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The building stones of Ludlow: a walk through the town

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ROSENBAUM, M.S. (2007). The building stones of Ludlow: a walk through the town. *Proceedings of the Shropshire Geological Society*, **12**, 5-38. The buildings in the centre of Ludlow reveal the geology of south Shropshire, reflecting both the availability of suitable stone and the changing fashions and technologies of using it. This ranges from the local, somewhat friable, grey calcareous siltstone of Whitcliffe, through the stronger yellow, red and purple sandstones of late Silurian age, to the Carboniferous dolerite intrusions of the Clee Hills to the east.

A number of glaciers almost met in late Quaternary times, bringing with them a wide variety of sand and gravel, some of which has been employed in the town.

Improved bulk transport from Georgian times onwards (canals, then railways and latterly roads) has enabled use to be made of better quality stone sourced from more distant quarries.

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1. GEOLOGICAL SETTING

The bedrock geology of Ludlow is predominantly Silurian in age, deposited some 420 million years ago. The dome-shaped hill of Whitcliffe Common that overlooks the town (Figure 1), rising into Mortimer Forest to the west, is the result of an upfold in these rocks, effectively demonstrating an anticline. Its detailed characteristics within Mortimer Forest are described in the guide by Andrew Jenkinson (2000) whilst the basic stratigraphy may be studied in the shorter walk along the banks of the River Teme below Whitcliffe Common in the leaflet written by Kate Andrew and Martin Allbutt (Andrew, 2002).

Figure 1. Whitcliffe Common overlooking the town is the result of an anticlinal upfold in calcareous Silurian rocks. The weaker Raglan Mudstone Formation outcrops to the right (north). View from the top of St. Laurence's church tower.

Geological maps of the area have been available in published form for some time, the earliest being in 1832 (Wright & Wright). Their evolution chart the development of geological science in general as well as knowledge concerning the local structure and stratigraphy in particular, yet significant uncertainties still remain. Copyright restrictions prevent their reproduction here, but the interested reader is referred to the References (Murchison, 1839; Curley, 1863; Elles & Slater, 1906; Holland *et al.*, 1963; Lawson, 1973; IGS, 1973; Cross & Hodgson, 1975; BGS, 2000). Copies of most of these maps may be studied at the Ludlow Museum Resource Centre by appointment.

This walk picks up on the published geological record, and will briefly point out the local geology and how it has helped the town to become established and flourish, focussing on where buildings have been built on and with stone, and from where that stone has come.

The whole route is likely to take a full day, beginning around the foot of the castle, progressing around its north side to St Laurence's church, thence north to St Leonard's, east by the railway station to Gravel Hill and up to St Peter's church, then back to the centre of town. Having studied the buildings in Mill Street and Broad Street, the walk heads south over Ludford Bridge to Ludford Corner and back through Whitcliffe Common. Breaks can conveniently be taken at any of the numerous public houses and tea rooms within the town.

The walk is designed as a Trail to lead the visitor through the evidence exhibited in

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building materials won from the ground, both rock and soil. This traces over four hundred million years of Earth history from the late Silurian when life was just beginning to become established on land, 420 million years ago, through the Devonian when major tectonic forces folded and later faulted the ground, largely as a result of being draped over crustal blocks beneath. These blocks are composed of even older rocks moving along faults at depth in response to huge stresses generated by the collision of two continental plates towards the end of the Silurian. Subduction (destruction) of the intervening oceanic crust of the *Iapetus Ocean* was taking place north and west of Shropshire; movements continued for some considerable time as the stresses equilibrated.

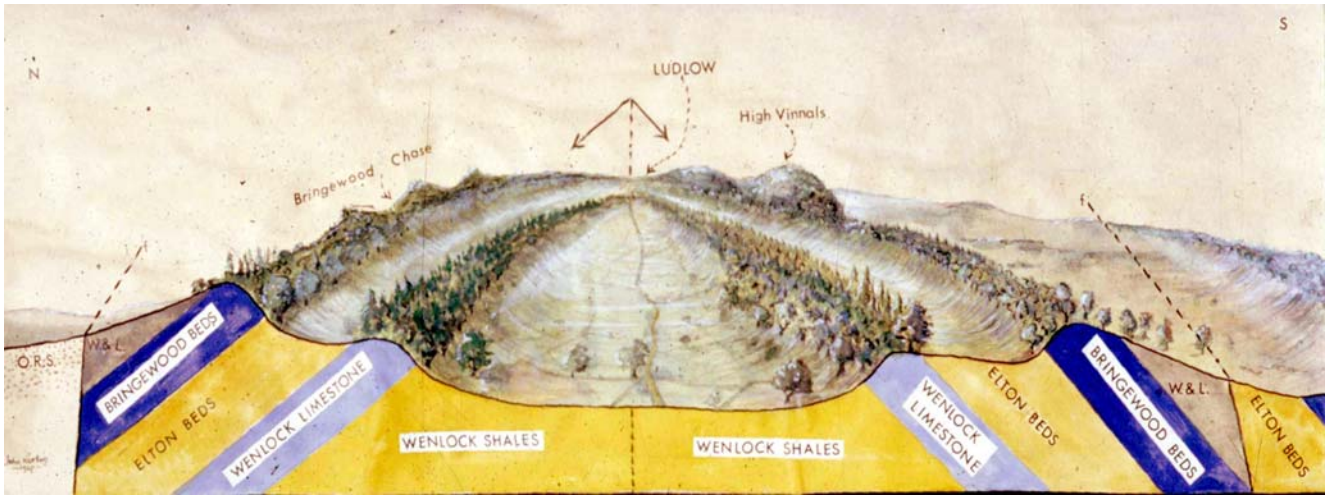

Figure 2. John Norton's unpublished geological summary of the Ludlow anticline (ca. 1970). Image taken from a 35 mm slide in the Ludlow Museum Resource Centre collection.

Later deposits have been laid on top and subsequently eroded away, so that we now see the Silurian and Devonian overlain by material resulting from the later phases of the Quaternary Ice Age, particularly the Devensian Stage which saw the last great advance of the glacial ice across northern and western Britain (from 120,000 to just 11,000 years before present), and whose meltwater scoured the gorge through which the present-day River Teme now flows.

The basic configuration of the bedrock geology is illustrated by the cross-section prepared by Sir Roderick Murchison for a lecture he gave in 1852 to the Ludlow Natural History Society. This was based on fieldwork commenced in 1831 and published in his major volume *The Silurian System* (Murchison, 1839). The cross-section is currently hanging in the Ludlow Museum, Assembly Rooms, Market Street, Ludlow. This was subsequently modified by later research and a composite diagram was published by John Norton, curator of Ludlow Museum for many years in the second half of the 20th Century (Figure 2).

A summary stratigraphic table is presented to provide an overview of the stratigraphic succession (Figure 3).

The Trail (Figure 4) has been designed to be followed on foot using public roads and footpaths. A hand lens will be found useful but visitors should refrain from using hammers since the exposures are few in number and small in size. Visitors should also follow both the Countryside Code (Anon., 2006) and the Geological Fieldwork Code (Geologists' Association, 2006).

The numbers within squared brackets in the text refer to grid references for the stopping points ('Localities'). 8-figure grid references locate the feature to the nearest 10 m.

Start at the Dinham Millennium Green [5073 7445], by Dinham Bridge on the River Teme below the west end of the Castle. There is limited parking for private cars across the bridge, away from the town. There is a seasonal public car park (fee) and toilets along Linney, beneath the castle, some 200 m upstream of the bridge on the town side.

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TIME (Ma)			LITHOSTRATIGRAPHY			THICKNESS m	LITHOLOGIES	DEPOSITIONAL ENVIRONMENT	BUILDING MATERIALS
			GROUP	FORMATION / member	LOCAL NAME				
.02	Quaternary			DEVENSIAN	Superficial Deposits	up to 10	Soils, alluvium, glacial till, fluvioglacial gravel, glacial lake clays, tufa.	Glacial-Periglacial. 50°N ie. ½ km to the south	Concrete aggregate, drainage filters, Building stone (tufa)
									Variscan (Hercynian) folding
320	CARBONIFEROUS	WESTPHALIAN	KINLET	CLEE DOLERITE	Dhu Stone	50+	Dolerite, very strong, with olivine and analcite.	Basic igneous intrusion. 10°N i.e. 4500 km to the south	Road aggregate; formerly paving setts and kerb stones
					Coal Measures	up to 80	Clays, grey and yellow. Sandstones, fine to coarse. Coals. Ironstone nodules.	Alluvial-deltaic plain. Tropical, high rainfall forest-swamp	Coal, Fireclay, Iron ore, Building stone
330				CORNBROOK SANDSTONE		up to 200	Sandstones, coarse, yellow-grey, iron-stained. Shales, clays, thin coals	Alluvial to deltaic. Tropical, patchy forest	Building stone, Millstones
									Emergence
359		TOURNASIAN		ORETON LIMESTONE	Clee Hill Marble	up to 45	Limestones, grey, buff, blue, some hard, crystalline, some oolitic, crinoidal. Shale layers. Sandstone at base.	Shallow open marine. 0° i.e. 5500 km to the south	Lime, building and ornamental stone
									Marine transgression
375	DEVONIAN	FAMM-FRAS	FARLOW (formerly Upper Old Red Sandstone)	U L		up to 20	Conglomerates, grey-green. Mudstones. Conglomerates with quartzite pebbles. Sandstones, yellow and brown.	Alluvial. 4°S i.e. 5940 km to the south	Building stone
									Acadian (Late Caledonian) folding
416		GEDINNIAN	DITTON (formerly Lower Old Red Sandstone)	ST MAUGHANS	*Psammosteus* Limestone	300	60% Mudstones, red-brown, alternating frequently with Sandstones (25%), red, brown, olive. Concretionary and conglomeratic 'cornstones' (calcretes). Coarse Sandstones increasingly common towards top.	Alluvial plains with stream channels; calcrete soils. Hot arid. Low seasonal rainfall	Building stone Lime
419	SILURIAN	PRIDOLI	DOWNTON (formerly Lower Old Red Sandstone)	RAGLAN MUDSTONE (formerly LEDBURY)	Holdgate Stone (red-purple) Felton Stone (red, mottled green-grey)	450	80% Mudstones-Siltstones, red, alternating with Sandstones (20%), coarse, red-purple, micaceous. Pedogenic carbonate nodules, 'cornstones' (calcretes) and conglomerates.	Alluvial muds, channel sands; calcrete soils. Largely arid. Spasmodic rain. 24°S i.e. 7900 km to the south	Brick and Tile clays Building stone (Felton and Holdgate)
				TEMESIDE SHALE	Tilestones	30	Mudstones, Siltstones, green, olive, pale red. Thin Sandstones ('Tilestones').	Estuarine mud flats	Possibly flags and tiles
				DOWNTON CASTLE SANDSTONE	*Platyschisma* Shale Ludlow Bone Bed	up to 20	Sandstones, yellow, fine, micaceous, cross-bedded, channelled. *Lingula.*	Beach sand, intra-tidal mudflat	Building stone (Downton Castle Sandstone)
									Emergence
423		LUDLOW	LUDFORDIAN (formerly Upper Ludlow Shales and Aymestry Limestone, but the latter is actually older than the Leintwardine)	WHITCLIFFE (UPPER)		30-55	Siltstones, olive-grey weathering brown, thinly bedded (flaggy), calcareous; local shelly limestone. Fossiliferous, esp. brachiopods: *Microsphaeridiarhynchia [Camarotoechia]*, *Protochonetes*, *Salopina.*	Shallow open marine	Rubble stone
				WHITCLIFFE (LOWER)	Blue-hearted Stone Pendle	24-120	Siltstones, yellowish grey weathering brown, poorly bedded to massive due to bioturbation by the worm *Serpulites* and to slumping, calcareous; local shelly limestone. Volcanic ash bands.	Shallow open marine. 25°S i.e. 8000 km to the south	Building stone
				LEINTWARDINE (UPPER)		up to 6	Siltstones, calcareous with shelly limestone beds, grey, thinly bedded; carious (honeycomb) weathering.	Shallow open marine	
				LEINTWARDINE (LOWER)		30-110	Siltstones, calcareous with shelly limestone beds, grey, thinly bedded.	Shallow open marine	Lime

Figure 3. Summary stratigraphic table to provide an overview of the stratigraphic succession (inspired by the stratigraphic column from the Black Country Geological Society's Clee Hill fieldtrip handout dated 27th June 1993).

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Figure 4. Street map of central Ludlow showing the localities described in the text.

LOCALITY 1: Castle Mill, Dinham Millennium Green [5071 7450]

The mill building was rebuilt as a swimming baths in 1961, but closed 30 years later. The north wall shows its stone construction, with blocks of grey calcareous siltstone. These are of Upper Silurian age and have come from the Whitcliffe Beds which have been extensively quarried across the River Teme, within Whitcliffe Common.

The rock is sedimentary, laid down in a shallow warm sea teaming with life, but at a time when life had only just begun to emerge onto land. Indeed, when this area was visited in the mid 1800's by Murchison, the eminent geologist who helped define the modern science of stratigraphy, it was thought that these rocks preceded the emergence of life onto land, and that the very first fossil evidence does not appear until the time when the rocks which

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overlie the Whitcliffe Beds were deposited; these are from what is now known as the Ludlow Bone Bed, which outcrops at Ludford Corner (Locality 30).

From a building stone point of view this siltstone is reasonably good, but has a poor reputation locally since it flakes. This is in part due to frost action, particularly where the calcite cement is poorly developed. The fresh rock is mid-grey in colour, but it weathers to a brown colour due to the oxidation of iron sulphide to iron oxide.

However, the success with which stone can be used as a building material depends not only on its intrinsic properties (e.g. strength, durability, colour) but also how it is used (and abused!). It is best to think of stone as a person, happier kept the same way up as it was in the ground, allowed to closely hug its neighbours, and be able to breath. Problems arise when this isn't done, for instance stones stood on end (aggravating weathering and spalling), rendered and then covered with impermeable paint (leading to damp), or separated by thick layers of mortar (especially OPC rather than lime mortar since this not only inhibits moisture movement, forcing water through the stone, but its high alkalinity can also cause chemical reactions with neutral or acid stone leading to decay).

From the Dinham Millennium Green, cross the road (Linney) and walk north-north-east up the footpath below the western wall of Ludlow Castle. This was laid out for recreation purposes in the 1770s by the Earl and Countess of Powis. As the path curves to the east note the exposure of calcareous siltstone on the right.

LOCALITY 2: Below the walls of Ludlow Castle [5075 7455]

The Whitcliffe Beds are exposed at the base of the castle walls at the top of this bank, but it is a scramble to reach them (Figure 5). However, the features here are difficult to see because of the shadow cast by the trees and the growth of moss and lichen.

Figure 5. Whitcliffe Beds forming the base of the castle walls and the material for constructing those walls.

The dip of the Whitcliffe Beds here is 2° towards the north, consistent with its position on the northern flank of the Ludlow Anticline.

The strength is comparable to brick, and the walls of the Norman castle above are largely made of this material (won by quarrying the moat that surrounds the keep). Later medieval construction utilised somewhat stronger red-brown sandstone, probably the Holdgate Stone from upper Corvedale and, later (in early Tudor times), the purple Felton Stone that had just been used for St Laurence's church (Figure 6).

Figure 6. Red-brown Holdgate Stone used for the quoins to the walls of the castle keep.

Note the open fissures within the siltstone hereabouts. These are not characteristic of the exposures seen the other side of the river and indicates that the rock here has been severely

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stressed. One possibility that comes to mind is that the weight of the rock above, helped by the castle walls, has pushed the rock down and out. Another possibility relates to the effects of the relatively recent Ice Age, when the slope was rapidly excavated by meltwater (the glaciers reached Craven Arms and the meltwater flooded south, spreading huge quantities of gravel as an apron in front of the ice sheet, currently being excavated around Bromfield).

However, the ground to the north is quite low, and the soils much redder than beneath the Castle or to the south. When the railway tunnel by Ludlow station was excavated in the 1850's a fault was discovered, and this lies on a direct line with the north side of the Castle. So here we have an extensive fault, which downthrows the rock on the north-western side; it continues south-west along the north-western side of Bringewood Chase. The downthrown rock at this level is younger than the siltstone, and is a red-brown mudstone known as the Raglan Mudstone Formation (Figure 7).

Figure 7. A summary of the bedrock geology along the north side of Ludlow Castle.

Figure 8. Raglan Mudstone exposed in the face of the old brick pit, Fishmore Road. Whittles bus garage beyond.

Figure 9. Close-up of the Raglan Mudstone exposed in the face of the old brick pit, Fishmore Road, showing reduced iron oxide along siltstone horizons. The prominent bed above is a fine grained sandstone, thin beds of which were referred to as "Tilestones" by Murchison and used for roofing purposes in Herefordshire and Breconshire prior to the widespread availability of Welsh slate (Figure 10 below).

Figure 10. Fine grained sandstone, thin beds of which were referred to as "Tilestones" by Murchison and used for roofing purposes. Example from archaeological excavation opposite Tesco, Corve Street.

The Raglan Mudstone Formation is also important to Ludlow since it supported a major brick and tile manufacturing industry during Georgian and Victorian times, with two major brick works operating in the north of the town

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(by the railway station at Quarry Gardens and along Fishmore Road, behind the Whittle bus garage; the Fishmore Road works closed as recently as 1948) (Figures 8 to 10).

Continue along the level footpath towards Upper Linney, stopping by the south wall of the first stone house on the right.

LOCALITY 3: Castle Walk House [5090 7470]

Castle Walk House provides a good example of Georgian vernacular building construction, with walls built of calcareous siltstone from the Whitcliffe Beds (Figure 11). The render is partly for appearance and partly for protection, to reduce spalling. However, use of modern cement tends to inhibit moisture movement and can lead to problems of damp within. Lime mortar allows a building to 'breath'.

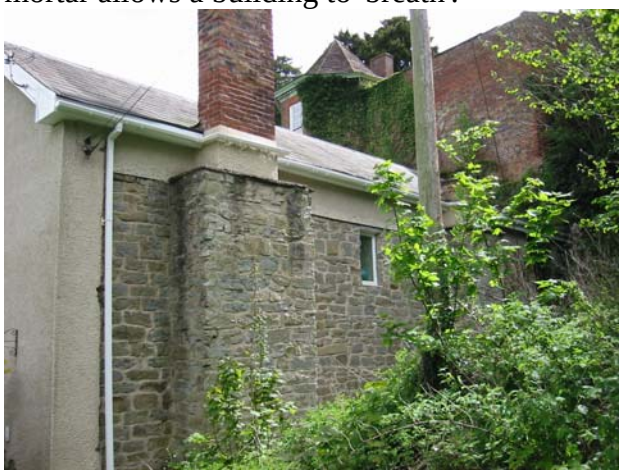

Figure 11. Whitcliffe Beds used for the walls of Castle Walk House.

Look across the road to the house that has recently (2005) been constructed by the side of the Linney, above the tennis courts.

LOCALITY 4: Castle Meadow, Linney [5095 7475]

Castle Meadow was constructed in 2005 having specified the use of natural building stone for the walls, although this just forms a visual skin since the structural strength comes from the use of concrete construction blocks.

A pale brown limestone has been chosen. This is of Middle Jurassic age quarried in the Cotswolds, a geologically much younger rock than any which outcrop in South Shropshire. The corners are of red brick (Figure 12). The appearance may contrasted with Castle Walk House.

Figure 12. Jurassic limestone used for Castle Meadow, the new house constructed in Linney 2005, above the tennis courts.

How do you feel about the use of natural building materials imported from other regions as opposed to the use of locally sourced materials? Consider this not only visually but also in terms of the impact on the environment, considering aspects such as the urban landscape (atmosphere and neighbourhood), the natural environment (quarrying), and economics (employment and skills). To what extent are the use of natural material and local skills sustainable, bearing in mind cost and availability? The concepts of 'footprints' and recycling may be relevant to the discussion.

Continue uphill, along Upper Linney. Looking to the right, behind some of the houses the Town Wall can be seen to be founded directly on exposed Whitcliffe Beds siltstone, for instance behind Gallery House at the west end of Upper Linney. Proceed to the junction with College Street, the site of Linney Gate which once provided pedestrian access through the Town Wall.

LOCALITY 5: Linney Gate [5100 7475]

The Town Wall is 13th Century in age and this section is largely constructed of Whitcliffe Beds calcareous siltstone excavated from the outer side along the line of the Town Ditch. The Ditch is no longer visible, having been completely infilled during the Middle Ages.

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The sedimentary details of the Whitcliffe Beds calcareous siltstone can be more readily observed in the building stones than back in the shade of the castle walls. Note the stratification, formed by successive deposits of silt on the sea bed. Silt is intermediate in grain size between sand and clay, and is characteristic of wind-blown dust ('loess'). Evidence of life can be seen as fossils: burrows, where crustaceans and worms dug for food or shelter in the sea bed, and shells (brachiopods and gastropods). Some of the brachiopods are distinctive of this Ludfordian age: notably *Microsphaeridiarhynchia (Camarotoechia), Salopina* and *Protochonetes*.

Not all the laminations are regular - some are clearly disturbed, evidence of contemporary slope instability (Figure 13). From a building stone viewpoint these slumped beds yield poorer quality stone since the slumps behave rather like knots in wood. This made it difficult to produce consistent quality stone and the variation in strength made the stone more susceptible to decay on exposure to the weather. Certain beds within the Whitcliffe quarries were significantly affected by such slumping and were avoided by the quarrymen for the better quality building stone. The best quality was known as "blue-hearted" stone and can be won from the horizon classified by geologists as the Lower Whitcliffe Beds.

Figure 13. Slumping of sediment soon after deposition revealed by disturbed bedding in Whitcliffe Beds siltstone used in the wall of the Old Coach House, Upper Linney. Beds above are undisturbed and post-date the slumping episode.

The rounded corner of the Old Coach House, just above head height, displays a spectacular fossil cephalopod *Orthoceras*, the hard part of a creature related to the ammonites and cuttlefish (Figure 14).

Figure 14. *Orthoceras*, a fossil cephalopod, just above head height in the wall of the Old Coach House, Upper Linney.

Figure 15. Base course of sandstone flags (probably Downton Castle Sandstone Formation) to No.4 College Street. The apron consists of assorted gravel from the fluvioglacial deposit at Bromfield.

Next door is No.4 College Street, the Rectory for St Laurence's. The ground floor is built of calcareous siltstone from the Whitcliffe Beds. The foundation is lined with sandstone slabs placed vertically, and thus likely to be rather younger than the age of the walls. The stone slabs are similar in appearance to the facing of the gate to the cemetery on the site of the former Carmelite Friary in Corve Street (Figure 15). It may have been recycled from there, since both sites are owned by the church. However, its origin is uncertain and is unlike any other sandstones currently exposed in the vicinity. The probability is that this came from a small quarry in the Downton Castle

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Sandstone Formation to the northwest of Ludlow, but there are other possible origins too (discussed in more detail at Locality 8).

Proceed up College Street, stopping at the west end of St Laurence's to view the north wall of the Parish Church.

LOCALITY 6: St Laurence's Parish Church [5100 7465]

St Laurence's was rebuilt in 1199 but significantly enlarged in the 14th Century with wealth from the wool trade, and extensively transformed in the 15th Century. This may be seen from the change of stone halfway up the north chancel (St Margaret's Chancel in the North Transept). Little remains of the 12th Century church, but fragments can be recognised such as in the lower part of the north wall of the nave, incorporated within the present structure (Figure 16).

Figure 16. North side of the nave, St. Laurence's church, with lower courses (above the lower rib) of grey calcareous siltstone from the Whitcliffe Beds. The predominant material is pale green-grey and red-brown sandstone, also of Silurian age but somewhat younger, formerly known as the Old Red Sandstone and deposited on a terrestrial alluvial fan rather than in the shallow shelf sea of Whitcliffe times. The prominent rectangular blocks date from the 1950's restoration, which utilised red Hollington Stone (of much younger, Triassic, age).

The early church was originally built of greenish grey flaggy calcareous siltstone from the Whitcliffe Beds: (of the Whitcliffe Formation of Upper Silurian age), similar to the stone used for the 14th Century South Transept which can still be clearly seen (Figure 19). The Whitcliffe Beds weather to a brown colour along discontinuities such as bedding planes and joints. It was also used for some of the window surrounds but it is prone to weathering when placed adjacent to mortar, especially OPC which prevents moisture passing through and thus increases the dampness of the mudstone, making it prone to frost and leading to severe spalling.

However, the principal stone is a pale greenish-grey and red-brown sandstone. This is from what was known in Murchison's day as the Old Red Sandstone. Although still in common usage, scientifically this name is quite misleading since rocks of this age are not necessarily red or of sandstone! Silty mudstones and thin cornstones (a kind of limestone created from fossil soils) are rather more common than the sandstone horizons! These are well displayed in the 16th Century extensions within the Outer Bailey of Ludlow Castle, next to the souvenir shop (Figure 17).

Figure 17. A block of cornstone from the wall of the Judge's Lodging, Ludlow Castle.

The 'Devonian' is the age term that has generally replaced it, although after more than a century of controversy there is now international agreement that the lower part of the sequence should be ascribed instead to the Upper Silurian, and this is the age of the deposits closest to Ludlow. This is the result of discovery of fossiliferous rocks of similar age at Pridoli, in the Czech Republic.

The source of this sandstone, the principal building material of the 13th and 14th Centuries, is not known for certain. It is similar in appearance and colour to the stone used for some farm outbuildings about one mile east of Ludlow, for example at Rock Farm and Dodmore Manor, although neither are known to be associated with quarries. Lloyd (1980)

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considers this to be a likely source, listing the area now known as Rockgreen; Rock Lane has existed since medieval times and achieved some notoriety as a no-mans land between two major parishes. The name 'Rock' would seem to suggest a suitable source of stone, but there is no direct evidence on the ground for past quarrying. This could possibly be a sandstone bed within the Raglan Mudstone Formation which is relatively poor in iron oxide

Some 2 miles to the north-east of Ludlow, around Middleton and on the Downton Hall estate, there are a number of disused quarries. Old buildings in the vicinity are constructed of mottled red and green sandstones but with a stronger brown colouration than those used in the 13th to 14th Centuries at St Laurence's, so on balance it seems more likely that the source of the sandstone for the church lies somewhere to the east of town, about one mile distant.

A somewhat more reddish sandstone was used for some of the 14th Century construction. This is similar to the sandstone used for Broncroft and Holdgate Castles, built around the same time and located a few miles up Corvedale. This material is known as Holdgate Stone, the South Porch of St Laurence's being perhaps the best example (Figure 24).

For the extensive transformation in the 15th Century and the reconstruction of the 19th Century a different stone was used, of similar age to the reddish Holdgate Stone. This is the purple coloured Felton Stone, which tends to be coarser than the Holdgate and micaceous (Dineley, 1950) (Figures 19 and 20).

This sandstone is local too, some of which has been supplied from quarries north of Ludlow, just east of Felton between Ludlow and Bromfield (Figure 18). It was deposited on land by rivers flowing from hills being eroded far to the north-west. It has a characteristic reddish purple colour, but often contains pale greenish grey patches where the iron minerals have been reduced as a result of chemical changes ('diagenesis') during geological history. Church Warden accounts from the 15th Century note the supply of stone from Felton.

Figure 18. Felton Quarry, the source of much of the purple and red sandstone for St. Laurence's church.

This same stone was extensively used by Sir Henry Sydney in his mid 16th Century reconstruction and development of Ludlow Castle. However, transport would have had to have been by packhorse or cart. An alternative source of supply with transport by barge could have been from Herefordshire, where stone of similar appearance was quarried from Capler Quarry on the River Wye and used for the Cathedral. The Wye links to the Severn and thence to the Teme, but the distance is considerable and the Teme is too shallow to be easily navigated.

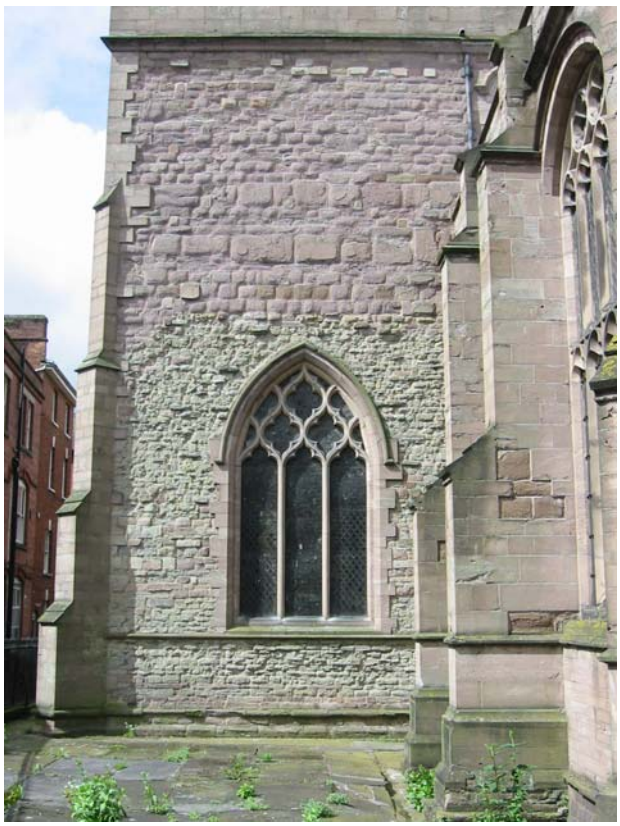

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Figure 19. Calcareous siltstone beneath contrasted with sandstones (Felton Stone) above (larger block size; deep purple in colour). St Catherine's Chancel, St. Laurence's.

Figure 20. Two contrasting sandstones: Holdgate Stone below, Felton Stone above (larger block size; deeper purple in colour). St Margaret's Chancel, St. Laurence's church.

The Felton Stone may be readily inspected around the Vestry, where cross-bedding can be seen (similar to that present in the Old Red Sandstone, Figure 21), as can intra-formational conglomerates, with mudstone clasts (Figure 22), indicative of an alluvial environment with periodic flooding (and ripping up of alluvial muds). The mudstones easily weather, leading to a pock-marked surface.

The paving stones outside the Vestry are old gravestones, largely of Georgian age (Figure 23). York Stone from the Upper Carboniferous around Halifax is one common source, but transport would have been difficult and expensive from Yorkshire in Georgian times. It is more likely that these are from the similarly aged Highley Group that was being quarried around Highley and Upper Arley in the Severn Valley in the 18th Century. This sandstone has a greenish-grey colour and is cross-bedded, often with deep small scale ripple marks. Transport to Ludlow would have been relatively straightforward; indeed, many materials were carried to Ludlow at that time by carts from Bewdley where there were wharves on the River Severn.

Figure 21. Cross-bedded sandstone revealed in the Old Red Sandstone of the doorway in the north wall of the nave, St. Laurence's church.

Figure 22. Dark reddish brown mud clasts ripped up by the flood responsible for the cross-bedded sandstone revealed in the Felton Stone of the vestry, St. Laurence's church.

Both the Felton and Holdgate Stones are quite good for rubble wall construction, but as ashlar they are prone to spalling, especially where differential weathering occurs around the lithic and mudstone clasts within conglomerate bands of the sandstone.

Extensive repairs during the 1880's specified the use of the same stone as the original, against the wishes of the architect who favoured stone from Runcorn (this would have been of Upper Carboniferous age). Although not so resistant to weathering, the Felton Stone would have visually sat alongside the original

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stone in a much better way than would the more durable alternatives.

Figure 23. Ripple marks on sandstone flag, once used as a gravestone but now employed as paving in front of the vestry, St. Laurence's church. It is likely to have been quarried from Highley, in the Severn Valley.

Nevertheless, the stronger Carboniferous sandstone from around Wrexham was used to replace the pinnacles on top of the buttresses in the restoration work of 1889-91 due to its suitability for carving.

Restoration of the windows and the hexagonal south porch in the 1950's employed red stone of much younger age. This comes from Hollington near Uttoxeter and is from the New Red Sandstone, laid down in similar conditions to the Felton Stone but of Triassic age, and with a stronger development of natural cement making it much stronger. The stone can be seen to have a rather brighter red hue with pale grey patches (where there is less iron oxide tint) and is better resisting the effects of exposure to the weather. Unfortunately it will always look different from the rest of the church fabric.

The patches of stone repair on the north side of the main body of the church have utilised the same source. Although both the new and the old stone are red in colour and are composed of sandstone, their appearance will always be different (Figure 24).

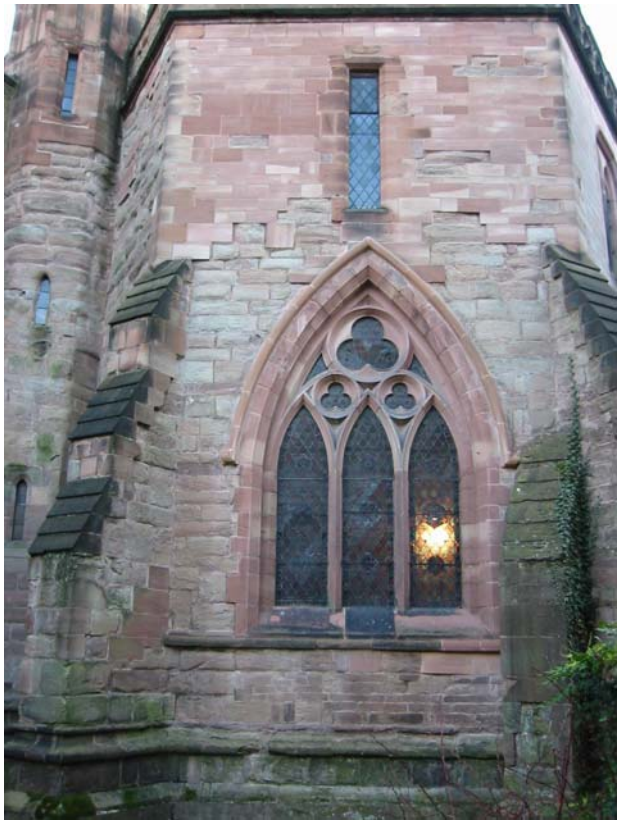

Figure 24. Two contrasting sandstones: (older) Silurian Holdgate Stone below, (younger) Hollington Stone above (larger block size; brighter red in colour). South Porch, St. Laurence's church.

Repairs in the early part of the 21st Century utilised another Triassic alluvial sedimentary rock, from Cumbria: the St Bees Sandstone. This has a more uniform red colour but a more mellow appearance which blends well with the older red stone but quite different from the Felton Stone used in the original construction (Figure 25).

The sourcing of appropriate stone raises a major issue for stone conservation work. Few quarries are still in operation and many can no longer realise the full range of properties of natural materials that have been utilised locally. There are also significant economic factors: these include the environmental cost of transporting materials considerable distances, the retention of relevant skills within the workforce, and the provision of local employment.

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Figure 25. Stone for conservation: the mellow deeper red tone of the recently emplaced St Bees Sandstone contrasting with the brighter red Hollington Stone of similar age installed several decades earlier. The original wall was constructed of local Old Red Sandstone. Felton Stone, appearing with a range of colours from grey-green to purple-red, and with weathered margins and faces was also used here for the 15th Century transformation. West wall of the nave, St. Laurence's church.

At present these is no database of information to guide planners or conservationists. English Heritage are soon (2007) to embark on a major project to help remedy this situation.

The brick used for the extension of the Church Inn facing the church has been constructed of locally bricks. The clay came from the Raglan Mudstone Formation beneath the gravel at Bromfield (of the same age as the local brick clays from around Ludlow railway station and Fishmore Road) but had to be taken south to be fired at a kiln near Gloucester. Due to the lack of weathering, its red colour is currently considerably brighter than that of the older brick of the main body of the Inn, but should mellow with time. Its appearance may be contrasted with the more readily available red bricks from Staffordshire made from the clay of the Etruria Marl, within the much younger Upper Carboniferous Coal Measures and the principal source for brick-making clay in the Coalbrookdale Coalfield. These compare favourably with the Ludlow bricks, and have been used for the recent renovations at 18 Castle Street and 16 Lower Broad Street.

Walk past the Readers House (of Whitcliffe Beds) and down the steps through the courtyard of The Bull. Turn left (north) down Corve Street.

LOCALITY 7: Old Post Office Building, 7 Corve Street [5117 7482]

This building dates from the 1930s and is faced with limestone.

The main entrance is of yellow-brown Jurassic oolitic limestone (Bath Stone). The base is faced with the somewhat younger white Portland Stone, from the Dorset coast, which is also oolitic but contains characteristic large bivalve fossil shell fragments and lacks the prominent brown bedding of the Bath Stone.

Continue north along Corve Street.

LOCALITY 8: Cemetery Gate immediately southeast of St Leonard's chapel (now the Printing Press) [5110 7510]

The old gate leading to the cemetery adjacent to St Leonard's chapel (the chapel was rebuilt and relocated in late Victorian times, and is now the Printing Press) is faced with an olive-green sandstone, of unknown origin and quite unlike any other seen within Ludlow (Figure 26). The cemetery lies in the grounds of the medieval Carmelite Friary, founded in 1350, whose church is believed to have been comparable in size to Ludlow's Parish Church: St Laurence's. With the assistance of the local MP, Viscount Clive, the new cemetery became established in 1824 to succeed St Laurence's, which by then had become completely full.

The original St Leonard's Chapel was a Norman building located just to the north of the Carmelite Friary, on what is now Linney. It was demolished in 1788 and the stone, characteristic golden yellow Downton Caste Sandstone, utilised for reconstruction of Corve Bridge at the north end of Lower Corve Street, where what is now known as the Bromfield Road crosses the River Corve.

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Quarries within Downton Estate produced good quality sandstone from the Downton Castle Sandstone Formation. Usually this is pale golden yellow, as seen in the recycled stone in Corve Bridge, but it is just possible that a seam yielded stone of a different colour for a time which could have sourced the olive-green sandstones in the 1824 cemetery wall. The answer probably lies in the material used for the medieval Carmelite Friary.

Figure 26. Sandstone (possibly Downton Castle or Ordovician Sandstone) as a facing to the 1824 wall of the cemetery gate, immediately southeast of St Leonard's Chapel.

The colour and occasional banding of this sandstone is reminiscent of Ordovician sandstones found around the Longmynd. It is therefore interesting to speculate if this stone's origin lies within the estate of Sir Laurence de Ludlow of Stokesay Castle. It was de Ludlow who formerly owned the land on which the Friary was built and he may well have made any quarries on his estate available to the friars for their work (Klein, *pers. comm.*). Thus Ordovician sandstone such as the Cheney Longville Flags that outcrop just northwest of Craven Arms could have been utilised not only for Stokesay Castle but also for the Carmelite Friary in northern Ludlow. It is actually a facing stone to an older wall constructed of purple-red and green-grey Old Red Sandstone, whose origin may be the same as the C14 stone used for St Laurence's (Locality 6).

Old buildings, bonded with lime mortar, were easily taken apart and the good stone separated out for re-use - even foundation trenches were routinely robbed out, which is something very frequently found on excavation sites of medieval buildings (Klein & Roe, 1987, pp. 25-35).

The late Victorian reconstruction of St Leonard's chapel, opened in 1871, used red-brown micaceous sandstone ashlar for the walls, generally referred to as Bromsgrove Sandstone, probably transported to Ludlow by rail since a nearby quarry for the similar Felton Stone was not reopened (for the renovation of St Laurence's) until 20 years later. A paler mottled brown and grey coarse sandstone was used for the buttresses and windows, probably Carboniferous sandstone from the Highley Quarry in the Severn Valley.

Cross Corve Street to the Stone House (the principal building for the South Shropshire District Council).

LOCALITY 9: Stone House (South Shropshire District Council Headquarters), Corve Street [5115 7510]

The rear of the Stone House, built in 1812, reveals its stone construction (Figure 27). The predominant lithology is the pale grey Whitcliffe Beds; weathered surfaces are pale brown (this develops over geological time, along natural discontinuities within the *in situ* rock, especially joints, faults, and bedding planes against well-cemented horizons). Note the fossil shells. The mortar is of lime and has a coarse aggregate filler comprising local gravel reflecting a wide variety of lithologies. These are probably derived from the fluvio-glacial gravels at Bromfield carried down by the Rivers Corve and/or Onny.

Figure 27. Stone construction (to the right) behind the Palladian façade of Stone House, Corve Street.

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However, there are a number of other lithologies that can also be observed, for instance purple Felton Stone as used for some of the more important buildings in the vicinity. Around one of the window frames is also some Soudley Stone, a brown and grey banded siltstone which outcrops east of Church Stretton. How such a wide variety of stones came to have been incorporated within the Stone House is not known. The more exotic stones appear to be limited to the surrounds to the window frames, and were perhaps introduced during reconstruction of the building when the frames were renovated. It is possible that this material was sourced from the gravel pits at Bromfield, where glacial meltwater had deposited stones transported by former glaciers, one of which came south through the Stretton Valley. Another came from the north-west, along the Clun Valley. Meltwater subsequently flooded down the course of the present River Onny, from the Stiperstones and through Plowden. A great variety of stones could thus be assembled.

The original windows sills are quite irregular sandstone slabs, probably from the Raglan Mudstone Formation which was being worked for brick and tile clays in the northern part of Ludlow at that time.

Turn left (east) up Station Road towards the railway station and then on, up the hill, to Upper Galdeford, at the traffic lights.

LOCALITY 10: Upper Galdeford [5140 7480]

Along Station Road, note the steep rise of the slope above the left (eastern) side of the railway; this hosted brick and tile pits in Victorian times which worked the Raglan Mudstone Formation.

Geologically older cobbles, originally derived from the Lower Palaeozoic but then redeposited in a late Pleistocene fluvioglacial deposit now worked by Bromfield Sand & Gravel Pit, have been utilised as a facing for the retaining wall on Platform 2 (southbound) of Ludlow railway station. Their rounded shapes indicate transport by rivers for considerable distances, but their final journey was by glacier from which they were subsequently dumped by meltwater issuing from the waning ice front to the north of Ludlow, described in more detail elsewhere (Rosenbaum, 2006).

The paved area by the traffic lights at the junction of Station Road with Upper Galdeford, in front of the relatively recent housing development, has also utilised rounded cobbles to restrict vehicles and pedestrians from approaching too close to the buildings, a feature introduced as part of the recommendations by the famous civil engineer Thomas Telford in the late Georgian Period for the reconstruction of Broad Street, which will be visited later.

These cobbles in Upper Galdeford were placed here in the 1970's and originated in geologically much younger rocks than those seen at the railway station since they have utilised flint cobbles imported from southern England. These flints are Cretaceous, and much younger than any of the bedrock encountered in Shropshire or surrounding areas.

Proceeding up Gravel Hill will lead to East Hamlet and the Henley Road.

LOCALITY 11: St Peters Roman Catholic church, Henley Road [5160 7545]

St Peters was constructed in 1933-5 (Figure 28) and used a strong limestone of Carboniferous age quarried from the far side of Clee Hill.

The Carboniferous Limestone provided the raw material for important lime works that once operated on Clee Hill. Known locally as the Oreton Limestone, this is Tournaisian in age (350 Ma), formed as a sediment in shallow relatively clear seas. It is oolitic in places and contains many fossil fragments, mainly of crinoids and shells. At the time of its formation it was located close to the Equator but has moved progressively northwards since then due to plate tectonics. It appears to have been formed on the southern margins of a land mass (*St George's Land*) which stretched east-west. This limestone has features more in common with the thicker Carboniferous Limestones to the south (e.g. South Wales, Bristol, Mendips) than with those to the north (e.g. Northwest Shropshire, Derbyshire, North Pennines).

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Figure 28. St Peters RC church, Henley Road, constructed of strong Oreton Limestone of Carboniferous age.

Return to town along Gravel Hill and cut left through St Stephens Yard to Lower Galdeford.

Figure 29. The Bishop Mascall centre, formerly the National School of 1857, with walls constructed predominantly of Whitcliffe Beds and the quoins of Jurassic oolitic limestone transported from the Cotswolds.

LOCALITY 12: Bishop Mascall Centre, Lower Galdeford [5152 7464]

The Bishop Mascall centre was the pride of the town when opened as the National School in 1857. The building materials were chosen carefully, the walls being predominantly calcareous siltstone (Whitcliffe Beds) and the quoins of Jurassic oolitic limestone ("Bath Stone") (Figure 29).

Proceed up Galdeford and bear right along the alley between the One Stop store and Somerfield. This leads to the Galdeford car park adjacent to which is the Public Library.

LOCALITY 13: Ludlow Museum Resource Centre and Public Library [5130 7490]

The Local Collection within the Public Library contains a variety of maps, books and pamphlets that have been published concerning the local history and architecture. The Resource Centre supports the County Museum service which hosts the Shropshire Geological Records Centre. The Museum has a valuable collection of geological specimens and literature dating back to the earliest investigations of the area. These form a nationally important base for research and are accessible to the public by appointment (Tel. 01584 813 640).

Keep to the right of the car park and go through the hole in the wall to enter Wood Yard.

LOCALITY 14: Wood Yard, off Corve Street [5130 7475]

Here the north-eastern corner of the town wall now forms the foundation to one of the Feathers Hotel buildings. The town wall is on the right as one walks along Wood Yard from the Corve Street end. The walls and buildings on the left are somewhat younger and have been constructed in the former defensive ditch to the town wall. Note the watch tower by the passageway leading to the town centre.

As remarked earlier, the Town Wall is 13th Century in age but whereas this section is largely constructed of Whitcliffe Beds calcareous siltstone, other lithologies have been used too, especially in the lower (older) parts of the wall. In part this reflects rebuilding and reuse of materials to hand, but it also reflects a change in the outcrop, since this part of the Town Wall has been founded on the younger Downton Castle Sandstone Formation. The contact between the two is exposed at Ludford

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Corner and is believed to extend up Broad Street (published geological maps show the contact to the west, along Raven Lane, but rock seen in cellars would suggest that the contact is a little further to the east, between Broad Street and Old Street, possibly along the line of the former Fish Street).

The Downton Castle Sandstone has a yellow colour, lacks the calcareous cement of the Whitcliffe Beds, and frequently exhibits cross-bedding. This may be contrasted with the Whitcliffe Beds siltstones, with their grey colour weathering brown, and exhibiting a wide range of sedimentary structures (Figure 30). The latter also include a fossil fauna characteristic of a shallow warm sea shelf, in contrast to the sandstone which is probably intra-tidal in origin. Contrast the styles of weathering (between sandstone and siltstone).

Figure 30. The Town Wall in Wood Yard revealing use of both Downton Castle Sandstone (right) (which has a yellow colour and frequently exhibits cross-bedding) and Whitcliffe Beds siltstones (left) (with their grey colour weathering brown, and exhibiting a wide range of sedimentary structures).

The roadstone here is dolerite ("Dhu stone") from Titterstone Clee - the dark green crystals of olivine can be discerned.

Continue onto Corve Street, turning left (south) up towards the Bull Ring.

LOCALITY 15: HSBC Bank, 10 Bull Ring [5120 7473]

The bank was rebuilt in 1905, and shows a more appropriate use of the New Red Sandstone from Hollington than was seen at St Laurence's (Locality 6), here displaying an attractive red stone with pale patches where the iron oxide content is lower (Figure 31).

The roof is also of stone: thin slabs of sandstone from Cheney Longville, near Church Stretton. The presence of the platy mineral mica within this sediment enables the rock to be split into relatively thin slabs, suitable as a roofing material. Until the construction of the railway system and the relative ease with which slate from North Wales could be distributed around the country, such local sourcing of stone roofing materials was commonplace. Stokesay Castle is an example. However, excavation was expensive (requiring skilled labour) and roofing support had to be substantial due to the great weight of the (comparatively thick) stone slabs. Vernacular buildings therefore often tended to be of thatch until the development of tiles, associated with local brick industry already mentioned.

Figure 31. The HSBC bank was rebuilt in 1905 using the New Red Sandstone from Hollington. Thin slabs of sandstone from Cheney Longville form the roof.

Proceed west along the Bull Ring to the High Street at the top of Broad Street.

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LOCALITY 16: Butter Cross, High Street [5113 7465]

The Butter Cross was constructed in 1740 to a design by William Baker, an architect from Chester who also project managed its construction. Sandstone, with distinctive coarse bedding and occasional seams of gravel, was used for facing the brick. There is no sandstone anything like this elsewhere in Ludlow. Baker might have sourced this from the Late Devonian Farlow Sandstone, quarried east of Clee Hill. More recent repairs (1984) have utilised Triassic stone from the Grinshill quarries a few miles north of Shrewsbury (the same stone used for the Old Market Hall in Shrewsbury, constructed some 150 years earlier in a comparable style) (Figure 32).

Figure 32. Grinshill Sandstone (below the plaque) used for repairs to the Butter Cross in 1984. Note the characteristic veins of the mineral quartz, known as "granulation". However, the stone employed for the initial construction (above the plaque) was probably Farlow Sandstone, quarries for which were much closer.

The Farlow Sandstone displays spectacular cross-bedding indicative of deposition in a river environment.

However, use of such distant stone, whilst very attractive, imposes a high environmental cost with the expense of transport, and local skilled labour is unlikely to have been employed. Baker probably used masons from his home town of Chester.

Beneath the Butter Cross is an old millstone, worn smooth by grinding corn. Millstone grit is commonly used, giving its name to rocks of Middle Carboniferous age in the Pennines. On Titterstone Clee there is a similar material of slightly younger age (Upper Carboniferous), called the Cornbrook Sandstone, which has a characteristic coarse grain size containing abundant well rounded white quartz pebbles (Figure 33). However, this millstone is actually a French import: a calcified travertine of Lower Oligocene age from within the Paris Basin. It was brought here from the old mill at the bottom of Old Street when the Museum was occupying the building above.

Figure 33. Cornbrook Sandstone, used in a farm building south of Clee Hill; once a potential source for millstones.

The colonnade at the top of Broad Street dates from 1792, a time when the Burrington Furnace in Bringewood was still operating and so could have supplied the cast-iron columns, made from iron ore transported from Clee Hill. The ore for the foundries came from ironstone concretions of siderite which occur within the seatearths of the Coal Measures, locally known as 'Clumper'.

Proceed along the pedestrianised Church Street to just beyond the archway leading to the top of the Butter Cross.

LOCALITY 17: High Cross, Church Street [5110 7467]

On the right, looking like a stone bench, is the site of one of the four standpipes for the town,

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fed by groundwater. This is High Cross (Figure 34).

The water was transported *beneath* the River Teme at the Mill Street Weir from a source near the confluence of the Rivers Corve and Teme. The scheme was designed by Henry Sydney in the mid 16th Century, and was originally intended as a water source for the castle, to replace the well within the Norman keep that took groundwater from just above the level of the River Teme.

Figure 34. High Cross, the site of one of the four standpipes for the town.

Other standpipes include the east side of the Tolsey, in the Bull Ring, fed by spring water issuing from the base of the gravels towards the top of what is now Livesey Road, at St Julian's Well (this had previously flowed as the Whitehall Brook to the Austin Friary in Lower Galdeford). These gravels form an extensive sheet beneath East Hamlet. Their base is at an elevation of about 115 m above sea level resting on the much less permeable Raglan Mudstone Formation. This is much higher than the present River Teme, which is at about 75 m. It is thought that these gravels were deposited by a river long before the River Teme cut its present course, and indeed may well belong to a proto-river Corve, or possibly Onny, and may well have flowed south-east along the course of the present-day Ledwyche Brook and not west of the medieval town of Ludlow at all. At that time the Teme flowed some 10 km to the west, south through Aymestrey. The spring line around East Hamlet is still responsible for wet conditions at this elevation.

Continue west to the Market Square.

LOCALITY 18: Ludlow Museum, Market Square, Castle Street [5100 7457]

A very good display of the local geology may be visited in the Ludlow Museum, located next to the Tourist Information Centre.

Cross Mill Street outside the Museum and proceed downhill.

LOCALITY 19: Guildhall (now the Magistrates Court), Upper Mill Street [5099 7450]

Like Broad Street, Mill Street was an important residential area in Georgian times. Here the paved area in front of the housing development has utilised rounded cobbles to restrict vehicles and pedestrians from approaching too close to the buildings. Some of this paving dates from its introduction in 1829, the result of a commissioned report by the famous civil engineer Thomas Telford. These cobbles are very varied, with sedimentary, igneous and metamorphic rocks present, including tuffs which are found in the vicinity of the Longmynd, and thus probably derived from there by glacial and fluvio-glacial action, and recovered from the gravels bordering the River Teme in Ludlow.

However, between Nos.44 and 45 there is a patch of pale grey cobbles. These are much younger, and have utilised flint cobbles imported from southern England. These flints are Cretaceous in age, and much younger than any of the bedrock encountered in Shropshire or surrounding areas. Note the pale patina surrounding the black core, representing the growth front of the silica nodule as it developed

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within its chalk host (Figure 35). The cryptocrystalline needles of quartz in the patina had not developed sufficiently to coalesce, leaving the porcelaneous appearance. The cracks on the surface are due to abrasion and impact as the pebble was being transported by water, and is characteristic of the sediment deposited by meltwater from glaciers as well as in coastal beach deposits affected by breaking waves.

Figure 35. Flint cobbles (lower) contrasting with locally quarried fluvioglacial cobbles of mixed origin (upper), largely from the northwest (of Shropshire and Wales, reflecting movement of the glacial ice). Between 44 and 45 Mill Street.

Cross Mill Street and proceed downhill to just before its junction with Silk Mill Lane.

LOCALITY 20: Grammar School, Upper Mill Street [5107 7436]

A variety of rock types can be seen in the school.

The oldest building is at the bottom of the site, adjacent to Silk Mill Lane, and is constructed predominantly of sandstone from the Old Red, once considered to be of Devonian age but now ascribed to the youngest Silurian. The presence of pebble beds and the character of the cross-bedding suggests deposition by rivers on land (Figure 36).

Figure 36. A range of small-scale structures, including cross-bedding and banding due to slow groundwater percolation, revealed in the Grammar School wall, Mill Street.

Similar sandstone has been used for the main door and window frames in the school hall, but are weathering severely (Figure 37). This illustrates a rule of stone masonry, that the stone should be placed as it was in the ground, i.e. the bedding should remain horizontal and not tipped on end. Otherwise the kind of spalling seen here can occur all too easily. Compare the sandstone with the limestone used to the right (south).

The Victorian renovation of the school hall in the 1880s, adjacent to Mill Street, utilised fashionable pale brown oolitic limestone, of Jurassic age from the Cotswolds (Figure 38). These contain oolites (sand grain sized pellets of calcite formed by algae in warm shallow sea water). Fossils are predominantly bivalve shells, other animals having been broken up by wave action. This stone has performed well in the window lintels, but similar stone has decayed badly where placed in the more exposed situation by the school gates. Care must be taken to fully and clearly specify the stone properties desired, and to bear in mind the situations where it will be used. However, there will be an inevitable cost implication from over-specifying the stone!

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Figure 37. Window frame in the Grammar School of Old Red Sandstone. Weathering is causing significantly more deterioration than might otherwise have been the case due to the stone having been placed vertically rather than as it was in the ground prior to quarrying.

Figure 38. Window frame in the Grammar School of Jurassic oolitic limestone.

Continue downhill past the site of the Mill Street Gate through the Town Wall.

LOCALITY 21: Ludlow College, Lower Mill Street [5103 7430]

The foundations of both the Mill Gate and the Town Wall can be seen here to rest on *in situ* Whitcliffe Beds (Figure 39). The calcareous siltstones dip gently east, as they do on the opposite bank of the River Teme, and occupy the corresponding position on the south flank of the Ludlow Anticline.

The dip of the Whitcliffe Beds here is 10° towards the south-east, consistent with its position on the southern flank of the Ludlow Anticline (*cf.* Locality 1 where the dip was towards the north) (Figure 40).

The composition of the Town Wall is predominantly of blocks quarried from the Whitcliffe Beds.

Figure 39. Mill Gate and the Town Wall resting (to the right) on *in situ* Whitcliffe Beds of calcareous siltstone dipping gently east.

Figure 40. SE-dipping Whitcliffe Beds in the allotments below Camp Lane, just west of Lower Mill Street.

Return up Mill Street and turn right (east) along Silk Mill Lane.

LOCALITY 22: Silk Mill Lane [5110 7435]

Along the Silk Mill Lane boundary of the Grammar School note the variety of lithologies in the wall of the 13th Century Barnabay House and their relation to the architectural style (Figure 41). These reflect the commonly available materials of the day, successively younger repairs incorporating siltstones from the Whitcliffe Beds, Jurassic limestone, Oreton Limestone (the local equivalent of the Carboniferous Limestone), and Dhu Stone (dolerite from Clee Hill, an intrusive igneous rock of Carboniferous age).

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The use of Oreton Limestone is unusual, but it was employed for the Roman Catholic church of St Peters (1936) and thus it might have been a logical choice at the time of this wall's construction (Figure 42).

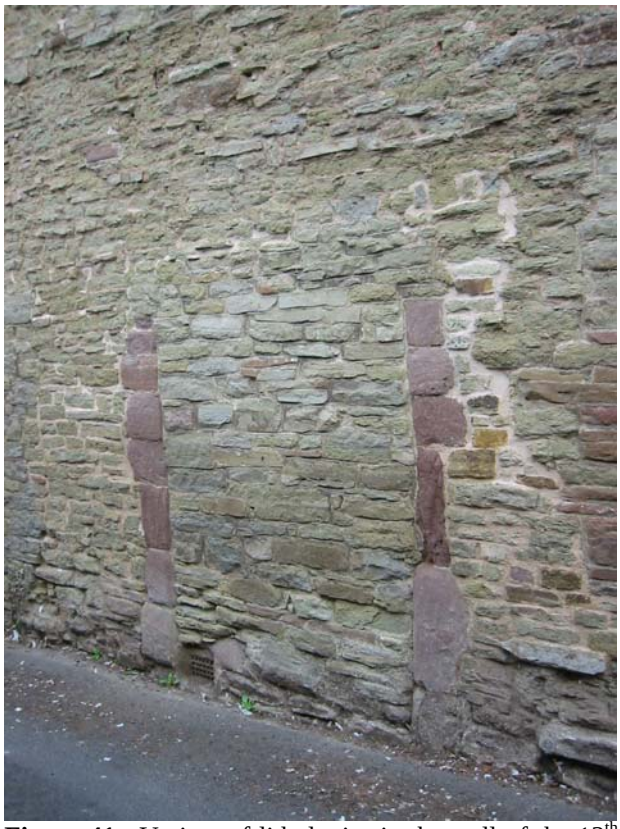

Figure 41. Variety of lithologies in the wall of the 13th Century Barnaby House on the Grammar School site, Silk Mill Lane. See text for details.

Figure 42. Oreton Limestone used to cap the wall at the corner of Silk Mill Lane with Lower Raven Lane.

Turn north and proceed up Raven Lane, taking the first right into Bell Lane. The next junction is with Upper Broad Street.

LOCALITY 23: Upper Broad Street [5118 7440]

A wide variety of stones has been used in Broad Street. This was not only an important residential area in Georgian times but lay on the mail coach route from London. However, the low headroom beneath Broad Gate and the steep gradient leading up from Ludford Bridge caused problems. Thomas Telford, whose public career had begun in Shrewsbury in the 1780s as County Surveyor but destined to become a world-famous civil engineer, was commissioned in 1828 to report on how best to tackle the problem of facilitating access to the larger carriages then coming into fashion, and assisting the street drainage (Lloyd, 2001). In effect, Telford recommended lowering the road level beneath Broad Gate by almost one metre, lessening the gradient uphill, and placing the spoil as an embankment downhill, the works being completed in 1829.

In order to inhibit vehicles and pedestrians from approaching too close to the buildings, the paved area has utilised rounded cobbles. These cobbles are very varied, with sedimentary, igneous and metamorphic rocks present, including tuffs which are found in the vicinity of the Longmynd, and thus probably derived from there by glacial and fluvio-glacial action, and recovered from the gravels bordering the River Teme in Ludlow.

The limit of outcrop of the Whitcliffe Beds occurs hereabouts. To the east, between Broad Street and Old Street, the Downton Castle Sandstone outcrops. This yields a relatively thin but superior building stone, which may be seen in the magnificent stone house at No.27 (rather than the “local Silurian limestone, probably quarried in Whitcliffe” noted by Lloyd, 2001, although this may have been used elsewhere within the structure).

Using a hand lens, the difference between limestone and sandstone can be readily appreciated since fine grains of sand are visible in the latter. This building, believed to date from the 1680s, was the Charlton’s town house (Figures 43 and 44). It is likely that their estate in Ludford hosted the quarry; similar stone is exposed in the upper parts of the exposure at Ludford Corner, world-famous as the site of the Ludlow Bone Bed.

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Figure 43. The magnificent stone frontage of the 17th Century house at No.27, Broad Street, was renovated in the 1950's.

Figure 44. Detail of the downhill end of No.27, Broad Street, showing the yellow Downton Castle Sandstone which was probably quarried from the Charlton's estate at Ludford, just to the south of Ludlow.

The sandstone used next door (No.26) is weathering much more rapidly. The window sills are quite irregular sandstone slabs, probably from the Raglan Mudstone Formation which was being worked for brick and tile clays in the northern part of Ludlow at that time. Thin sandstones in this Formation were referred to as "Tilestones" by Murchison when he first visited Ludlow, in 1831, following his earlier study of such rocks around Brecon where they had been successfully employed as stone roofing slates. The stone used for No.28 came from that area too, the Forest of Dean (Lloyd, 2001), probably from the Upper Carboniferous which was also being worked for coal and ironstone in Georgian times.

Very large sandstone flags outside No.36 (1757) are of a similar material to that used at Arley Castle, and thus likely to be from Upper Arley or Highley where there were quarries in the Coal Measures sandstones of the Highley Group, Upper Carboniferous in age ('Highley Stone'). This sandstone is strong, with a yellowish- or greenish-grey or buff colour and cross-bedded, often with deep small scale ripple marks (Figure 45). Its success was in part due to proximity to the River Severn. Transport to Ludlow would have been relatively straightforward; indeed, many materials were carried to Ludlow at that time by carts from Bewdley where there were wharves on the River Severn. In Georgian times this stone was the material of choice for construction of many of the bridges over the River Severn.

Figure 45. Sandstone flags supported by brickwork outside No.36, Broad Street.

Proceed downhill through the Broad Gate, noting the predominant use of Old Red Sandstone. When repairs had to be conducted in 2006 to remedy the damage caused by road salt and vehicular collisions, the lack of local quarries with suitable stone led to the use of Carboniferous sandstone brought in from Dukes Quarry near Whatstandwell in Derbyshire. This is a cross-bedded medium grained sandstone, pink/lilac

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in colour so providing a good match to the older stone (incidentally this was also employed for the new Mappa Mundi library at Hereford Cathedral).

LOCALITY 24: Broad Gate and the Wheatsheaf Public House, Lower Broad Street [5123 7437]

Passing through the Broad Gate, note the predominant use of Old Red Sandstone. When repairs had to be conducted in 2006 to remedy the damage caused by road salt and vehicular collisions, the lack of local quarries with suitable stone led to the use of Carboniferous sandstone brought in from Dukes Quarry near Whatstandwell in Derbyshire. This is a cross-bedded medium grained sandstone, pink/lilac in colour so providing a good match to the older stone (Figure 46). Incidentally, this was also employed for the new *Mappa Mundi* library building at Hereford Cathedral, along with Wattscliffe Stone quarried at Elton near Matlock.

Figure 46. Within the arch of the Broad Gate can be seen Old Red Sandstone, either side of the groove that once housed the portcullis. The fresher material utilised for repairs in 2006 is Carboniferous Sandstone, of similar colour but greater strength, from Dukes Quarry in Derbyshire. Other stone, including Whitcliffe Beds calcareous siltstone, has been used elsewhere in the structure, for instance in the right of this view.

The very dark grey dolerite setts and kerb stones are of dolerite from the quarries on Clee Hill (Figures 47 and 48). These were opened in the 1860's and production is still active, but nowadays largely for roadstone and concrete aggregate.

Known locally as *Dhu Stone*, this is dolerite, an igneous rock intruded into the Coal Measures of Clee Hill as a molten magma. Its crystallisation has produced a particularly hard stone of considerable thickness, nationally important as a source of roadstone.

Figure 47. Paving with Dhu Stone outside the Wheatsheaf Public House, Lower Broad Street.

Figure 48. Incline Quarry; one of the major sources of Dhu Stone, won from the columnar jointed dolerite sill of Carboniferous age intruded into Coal Measures mudstones and coal seams. The information board is located at the public viewing platform above Clee Hill village.

Turn left (east) along St Johns Road and proceed as far as Old Street. Note the Town Wall on the left.

LOCALITY 25: Friars Walk, Old Street [5135 7450]

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Dark grey dolerite setts and kerb stones from the quarries on Clee Hill are seen here too. The brick is from Knowbury, fired from Coal Measures clays and characterised by a sooty appearance due to the use of coal dust as a dusting agent to facilitate removal of the brick from its mould (Figure 49).

Figure 49. Paving with Dhu Stone, Friars Walk. The brick is from Knowbury, fired from Coal Measures clays.

Across the road is Old Gate. Note the use of Downton Castle Sandstone as well as Whitcliffe Beds (Figure 50).

Figure 50. The Old Gate House, Old Street, utilising yellow Downton Castle Sandstone at the base; grey calcareous siltstone from the Whitcliffe Beds predominates in the rest of the structure. The building is founded on the Downton Castle Sandstone Formation.

Return (west) along St Johns Road and turn left (south) down St Johns Lane.

LOCALITY 26: Homecare Bedding, St Johns Lane [5134 7432]

This relatively recent steel-framed building (1970s) has utilised almost all the local rock types used for the east wall facing the road.

How many rock types can you identify? In rough order of decreasing frequency, these include:

- calcareous siltstone from the Whitcliffe Beds predominates
- red-brown sandstone (Holdgate Stone)
- oolitic limestone (Middle Jurassic, from the Cotswolds), including karstic surfaces covered with calcite crystals
- dolerite ("Dhu stone") from Clee Hill
- yellow sandstone (Downton Castle Sandstone)
- white quartzite cobbles (from fluvio-glacial gravel derived from much older rocks, possibly from North Wales)
- compact grey limestone from the Oreton (Carboniferous) Limestone

Cross the road, towards the children's play area.

LOCALITY 27: Lower Fee [5136 7430]

The paved area in front of the housing development has utilised rounded cobbles to restrict vehicles and pedestrians from approaching too close, mimicking the feature introduced by Telford. These cobbles are predominately pink and red-brown quartzite, characteristic of the Kidderminster Conglomerate (formerly the Bunter Pebble Beds) of Triassic age, quarried around Kinlet, for example (Figure 51). These sediments were deposited in alluvial fans associated with flash floods in a hot arid environment.

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Figure 51. Paving with pebbles of pink and red-brown quartzite, characteristic of the Kidderminster Conglomerate.

There are also a few granitic pebbles which are characteristic of Cornubia (Britanny), reflecting the transport direction of the rivers flowing at that time. These may be contrasted with the wide range of lithologies in gravel for similar usage in Broad Street (from the cold environment responsible for the fluvio-glacial gravels of Devensian age).

Continue downhill and turn right (west) along Temeside and right (north) up Lower Broad Street.

LOCALITY 28: Lower Broad Street [5124 7427]

The regrading recommended by Telford can again be appreciated (Figure 52).

Figure 52. David Turner's Victorian photograph of Lower Broad Street clearly showing the regrading works carried out following the recommendations by Telford.

Stone flags have been used as a roof to the porch of No.40. These have employed a thin-bedded sandstone from the Chatwall Flags of the Stretton Valley (Figure 53).

Figure 53. Chatwall Flags on the porch of No.40 Lower Broad Street.

Note the brick used for the renovation of 16 Lower Broad Street. This is similar in appearance to the local Ludlow bricks (as noted at the Church Inn) but utilising the more readily available red bricks from Staffordshire made from the clay of the Etruria Marl, within the much younger Upper Carboniferous Coal Measures and the principal source for brick-making clay in the Coalbrookdale Coalfield.

Proceed south across Ludford Bridge.

LOCALITY 29: Charlton Arms Public House, Ludford Bridge [5122 7415]

From Ludford Bridge, the cliff behind the car park of the Charlton Arms Public House can be readily appreciated (Figure 54). It reveals the bedding of the Whitcliffe Beds, here dipping east at about 10°.

The cliff is the result of quarrying during the 18th Century.

Charlton lived in Ludford House, nearby.

Figure 54. The cliff behind the car park of the Charlton Arms Public House reveals the bedding of the Whitcliffe Beds, here dipping east (towards the left) at about 10°. Photograph taken during construction of the annex to the pub (2006).

Continue south (uphill) to the junction with Whitcliffe Road. This is known as Ludford Corner.

LOCALITY 30: Ludford Corner, Whitcliffe Road/Overton Road [5120 7410]

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The small cliff here is the result of quarrying for sandstone to supply the early 19th Century renovation of Ludford House (Figure 55). It revealed the top of the Whitcliffe Beds, comprising calcareous siltstone which had once been the predominant building stone in Ludlow. Overlying it is the yellow cross-bedded sandstone of the Downton Castle Sandstone, upon which Ludford House has been founded (Figure 56). Between are two metres of fissile grey sandy mudstones, the Platyschisma Shale (*Platyschisma* is a small gastropod) (Figure 57), at the base of which is the Ludlow Bone Bed, a thin brown siltstone rich in phosphatic fragments of the earliest fossil fish as well as burnt plant fragments, and having the appearance of 'ginger bread' (Figure 58). This is thought to represent a change from shallow open marine shelf to intra-tidal or coastal plain conditions. The burnt plant fragments have been interpreted as having arisen from a wildfire – the earliest record of such a phenomenon anywhere in the world (Glasspool *et al*., 2004)!

Figure 55. The classic locality of the Ludlow Bone Bed, Ludford Corner, now protected by conservation works. Image taken from a 35 mm slide in the Ludlow Museum Resource Centre collection.

Figure 56. Characteristically cross-bedded Downton Castle Sandstone, quarried here for the reconstruction of Ludford House, Ludford Corner.

Figure 57. The *Platyschisma* Shale, a mudstone far too weak to be used as a building stone, Ludford Corner.

Figure 58. The Ludlow Bone Bed, approximately 20 mm thick, exposed within the Woolhope Dome, southeast of Hereford.

This locality is world famous, first seen by Murchison in 1831 and, later that decade, used by him to define the base of the Devonian, on the basis of evidence for the earliest life on

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land that was known at that time. Subsequently it has been shown that this important evolutionary step actually occurred a little earlier and, a century and half later, international agreement moved the base of the Devonian a little higher in the succession, on the basis of evidence from a fully marine sequence of sediments in central Europe where the fossil record is more complete.

Up the Overton Road to the south the character of the Downton Castle Sandstone can be readily appreciated, showing the finely laminated and cross-bedded nature of these sandstones.

The dip of the strata here is 7° towards the east, slightly less than at the previous Locality. Such variation over short distances is commonly encountered, in part due to local warping of the strata and in part due to disturbance near surface by weathering and/or the activities of Man.

Extensive use of the Downton Castle Sandstone has been made in the walls of Ludford House (on the opposite side of Overton Road). Note the direct founding of the walls on the *in situ* Downton Castle Sandstone by the main gate.

The older part of No.1 Whitcliffe Cottages (opposite) is made of Whitcliffe Beds siltstone but the house has been renovated and some of the more recent stone (recognised by the relatively fresh tool marks) is the Downton Castle Sandstone, recognisable by the yellow colour, sand grain size, and cross-bedding.

Proceed west into Whitcliffe Common.

LOCALITY 31: Whitcliffe Quarry [5100 7411]

The last face of the main quarry to be worked hereabouts for the Whitcliffe Beds calcareous siltstone can still be seen, even though two centuries have elapsed since it was last quarried (Figure 59). Note the extensive natural joints which facilitated extraction of building stone. Blocks were extracted by hammering wedges in sequence.

Figure 59. Whitcliffe Quarry in the late 19th Century, prior to becoming obscured by the growth of vegetation during the next hundred years. © Francis Frith Collection (Ref. 30801).

The rock in the quarry comprises principally a moderately bedded calcareous siltstone. It may have been quarried here since medieval times, but demand waned during the Georgian period as fashion swung towards the use of brick. The rock here is relatively young compared to others outcropping within Whitcliffe.

The lowest part of Whitcliffe, by the river 150 m south of Dinham Bridge, exposes the older Lower Leintwardine Beds, the lithological equivalent of the Aymestry Limestone but actually a bit younger: a valuable source of rock for making lime and cement but too nodular for use as a building stone (Figure 60). Above this are the Upper Leintwardine Beds, a calcareous siltstone with a characteristic honeycomb style of weathering and containing the ostracod zone fossil *Neobeyrichia* (Figure 61).

Figure 60. Lower Leintwardine Beds exposed below Whitcliffe; too nodular for use as a building stone.

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Figure 61. Fossiliferous Upper Leintwardine Beds similar to those outcropping below Whitcliffe. Delbury Quarry, Corve Dale.

Above is the outcrop of the Whitcliffe Beds, comprising two formations: Lower and Upper. The fauna becomes confined mostly to three brachiopods (*Microsphaeridiarhynchia (Camarotoechia), Salopina* and *Protochonetes*) and a bivalve (*Fuchsella*). Bioturbation was intense, destroying the bedding (but making it much better as a building stone since its properties are thus more uniform and planes of weakness fewer), especially in the Lower Whitcliffe Beds. Tracks of the worm *Serpulites* have been found.

Both the Upper and Lower Whitcliffe Beds consist of calcareous siltstones. However, it tends to rapidly crack and disintegrate unless quickly protected from the weather (Lightbody, 1878).

Decalcification seems to be prevalent, the calcite having been dissolved out by groundwater, at least along the more open discontinuities (joints and bedding planes). The stone breaks more easily along such partings, thereby giving the appearance of the whole rock being decalcified (and this would have significantly weakened the stone) (Figure 62). Furthermore the decalcified parts of this siltstone when used as a building stone tend to weather on exposure more readily, probably adding to its poor reputation locally with respect to its durability.

Figure 62. Honeycomb style of weathering due to decalcification, characteristic of the Upper Leintwardine Beds and similar to those outcropping below Whitcliffe. Delbury Quarry, Corve Dale.

The Lower Whitcliffe Beds are clearly seen at the bottom of the steps on the Bread Walk (Figure 63). These tend to have somewhat thicker beds and yielded a "blue-hearted" stone that was relatively good for building (Figures 64 and 65). The thicker beds were known as "pendle" by the quarrymen (Howe, 1910), although elsewhere in the country this term tended to be used for flaggy beds.

Figure 63. Lower Whitcliffe Beds (“pendle”) exposed at the foot of the steps along the Bread Walk.

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Figure 64. Blue-hearted "pendle" characteristic of the better quality building stone from the Lower Whitcliffe Beds, as once quarried on Whitcliffe. Delbury Quarry, Corve Dale.

Figure 65. Contrasting durability: blue-hearted "pendle" is much more resistant to weathering than the brown weathered calcareous siltstone of the Whitcliffe Beds. Outbuilding, Culmington Rectory.

The main face in the upper part of the quarry *[which should not be approached unless wearing a protective hard hat]* exposes two substantial slumped beds (Figure 66). The higher slumped bed separates the Lower Whitcliffe Beds from the higher Upper Whitcliffe Formation, the latter yielding a rather better defined thinly bedded siltstone (with less bioturbation). This has a yellowish grey colour but, not only is it more prone to spalling, it has proved difficult to quarry for stone of sufficient size to be useful for building construction. In compensation, the Upper Whitcliffe Beds are somewhat more obviously fossiliferous!

There are occasional shale bands, for instance one metre above the quarry floor, probably due to the diagenesis of volcanic ash (Figure 67). This, and the slumped beds, are indicative of the active tectonic environment of the Silurian, with the progressive closure of the Iapetus Ocean.

Figure 66. Slumping of sediment soon after deposition revealed by disturbed bedding in Lower Whitcliffe Beds, near Dinham Quarry.

Figure 67. A 10 mm thick clay band within the Lower Whitcliffe Beds, altered from a thin layer of volcanic ash, Whitcliffe Quarry.

The exact method of quarrying is not obvious, but elsewhere quarries at this time only rarely used explosives. Excavation was primarily by use of hammering wedges in line to prise large blocks of stone away from the *in situ* face, and these blocks would then be split and shaped on the quarry floor according to demand. The wedges would be driven along natural planes of weakness; here these comprise the bedding planes (which dip gently eastwards) and joints (which are generally vertical). As a result, clean, smooth quarry faces of *in situ* rock are characteristic. Furthermore, there will be little additional fracturing of the *in situ* rock since there is an absence of damage by explosives or heavy machinery. Such faces can be steep and

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high, and are able to retain their profile for much longer periods than would be encountered in modern quarrying operations.

Once the quarried stone has been removed, the rock left behind begins to relax, a consequence of the reduction in confining stress. This causes the rock material to expand and thus for fracture surfaces to open slightly, loosening the rock mass as a whole. The open fractures enable (and often encourage) water to penetrate, facilitating weathering (which weakens the rock adjacent to the fractures) and the intrusion of tree roots. The latter can be very effective at further opening the rock mass as the roots grow with time. All these processes appear to have been active in this quarry face, and substantial tree roots can be seen within the open fractures (Figure 68).

Proceed along the Bread Walk towards Dinham Bridge. The Walk was originally laid closer to the water, opened in 1850, but following flood damage 30 years later was reconstructed in its present location.

Successively lower (older) Silurian beds outcrop, leading to the core of the Ludlow anticline some 150 m before Dinham Bridge. In turn these reveal the Lower Whitcliffe Formation (medium bedded to massive), Upper Leintwardine Fm (honeycomb weathering), and the Lower Leintwardine Fm (thinly bedded, lithologically similar to the Aymestry Limestone, but younger; good for lime, but too nodular as a building stone).

Note the so-called pack horse track where the iron ore from Clee Hill was supposedly carried to the furnaces in Bringewood and Downton in the 18th Century - another geological benefit to Ludlow (Figure 70). However, the topography would have been easier over Ludford Bridge and up the Wigmore Road, so could the deep trenches ascribed to the Parliamentarian forces during the Civil War have possibly had their origins from such transportation (Figure 69)?

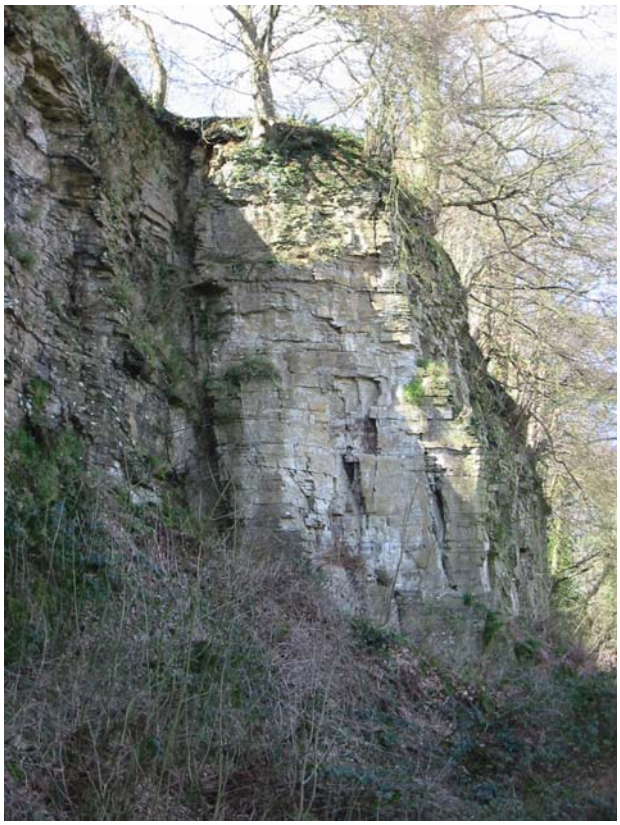

Figure 68. Stress relief fractures within the Upper Whitcliffe Beds, which once assisted manual quarrying; Whitcliffe Quarry.

Figure 69. Deep trenches above Whitcliffe. These have been ascribed to the Parliamentarian forces during the Civil War, but may have arisen from horse traffic, such as the packhorse trains carrying iron ore from Clee Hill to Burrington, or even exploited tension cracks opening behind Late Glacial landslides when the Teme rapidly eroded the gorge below.

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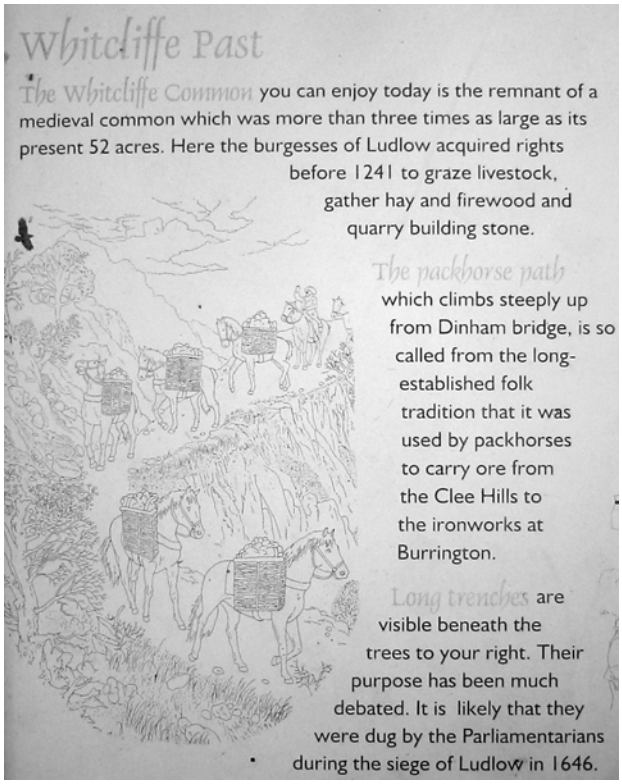

Figure 70. Information board on Whitcliffe Common linking transport, resource geology and military geology in the vicinity.

Continue to the end of the Bread Walk and onto the road to the north end of Whitcliffe, north of and behind Clive Cottages. Dinham Quarry lies to the left just past the left-hand bend in the road.

LOCALITY 32: Dinham Quarry [5055 7457]

Another major quarry in the Whitcliffe Beds for extraction of building stone, in medieval times owned by Bromfield Priory and operated on their behalf (Figure 71).

The dip of the Whitcliffe Beds here is 10° towards the north-north-west, consistent with its position on the northern flank of the Ludlow Anticline (*cf.* Locality 1 where the dip was also towards the north).

Figure 71. The notches are due to outcrops of beds of clay altered from volcanic ash. The upper notch, about one third of the way up the main face, corresponds to the contact between the Lower and Upper Whitcliffe Formations; Dinham Quarry.

Return to Dinham Bridge.

LOCALITY 33: Dinham Bridge [5068 7443]

The display board at the western end of the bridge presents an outline of the local geology. This is dominated by the Whitcliffe Beds but in the valley floor there are small exposures of the underlying geological unit, the Upper Leintwardine Beds, along the so-called packhorse track to the south. This comprises similar calcareous siltstones, but the fossil content is somewhat different, representing an earlier stage in their evolutionary development. The Upper Leintwardine also weathers to a characteristic carious (honeycomb) appearance as a result of solution of concretions.

The dip of the Upper Leintwardine Beds here is 5° towards the north-east, gentler than the previous Locality and reflecting the proximity to the core of the Ludlow Anticline (some 150 m downstream).

The bridge itself dates from 1822 (the alignment of the former wooden structure can

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be seen just downstream) and is largely constructed of calcareous siltstone from the Whitcliffe Beds. However, the lintels are sandstone, probably Highley Stone (Upper Carboniferous) (Figure 72). In Georgian and Victorian times this stone was the material of choice for construction of many of the bridges over the River Severn.

Figure 72. Dinham Bridge, constructed of Whitcliffe Beds with lintels of Carboniferous Highley Stone.

The flood plain of the River Teme within the gorge is narrow, and the relatively recent alluvial silt is thin. However, when the water level is low, banks of gravel can be seen. These have often been worked as a source of aggregate. They are of fluvio-glacial origin and similar to the large deposit currently being excavated at Bromfield.

Erosion by the modern-day river is in part controlled by the weirs and in part by revetments. Large blocks of stone for the latter can be seen below the wall by Castle Mill. These are of dolerite ('Dhu Stone') from Clee Hill. Their shape is columnar with approximately hexagonal sides, characteristic of slow cooling within a 'sill' (an igneous intrusion formed as molten magma forced its way along the bedding, in this case of the Upper Carboniferous Coal Measures sediments). Its choice is also good since dolerite has a significantly higher density than most sedimentary rocks (3.0 *cf.* 2.5).

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Disclaimer - The information contained in this account has been prepared following a summary of the geological literature of the area and visits to all the locations described. Its sole aim is to give visitors to the area an insight into its geology and the links between it and past and present building within Ludlow. It should not be used for any other purpose or construed as permission or an invitation to visit the sites or localities mentioned.

Hazards - take care underfoot along paths, and beware of motor traffic.

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