Historic England

Strategic Stone Study

A Building Stone Atlas of West Sussex (including part of the South Downs National Park)

Published June 2015

Introduction

The solid geology of West Sussex comprises gently-dipping Cretaceous and younger Cenozoic sedimentary rocks which form a series of east-west trending ridges and vales across much of the southern and central parts of the county.

The oldest rocks are of Early Cretaceous age and crop out in the north-east of the county in the High Weald area. Here, the Ashdown and Tunbridge Wells formations (belonging to the 'Hastings Beds') have provided a number of sandstones for building purposes, including the Ardingly Sandstone. Further west in the county, thin sandstones within the overlying Weald Clay Formation have been quarried mostly on a minor scale for building stone, with the exception of the Horsham Stone and Horsham Stone-slate. The latter is the most important indigenous roofing stone in the county. The Weald Clay Formation is also well known for the occurrence of Sussex Marble, a limestone packed with fossil gastropod shells, which polishes well and has been much-used for internal decorative work.

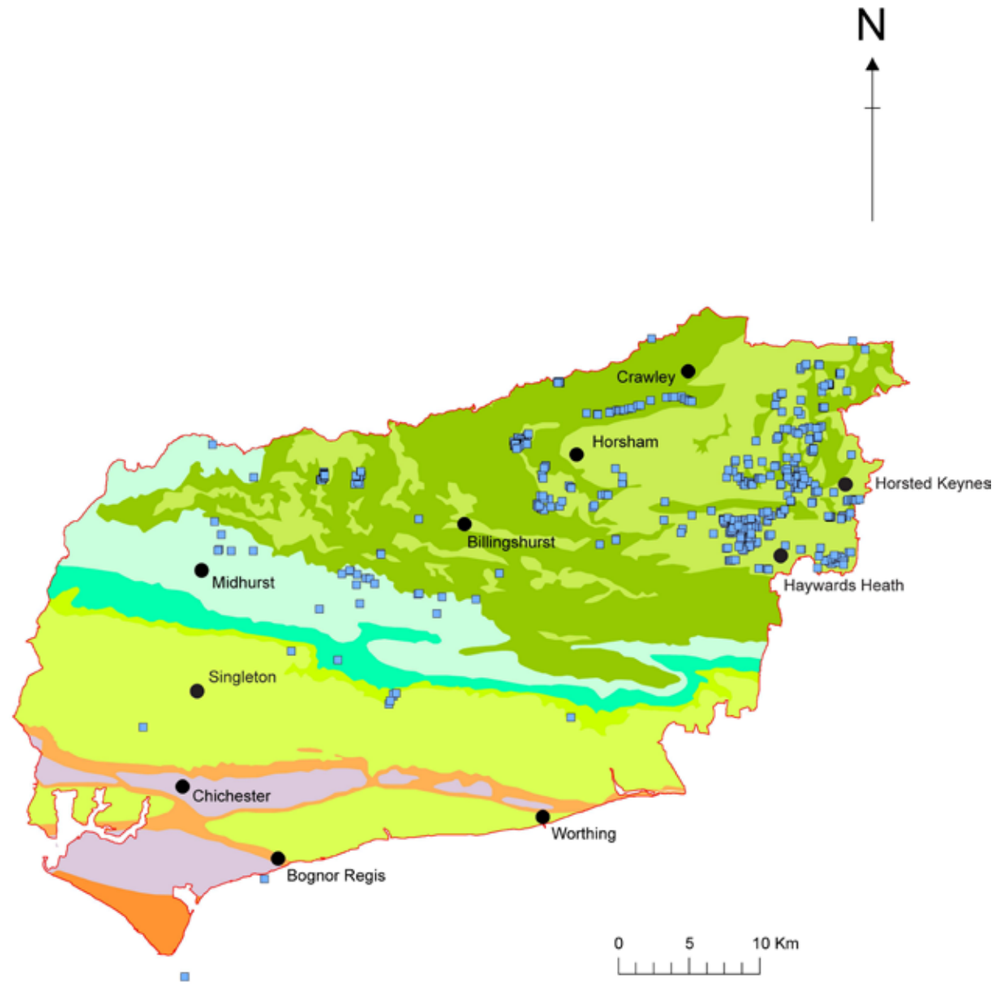
The oldest east-west trending belt of rocks in the county comprises the Lower Greensand Hythe Formation (one of the most important sources of building stone in West Sussex), overlain by the Folkestone and Upper Greensand formations. These provide the sources for two other much-used building stones: the deeply coloured Carstone (an ironstone) and the pale grey Malmstone, respectively. Above these lie the Upper Cretaceous Chalk Group deposits. Typically, these are too soft to be employed as an external building stone, although Lavant Stone (a gritty phosphatic chalk), Chalk Calcrete and Flint are more resistant and have been used externally, mainly in the southern part of the outcrop.

There is a major unconformity between the Cretaceous strata and the oldest Tertiary (Palaeogene) sediments. The latter mainly crop out south of a line extending roughly east-west from near Westbourne via Chichester and Arundel to Worthing. These Palaeogene strata consist largely of shallow marine clays and sands, but they do include concretionary layers (Bognor Rock and London Clay Cementstone) and calcareous sandstones (Mixon Stone) which have been used locally as building stones.

Above the Tertiary deposits is a further stratigraphic gap, over which the Quaternary-aged deposits lie. Without doubt, the most important of these from a building stone perspective are the various, extremely resistant, types of 'Quaternary flints' (derived from the older Cretaceous White Chalk Subgroup) such as Downland Field Flint and Beach Pebble Flint. The youngest building stone to have been used in West Sussex is Tufa, although this has a very limited distribution and is employed only on a minor scale.

West Sussex has a very long history of stone extraction and usage. This began in Neolithic times when flint for making tools was mined and worked at various sites along the South Downs, although the earliest flint implements found so far in West Sussex (at Boxgrove), are much older and date from approximately 490,000 years ago. Numerous quarries were opened to provide building stone from Roman times onwards, several of which were re-used during the Saxon period (from about 950 AD) for the construction of small churches. After the Norman Conquest in 1066, large quantities of building stone were required for the construction of military, civic and religious buildings. New quarries were opened, existing quarries were enlarged and barge access permitted the importation of large amounts of Caen Stone from Normandy and Quarr Stone from the Isle of Wight.

West Sussex Bedrock Geology



West Sussex Bedrock Geology

- BUILDING STONE SOURCES
- BRACKLESHAM GROUP AND BARTON GROUP (UNDIFFERENTIATED) - SAND, SILT AND CLAY
- THAMES GROUP - CLAY, SILT, SAND AND GRAVEL
- LAMBETH GROUP - CLAY, SILT, SAND AND GRAVEL
- CHALK GROUP - CHALK
  - WHITE CHALK SUBGROUP
  - GREY CHALK SUBGROUP
- GAULT FORMATION AND UPPER GREENSAND FORMATION (UNDIFFERENTIATED) - MUDSTONE, SANDSTONE AND LIMESTONE
- LOWER GREENSAND GROUP - SANDSTONE AND MUDSTONE
- WEALDEN GROUP (principally Weald Clay Formation, but also includes stratigraphically lower mudstone-bearing units) - MUDSTONE, SILTSTONE AND SANDSTONE
- WEALDEN GROUP (principally Tunbridge Wells Sand Formation, but also includes coarser grained lithologies of stratigraphically higher mudstone-dominated units) - SANDSTONE AND SILTSTONE, INTERBEDDED

Fewer building stone quarries operated post-C14th and especially after the Dissolution of the Monasteries and it was not until the C18th and C19th that social and industrial changes created a need for more construction stone. The by-product of chalk extraction for agriculture purposes was flint, which was extensively used for building; large amounts of flint gravel were also removed from beaches along the coast, although even in the early C19th the removal of stone from offshore reefs was recognised as leading to a steady increase in coastal erosion. By the mid-C20th, most of the building stone quarries had closed either due to having been worked out or to rising costs and stricter environmental regulation making production uneconomic.

Today, a few quarries extract Hythe Sandstone and Horsham Stone intermittently in West Sussex. The only quarry currently in full-scale production is Philpots Quarry at West Hoathly, which works Ardingly Sandstone.

Useful accounts of the geology and use of building stones in West Sussex are provided in the relevant memoirs of the British Geological Survey (BGS) and in the key references listed at the end of this Atlas. The Cretaceous rocks, in particular, have a complex history of classification and various names have been assigned to both the strata themselves and to the building stones they have yielded. For clarity, the building stone types recognised during this study are summarised in Table 1 on page 4 opposite, set against the modern stratigraphical framework (which is adhered to throughout).

PERIOD	GROUP		FORMATION/MEMBER		BUILDING STONES
QUATERNARY	Various/not defined		Various/not defined		• Tufa • Ferricrete • Downland Field Flint, Beach Pebble Flint, River Terrace & Fan Gravel Flints
TERTIARY (PALAEOGENE)	Barton Group		Barton Clay Formation		
	Bracklesham Group		Selsey Sand Formation		• Mixon Stone, Hounds Stone
			Marsh Farm Formation		
			Earnley Sand Formation		
			Wittering Formation		
	Thames Group		London Clay Formation		• London Clay Cementstone, Turritella Bed Concretions • Bognor Rock • 'Harwich Formation Siltstone'
			Harwich Formation		
	Lambeth Group		Reading Formation		• 'Reading Formation Ironstone'
			Upnore Formation		• Sarsen Stone
CRETACEOUS	Chalk Group	White Chalk Subgroup	Portsdown Chalk Formation		• Top Chalk
			Culver Chalk Formation		
			Newhaven Chalk Formation		• Lavant Stone
			Lewes Nodular Chalk Formation		
			New Pit Chalk Formation		
			Holywell Nodular Chalk Formation (Plenus Marls at base)		Chalk (incl. Amberley Chalk) and Quarry Flint
		Grey Chalk Subgroup	ZigZag Chalk Formation		
			West Melbury Marly Chalk Formation (Glauconitic Marl at base)		
	Selborne Group		Upper Greensand Formation		• Malmstone
			Gault Formation		
	Lower Greensand Group		Folkestone Formation		• Carstone
			Sandgate Formation	Marehill Clay Member	
				Pulborough Sandrock Member	• Pulborough Sandrock
				Rogate/Fittleworth Members	
				Easebourne Member	• Bargate Stone
			Hythe Formation		• Hythe Chert • Hythe Sandstone (Pulborough Stone, Lodsworth Stone, Midhurst Stone, Petworth Stone)
			Atherfield Clay Formation		
	Wealden Group ('Wealden Sandstones')		Weald Clay Formation		• Sussex Marble ('Paludina Limestones') • Weald Clay Sandstones (Hadfold, Alfold, Oakhurst, Billingshurst, Wisborough and Andrews Hill Sandstones)
				Horsham Sand Member	• Horsham Stone, Horsham Stone-Slate
		'Hastings Beds (Subgroup)'	Tunbridge Wells Sand Formation	Upper Tunbridge Wells Sand	• Forest Sandstone (Shelley Plain, Colgate and Roffey Park Sandstones)
				Grinstead Clay Member	• Cuckfield Stone, Tilgate Stone
				Lower Tunbridge Wells Sand & Ardingly Member	• Ardingly Sandstone
			Wadhurst Clay Formation		
			Ashdown Formation		• Ashdown Sandstone

Table 1. Summary of stratigraphical names applied to Cretaceous and Cenozoic sediments in West Sussex (the main sources of building stones are highlighted in blue).

Lower Cretaceous
Wealden Group
Wealden Sandstones and Sussex Sandstones

The Wealden Group, in South-East England, comprises a thick sequence of Early Cretaceous sediments. The history of the Wealden Group stratigraphy is long and complex, and various names have been applied to different parts of the succession at various times. This is partly the result of the lateral facies variations shown by these sediments across their outcrop area, which is an issue that has particular relevance to the numerous sandstones that occur within the Wealden Group and have been employed for building purposes.

The situation is further complicated by the recognition that even within individual formations a wide range of sandstone varieties may be present; several named varieties of sandstone may even occur together within the same quarry. Consequently, distinguishing individual sandstones when seen *ex-situ* or assigning them to specific formations or source quarries is, at best, extremely difficult, and often impossible.

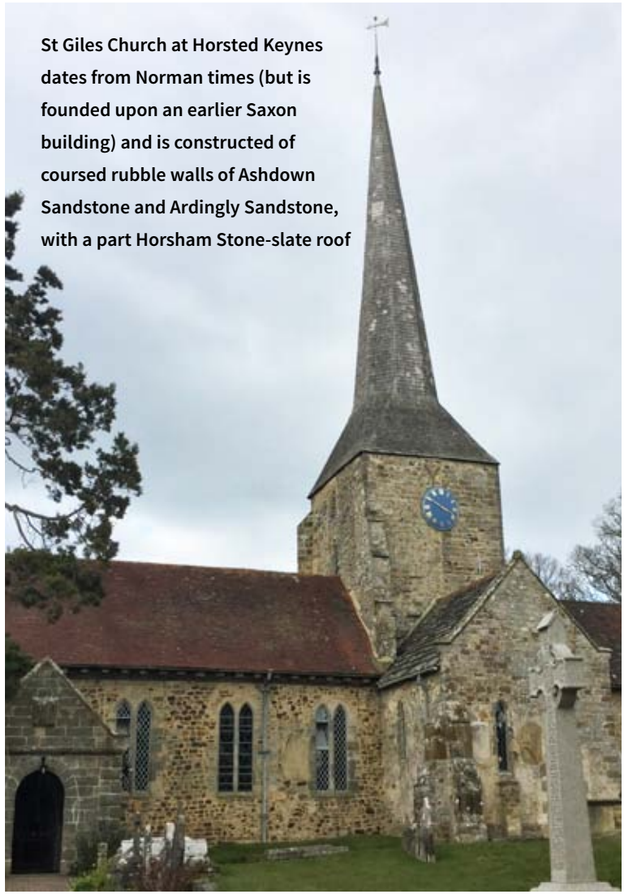
For convenience therefore, the term 'Wealden Sandstone' is used in this study of West Sussex building stones in a generic sense for any sandstone that is believed to originate from within the Wealden Group, but is otherwise of uncertain stratigraphic position. Accordingly, the term 'Sussex Sandstone' is applied to any sandstone of uncertain stratigraphic origins, but which is believed to be from either the Ashdown Formation or the Tunbridge Wells Sand Formation (i.e. from within the 'Hastings Beds' – a unit considered to have subgroup status by BGS, but pending formal definition and upgrade at the time of writing).

Ashdown Formation
Ashdown Sandstone

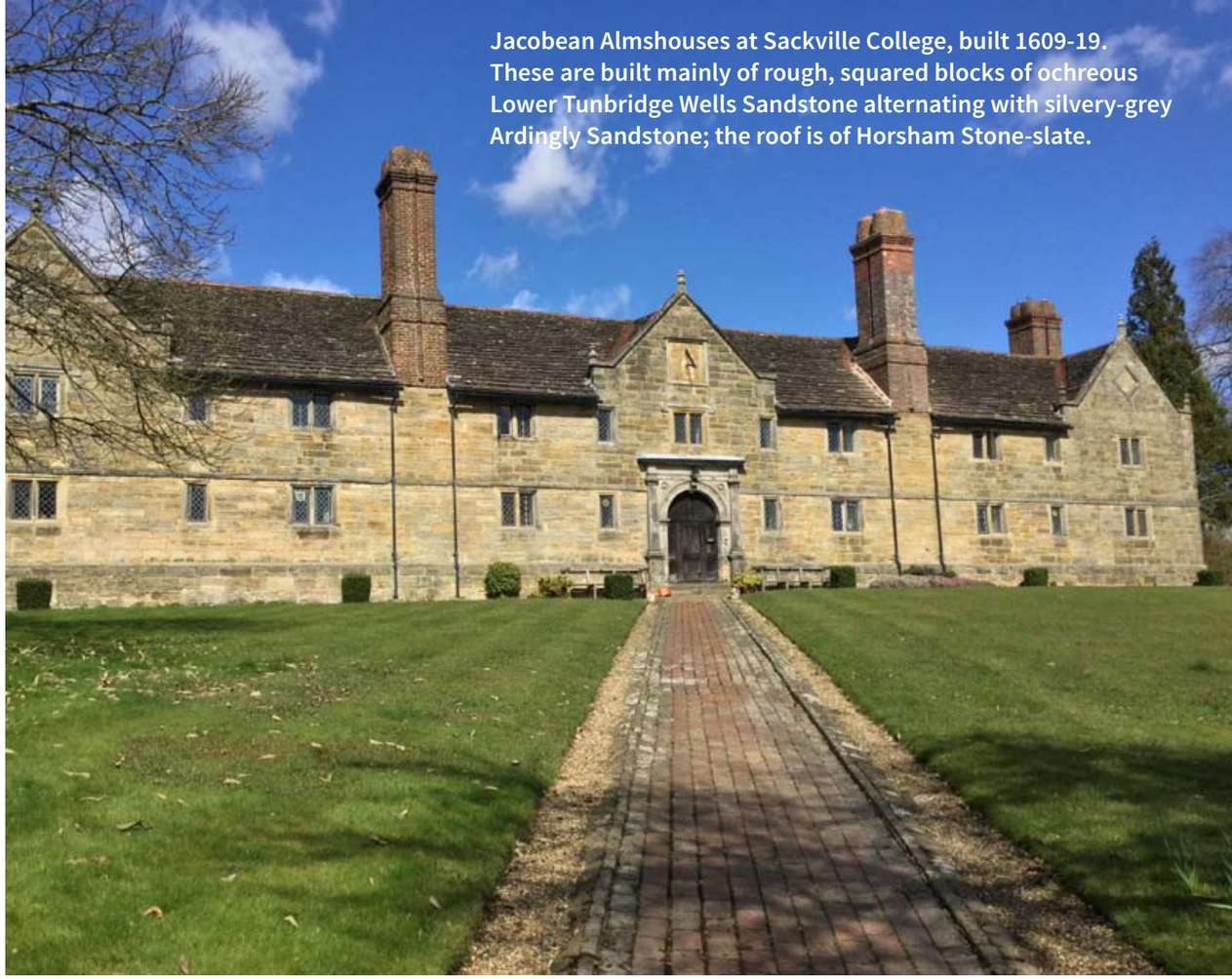
The oldest exposed strata in West Sussex, equating to the uppermost 60m of the Ashdown Formation, crop out in the far north-east of the county around Horsted Keynes and Sharpthorne. The sequence comprises mainly siltstones and clays with four main sandstone units - the uppermost of which is named the Top Ashdown Sandstone.

Distinguishing between individual sandstones is usually not possible unless their exact provenance is known from documentary evidence. Each sandstone unit is up to 6m thick and comprises yellowish-brown to pale grey, fine-grained sandstones with a thin, pebbly base. Sandstone varieties occur in each unit and range from massive to flaggy lithologies, sometimes with ripple-marks on the uppermost surface, and they are often cemented with calcite and iron oxides. The latter varieties are more resistant to weathering. Throughout the sandstone units, fossils are generally sparse and poorly preserved, but locally they may be abundant and include freshwater bivalves, gastropods and plants, with occasional rolled dinosaur bones occurring in the thin basal pebble-bearing beds.

All four Ashdown Sandstone units have been used historically as a source of local building stone and were formerly quarried around Horsted Keynes and Sharpthorne. They were mainly used to a limited extent in walls of coursed rubble.



St Giles Church at Horsted Keynes dates from Norman times (but is founded upon an earlier Saxon building) and is constructed of coursed rubble walls of Ashdown Sandstone and Ardingly Sandstone, with a part Horsham Stone-slate roof



Jacobean Almshouses at Sackville College, built 1609-19. These are built mainly of rough, squared blocks of ochreous Lower Tunbridge Wells Sandstone alternating with silvery-grey Ardingly Sandstone; the roof is of Horsham Stone-slate.

Tunbridge Wells Sand Formation

The Tunbridge Wells Sand Formation is approximately 75m thick and comprises fine- to medium-grained, pale or silvery grey to ochreous or buff sandstones and siltstones with darker coloured finely-bedded mudstones. The formation can be divided into three: the informally named Lower Tunbridge Wells Sand and the Upper Tunbridge Wells Sand, and the intervening Grinstead Clay Member. The succession commences with rhythmically bedded sandstones, siltstones and mudstones of the lower part of the Lower Tunbridge Wells Sand which pass up into the massive sandstones of the Ardingly Sandstone Member. These are overlain by the Grinstead Clay Member, which is itself divided into upper and lower parts by the cross-bedded, fine-grained sandstone of the Cuckfield Stone Bed. Above the Grinstead Clay Member, the Upper Tunbridge Wells Sand comprises a generally more argillaceous rhythmic succession, including mudstones, siltstones and silty sandstones.

In common with many of the other Wealden Group sandstones, the sandstones of the Tunbridge Wells Sand Formation often possess very similar lithological characteristics. Consequently, they usually cannot be distinguished from one another when seen *ex-situ* unless their exact provenance is known by other means. One exception to this is the Ardingly Sandstone, as demonstrated by the Jacobean Almshouses at Sackville College.

The most important building sandstones originating from within the Tunbridge Wells Sand Formation are further described overleaf.

Lower Tunbridge Wells Sand & Ardingly Sandstone Member

Ardingly Sandstone

Ardingly Sandstone is a high quality freestone which has been widely used for ashlar throughout the Wealden area, and to a lesser extent in the southern part of West Sussex along the lower Adur valley. It crops out in the north-eastern part of the county around East Grinstead, Turners Hill, West Hoathly, Balcombe, Ardingly and Cuckfield.

The Ardingly Sandstone Member is 15-20m thick and comprises mainly silvery-grey coloured, massive, fine-grained, well-sorted quartz sands and sandrock. The best quality and hardest building sandstone beds contain a small amount of calcite cement and occur towards the top of the member, below the overlying Grinstead Clay.

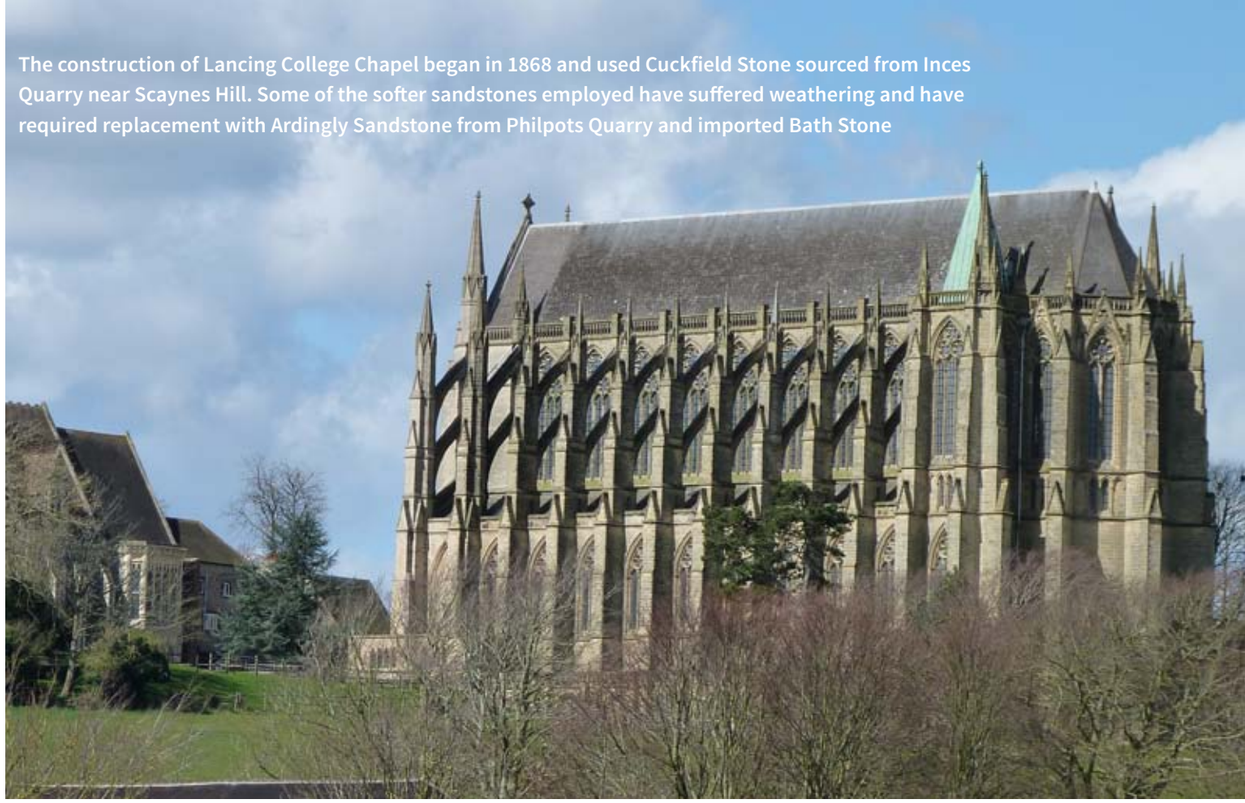
Lower beds of the Ardingly Sandstone show a wide variety of textures and structures, including cross-bedding, ripple structures, slumped beds and sand-filled scours. Some strata contain small carbon flecks (lignite), and are iron-stained and exhibit Liesegang banding.

Fossil burrow structures are common and are often seen on the surface of building stones; other fossils include freshwater bivalves, gastropods, scales and teeth of fish and sharks, pieces of carbonised wood and giant fern logs, with scattered, rolled and disarticulated dinosaur bones (*Iguanodon*). Thin pebble-bearing beds lie at both the top and base of the Ardingly Sandstone.

Generally, Ardingly Sandstone weathers evenly. It is soft when freshly quarried, but hardens over time. A tough surface skin (caused by weathering where salts accumulate and harden on the surface of the rock) develops on naturally-exposed stone surfaces. The Sandstone is worked today at Philpots Quarry, West Hoathly; there are numerous former quarries in the outcrop area.

Ardingly Sandstone is often the sole building stone employed in a building, and is used for high quality ashlar, walls and fine decorative and ornamental work (it is readily carved). The ashlar work in many churches in the north-east of the county is of Ardingly Sandstone.

The Elizabethan-aged Gravetye Manor, built in 1598, is constructed mainly of Ardingly Sandstone ashlar, with mullion and transom windows with hood moulds, and a roof of Horsham Stone-slate



The construction of Lancing College Chapel began in 1868 and used Cuckfield Stone sourced from Inces Quarry near Scaynes Hill. Some of the softer sandstones employed have suffered weathering and have required replacement with Ardingly Sandstone from Philpots Quarry and imported Bath Stone

Grinstead Clay Member

Cuckfield Stone Bed (Cuckfield Stone)

The Cuckfield Stone Bed has a complex outcrop pattern and is cut by numerous faults. It occurs between West Hoathly and Handcross, south of an area between Lower Beeding to Horsted Keynes, and then again from Crabtree eastwards to Cuckfield, Haywards Heath and Scaynes Hill, where it reaches a maximum thickness of 8m.

Typically, Cuckfield Stone is a fine- to medium-grained sandstone which ranges from grey to light-brown in colour, but it occurs in a number of different lithological varieties which are often similar to those that occur throughout the lower part of the Wealden Group. Therefore, this building stone can only be identified with certainty if the quarry from which it was sourced is known from documentary evidence, or if it can be matched unquestionably to the bedrock in a nearby quarry.

Near Turners Hill, Cuckfield Stone is a buff coloured, sandy-siltstone with reworked sandstone pellets and abraded fossil shell and bone material; around West Hoathley, the lower part of the Cuckfield Stone is flaggy, and often ripple-marked, with more massive, blocky stone above. In the Haywards Heath-Scaynes Hill area, Cuckfield Stone is a freestone and similar in appearance to Ardingly Sandstone.

In the central part of its outcrop, the basal part of the Cuckfield Stone features a thick quartz-pebble conglomerate, which includes rolled dinosaur bones and teeth.

The sandstones include trough cross-bedded units and horizons of lenticular bedding with ripple and scour structures filled with coarse-grained sand and grit. Some beds exhibit a fissile structure due to repeated thin silt laminations containing muscovite mica. Fossils tend to be widely dispersed, but may be abundant in certain beds, and include freshwater bivalves, gastropods, fish, turtles, crocodiles, dinosaur bones and teeth, and rafted plant or woody material.

Many of the sandstones exhibit Liesegang banding and are iron stained to various degrees, making the stone attractive for building purposes.

Cuckfield Stone is mainly used as ashlar and coursed rubble. Examples of its use include Holy Trinity Church, Cuckfield (in association with Ardingly Sandstone and Horsham Stone-slate) and Lancing College Chapel.

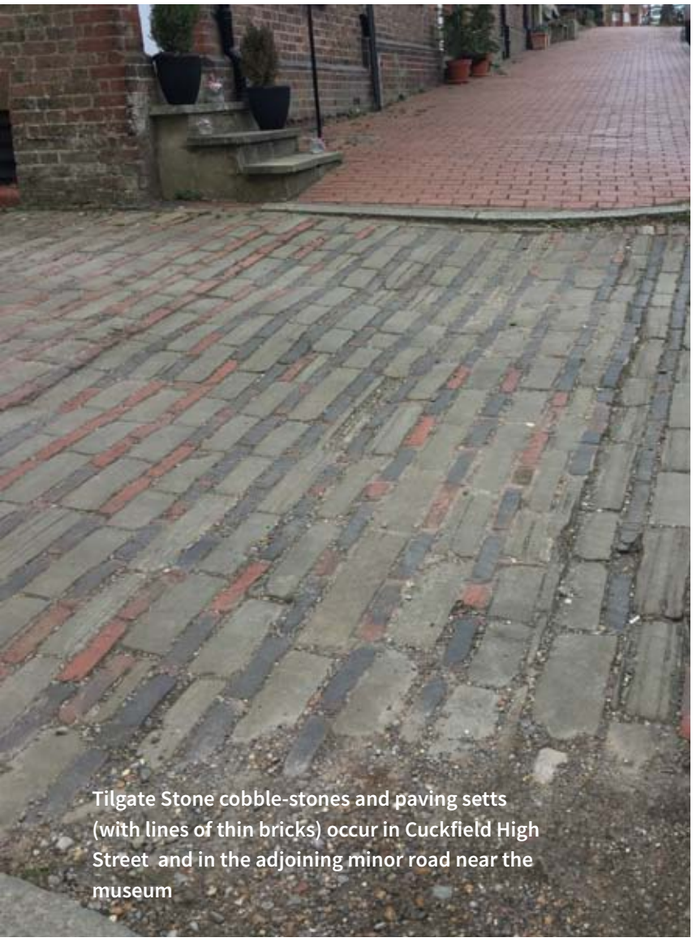
Tilgate Stone

The name Tilgate Stone is herein applied to beds of flaggy sandstone that occur within the Cuckfield Stone Bed and have a relatively minor, localised use in the Cuckfield area. The name was originally applied by the eminent early C19th geologist Gideon Mantell to strata at 'Tilgate Stone Quarry' at Whitemans Green, north of Cuckfield, from which the bulk of his famous dinosaur fossil finds, including *Iguanodon,* were made.

Tilgate Stone is a fine- to medium-grained, yellowish grey to pale brown, tough, calcite-cemented, concretionary sandstone, which is often micaceous and contains closely-spaced bedding laminations. It is distinguished from Cuckfield Stone by its more thinly-bedded and flaggy nature.

Tilgate Stone is locally important in the Cuckfield area and has mainly been used as paving, or broken-up for use as road stone, or occasionally used as a roofing material.

Blocks of Tilgate Stone were employed in the C13th and C14th rebuilding of Cuckfield's Norman church.



Tilgate Stone cobble-stones and paving setts (with lines of thin bricks) occur in Cuckfield High Street and in the adjoining minor road near the museum

Unpublished sketch by Gideon Mantell (c. 1833) of his reconstruction of *Iguanodon*

Upper Tunbridge Wells Sand

Upper Tunbridge Wells Sandstone (Forest Sandstone)

The Upper Tunbridge Wells Sand crops out in the far north-east corner of West Sussex, in the Horsted Keynes and Sharpthorne areas and notably in the area of St. Leonard's Forest (from which the name Forest Sandstone is derived). Three separate sandstone beds were formerly worked as building stone in the St Leonard's Forest area – in ascending order these have been named **Shelley Plain Sandstone**, **Colgate Sandstone** and **Roffey Park Sandstone.** However, in common with many of the other Wealdon sandstones, these varieties of Forest Sandstone are lithologically very similar, and they usually cannot be distinguished from one another unless their exact provenance can be determined by other means.

Typically, Forest Sandstone is a fine-grained, buff, brown or pale grey stone that shows a wide variety of textures and colours. It occurs in beds up to 3m thick, which sometimes comprise two distinct sandstone units, the lower unit being more flaggy. The sandstones are composed of angular to sub-angular quartz grains (0.06mm), with minor muscovite mica flakes, set in a limonite-goethite matrix (which often gives rise to a very ferruginous stone). Some sandstone beds are finely-bedded and exhibit planar lamination or low-angle cross bedding; other more massive sandstone beds display ripple marks. Fossil plant debris may also occur.

Sandstone from the St Leonard's Forest area has been employed as a building stone on a small scale in the vicinity of Horsham and Crawley, usually in walls as coursed rubble. Examples of its use include the old town hall at Horsham and churches at Roffey, Coolhurst, Cowfold and Nuthurst.

Nuthurst Church dates from the C12th and was originally constructed in Horsham Stone; it was completely restored in 1907 using Upper Tunbridge Wells Sandstone which probably came from Sun Oak Quarry

Weald Clay Formation

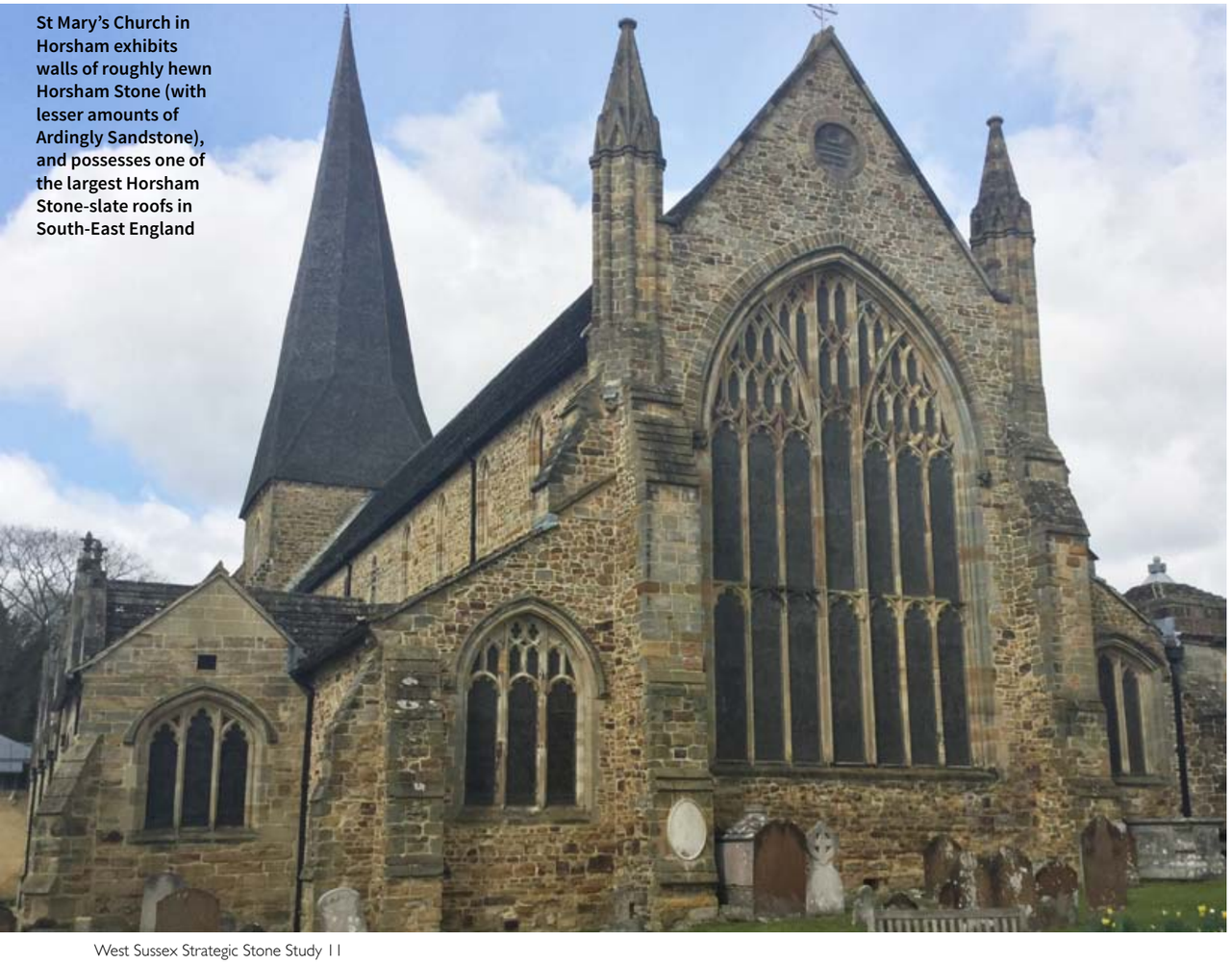
Horsham Stone

Horsham Stone was used on a much larger scale as a building stone than any other Weald Clay Formation sandstone. It forms a prominent scarp slope in the Horsham area, and is traceable from Slinfold to Crawley. From Christ's Hospital, to the east of Itchingfield, the outcrop strikes eastwards to Cowfold and then thins eastwards towards Burgess Hill and Wivelsfield, where it dies out. To the south and west of Horsham, the Horsham Stone splits into two beds: the lower part of each bed is a hard calcareous sandstone (named Horsham Stone); the upper part of each bed is a laminated sandstone or stone-slate (named Horsham Stone-slate, which is described in the following section).

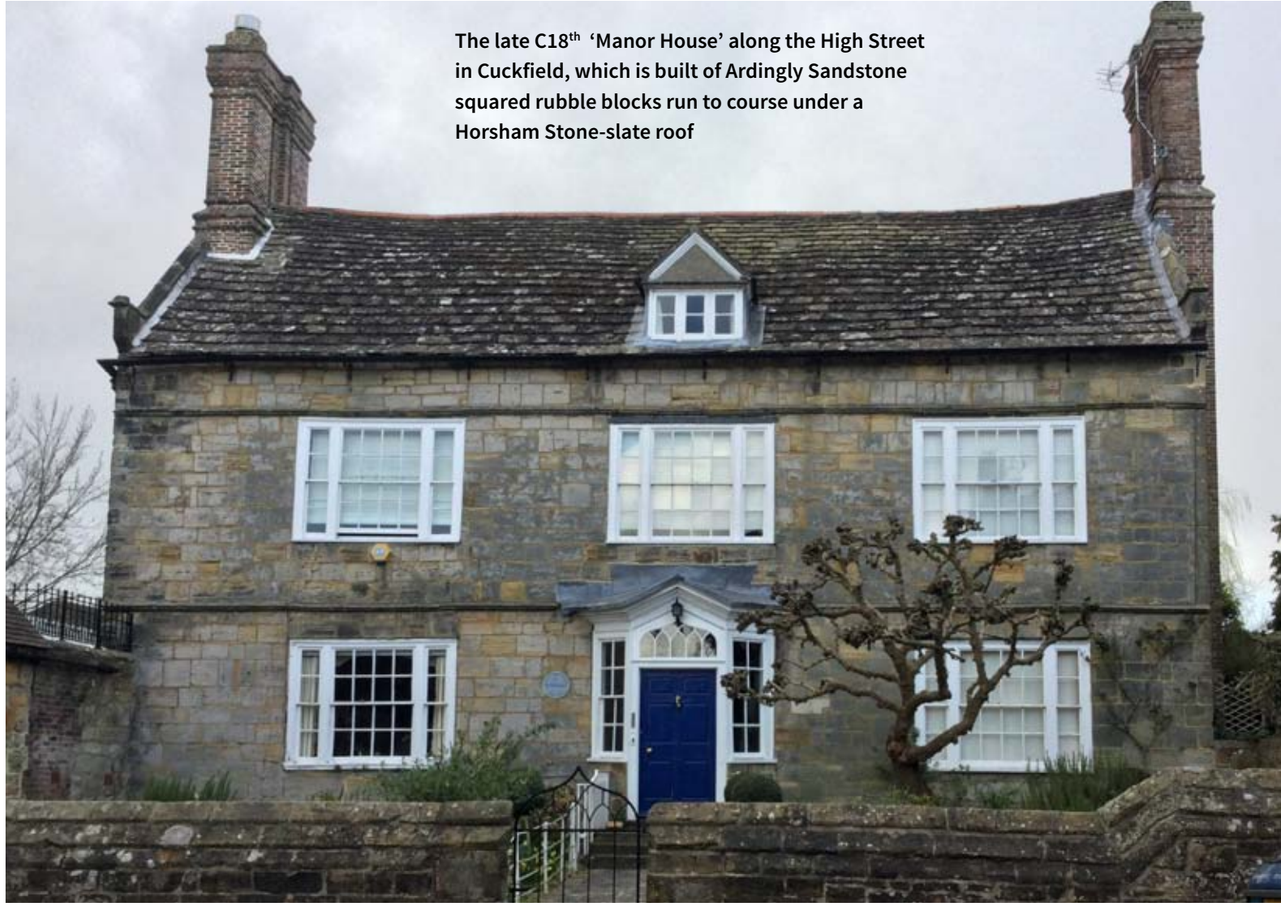
Horsham Stone is a very fine- to fine-grained, hard, massive to flaggy, calcareous sandstone, typically pale buff or honey-brown to pale grey in colour; bands of iron-staining are commonplace. Ripple structures and cross-bedding are widely present along with linear 'bounce marks' and load casts.

With the exception of trace fossils and bioturbation features, fossils are uncommon in the Horsham Stone, but include poorly-preserved casts and moulds of freshwater bivalves, wood fragments (lignite) and rare impressions of dinosaur footprints and coprolites.

Horsham Stone was widely used for flagstone paving and occasionally walling. The earliest known evidence of the use of Horsham Stone is provided by the quern stones excavated from an Iron Age site (Amberley Mount) on the South Downs. More recent use of Horsham Stone can be seen at Roffey Church, in the villages of Itchingfield, Steyning and Rusper, and in new-build houses at Budgenor, Easebourne (with brick facings); ripple-marked Horsham Stone flagstones were used at Clayton Church. There are numerous quarries that once worked Horsham Stone and Horsham Stone-slate, including Stammerham at Christ's Hospital. The stone is currently quarried intermittently near Slinfold, and is then dressed at Broadbridge Farm, Broadbridge Heath.



St Mary's Church in Horsham exhibits walls of roughly hewn Horsham Stone (with lesser amounts of Ardingly Sandstone), and possesses one of the largest Horsham Stone-slate roofs in South-East England



The late C18th 'Manor House' along the High Street in Cuckfield, which is built of Ardingly Sandstone squared rubble blocks run to course under a Horsham Stone-slate roof

Horsham Stone-slate

Horsham Stone-slate is usually honey to grey in colour, and exhibits few structures apart from fine laminations and occasional broad amplitude ripple marks. It readily cleaves into 2-3cm thick slabs which are ideal for use as roofing slates and flagstones. Over time, roofs of Horsham Stone-slate often develop a black surface due to algae colonisation, whilst weathered edges may reveal laminations resulting from the thin bedding.

Horsham Stone-slate was formerly in great demand for roofing and the stone was utilised in numerous churches, townhouses and farmhouses, giving a solid and traditional appearance to many medieval and younger buildings, especially in the eastern part of West Sussex. The slates were traditionally top-hung on split-wood laths, the largest slates laid along the lower part of the roof, with a progressive decrease in slate size towards the roof ridge. Older roofs (pre-C19th) used a double-lap system, but as Horsham Stone-slate became more expensive and difficult to source, a single-lap system was more commonly employed.

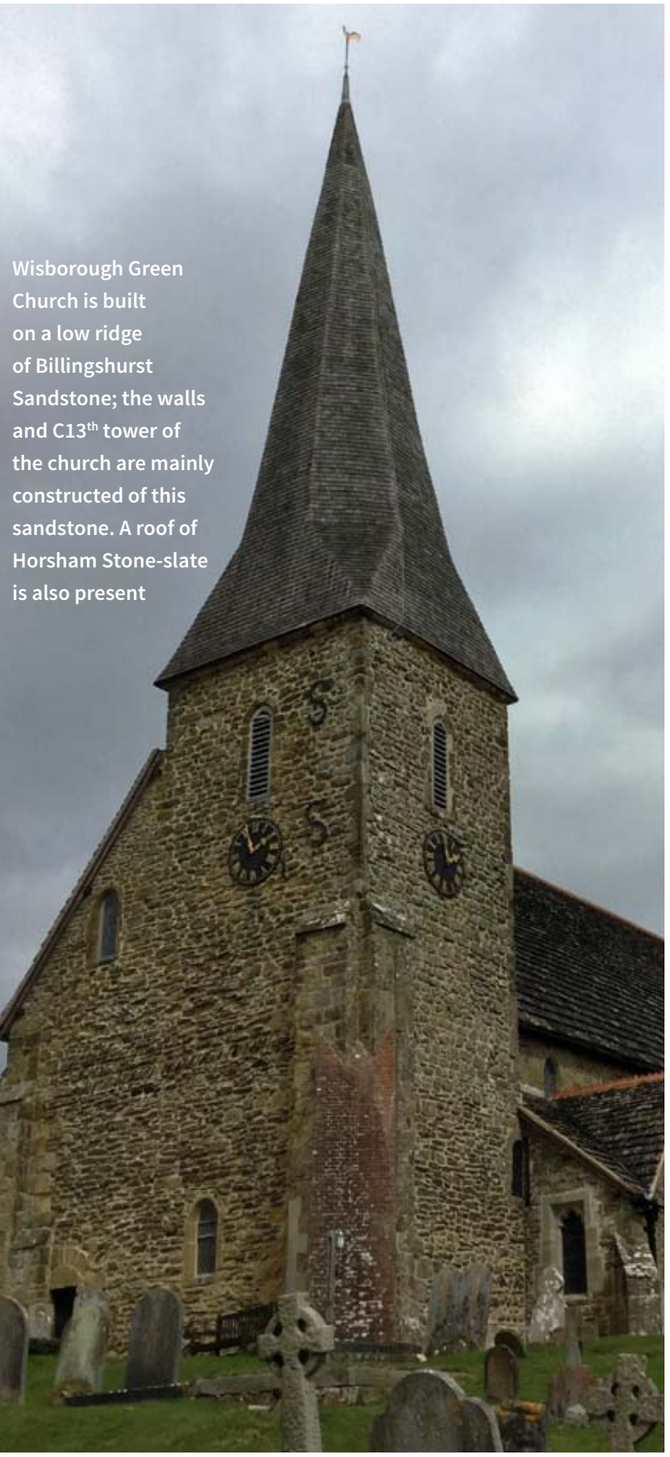
Several examples of the use of Horsham Stone–slate are provided elsewhere in this Atlas.

Other sandstones derived from the Weald Clay Formation

In addition to Horsham Stone and Horsham Stone-slate, the Weald Clay Formation contains several other thin sandstones that have in the past been quarried to a minor extent for building stone. In ascending order, these sandstones have been named: **Oakhurst Sandstone, Billingshurst Sandstone, Wisborough Sandstone, Andrews Hill Sandstone, Hadfold Sandstone** and **Alfold Sandstone**. However, they are all very similar lithologically, and unless their provenance is known with certainty from documentary evidence, it is extremely difficult to distinguish the individual sandstones when seen *ex-situ*.

These sandstone beds crop out within the Weald Clay Formation as a series of low ridges stretching westwards from Charlwood towards Haslemere, and which then swing eastwards around Billingshurst and to the north of Steyning towards Bolney. They are mainly fine-grained (occasionally medium-grained), finely laminated, and often micaceous and flaggy; individual sandstones range in thickness from 1-5m. Their colour also varies, but is typically buff to pale grey, weathering to an orangeish-brown or brown colour due to iron staining, and they often exhibit Liesegang banding.

The sandstones are composed of pale quartz sand, with scattered flakes of mica, and are cemented with minor amounts of calcite, clay minerals and iron oxides. Many of the sandstones show 5-10cm thick cross-bedded units, with varied ripple structures being commonly seen in the upper part of each bed. Occasional scour structures are also present.



Wisborough Green Church is built on a low ridge of Billingshurst Sandstone; the walls and C13th tower of the church are mainly constructed of this sandstone. A roof of Horsham Stone-slate is also present

Sussex Marble (Paludina Limestone)

Sussex Marble is one of the best known stones in West Sussex. Cut surfaces readily take a good polish, and it was highly valued as an important and attractive internal decorative stone. It has also been used occasionally as an external building stone.

Sussex Marble is a freshwater limestone and occurs in the upper part of the Weald Clay Formation in beds which typically are up to 30cm in thickness, but may be considerably thicker, up to 70cm. The limestone is usually light grey or buff in colour, but varies to shades of blue or green depending on the presence of clay and iron minerals (which often become brownish upon weathering). The limestone is readily identified by the presence of abundant fossil gastropod shells, *Viviparus,* which often appear somewhat paler (whitish in section), and are commonly infilled with patches of transparent crystalline calcite.

Two forms of the limestone occur in West Sussex:

A lower **Small Paludina Limestone** (also called **Charlwood Marble**), which is confined to a narrow area between Crawley, Charlwood and west of Horsham. This limestone occurs in beds up to 15cm thick, and contains closely packed fossil shells of the small freshwater gastropod *Viviparus infracretacicus*.

An upper **Large Paludina Limestone** (also called **Winklestone** or **Petworth Marble**), which extends over a much larger area stretching from near Cranleigh southwards to Petworth then eastwards to Billingshurst and West Grinstead. This limestone occurs in beds varying from 10-30cm or more in thickness, and is composed mainly of the fossil shells of the larger, more globose freshwater gastropod *Viviparus fluviorum*.

Sussex Marble was formerly dug from numerous shallow pits (known locally as delves) in the Weald Clay outcrop; the limestone was easy to extract as the beds dip very gently and could be quarried for some distance laterally down the shallow dip. Although relatively hard when fresh, Sussex Marble weakens due to water penetration, which causes the rock to crumble and decay; exterior memorial stones rarely last more than 100 years.

Consequently, the limestone is mainly used for internal decorative and monumental work such as altar tables, tombs and ledgers, fonts, columns and fire-places. Sussex Marble is occasionally seen as a walling stone in barns, farmhouses and cottages in the Low Weald, such as the barn at Mitchell Park Farm, Northchapel.

Warminghurst Church is composed mainly of light-brown Sussex Marble random rubble run to course, with a Horsham Stone-slate roof.

Lower Greensand Group

Hythe Formation

Hythe Sandstone

Hythe Sandstone is one of the most common and widely used building stones across the southern part of West Sussex, especially where the Wealden Group sandstones are not employed. It has an extensive outcrop, from Linchmere in the north-west, south to Rogate then east across the county to Hurstpierpoint. The main outcrop stretches from Stedham and Midhurst in the west, and extends eastwards north of the River Rother, via Lodsworth, Petworth, Byworth and Pulborough, to West Chiltington.

Hythe Sandstone is also referred to as Greensand as the fresh sandstone may exhibit a dark-green colour due to the presence of glauconite.

The formation is highly variable, however, and contains medium- to coarse-grained sandstones which range in colour from pale brown, yellowish-orange to dark green or pale grey, or sometimes exhibit a bluish sheen.

Individual sandstone units may be thinly bedded or more massive; some contain grey cherty layers or are friable and striped with alternating paler quartz-rich and darker glauconite-rich bands. Many of the sandstones are bioturbated and contain the fossil burrow structures of *Planolites* or *Macaronichus*, or are iron-stained and exhibit Liesegang banding. The more finely-bedded units often exhibit sedimentary structures including ripple marks and planar and trough cross-bedding on a variety of scales.

Several ‘varieties’ of Hythe Sandstone have been informally named after the villages near to which they were quarried and where they were widely used. However, these ‘varieties’ are not necessarily confined to their respectively named villages, as individual local quarries often each produced several different varieties of the sandstone:

Midhurst Stone – a massive, pale brownish-grey, slightly calcareous sandstone, sometimes iron-stained. Contains small, scattered ferruginous nodules which sometimes weather out leaving behind sub-spherical cavities. Often exhibits a distinctive 'salt and pepper' texture.

Fittleworth Stone – a slightly lighter coloured form of Midhurst Stone.

Lodsworth Stone – a hard, dark green and bioturbated sandstone.

Petworth Stone - a pale grey or greyish-blue, cherty, banded sandstone; the high percentage of chert gives the distinct bluish colouration. The chert layers are often thin, disjointed and cut by bioturbation structures.

Pulborough Stone - a pale grey to greyish-green, glauconitic, finely-bedded, bioturbated sandstone. The bedding planes are packed with small irregular chert nodules, up to 5cm long. Weathers with a distinct knobbly texture with the chert nodules standing proud.

Hythe Sandstone is one of the most common and widely used building stones in West Sussex. It has been extensively employed for ashlar work, roughly dressed and coursed rubble walling, carved mouldings and some decorative work. Particularly good examples of its use include: the bridges at Selham, Pulborough (Swan Bridge) and Stopham (the latter being constructed of blocks of Midhurst Stone); churches at Kirdford, Fittleworth, Trotton, Stopham, Tillington, Easebourne and Rogate; the ruins of Cowdray House (Midhurst Stone) and the walls and keep entrance of Arundel Castle. The front ashlar work, the rubble side elevations and the dressings of both Petworth House and Somerset Lodge are of Petworth Stone. Lodsworth Stone was also used for quern stones in Iron Age and Roman times.

There are numerous historic quarries of Hythe Sandstone and its named varieties, but it is currently only worked for rubble stone at Bognor Common Quarry and intermittently for building stone at Winters Pit, Easebourne (Midhurst Stone).

Stopham Bridge, constructed of Hythe Sandstone

Somerset Lodge in Petworth - Hythe Sandstone

Hythe Chert

Chert occurs within the Hythe Formation as nodular beds and impersistent layers up to 1m thick. Much of the chert employed for building is a hard, very fine-grained, grey rock with a splintery fracture; a translucent, amber coloured chert variety with a vitreous lustre also occurs, but is less common.
The cherty sandstone contains numerous minute fossil sponge spicules with scattered grains of dark green glauconite; this weathers to give the rock a distinctive 'salt and pepper' texture.

Hythe Chert has been quarried on a small scale from Norman times as a by-product of sandstone extraction; it was only later, in the C18th and C19th, that this stone was specifically quarried for building work mainly from pits around Petworth, Little Bognor and Stopham. It has been used locally as a minor, but occasionally abundant, rubble stone constituent in many older buildings in villages along the base of the Hythe Formation dip-slope, especially west of the River Arun, between Petworth and Pulborough. Particularly good examples of its use are provided by the cobblestone setts and some of the walls in Petworth, including the random rubble of the United Reform Church. Lurgashall Church exhibits roughly-dressed 10cm thick slabs of Hythe Chert laid to course and alternating with Hythe Sandstone ashlar, together with some chert galleting. At Coates Church, Hythe Chert is employed as a rubblestone in walls along with contrasting brown-coloured Carstone.

Sandgate Formation

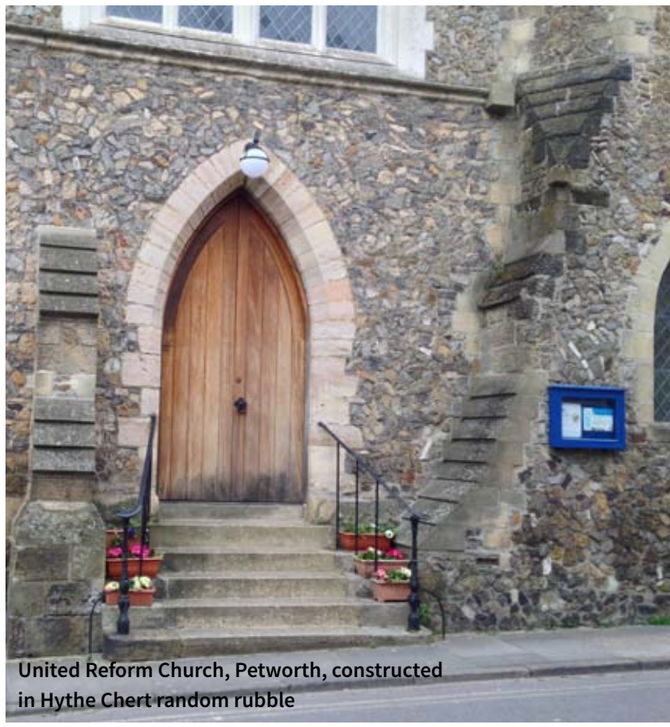
Easebourne Member

Bargate Stone

Bargate Stone occurs mainly in the Petworth to Rogate area, where it is intermittently exposed along the upper edge of the Hythe Formation outcrop. The main lithological variety is a medium-grained, hard, calcareous sandstone, although two types of the stone are recognised in West Sussex: the first is a rich honey-brown coloured sandstone or gritstone; the second is a grey, glauconitic, often flaggy calcareous sandstone with sandstone concretions. Layers of cherty sandstone and chert also occur.

The sandstones vary from massive to well-bedded varieties, which naturally break into slabby layers 10-15cm thick, so they can be easily used as brick-sized blocks. They also sometimes exhibit cross-bedding or honeycomb weathering textures. The sandstones also contain layers of the fossil burrow *Macaronichus*, which are typically 0.5cm wide cylindrical structures, each surrounded by a rim of glauconite grains.

Bargate Stone was mainly a by-product of quarries that worked the Hythe Sandstone between Easebourne (including Winters Pit) and Woolbeding. In the C18th and C19th, the stone was broken up for use as road stone. Its use as a building and paving stone is, relatively speaking, very small-scale. It may be seen in churches at East Worthing and Aldwick, Bognor Regis, and as paving slabs at Woolbeding Church entrance.



United Reform Church, Petworth, constructed in Hythe Chert random rubble

Greatham Church - constructed of Pulborough Sandrock rubble

Pulborough Sandrock Member

Pulborough Sandrock

Pulborough Sandrock crops out within a narrow belt of country, from Rogate in the west to West Chiltington in the east, where it varies from 10-20m in thickness.

The Member comprises orange-brown to deep purple-brown or blackish ferruginous sandstones and siltstones with ironstone concretions (which contain a wide variety of fossil shells). The sandstones are often finely laminated and exhibit a 'milk-flake' texture. The ironstone concretions typically demonstrate spheroidal weathering. Some sandstone units, up to 1m thick, show slumped-bedding structures similar to those more commonly seen in the underlying Hythe Formation sandstones.

Pulborough Sandrock is of comparatively little value as a building stone due to its relative softness and limited outcrop extent, but was occasionally used as a rubble walling stone (often coursed). In the Pulborough area, up to 50cm of iron-oxide-cemented sand and siltstone at the top of the Member (lying immediately below the overlying Marehill Clay Member) was locally used for minor building purposes.

It can be seen in the walls of churches at Wiggonholt and Stopham, in house walls in Pulborough along the main A283 road and in the walls of C18th and C19th cottages in Marehill. It was also used in the walls of Greatham Church, where the ironstone concretions exhibit spheroidal weathering.

Pulborough Sandrock is exposed in the old sand workings at Marehill, and was formerly obtained from quarries on Hesworth Common and Northpark Wood on the Parham Estate.

Folkestone Formation

Carstone

Carstone (commonly known as Ironstone) occurs across the south-central part of West Sussex, extending from Washington and Storrington in the east through Midhurst towards Petersfield in the west. It is a hard, medium- to coarse-grained, ochreous to dark brown or reddish-black quartzose sandstone or gritstone, containing chert and quartz pebbles set within a matrix of iron oxides and hydroxides. Carstone occurs as irregular shaped masses, thin layers and veins within the 'typical' sands that comprise the Folkestone Formation.

A bed of iron-oxide cemented quartz grit (the 'Iron Grit', which is up to 30cm thick) occurs at the top of the Folkestone Formation between Graffham and Washington. This bed has a distinctive bright orangeish-red colouration and contains thin layers of small quartz pebbles. It is very similar to coarse-grained Carstone and is therefore not readily distinguishable as a separate building stone type. Other ferruginous sandstones and siltstones occurring in West Sussex (such as the Pulborough Sandrock) generally have a finer-grained texture and lighter colour than typical Carstone.

Carstone is often massive, but larger blocks may reveal cross-bedding structures and display Liesegang banding. The surface of cut blocks may exhibit a bluish sheen caused by a thin layer of iron oxide. Generally, Carstone is a hard, durable, tough rock, that is resistant to weathering.

Carstone has been valued in West Sussex since Roman times as a building stone. It was also utilised in late Saxon and Norman churches. During the C18th to early C20th, Carstone was worked as a by-product of the sand quarries (or collected as field brash) along the outcrop of the Folkestone Formation.

Many old cottages in Fittleworth are constructed of Carstone blocks laid to course

Many cottages in Graffham, Washington and Fittleworth are built entirely of Carstone laid to course in brick-sized blocks. It is also widely used as rubble walling stone, and occasionally as cobbles. Galleting, using small chips of Carstone placed in the mortar between dressed Malmstone and Hythe Sandstone, is evident in many house and cottage walls in Midhurst, Pulborough, Storrington and Washington.

The front elevation of the White Hart Inn shows the contrast between roughly-dressed Carstone and squared Hythe Sandstone

Selborne Group

Upper Greensand Formation

Malmstone

Malmstone crops out along the foot of the South Downs escarpment from South Harting in the west to Fulking in the east, and the stone adds character and charm to many villages, churches, cottages and farms along the Upper Greensand outcrop in West Sussex.

Malmstone is a massive, rarely fossiliferous calcareous siltstone which exhibits a notable colour difference when traced along its outcrop. East of Amberley, the rock is a massive, grey, cherty siltstone with a sub-conchoidal fracture which weathers to a pleasant buff or brownish colour; to the west, white siltstone predominates. The best quality and harder building stone varieties are known as Amberley Blue and Blueheart; these have a bluish sheen and contain more chert and calcite cement than the softer white siltstone varieties.

All varieties of Malmstone have been widely employed for building purposes along its outcrop. Although much of the stone is a freestone, it is generally roughly dressed and laid to course, or used as rubble stone. Historically, some Malmstone was worked along sunken roadside lanes, although small pits may also have existed. It is no longer worked.

Good examples of the use of Malmstone can be found at the C14th Amberley Castle, the dovecote and stable block on Parham Estate and in several late Tudor country houses, such as Cowdray House, Parham House and Wiston House. The majority of older buildings and many boundary walls in the villages of Sutton and West Burton are constructed of trimmed rectangular blocks of blue Malmstone.

When used as infill rubble, Malmstone is sometimes referred to as 'clunch' (a term also confusingly used for Chalk infill).

C14th Amberley Castle (with source strata exposed at the base of the outer walls)

Upper Cretaceous

Chalk Group

Chalk

Chalk is a relatively soft, fine-grained, white limestone; it is typically structureless, and sometimes powdery. The Chalk Group succession in West Sussex is up to 400m thick, and the upper 70% of this is represented by the White Chalk Subgroup. This is distinguished by its white colour and layers of flint nodules, and it forms much of the south-facing dip slope of the Sussex Downs. The lower 30% is represented by the Grey Chalk Subgroup, which crops out along the northern escarpment; this is a darker, typically greyish colour and is devoid of flints, but includes thin marly layers between thicker chalk beds.

The use of chalk as a building stone in West Sussex is mainly confined to the southern part of the county. However, chalk is generally unsuitable for exterior building stone-work as repeated wetting, drying and freezing cycles cause the rock to powder and disintegrate. When used externally, softer forms of the stone may weather in a concave manner away from mortar lines.

There are, nonetheless, numerous impressive examples of chalk having been used for interior ashlar work, mouldings, ceiling vaulting, arches and transept walls in a number of churches in West Sussex, including Burpham, Shoreham-by-Sea, East Levant, Bramber and Amberley; chalk was also used for the roof of the cloisters in Chichester Cathedral. The heavily weathered remains of external chalk walls can be seen at Blackfriars Priory and Amberley Castle.

Harder beds within the Chalk sequence have been used as infill rubble and bonding between facings of flint and brick (this infill material is sometimes referred to as 'clunch' although this term is also confusingly used in connection with Malmstone when used for a similar purpose).

One variety of chalk – the relatively hard Amberley Chalk – has seen some use as an external building stone. This is a fine-grained, creamy white stone, which is typically thickly-bedded to massive or blocky, with an ill-defined nodular structure and rough texture. Occasional fossils include *echinoids*, *inoceramid* bivalves, and *rhynchonellid* and *terebratulid* brachiopods. Amberley Chalk was formerly quarried from pits within the general Amberley area, notably from large workings near the present-day Amberley Museum and Heritage Centre.

Amberley Museum & Heritage Centre - constructed of Amberley Chalk blocks sourced from the adjacent former quarry

Amberley Chalk is used locally, again mainly for interior work or rubble infill. Occasionally, as at the modern entrance building to Amberley Museum and Heritage Centre, it has been used as small, cut blocks.

In addition to Amberley, Chalk was formerly quarried for building stone from quarries alongside the River Arun at Houghton. Here, the Chalk provided massive freestone blocks (of up to 1m in size) free from flints. Today, the only working Chalk building stone quarries are at Duncton Hill and Upper Beeding.

White Chalk Subgroup

Quarry Flint

Quarry Flint is one of the most common and widely used building stones in West Sussex. It originates from bands and nodules of flint that occur within the White Chalk Subgroup. Quarry Flint was dug from chalk pits and has been used extensively close to and within the outcrop area of this subgroup along the South Downs.

Quarry Flint is an extremely fine-grained (cryptocrystalline) and hard form of silica containing microscopic, quartz-crystal aggregates. It usually occurs as irregularly-shaped nodules that are 10-20cm across, or as (sub-)rounded pebbles and cobbles; occasionally, it is also found as weakly banded tabular sheets or layers up to 20cm thick.

The Old School House at Angmering, where high quality Victorian flint-work in the main building contrasts with random flint work (using flint beach cobbles) used in the perimeter walls

The colour is very distinctive; fresh flint nodules have a white outer cortex with darker coloured (black, dark grey) interior. The red colouration shown by some flints in old walls may be indicative of 'burning' by fire at some time (the red colouration being due to the formation of iron oxides).

Quarry Flint breaks with a characteristic conchoidal fracture, producing razor-sharp, fine edges; the cleaved surfaces may exhibit banded structures resulting from the alternation of layers of slightly different composition. Flint nodules may contain cavities lined with translucent botryoidal chalcedony or small transparent quartz crystals; some flints contain well preserved fossils - echinoids, sponges, bivalves and burrow-structures being the most commonly encountered types.

Quarried flint is used extensively in walls in a wide variety of ways: it is laid to course as rough tabular 'sheets' or nodules; in squared chequer-work; as knapped, faced, trimmed or cleaved-faced stone in random or decorative arrangements; or as galleting used to fill interspaces between irregular flint nodules or other stones when the mortar is wet, thus reinforcing the mortar.

Oakford Park, Halnaker - 'new-build' houses constructed in flint

It is also frequently seen interlocking with brick or other stone dressings, quoins, window and door jambs which help consolidate the building. West Dean, Lavant, Halnaker and Steyning provide good examples of villages built mainly from freshly quarried flint. Particularly fine examples of the use of flint can be seen in new-build houses at Oakford Park, Halnaker and the Old School House at Angering.

The extremely hard and resistant nature of Quarry Flint-type nodules has resulted in their having been recycled by natural processes into younger deposits, where they show specific characteristics - these types of flint are described in the Quaternary section of this Atlas.

Newhaven Chalk Formation

Lavant Stone

Lavant Stone occurs as a localised lenticular bed within the Newhaven Chalk Formation. It was formerly quarried exclusively from a Roman/medieval pit on the Chalk Downs at Langford Farm, near Mid-Lavant. Most of the stone was likely worked out by the C15th.

The stone is a medium- to coarse-grained, white to pale grey, 'gritty' phosphatic chalk calcarenite containing scattered brown, phosphatised grains; in places, these grains may be sufficiently abundant to give a pale brown colour to the whole rock. Lavant Stone is noted for its well-preserved fossils including abundant minute sponge spicules and other small, shelly detritus, along with echinoids, belemnites, serpulid worm tubes and occasional shark teeth. Lavant Stone is variably cemented, and can weater in a manner such that the more resistant fossils stand proud of the stone surface.

Three main varieties of Lavant Stone have been recognised:

Massive white calcarenite: this is the most commonly encountered type, and is composed of broken shell debris and other fossils; its weathered surface is often colonised by red algae.

Grey-coloured, phosphatic limestone: weathered bioturbation structures impart a coarsely textured appearance to this stone which also contains scattered glauconite grains. Large fossils are occasionally encountered.

Pale brown, rough textured, soft limestone: this stone contains phosphatic nodules and well preserved fossils. The surface becomes notably pitted upon weathering.

Lavant Stone is an excellent freestone and since Roman times has been commonly used for ashlar work, quoins and buttresses in a range of ecclesiastical buildings within an approximate 10-mile radius of Chichester, including churches at East Lavant, Mid-Lavant, Chidham, Earnley and West Stoke. It has also been used as a rubble stone, which likely represents reused Roman material (for example, in the southern walls around Chichester Cathedral precinct), and has seen occasional decorative use.

One of the most notable uses of Lavant Stone is in the late C12th archways and pillars of the ruins of Boxgrove Priory, immediately adjoining Boxgrove Church

Portsdown Chalk Formation

Chalk Calcrete (Top Chalk)

Chalk Calcrete is a hard, buff to very pale grey, cemented chalk that occurs at the top of the Chalk sequence, immediately below the Tertiary Lambeth Group sediments. The rock has been cemented by karstic processes, and hardened by the crystallisation of calcite. Chalk Calcrete only reaches 5m in thickness and, given that it is typically crossed by close-spaced joints, it is usually only available as small blocks of rubble. The stone typically exhibits patches of reddish-brown iron staining (especially along hairline fractures or small joints) or brown Liesegang banding. It may also be affected by the borings of marine organisms if sourced from the foreshore.

Chalk Calcrete was formerly collected from foreshore exposures along the West Sussex coast, around Dell Quay, Felpham, Lancing and Thorney Island in Chichester Harbour. Inland, it is reported to occur as blocks and brash in ploughed fields near Patching. Chalk Calcrete was formerly used locally as a rubble stone in minor amounts (mainly in walls) in the coastal areas around Chichester Harbour, in Bognor Regis and Felpham, and in the lower Adur valley.

Tertiary (Palaeogene)

Lambeth Group

Upnor Formation

Sarsen Stone (erratics)

Sarsen Stones represent the eroded remnants of a bed of silica-cemented sand that is believed by some geologists to have lain at the base of the Lambeth Group (Upnor Formation), and which sat directly above the Cretaceous Chalk of the West Sussex Chalk Downs. Today, numerous Sarsen Stones occur as boulders on the coast and beaches to the west of the county, notably along the foreshore at Chichester Harbour.

Sarsen Stones are usually grey to pale brown in colour, becoming distinctly creamy-buff when weathered. They are very fine- to fine-grained, and comprise sub-rounded quartz grains set within a silica matrix, which is visible on fractured surfaces. Sarsens often occur as rounded or elongate pebbles, cobbles, boulders or even metre-scale slabs (up to 3m in length). Sarsen Stones are very hard and resistant. Their surfaces are often smooth and may occasionally show poorly-defined bedding structures; beach-worn Sarcens may exhibit an 'elephant-skin' surface texture.

Westbourne Church - the east walls include pieces of 'Harwich Formation Siltstone'

Sarsen Stones are a relatively minor building stone in West Sussex. They are usually encountered as isolated or scattered pebbles and water-worn beach cobbles in old flint walls of ancient churches, buildings and general walling across the West Sussex coastal plain (including Felpham, Pagham, West Wittering and Bognor Regis).

Reading Formation

'Reading Formation Ironstone'

This fine-grained ironstone has a very distinctive, rich reddish-brown or orangeish-brown colour, which helps distinguish it from the otherwise very similar Carstone. In West Sussex, 'Reading Formation Ironstone' has seen only very minor use as a building stone, and its presence appears to be limited to occasional stone in the walls of medieval churches lying along the coastal plain in the Chichester area. The provenance of this building stone remains uncertain: similar rock is exposed near Chichester Harbour, but the local superficial deposits are an alternative potential source.

Thames Group

Harwich Formation

'Harwich Formation Siltstone'

This siltstone (formerly known as the London Clay Basement Bed) is a thin unit, only 4m thick, which crops out on the foreshore in Chichester and Langstone harbours. It comprises grey to brown, fossiliferous siltstones with occasional shelly argillaceous limestones. Some beds are packed with small, straight, calcareous fossil tubes of the serpulid worm *Ditrupa*, which may reach up to several cm in length.

The stone was formerly collected from the foreshore at Chichester Harbour, and has a very limited and localised use in the Chichester and Langstone Harbour areas. Some pieces are employed as occasional rubblestone in local churches, for example in the east walls of Westbourne Church.

London Clay Formation

The London Clay Formation is approximately 100m thick. Although the dominant lithology is clay, there are layers of concretionary sandstones and cementstones throughout the formation which have been locally used for building. The two main building stones types are known as Bognor Rock and London Clay Cementstone.

Bognor Rock

Bognor Rock occurs as hard, calcareous concretions in the lowest 7m of the London Clay Formation (the Bognor Sand Member) visible at low tide on the Bognor Regis foreshore. Individual concretions may be up to 3m in diameter and are composed of dark grey, glauconitic, carbonate-cemented sandstones which typically weather to a distinctive, light ochreous-brown colour. The rock is well known as a source of fossil shells, with the commonest types (the thick-shelled bivalve *Glycymeris brevirostris* and the coiled serpulid worm *Rotularia bognoriensis*) often being seen in rubble stone walls. These fossils help distinguish Bognor Rock from otherwise similarly coloured lithologies such as Hounds Stone (the latter is unfossiliferous).

Bognor Rock is mainly used as coursed and random rubble in old walls and churches in the coastal strip between Pagham and Felpham including South Bersted, Oving, Westergate, Aldingbourne and Merston (where it is also employed in farm buildings). The stone also occurs as derived blocks in the sands and gravels around Chichester and Chichester Harbour, and has been used in Providence Chapel, Chichester.

In Bognor Regis itself, Bognor Rock may be seen in walls along Ellasdale Road and Sylvan Way.

Bognor Rock varies in hardness from a relatively soft, slightly friable sandstone to a very tough, resistant, calcite-cemented rock. Much of the rock used as building stone in old walls around Bognor Regis is relatively soft and shows the effects of weathering; fossil shells and burrows often stand out in relief.

West of Bognor Regis, at Barn Rocks (Aldwick), the sandstone concretions are thinner and greenish-coloured; they are only exposed under low spring tide conditions. '**Barn Rock Sandstone**' is very similar to Bognor Rock, and has been used as a very minor rubble stone in the Aldwick area.

Occasionally, Bognor Rock was cut into ashlar for higher-quality building work, for example at Hotham Park wall and gatehouse in Bognor Regis

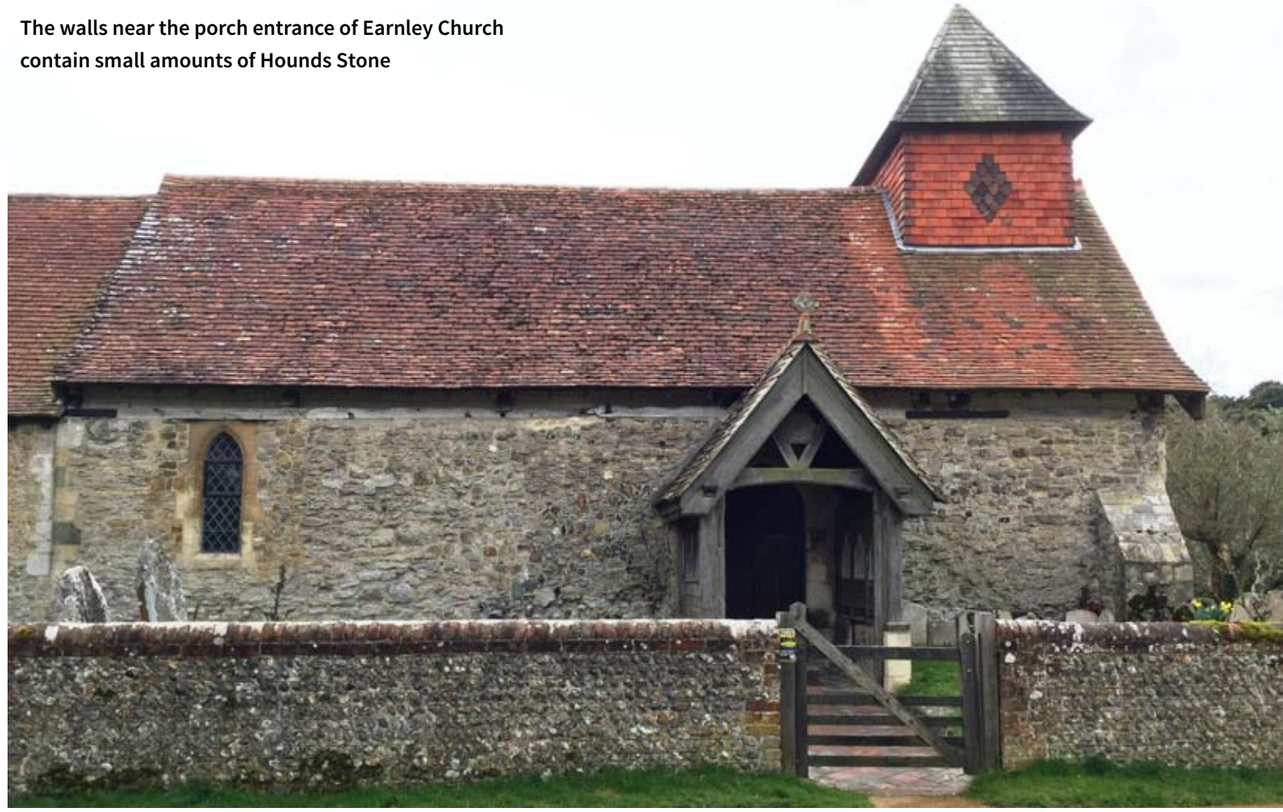
London Clay Cementstone

This cementstone comprises ellipsoidal concretions of fine-grained mudstone and siltstone, which reach 60cm in size. The individual concretions are either massive or septarian, and exhibit a traverse network of pale coloured calcite veins or mud-filled cracks. The pale to dark brown colouration of the concretions is distinctive, although upon weathering they sometimes develop a pale greyish or whitish 'skin'.

London Clay Cementstone is a relatively minor building stone used for rubble walling around the Bognor Regis, Pagham and Chichester Harbour areas; typically, it is seen mixed with other stone in local walls. It was collected from the foreshore at low tide at Bognor Regis and West Wittering. Historically, it was also dredged from Chichester Harbour and the septaria were used in cement manufacture at Bognor Regis.

A minor variety of London Clay Cementstone, referred to as Turritella Bed Concretions, occurs at Ella Nore in the West Wittering area. Here, the cementstone concretions contain the distinctive, white-coloured fossil gastropod shells *Turritella*.

A cottage off the High Street, Selsey, constructed mainly of Mixon Stone



The walls near the porch entrance of Earnley Church contain small amounts of Hounds Stone

Examples of the use of London Clay Cementstone include the old quayside walls at Bosham Harbour

Bracklesham Group

Selsey Sand Formation

Mixon Stone (Mixon Rock)

Mixon Stone was formerly quarried from the Mixon Reef, off Selsey Bill, a rocky islet only visible at low water. It was first worked during the Roman period, and became an important local building stone in late-Saxon times and during the C11th to C13th.

Mixon Stone was still being used in the early C19th but quarrying of the stone ceased in 1827 following an Admiralty prohibition order as removal of the stone was causing coastal erosion and affecting the sheltered anchorage on the leeward side of Selsey Bill. No legal quarrying has occurred since that date, and more recent buildings are constructed from reused stone.

Mixon Stone is a tough, coarse-grained, pale grey to honey-yellow bioclastic limestone or calcareous sandstone. It characteristically contains numerous microfossils, such as foraminifera, along with shell debris, sponge spicules and echinoid spines plus occasional corals, bryozoans and shark teeth; examples of the disc-shaped foraminifera *Fasciolites (Alveolina)* are conspicuous.

The rock also contains scattered sand grains and glauconite, and may exhibit bored surfaces caused by modern-day marine organisms.

The main centre of use of Mixon Stone was on the Selsey Peninsula and also within an area bounded by Westbourne, Westhampnett, Oving and South Bersted. It was employed in a wide variety of buildings ranging in date from Roman (e.g. Fishbourne Roman Palace) to mid C19th. Good examples of its use as roughly-shaped blocks of walling stone can be seen today in South Street, Chichester and in several C18th properties located along the High Street in Selsey, such as The Neptune Public House and nearby cottages and walls.

Hounds Stone (Hounds Rock)

As its name implies, Hounds Stone was formerly quarried from The Hounds (or Houndgate Rocks) which lie offshore to the west of Selsey. Historically, it may also have been sourced from the Church Rocks off Hayling Island.

Hounds Stone is readily distinguished from Mixon Stone as it is a finer-grained, grey to greenish-grey coloured, unfossiliferous, calcareous sandstone.

It is a relatively poorly consolidated and variably cemented rock, and typically weathers with a powdery or knobbly surface. Stratigraphically, Hounds Stone may be continuous with, and equivalent to, strata exposed on the Mixon Reef, but this remains unconfirmed.

Hounds Stone has seen very limited use as coursed and random rubble in the walls of old buildings in the southern part of the county, notably in the Bracklesham, Earnley and Wittering areas.

Quaternary

Quaternary Flint

Quaternary Flint occurs in large quantities in southern West Sussex and is distributed across wide areas of the Chalk Downs and coastal plains. This widespread availability, combined with its hardness and resistance to weathering, means that Quaternary Flint is one of the dominant types of building stone used in the County. It typically occurs as irregularly-shaped nodules or as sub-rounded pebbles and cobbles (depending on the flint type). The colour may be variable; less weathered flint nodules or pebbles have a cream outer cortex with darker coloured (greyish) interior; weathered flints or those that have lain in soil or superficial deposits for a long period, may be variously discoloured or bleached, often with brown stained interiors due to the precipitation of iron hydroxides from percolating ferruginous water.

Quaternary Flint is used extensively as a walling stone in a wide variety of ways: as nodules or pebbles laid roughly to course; as squared blocks as part of chequer-work; as knapped, faced, trimmed or cleaved-faced stone in random or decorative arrangements; or as galleting (when flaked flints are used to fill the spaces between irregular flint nodules or other stones). Three main types of Quaternary Flint are recognised:

Downland Field Flint

This type of flint typically occurs as irregularly-shaped nodules on the field surface of the Chalk Downs. The size of the nodules varies from 10-30cm, but larger nodules occur. The outer cortex of the nodule is usually cream coloured with a darker brownish or greyish interior which becomes white on old fractured surfaces. This 'lightly weathered' appearance helps distinguish Downland Field Flint from the much 'fresher-looking' Quarried Flint, which has a white outer cortex and very dark grey or black interior.

Downland Field Flint is a very common and widely used stone in West Sussex, and is employed in a wide variety of buildings and structures across the area of the Chalk Downs and (to a lesser extent) along the coastal plains. It was used extensively in walls in a variety of ways, with nodules often being selected for their shape and size, and laid in either a random or coursed manner.

Beach Pebble Flint

Beach (and Raised Beach) Pebble Flint typically occurs as pale to dark greyish, rounded pebbles and cobbles up to 10cm in size, but are occasionally larger. The pebbles often exhibit a 'frosted' surface appearance or 'chatter-marks' (small surface cracks) caused by impacts with other beach pebbles.

Chichester city walls are constructed of River Terrace and Fan Gravel Flint

The Royal Bank of Scotland in South Street, Chichester, built in the 1820s, provides a classic Georgian example of Downland Field Flint nodules laid to course, with the intervening mortar containing flint galleting

The collection of Beach Pebble Flint is now prohibited, but it was formerly used as and where found, and was employed in a variety of ways in a range of structures in coastal villages and towns. Less commonly, it was also used in villages inland such as Patching and Storrington.

The main use for Beach Pebble Flint was for walling, and flint pebbles and cobbles were often sorted for size and laid to course, such as seen in the C18th cottages along The Street in Boxgrove. Occasionally, the pebbles were used in more decorative fashion, with the long axis either vertical or at an inclined angle creating an imbricate pattern.

River Terrace and Fan Gravel Flint

This type of flint occurs as water-washed, sorted, sub-rounded pebbles, usually up to 15cm long, which are either stained brown or bleached white. They are commonly seen in a variety of built structures in and around the Lower Arun valley. A particularly fine example of its use is Chichester city walls, parts of which date to Roman times. Sections such as Lower Walls Walk were constructed of flints from the underlying fan gravels and from nearby downland fields.

Cottages in Boxgrove with Beach Pebble Flint run to course

The C13th Norman tower and east wall of Rudgwick Church - built of Ferricrete, which has crumbled in places due to weathering

Ferricrete (Iron Pan)

The distinctive conglomeratic or brecciated texture, created by clasts of sandstone, chert or flint set within an iron-oxide sandy matrix, readily distinguishes this stone from the otherwise similar, dark reddish-brown coloured Carstone. Ferricrete occurs in irregular layers up to 50cm thick, and was formerly quarried as far back as Norman times. It was dug on a small scale from shallow pits along the River Alun lower terrace deposits and coastal plain gravels (raised-beach deposits) in the Horsham, Billingshurst, Greatham, and Lyminster areas. The ferruginous matrix is relatively soft when first excavated, but hardens upon exposure to air.

Ferricrete exhibits variable cementation and it has been relatively little-used as a building stone. It is typically seen as isolated, rounded blocks as part of rubblestone walling or as roughly hewn blocks in medieval church walls in the areas where it was quarried. Occasionally, it was employed in other structures such as the west wall of Parham House Estate.

Ferricrete was also used as low-grade iron ore, but was of low quality in comparison with the sideritic concretions mined from the Wealden Group.

Tufa

Tufa is a whitish or pale grey coloured, highly porous limestone formed by the precipitation of calcium carbonate (lime) from springs where the water has passed through calcareous rocks (such as limestone or Chalk).

Tufa is used occasionally as a rubble stone in medieval church walls in the lower Adur valley. The few sources of the stone in this area were probably exhausted by the end of the Medieval Period, and it is likely that some walling stones may be reused Roman material.

Very few springs in West Sussex are presently depositing tufa in any appreciable quantity. One exception is provided by the spring heads in the Duncton Mill area, where tufa is being formed as spring water emerges from the surrounding Malmstone strata.

Imported Stones

Building stone has been imported into West Sussex since Roman times. It was during Norman times, however, that this trade increased greatly with thousands of tonnes of stone being shipped into the county for the construction of military, religious and civic buildings. Sailing vessels carried up to 40 tonnes of Caen Stone at a time across the Channel from Normandy.

There was also considerable transport of British-derived stones into West Sussex, especially Purbeck Stone and Purbeck Marble from Dorset (Isle of Purbeck); Bembridge Limestone, Ventnor Stone, Quarr Stone and Bonchurch Stone from the Isle of Wight; Chilmark Stone from Wiltshire; and Bath Stone, Doulting Stone and Beer Stone from South-West England.

In terms of volumes imported and amounts of stone used, three of the most important building stones imported into West Sussex were Caen Stone, Purbeck Marble and Quarr Stone. A tabulated list of imported building stone types seen in West Sussex is provided on page 32.

Steyning Church provides one of the most extensive examples of the use of Tufa in West Sussex. Here, the stone was cut into blocks and laid to course in the walls. The tower displays dramatic chequer-work of Tufa ashlar alternating with Flint

Stone Name and Place of Origin	Source Stratigraphy	Stone Characteristics and Selected Examples of Use
Quarr Stone Binstead, Isle of Wight	Tertiary, Solent Group	Pale grey to buff, porous, open-textured, shelly limestone; the fossils typically present as internal moulds. Used as quoins in many West Sussex churches, such as Tangmere, Climping, and Yapton. Large amounts of Quarr Stone ashlar used in Norman walls of Chichester Cathedral in random chequer-pattern with Caen Stone
Bembridge Limestone Isle of Wight	Tertiary, Solent Group	Buff, fine-grained, shelly limestone (freestone); the fossils include the gastropod *Galba* and alga *Chara*. Used as rough block work and quoins in many West Sussex churches such as West Wittering, Singleton and Poling; also used as large ashlar block in Bosham Church wall and the sea wall
Ditrupa Limestone South Devon	Tertiary, 'Calcaire Grossier' (Lutetian)	Pale greyish limestone containing numerous, straight, fossil worm tubes of *Diptupa*. Important in Roman and Norman times, used at Fishbourne Roman Palace and as reused rubble stone in church walls at Chidham, Barnham, Bosham, Steyning and West Wittering, and also in old walls near Chichester Cathedral
Ventnor Stone Isle of Wight	Cretaceous, Upper Greensand Group (Upper Greensand)	Massive, grey-green, glauconitic, fossiliferous sandstone, often bioturbated and iron-stained; tends to weather badly. Often used for window tracery, but most noteworthy example in West Sussex is rough blockwork laid to course in the walls and buttresses of the C14-15th bell-tower of Chichester Cathedral
Bonchurch Stone Isle of White	Cretaceous, Selbourne Group (Upper Greensand)	Hard, grey to buff, calcareous, slightly glauconitic sandstone. Mainly employed on the IoW, relatively minor use in West Sussex, but used in exterior walls (with Ventnor Stone) in Oving Church and as triangular capstones along Westbourne Church wall
Purbeck Marble Isle of Purbeck, Dorset	Cretaceous, Purbeck Group	Dark grey to buff, shelly limestone, containing fossil *Viviparus* shells (smaller than Sussex Marble) finely-broken shell layers. Mainly used for internal ornamental and decorative work, including fonts in Bosham, Apuldram and Steyning churches and pillars, shafts and ledgers in Chichester Cathedral
Purbeck Limestone Isle of Purbeck, Dorset	Cretaceous, Purbeck Group	Dark grey-green, shelly limestone, often with pale coloured sections of fossil shells and oysters. Used mainly for internal ornamental work, and occasional external flagstone and wall stone uses. The C19th walls at Arundel Castle and street kerbstones in London Road, Arundel, provide good examples of its use
Chilmark Stone Wiltshire	Jurassic, Portland Group	Pale grey, fine-grained, shelly limestone, often showing sections of the fossil bivalve *Trigonia* and cross-bedding structures. Used for exterior repair work of Chichester Cathedral, including the bell-tower, during late Victorian times
Caen Stone Normandy, France	Jurassic, 'Middle Jurassic'	High quality, creamy or yellow coloured limestone (freestone). One of the most important and widely used imported building stones in West Sussex. Typically cut into squared blocks and laid to course, or used in ornate decorative column or arch work. Employed in numerous churches in West Sussex including Steyning, Kingston Buci, Buncton and also used extensively at Chichester Cathedral
Bath Stone Bath, NE Somerset	Jurassic, Great Oolite Group	Creamish to ochreous coloured, oolitic limestone (freestone). Used as replacement stone in Victorian church restoration works, extensive use in Arundel Cathedral
Clipsham Stone Rutland	Jurassic, Inferior Oolite Group	Durable, cream-buff, bioclastic limestone. Widely used in Victorian church reconstruction, mainly for quoins, window and door dressings

Table 2. Summary table of some of the main building stones imported into West Sussex

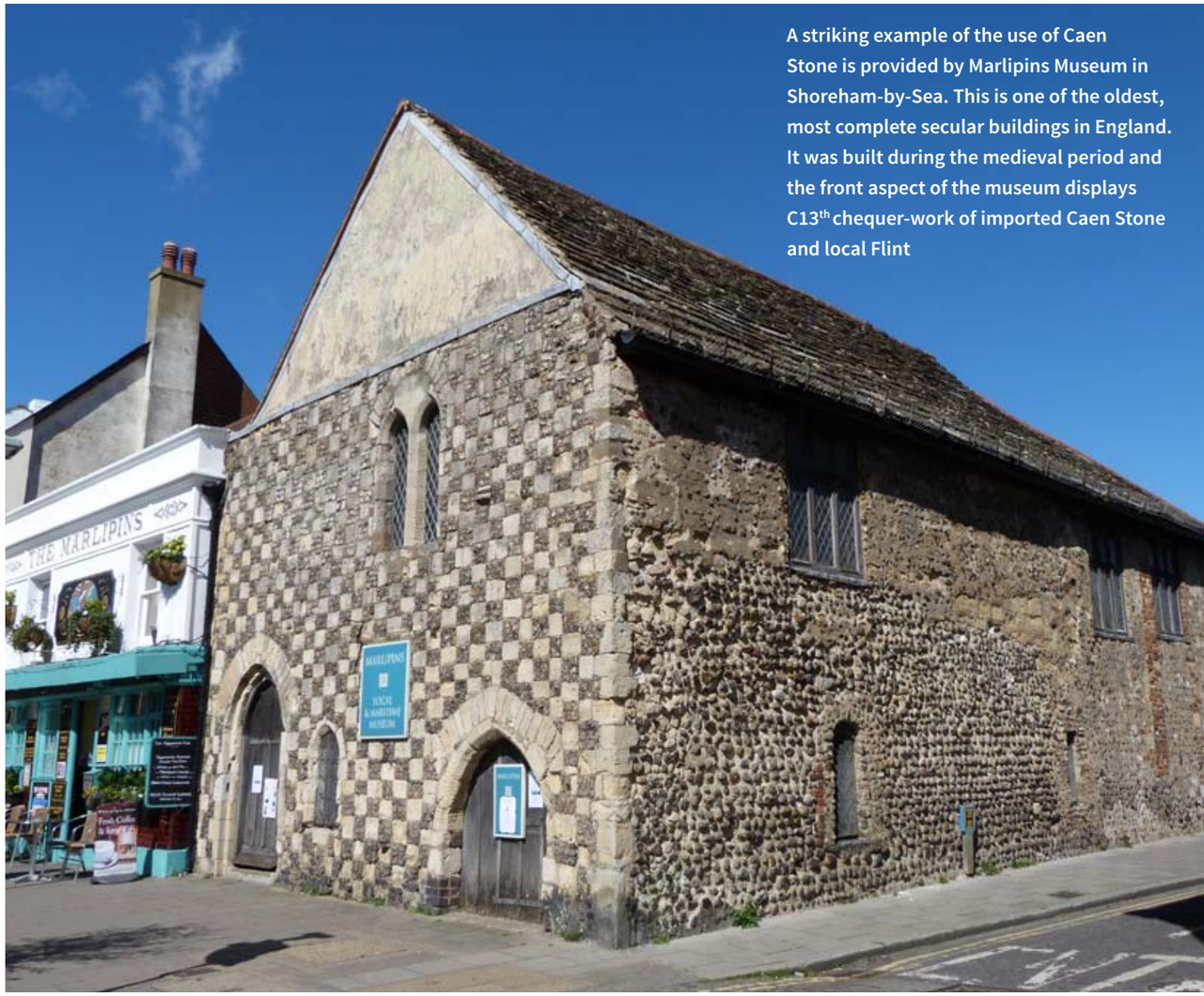
In addition to the main imported building stone types listed to the left, there were several other well-known building stones used in West Sussex, but in relatively minor amounts. These include:

Beer Stone – from the Cretaceous Chalk Group. A pale grey to buff, gritty limestone containing fine shell debris. Mainly used in C12th to C14th church walls in the lower Adur valley, but also features in the arch work at Amberley Castle.

Portland Stone – from the Jurassic Portland Group. A very pale limestone (freestone); the central façades of Petworth House and Edes House (Chichester) are noteworthy examples of its use.

Doulting Stone – from the Jurassic Inferior Oolite Group. A pale cream, bioclastic limestone (freestone) used in C19th work at Arundel Castle.

Comprehensive descriptions of imported stones used for building in West Sussex can be found in several of the references listed in the Further Reading section of this Atlas.



A striking example of the use of Caen Stone is provided by Marlipins Museum in Shoreham-by-Sea. This is one of the oldest, most complete secular buildings in England. It was built during the medieval period and the front aspect of the museum displays C13th chequer-work of imported Caen Stone and local Flint

Glossary

Ashlar: Stone masonry comprising blocks with carefully worked beds and joints, finely jointed (generally under 6mm) and set in horizontal courses. Stones within each course are of the same height, though successive courses may be of different heights. 'Ashlar' is often wrongly used as a synonym for facing stone.

Bioclastic limestone: A limestone composed of fragments of calcareous organisms.

Bioturbated: Sediments that have been reworked or disturbed by burrowing organisms such as worms.

Bivalve: A mollusc with two shells, which may be marine or freshwater. Examples are cockles, clams, scallops, oysters.

Botryoidal chalcedony: A pale coloured type of flint or chert, often found inside a flint nodule, which has grown with a smooth, grape-like structure.

Calcareous: A rock which contains significant (10-50%) calcium carbonate, principally in the form of a cement or matrix.

Calcrete: Carbonate nodules formed in the soil profile just below ground surface by evaporation e.g. Psammosteus Limestone (Bishop's Frome Limestone Member).

Cementation: The diagenetic process by which the constituent framework grains of a rock are bound together by minerals precipitated from associated pore fluids e.g silica, calcite.

Cementstone: See Concretion.

Chalk: A soft, white limestone, sometimes powdery, which was formed at the bottom of a sea during Late Cretaceous times.

Chert: A form of micro-crystalline quartz, just like flint, but usually brownish or greyish coloured.

Clast: A particle of rock or single crystal which has been derived by weathering and erosion. The basic building block of a clastic sediment.

Clunch: A loosely used builders term for rubble infill, usually referring to Chalk or Malmstone (a type of building stone).

Concretion: A rounded or elliptical mass of harder rock occurring within a (usually softer) sedimentary rock. Concretions are often calcareous, such as cementstone.

Cretaceous: A period of geological time that lasted from approximately 145 to 65 million years ago.

Conglomerate: A sedimentary rock made up of rounded pebbles (>2mm), cobbles and boulders of rock in a finer-grained matrix.

Cross-bedding: A feature principally of sandstones formed by the movement of sand grains in currents to produce layering oblique to the margins of the beds.

Echinoid: A type of marine organism formed of calcareous plates, commonly called a sea urchin. Often found in Chalk sediments.

Facies: A term describing the principal characteristics of a sedimentary rock that help describe its mode of genesis.

Ferricrete: A dark reddish-brown coloured iron-oxide cemented layer formed in soil profiles or superficial (surface) deposits of Quaternary age. Typically, it contains rounded or angular pebbles of flint, chert or sandstone up to 6 cm in diameter.

Flaggy: A finely laminated, sedimentary rock that splits into thin sheets when exposed to weathering.

Flagstone: A sedimentary rock, often a sandstone, which splits into slabs and may be used for paving.

Flint: A form of very hard, micro-crystalline quartz. Typically occurs in Chalk deposits as rounded or irregular shaped masses (nodules) and has a dark grey or black coloured inner 'core', with a white outer 'skin'.

Foraminifera: A very small single-celled marine organism that can be abundant in sedimentary rocks.

Formation: A named lithostratigraphic rock unit, with recognizable boundaries, readily identified by mapping, that forms part of a Group e.g. Bromsgrove Sandstone Formation.

Fossiliferous: Bearing or containing fossils.

Freestone: Term used by masons to describe a rock that can be cut and shaped in any direction without splitting or failing.

Galleting: Flakes of Flint (or sometimes Carstone) packed into mortar and used to fill in the spaces between flint nodules (or sandstones) in walls. This technique both strengthened the walls and reduced the amount of mortar needed.

Gastropod: A mollusc with one shell, may be marine or freshwater. Examples are whelks, snails, limpets.

Glauconite: A mineral composed of iron and silica. It often occurs in Cretaceous and Tertiary sedimentary rocks as small greenish coloured specks or grains. It gives the green colour to the rock type Greensand.

Greensand: A sandstone containing the mineral glauconite.

Ironstone: Sedimentary rock which is composed of more than 50% iron-bearing minerals.

Jamb: The vertical support of an opening for a door or window to which it is attached.

Knapped flint: Flint which has been fractured (cleaved) to show the interior of the stone, often a nodule.

Liesegang banding: Reddish or brownish stained patches usually seen on the weathered surfaces of sandstones or chalky rocks. It is caused by the deposition of iron oxides, and typically exhibits convoluted patterns of parallel or concentric bands.

Limestone: A sedimentary rock consisting mainly of calcium carbonate ($CaCO_3$) grains such as ooids, shell and coral fragments and lime mud. Often highly fossiliferous.

Lithology: The description of a rock based on its mineralogical composition and grain-size e.g. sandstone, limestone, mudstone etc.

Marble: Geologically speaking a limestone which has undergone a metamorphic process and been converted into a marble. However, the term is also often used in a loose sense by the quarrying or stone industry for a sedimentary rock (such as a limestone) that can take a good surface polish when cut or carved.

Massive: Describes a sedimentary rock which is homogeneous and lacks any internal structures (such as cross-bedding or ripple-marks) or fractures.

Mica: Group of silicate minerals composed of varying amounts of aluminum, potassium, magnesium, iron and water. All micas form flat, plate-like crystals. Crystals cleave into smooth flakes. Biotite is dark, black or brown mica; muscovite is light-coloured or clear mica.

Micaceous: A rock which contains a high proportion of the platey micaceous minerals muscovite and/or biotite.

Milk-flake texture: See spheroidal weathering.

Mudstone: A fine-grained sedimentary rock composed of a mixture of clay and silt-sized particles.

Nodule: A small, hard rounded or elliptical mass within a sedimentary rock. Resembles a pebble or larger cobble.

Outcrop: Area where a rock unit is exposed at the ground surface.

Quoin: The external angle of a building. The dressed alternate header and stretcher stones at the corners of buildings.

Quaternary: The period of geological time that has lasted from approximately 2.6 million years ago to the present day. It includes the last Ice Age.

Ripple marks: Wave-like structures that occur in sandstones caused by the movement of water or wind when the sands were being deposited (often best seen on the upper surfaces of sandstone layers or beds).

Salt and pepper texture: A texture seen in several sandstones, caused by the alternation of minute cavities left by fossil sponge spicules and disseminated glauconite grains.

Sandstone: A sedimentary rock composed of sand-sized grains (i.e. generally visible to the eye, but less than 2 mm in size).

Sarsen Stone: A very hard sandstone formed mainly of silica-cemented quartz grains, which is found as boulders on the Chalk Downs, in Chalk dry-valley deposits and in modern beach and raised beach deposits.

Septarian nodules: A type of nodule which contains angular cavities or cracks which are partially or wholly filled by calcite.

Serpulid: A fossil marine worm, with a straight, curved or coiled tube.

Setts: Cobble-stones or paving stones, cut to size and arranged in a regular pattern.

Spheroidal weathering: A type of weathering that produces concentric or spherical layers that tend to weather or fall off (spall) as concentric shells or flakes like the layers of a peeled onion or pieces of 'milk flakes'.

Spicules: Very thin calcium carbonate or silica spines making up the skeleton of marine organisms called sponges.

Stone-slate: A fine-grained sedimentary rock which can be split into thin layers (usually around 2cm thick) and used as slates for roofing or paving.

Stratigraphy: Branch of geoscience dealing with stratified rocks (generally of sedimentary origin) in terms of time and space, and their organisation into distinctive, generally mappable units.

Superficial deposits: Varied surface deposits and sediments formed during the Quaternary Period.

Tertiary: The period of geological time that lasted from approximately 65 to 2.6 million years ago.

Trace fossil: Fossil marks in a sedimentary rock left by animal activity such as burrows, or footprints.

Unconformity: The contact surface between two 'packages' of rock strata which are separated by a period of geological time when there was no deposition of any intervening strata or those intervening strata were removed.

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