Holocene in age. They include till, fluvo-glacial outwash sands, lacustrine clays, tufa deposits and extensive fluvial sands and gravels, as well as landslip and peat deposits. Of greatest significance as a building stone, however, is the Holocene limestone tufa. This has been used to a remarkable extent across the county. Pebbles from the conglomerates of the Chester Formation (Triassic) have been reworked and deposited in the terraces of the River Severn, and they are frequently found in the pavements and walkways of riverside towns.

As noted previously, the Bishop's Frome Limestone marks the junction between the Raglan Mudstone Formation and the St Maughans Formation of the Devonian Old Red Sandstone. Although only a few metres thick at best, this limestone played a major part in the formation of a series of Quaternary limestone tufa deposits (probably formed in the past 10,000 years) that run along the escarpment on the western side of the Teme Valley. Groundwater percolating through the sandstones of the St Maughans Formation has dissolved out calcium carbonate from the underlying Bishop's Frome Limestone and then reprecipitated it along a spring line at the contact with the underlying impermeable Raglan Mudstone Formation.

Impressive cliffs of tufa can be seen at Southstone Rock and in the woodlands of the escarpment in locations with spine-chilling names, such as Witchery Hole and Hell Hole.

This hard, light, porous tufa, which can be freely carved, has been used as a local building stone and can be seen to great effect in St Andrew's Church at Shelsley Walsh, St Kenelm's Church at Clifton-upon-Teme and SS Peter and

Paul's Church at Eastham, as well as in local houses and walls. However, its importance is best portrayed in Worcester Cathedral, where it has been used in the vaulted ceilings between the ribs.

Figure 28: Worcester Cathedral. Tufa between the ribs.

3 Examples of Imported Building Stones

Worcestershire is surrounded by counties that have produced a wide range of building stones, many of which have been imported into the county. Tixall Sandstone from Staffordshire was used in the construction of Worcester Bridge, and Grinshill Sandstone from Shropshire is the main building stone of Ombersley Court and church. River and canal transport enabled the use of both of these Triassic stones in Worcestershire, and also Holt Stone and Highley Sandstone. Repair work to the quayside in Bewdley, as part of recent flood prevention work, included red Permian St Bees Sandstone from Cumbria. This now forms part of the impressive riverside walls, alongside the much older constructions of Highley Sandstone, Holt Stone and Alveley Stone. Bath Stone was used in Croome Court at Croome D'Abitot, and for dressings at Chateau Impney near Droitwich Spa. Painswick Stone was employed in the construction of St Mary's Church at Croome Park. Another replacement stone that was used a great deal in repair work at Worcester Cathedral, Hartlebury Castle and various parish churches is the Triassic red and grey Hollington Stone from Staffordshire.

Figure 29: Worcester Cathedral. Hollington Stone.

There are notable examples of the use of white ooidal Portland Stone (Upper Jurassic) in Worcester. It stands out well, with its large bivalve fossils, in the extensive facing of the old police station (now the College of Technology) and the adjacent fire station. Other interesting constructions include Hewell Grange (now HM Prison) at Tardebigge, which is made of Runcorn Sandstone (Permo-Triassic), and buildings in Hanley Swan, Suckley and Malvern constructed of Cradley Stone (Silurian Downton Castle Sandstone).

Dolerite setts and kerb stones are found in many locations. The old ones from the Clee Hills are easily detected by their smooth surfaces and rounded corners. Palaeozoic sandstones and siltstones are used as flagstones and kerbs in many towns and villages and are particularly well represented in Bewdley.

Finally, reference should be made to the smoothly cut, grey and brown, fine-grained sandstones that are now being used in the pavements of many town centres. These Carboniferous Millstone Grit rocks, with their Liesegang patterns, are from Crosland Hill in West Yorkshire.

Figure 30: Chateau Impney Hotel, Droitwich Spa. Bath Stone dressings.

4 Further Reading

The Further Reading, Online Resources and Contacts guide provides general references on:

- Geology, building stones and mineral planning
- Historic building conservation, architecture and landscape.

There is also a separate glossary of geological terms.

Worcestershire references

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Herefordshire & Worcestershire Earth Heritage Trust 'Building Stones Database' http://www.buildingstones.org.uk/building-stones/

Herefordshire & Worcestershire Earth Heritage Trust trail guides:
Abberley Village Churches Building Stones & Geology Trail
Abberley Hill Landscape & Geology Trail
Bewdley Town Centre Building Stones & Geology Trail
Bredon Hill (west) Landscape & Geology Trail
Broadway Building Stones Trail
Bromsgrove Geology & Heritage Walking Trail
Clent Hills Landscape & Geology Trail
Great Malvern Building Stones Trail
Lickey Hills Landscape & Geology Trail
Malvern Hills (1) Landscape & Geology Trail
Malvern Hills (2) Landscape & Geology Trail
Malvern Spouts & Stones Geology & Heritage Walking Trail
Worcester Cathedral Building Stones Trail
Worcester City Centre Building Stones Trail
Wyche and Purlieu Geology & Landscape Trail
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Figures

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