Historic England

# West Sussex

## Building Stones of England

# The Building Stones of England

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

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

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

This guide was prepared by Andy King (Geckoella Ltd) for Historic England.

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Front cover: Buildings, Petworth. Hythe Sandstone.

# How to Use this Guide

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

## Geological time periods, groups, formations and building stones

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

**Middle Jurassic**
↑ geological time period

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

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

## Bedrock geology map and stratigraphic table

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

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

## Contents list

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

## Building stone sources and building examples

A companion spreadsheet to this guide provides:

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

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

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

## Further Reading, Online Resources and Contacts

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

## Glossary

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

The guides use the BGS lexicon of named rock units.

## Mineral and local planning authorities

This guide covers the West Sussex County Council and South Downs National Park Authority's Joint Minerals Local Plan area and the local planning authority areas of Worthing, Arun, Chichester, Horsham, Crawley, Mid Sussex, Adur and the national park.

# Contents

# 1 Introduction

The solid geology of West Sussex comprises gently dipping Cretaceous and younger Tertiary and Quaternary period sedimentary rocks that 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 Formation and Tunbridge Wells Sand Formation (belonging to the Hastings Beds Subgroup) 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 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 Group's Hythe Formation, one of the most important sources of building stone in West Sussex. This is overlain by the Folkestone Formation and the Upper Greensand Formation. 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 sediments. The latter mainly crop out south of a line extending roughly east to west from near Westbourne via Chichester and Arundel to Worthing. These strata consist largely of shallow marine clays and sands, but locally they 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, above which the Quaternary-aged deposits lie. Without doubt, the most important of these from a building stone perspective are the various extremely resistant 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. However, 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 reworked during the Saxon period 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 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.

Fewer building stone quarries operated after the 14th century, and especially after the Dissolution of the Monasteries in the 16th century. It was not until the 18th and 19th centuries that social and industrial changes created a need for more construction stone. The by-product of chalk extraction for agricultural purposes was flint, which was used extensively for building. Large amounts of flint gravel were also taken from beaches along the coast, despite the fact that, even in the early 19th century, the removal of stone from offshore reefs was known to cause a steady increase in coastal erosion. By the mid-20th century, most of the building stone quarries had closed. Some had been worked out, but others found that rising costs and stricter environmental regulation made 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.

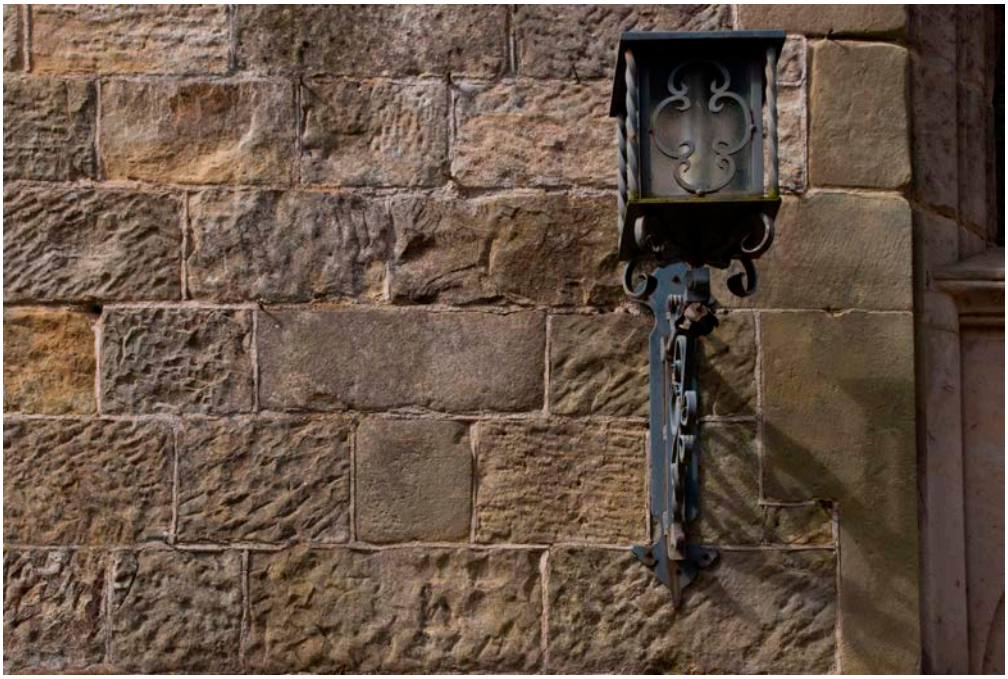
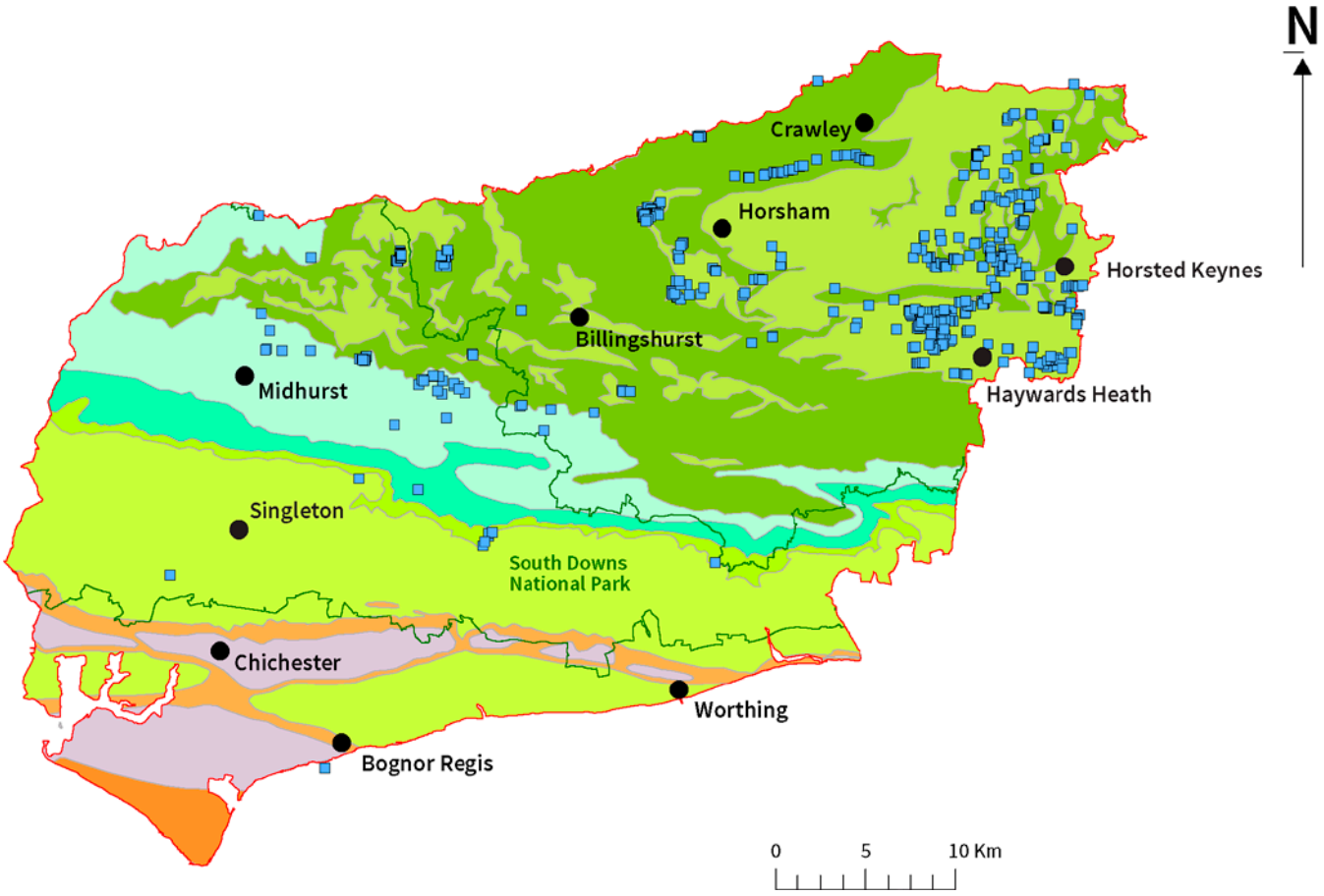


Figure 1: Wakehurst Place, Ardingley. Ardingly Sandstone.

# Bedrock Geology Map




**Key**

Building stone sources

**Bedrock geology**

Bracklesham Group and Barton Group (Undifferentiated) — sand, silt and clay

Thames Group — clay, silt, sand and gravel

Lambeth Group — clay, silt, sand and gravel

White Chalk Subgroup: Chalk Group — chalk

Grey Chalk Subgroup: Chalk Group — chalk

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 wealden, interbedded

# Stratigraphic Table

| Geological timescale | Group | Formation | Building stone | Page |
|---|---|---|---|---|
| Quaternary | various/not defined | various/not defined | Tufa (Travertine)<br>Ferricrete (Iron Pan)<br>River Terrace Flint, Fan Gravel Flint<br>Beach Pebble Flint, Raised Beach Pebble Flint<br>Downland Field Flint<br>Quaternary Flint | 36<br>35<br>34<br>33<br>33<br>32 |
| Tertiary | Barton Group | Barton Clay Formation | | |
| | Bracklesham Group | Selsey Sand Formation | Hounds Stone (Hounds Rock)<br>Mixon Stone (Mixon Rock) | 32<br>31 |
| | | Marsh Farm Formation | | |
| | | Earnley Sand Formation | | |
| | | Wittering Formation | | |
| | Thames Group | London Clay Formation | London Clay Cementstone (Turritella Bed Concretions)<br>Bognor Rock | 30<br>29 |
| | | Harwich Formation | Harwich Formation Siltstone | 28 |
| | Lambeth Group | Reading Formation | Reading Formation Ironstone | 28 |
| | | Upnor Formation | Sarsen Stone | 27 |
| Upper Cretaceous | Chalk Group – White Chalk Subgroup | Portsdown Chalk Formation | Chalk Calcrete (Top Chalk)<br>Chalk, Amberley Chalk<br>Quarry Flint<br>Lavant Stone | 27<br>25<br>23<br>22 |
| | | Culver Chalk Formation | | |
| | | Newhaven Chalk Formation | | |
| | | Lewes Nodular Chalk Formation | | |
| | | New Pit Chalk Formation | | |
| | | Holywell Nodular Chalk Formation (Plenus Marls at base) | | |
| | Chalk Group – Grey Chalk Subgroup | ZigZag Chalk Formation | | |
| | | West Melbury Marly Chalk Formation (Glauconitic Marl at base) | | |
| Lower Cretaceous | Selborne Group | Upper Greensand Formation | Malmstone (Amberley Blue and Blueheart) | 21 |
| | | Gault Formation | | |
| | Lower Greensand Group | Folkestone Formation | Carstone | 20 |
| | | Sandgate Formation | | |
| | | | Pulborough Sandrock<br>Bargate Stone | 19<br>18 |
| | | Hythe Formation | Hythe Chert | 17 |
| | | Atherfield Clay Formation | Hythe Sandstone (Pulborough Stone, Lodsworth Stone, Midhurst Stone, Fittleworth Stone, Petworth Stone) | 15 |
| | Wealden Group (Wealden Sandstones) | Weald Clay Formation | Sussex Marble (Paludina Limestone)<br>Hadfold Sandstone, Alfold Sandstone, Oakhurst Sandstone, Billinghurst Sandstone, Wisborough | 14 |
| | | Horsham Sand Member | Sandstone, Andrews Hill Sandstone | 13 |
| | | | Horsham Stone, Horsham Stone Slate | 12 |
| | | Tunbridge Wells Sand Formation | Forest Sandstone (Shelley Plain Sandstone, Colgate Sandstone, Roffey Park Sandstone) | 10 |
| | | | Tilgate Stone | 10 |
| | | Wadhurst Clay Formation | Cuckfield Stone | 9 |
| | | Ashdown Formation | Ardingly Sandstone<br>Ashdown Sandstone | 7<br>5 |

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

# 2 Local Building Stones

## Lower Cretaceous

### Wealden Group

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 has particular relevance to the numerous sandstones that occur within the Wealden Group and have been used for building purposes.

The situation is further complicated by the knowledge that a wide range of sandstone varieties may be present within individual formations; several named varieties of sandstone may even occur together within the same exposed quarry face. 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 guide 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 similarly applied to any sandstone of uncertain stratigraphic origins that is believed to be from either the Ashdown Formation or the Tunbridge Wells Sand Formation.

### Wealden Group, 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 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, pebble-bed base. Sandstone varieties occur in each unit and range from massive to flaggy lithologies, sometimes

with ripple marks on the uppermost surface. They are often cemented with calcite and iron oxides. These 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 beds have been used historically as a source of local building stone and they were formerly quarried around Horsted Keynes and Sharpthorne. They were mainly used to a limited extent in walls of rough-cut blocks and coursed rubble.

Figure 2: St Giles Church, Horsted Keynes. Ashdown Sandstone and Ardingly Sandstone, and part Horsham Stone slate roof.

## Wealden Group, 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 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 itself is 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 Wealden Group stones, the various 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 seen at the Jacobean Almshouse at Sackville College, East Grinstead.

Figure 3: Almshouses, Sackville College, East Grinstead. Lower Tunbridge Wells Sandstone, Ardingly Sandstone, and Horsham Stone slate roof.

## Ardingly Sandstone

Ardingly Sandstone is a high-quality freestone that has been widely used 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 to 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), 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, as well as 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 it is used for high-quality ashlar, walls, and fine decorative and ornamental work as it is readily carved. The ashlar work in many churches in the north-east of the county is of Ardingly Sandstone.

Figure 4: Gravetye Manor, East Grinstead. Ardingly Sandstone and Horsham Stone slate roof.

Figure 5: Manor House, High Street, Cuckfield. Ardingly Sandstone and Horsham Stone slate.

## 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 and 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 that ranges from grey to light brown in colour. It occurs in a number of different lithological varieties that 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 Hoathly, the lower part of the Cuckfield Stone is flaggy and often ripple-marked with more massive, blocky-bedded stone above. In the Haywards Heath to Scaynes Hill area, Cuckfield Stone is a freestone and similar in appearance to Ardingly Sandstone. In the central area of its outcrop, the basal part of the Cuckfield Stone Bed displays 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.

Figure 6: Lancing College Chapel, Lancing. Cuckfield Stone with Ardingly Sandstone and Bath Stone.

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 rough ashlar and coursed rubble. Examples include Holy Trinity Church at Cuckfield (in association with Ardingly Sandstone and Horsham Stone slate) and Lancing College Chapel.

### Tilgate Stone

Tilgate Stone is used here to mean flaggy sandstone beds 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 19th-century geologist Gideon Mantell to strata at Tilgate Stone Quarry at Whiteman's Green, north of Cuckfield, where he found the bulk of his famous dinosaur fossils, including the *Iguanodon*.

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. It has mainly been used as paving or has been broken up and used as roadstone. Occasionally, it was employed as a roofing material. Blocks of Tilgate Stone were used in the 13th and 14th-century rebuilding of Cuckfield's Norman Holy Trinity Church.

Figure 7: Cobblestones and paving setts, High Street, Cuckfield. Tilgate Stone.

### Forest Sandstone (Shelly Plain Sandstone, Colgate Sandstone, Roffey Park Sandstone)

The Upper Tunbridge Wells Sand Formation 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' derives). Three separate sandstone beds were formerly worked as building stone in the St Leonard's Forest area. In ascending order, these are Shelly Plain Sandstone, Colgate Sandstone and Roffey Park Sandstone.

However, in common with many of the other Wealden 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. Occasional 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 rough ashlar and coursed rubble. Examples include the old town hall at Horsham, the Church of All Saints at Roffey, the Church of St John at Coolhurst, the Church of St Peter at Cowfold and the Church of St Andrew at Nuthurst.

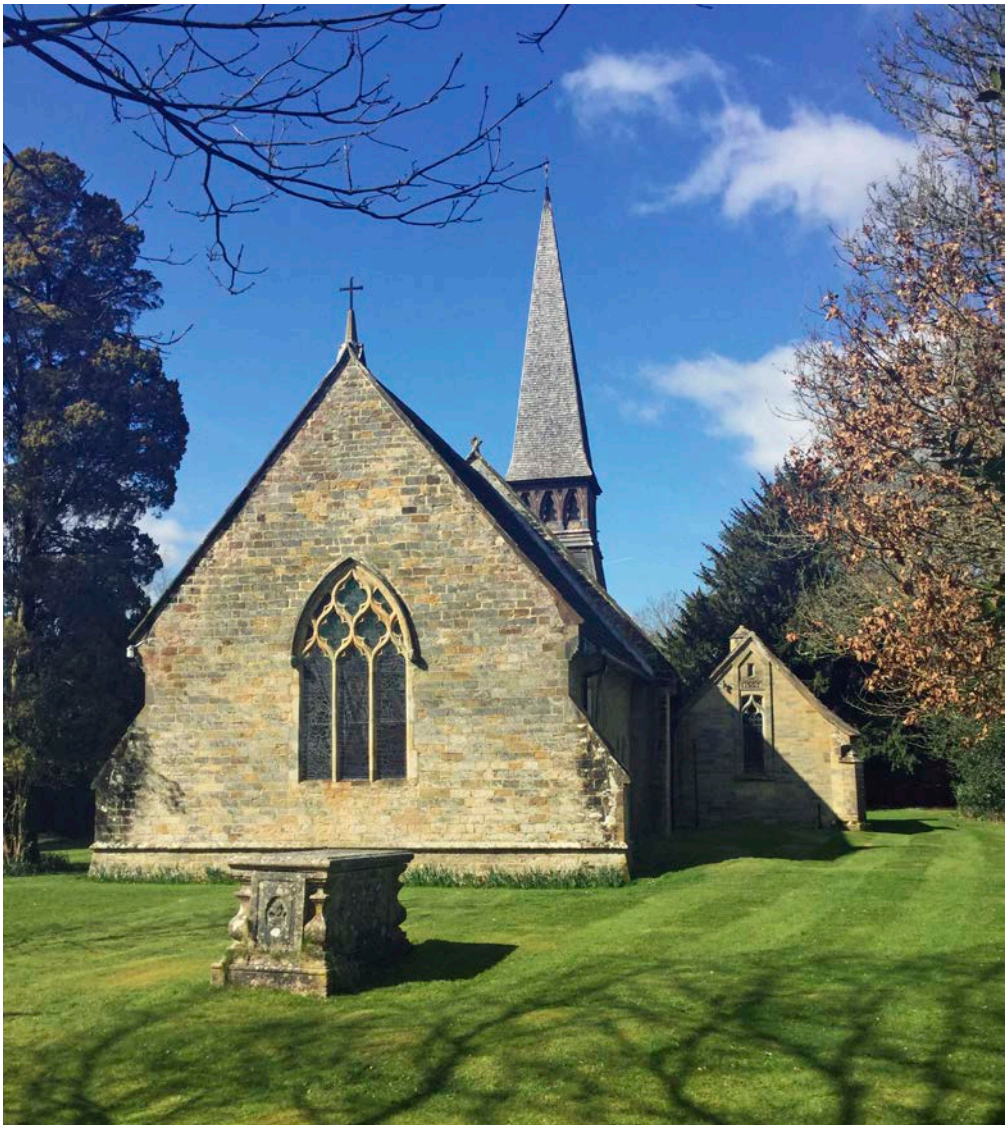


Figure 8: Church of St Andrew, Nuthurst. Originally Horsham Stone. Restored using Upper Tunbridge Wells Sandstone.

## Wealden Group, Wealden Clay Formation

### Horsham Stone, Horsham Stone Slate

Horsham Stone was used on a far larger scale as a building stone than any other Weald Clay Formation sandstone. It crops out as a prominent scarp-forming sandstone 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 (Horsham Stone); the upper part is a laminated sandstone or stone slate (Horsham Stone slate).

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 common. 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 very uncommon in the Horsham Stone, but may 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 the Church of All Saints at Roffey, in the villages of Itchingfield, Steyning and Rusper, and in new-build houses at Budgenor Lodge, Easebourne (with brick facings). Ripple-marked Horsham Stone flagstones were used at St John the Baptist's Church at Clayton.

Horsham Stone slate is usually honey to grey in colour and it exhibits few structures, apart from fine laminations and occasional broad amplitude ripple marks. It readily cleaves into 20 to 30mm-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, while 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-19th century) 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.

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 then dressed at Broadbridge Farm, Broadbridge Heath.

Figure 9: St Mary's Church, Horsham. Horsham Stone and Ardingly Sandstone, with Horsham Stone slate roof.

### Oakhurst Sandstone, Billingshurst Sandstone, Wisborough Sandstone, Andrews Hill Sandstone, Hadfold Sandstone, Alfold Sandstone

In addition to Horsham Stone, 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 are: 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 in buildings.

These sandstone beds crop out within the Weald Clay Formation as a series of low ridges stretching westwards from Charlwood towards Haslemere, 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 to 5m. Their colour also varies, but it is typically buff to pale grey, weathering to an orange-brown or brownish colour due to iron staining. They often exhibit Liesegang banding.

The sandstones are composed of pale quartz sand, with scattered flakes of mica, and they are cemented with minor amounts of calcite, clay minerals and iron oxides. Many of the sandstones show 50 to 100mm-thick cross-bedded units, with varied ripple structures commonly seen in the upper part of each bed. Occasional scour structures are also present.

Figure 10: St Peter's Church, Wisborough Green. Billingshurst Sandstone with Horsham Stone slate roof.

## Sussex Marble (Paludina Limestone)

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

Sussex Marble is a freshwater limestone and it occurs in the upper part of the Weald Clay Formation, in beds that typically are up to 300mm in thickness, but may be considerably thicker, up to 700mm. The limestone is usually light grey or buff in colour, but varies to shades of blue or green depending on the amount 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) is confined to a narrow area between Crawley, Charlwood and west of Horsham. This limestone occurs in beds up to 150mm 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) 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 100 to 300mm 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 weathers readily 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 fireplaces. Sussex Marble is occasionally seen as a walling stone in churches, barns, farmhouses and cottages in the Low Weald, including the Church of the Holy Sepulchre at Warminghurst and the barn at Mitchell Park Farm, Northchapel.

## Lower Greensand Group, Hythe Formation, Atherfield Clay Formation

### Hythe Sandstone (Pulborough Stone, Lodsworth Stone, Midhurst Stone, Fittleworth Stone, Petworth Stone)

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 because the fresh sandstone may exhibit a dark green colour due to the presence of glauconite.

The formation is highly variable and contains medium to coarse-grained sandstones, which range in colour from pale brown or yellowish-orange to dark green or pale grey. They 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*; some 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 types of Hythe Sandstone have been informally named after the villages near where 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 produced several different types of the sandstone. Pulborough Stone is a pale grey to greyish-green, glauconitic, finely bedded, bioturbated sandstone. The bedding planes

are packed with small irregular chert nodules, up to 50mm long. The stone weathers with a distinct knobbly texture, with the chert nodules standing proud.

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

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

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

Petworth Stone is 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.

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 include bridges at Selham, Pulborough (Swan Bridge) and Stopham (constructed of rough ashlar blocks of Midhurst Stone); churches at Kirdford, Fittleworth, Trotton, Stopham, Tillington, Easebourne and Rogate; the ruins of Cowdray House, Midhurst (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 in Petworth are of Petworth Stone. Lodsworth Stone was also used for quern stones in Iron Age and Roman times.

There are numerous historic quarries for Hythe Sandstone and its named varieties. However it is now only worked for rubblestone at Bognor Common Quarry and intermittently for building stone (Midhurst Stone) at Winter's Pit, Easebourne.

Figure 11: Stopham Bridge. Hythe Sandstone.

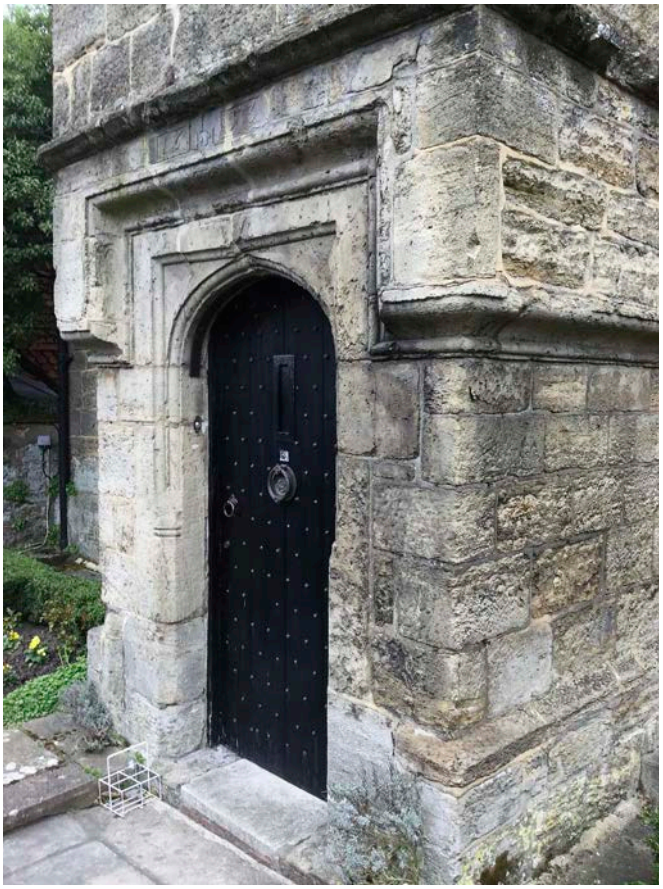


Figure 12a and b: Somerset Lodge, Petworth. Hythe Sandstone.

## 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 18th and 19th centuries, 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, rubblestone 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 the cobblestone setts at Petworth, including random wall facing in the United Reform Church. St Laurence’s Church at Lurgashall exhibits roughly dressed 100mm-thick slabs of Hythe Chert laid to course and alternating with Hythe Sandstone ashlar, together with some chert galleting. At St Agatha’s Church at Coates, Hythe Chert is employed as a rubblestone in walls, along with contrasting brown-coloured carstone.

Figure 13: United Reform Church, Petworth. Hythe Chert random rubble.

## Lower Greensand Group, Sandgate Formation

### 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 100 to 150mm thick that can be easily used as brick-sized blocks. They also sometimes exhibit cross-bedding or honeycomb weathering textures. The sandstones contain layers of the fossil burrow *Macaronichus*, which are typically 5mm-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 Winter's Pit) and Woolbeding. In the 18th and 19th centuries, the stone was broken up for use as roadstone. 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, and as paving slabs at the entrance to All Hallows Church at Woolbeding.

## Pulborough Sandrock

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

The member comprises orange-brown to deep purple-brown or blackish ferruginous sandstones and siltstones, with ironstone concretions that contain a wide variety of fossil shells. The sandstones are often finely laminated and exhibit a 'milk flake' texture. The ironstone nodules 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 because of its relative softness and limited outcrop extent. It has been used occasionally as a rubble walling stone, often coursed. In the Pulborough area, up to 500mm of iron oxide-cemented sand and siltstone at the top of the member (lying immediately below the overlying Marehill Clay Member) was used locally for minor building purposes. It can be seen in the walls of Wiggonholt Parish Church and the Church of St Mary at Stopham; in house walls in Pulborough along the main A283 road; and in the walls of 18th and 19th-century cottages in Marehill. It was also used in the walls of Greatham Church, where the ironstone nodules exhibit spheroidal weathering.

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

Figure 14: Greatham Church. Pulborough Sandrock rubble.

## Lower Greensand Group, Folkestone Formation

### Carstone

Carstone (or 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 300mm thick) occurs at the top of the Folkestone Formation, between Graffham and Washington. This bed has a distinctive bright orange-red colouration and contains thin layers of small quartz pebbles. This is very similar to coarse-grained carstone and it is, therefore, not readily distinguishable as a separate building stone type. Other ferruginous sandstones and siltstones that occur 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 as a building stone in West Sussex since Roman times. It was also utilised in late Saxon and Norman churches. From the 18th to the early 20th century, carstone was worked as a by-product of the sand quarries (or collected as field brash) along the outcrop of the Folkestone Formation.


Figure 15: Public house, Pulborough. Carstone and Hythe Sandstone.

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.

Figure 16: Cottage, Fittleworth. Carstone.

## Selborne Group, Upper Greensand Formation

### Malmstone (Amberley Blue, Blueheart)

Malmstone crops out along the foot of the South Downs escarpment, from South Harting in the west to Fulking in the east. 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 that 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 that 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 their outcrop. Although much of the stone is a freestone, it is generally roughly dressed and laid to course, or used as rubblestone. 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 Amberley Castle, the dovecote and stable block on Parham estate near Cootham and in several late Tudor country houses, such as Parham House; Cowdray House, Midhurst; and Wiston House, Steyning. 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 used for chalk infill.

Figure 17: Amberley Castle. Malmstone.

## Upper Cretaceous

### Chalk Group, White Chalk Subgroup, 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 15th century.

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 weather such that the more resistant fossils stand proud of the stone surface.

Three main varieties of Lavant Stone have been recognised. The massive white calcarenite is the most commonly encountered type. It is composed of broken shell debris and other fossils, and its weathered surface is often

colonised by red algae. The grey-coloured, phosphatic limestone variety contains scattered glauconite grains. Weathered bioturbation structures give a coarse textural appearance to this stone, and large fossils are occasionally encountered. The pale brown, rough-textured, soft limestone contains phosphatic nodules and well-preserved fossils. The surface becomes notably pitted upon weathering.

Lavant Stone is an excellent freestone and, since Roman times, it has been commonly used for ashlar work, quoins and buttresses in a range of ecclesiastical buildings within an approximate 16km radius of Chichester. These include churches at East Lavant, Mid Levant, Chidham, Earnley and West Stoke. It has also been employed as a rubblestone – likely reused Roman material (for example, in the southern walls around Chichester Cathedral precinct) – and has seen occasional decorative use.

Figure 18: Boxgrove Priory, Chichester. Lavant Stone.

## 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 100 to 200mm across, or as (sub-) rounded pebbles and cobbles. Occasionally, it is also found as weakly banded tabular sheets or layers up to 200mm thick.

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

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, with 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: laid to course as rough tabular sheets or nodules; in squared chequerwork; 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. It is also seen interlocking with brick or other stone dressings, quoins, and window and door jambs, serving to help consolidate the building. West Dean, Halnaker and Steyning provide good examples of villages built mainly from freshly quarried flint. Particularly fine examples can be seen in the Old School House at Angmering and new-build houses at Oakford Park, Halnaker.

The extremely hard and resistant nature of Quarry Flint-type nodules has resulted in them being recycled by natural processes into younger deposits.

Figure 19: Old School House, Angmering. Flint.


Figure 20: Houses built in 2012, Halnaker. Flint.

## Chalk, Amberley 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 per cent 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 per cent is represented by the Grey Chalk Subgroup, which crops out along the northern escarpment. This stone is darker, typically greyish, in colour and is devoid of flints. It includes thin marly layers between thicker chalk beds.

The use of chalk as a building stone is mainly confined to the southern part of West Sussex. However, chalk is generally unsuitable for exterior building stonework, 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 numerous impressive examples of chalk used for interior ashlar work, mouldings, ceiling vaulting, arches and transept walls in a number of churches in West Sussex, including at Burpham, Shoreham-by-Sea, East Lavant, 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 in Arundel 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 used to refer to Malmstone employed 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. The chalk is used locally, again mainly for interior work or rubble infill.

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

Figure 21: St Nicholas Church interior, Bramber. Chalk ashlar.


Figure 22: Amberley Museum and Heritage Centre. Amberley Chalk.

### 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 commonly 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 rubblestone 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

### Lambeth Group, Upnor Formation

### Sarsen Stone

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), which sat directly above the Cretaceous chalk on 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 a fractured surface. Sarsen stones often occur as rounded or elongate pebbles, cobbles, boulders or even metre-scale slabs (up to 3m in length). They are very hard and resistant. Their surfaces are often smooth and they may occasionally show poorly defined bedding structures. Beach-worn Sarsen stones may exhibit ‘elephant skin’ surface texture.

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 walls across the West Sussex coastal plain, including at Felpham, Pagham, West Wittering and Bognor Regis.

## Lambeth Group, Reading Formation

### Reading Formation Ironstone

This fine-grained ironstone has a very distinctive, rich reddish brown or orange-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 Harbour and Langstone Harbour (Hampshire). 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 centimetres 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 St John the Baptist Church at Westbourne.

Figure 23: St John the Baptist Church, Westbourne. Harwich Formation Siltstone.

## Thames Group, London Clay Formation

The London Clay Formation is approximately 100m thick. Although the dominant lithology is clay, there are layers of concretionary sandstones and cement stones throughout the formation, which have been used locally 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 (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 rubblestone walls. These fossils help distinguish Bognor Rock from otherwise similarly coloured lithologies, such as Hounds Stone, which does not contain fossils.

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.

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.

Figure 24: Hotham Park wall and gatehouse, Bognor Regis. Bognor Rock.

West of Bognor Regis, at Barn Rocks near Aldwick, the sandstone concretions are thinner and greenish coloured, but 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 rubblestone in the Aldwick area.

### London Clay Cementstone (Turritella Bed Concretions)

This cementstone comprises ellipsoidal concretions of fine-grained mudstone and siltstone, which reach 600mm 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 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 cement stone concretions contain the distinctive, white-coloured, fossil gastropod shells *Turritella*.

Examples of the use of London Clay cementstone include the 19th-century garden walls in the Ellasdale Road area of Bognor Regis, the church walls at West Wittering, Felpham, Chidham, Apuldram and Fishbourne, and the old quayside walls at Bosham Harbour.

Figure 25: Quayside walls, Bosham Harbour. London Clay Cementstone.

## 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 11th to 13th centuries.

Mixon Stone was still being used in the early 19th century but quarrying of the stone ceased in 1827 following an Admiralty prohibition order. This was put in place because the 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, with occasional corals, bryozoans and shark teeth. Examples of the disc-shaped foraminifera 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 (for example, Fishbourne Roman Palace) to mid-19th century. Good examples of its use as roughly shaped blocks of walling stone can be seen today in South Street, Chichester, and in several 18th-century properties located along the High Street in Selsey, such as The Neptune public house and nearby cottages and walls.

Figure 26: Cottage, Selsey. Mixon Stone.

### 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 can be readily distinguished from Mixon Stone because it is a finer grained, grey to greenish-grey, 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.

Figure 27: Earnley Church, Earnley. Hounds Stone.

## Quaternary

### Various groups, various formations

### 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 the stone's 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 a 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 chequerwork; 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 100 to 300mm, but larger nodules also occur. The outer cortex of the nodule is usually cream coloured, with a darker brownish or greyish interior that 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 it is employed in a wide range 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.


Figure 28: South Street, Chichester. Downland Field Flint.

### Beach Pebble Flint, Raised Beach Pebble Flint

Beach (and Raised Beach) Pebble Flint typically occurs as pale to dark greyish, rounded pebbles and cobbles up to 100mm in size. They are occasionally larger. The pebbles often exhibit a ‘frosted’ surface appearance or ‘chatter marks’ (small surface cracks) caused by impacts with other beach pebbles.

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, as seen in 18th-century 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 to create an imbricate pattern.


Figure 29: Cottages, The Street, Boxgrove. Beach Pebble Flint.

## River Terrace Flint, Fan Gravel Flint

This type of flint occurs as water-washed, sorted, sub-rounded pebbles, usually up to 150mm 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 this flint can be seen in the city walls at Chichester, parts of which date to Roman times. Some sections, such as Lower Walls Walk, were constructed of flints from the underlying fan gravels and from nearby downland fields.

Figure 30: City walls, Chichester. River Terrace and Fan Gravel Flint.

## 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 carstone. Ferricrete occurs in irregular layers up to 500mm thick, and it was formerly quarried as far back as Norman times. At that time, it was dug on a small scale from shallow pits along the River Arun lower terrace deposits and from 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.

Figure 31: Holy Trinity Church, Rudgwick. Ferricrete.

Ferricrete exhibits variable cementation and it has relatively limited use 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 compared to sideritic concretions mined from the Wealden Group.

### Tufa (Travertine)

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 rubblestone 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 occurs at spring heads in the Duncton Mill area, where tufa is being formed as spring water emerges from the surrounding Malmstone strata.

Figure 32: Steyning Parish Church. Tufa and flint.

# 3 Examples of Imported Building Stones

Building stone has been imported into West Sussex since Roman times. It was during the Norman period, 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.

A considerable amount of British-derived stones was also imported 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 brought into West Sussex were Caen Stone, Purbeck Marble and Quarr Stone.

## Jurrasic

### Great Oolite Group, Chalfield Oolite Formation

#### Bath Stone, Bath, NE Somerset and possibly Corsham area, Wiltshire

Bath Stone is a creamish to ochreous coloured, oolitic limestone (freestone). It was used as replacement stone in Victorian church restoration works, for example in Arundel Cathedral.

#### Caen Stone, Normandy, France

Caen Stone is a high quality, creamy or yellow coloured limestone (freestone). It is one of the most important and widely used imported building stones in West Sussex. Typically the stone was cut into squared blocks and laid to course or used in ornate decorative column or arch work. Caen Stone was employed in numerous churches in West Sussex including Steyning, Kingston Buci, Buncton and also used extensively at Chichester Cathedral.


Figure 33: Marlipins Museum, Shoreham-by-Sea. Caen Stone and flint.

### Inferior Oolite Group, Upper Lincolnshire Limestone Formation

#### Clipsham Stone, Rutland

Clipsham Stone is a durable, cream-buff, bioclastic limestone. The stone was widely used in Victorian church reconstruction, mainly for quoins, window and door dressings.

#### Doulting Stone, Somerset

Doulting Stone is a pale cream, bioclastic limestone (freestone) used in 19th-century work at Arundel Castle.

## Cretaceous

### Chalk Group, Holywell Nodular Chalk Formation

#### Beer Stone, Devon

Beer Stone is a pale grey to buff, gritty limestone containing fine shell debris. It was mainly used in 12th to 14th-century church walls in the lower Adur Valley, but also features in the arch work at Amberley Castle.

### Purbeck Group, Durlstone Formation, Lulworth Formation

#### Purbeck Limestone, Isle of Purbeck, Dorset

Purbeck Stone is a dark grey-green, shelly limestone, often with pale coloured sections of fossil shells and oysters. It was used mainly for internal ornamental work, and occasional external flagstone and wall stone uses. The

19th century walls at Arundel Castle and street kerbstones in London Road, Arundel, provide good examples of its use.

#### Purbeck Marble, Isle of Purbeck, Dorset

The stone is a dark grey to buff, shelly limestone, containing fossil *Viviparus* shells (smaller than Sussex Marble) in finely-broken shell layers. Purbeck Marble was mainly used for internal ornamental and decorative work, including fonts in Bosham, Apuldram and Steyning churches and pillars, shafts and ledgers in Chichester Cathedral.

### Portland Group, Portland Stone Formation

#### Portland Stone, Dorset

Portland Stone is a very pale limestone (freestone). The central facades of Petworth House (Petworth) and Edes House (Chichester) are noteworthy examples of its use.

#### Chilmark Stone, Wiltshire

Chilmark Stone is a pale grey, fine-grained, shelly limestone, often showing sections of the fossil bivalve *Trigonia* and cross-bedding structures. It was used for exterior repair work of Chichester Cathedral, including the bell-tower, during late Victorian times.

### Selbourne Group, Upper Greensand Formation

#### Ventnor Stone, Isle of Wight

Ventor Stone is a massive, grey-green, glauconitic, fossiliferous sandstone, often bioturbated and iron-stained. It tends to weather badly. The stone was often used for window tracery and the most noteworthy example in West Sussex is rough blockwork laid to course in the walls and buttresses of the bell-tower of Chichester Cathedral.

#### Bonchurch Stone, Isle of Wight

Bonchurch Stone is a hard, grey to buff, calcareous, slightly glauconitic sandstone. It was mainly employed on the Isle of Wight and only had relatively minor use in West Sussex. It was used, with Ventnor Stone, in the exterior walls in Oving Church and as triangular capstones along Westbourne Church wall.

## Tertiary

### ‘Calcaire Grossier’ (Lutetian)

#### Ditrupa Limestone, Paris Basin, France

The limestone is a pale greyish limestone containing numerous, straight, fossil worm tubes of *Ditrupa*. It was important in Roman and Norman times and it was used at Fishbourne Roman Palace. The limestone has been reused as rubble stone in church walls at Chidham, Barnham, Bosham, Steyning and West Wittering, and also in old walls near Chichester Cathedral.

### Solent Group, Bembridge Limestone Formation, Headon Hill Formation

#### Bembridge Limestone, Isle of Wight

Bembridge Limestone is a buff, fine-grained, shelly freestone. The fossils include the gastropod *Galba* and alga *Chara*. It was used as rough block work and quoins in many West Sussex churches such as West Wittering, Singleton and Poling; and also as large ashlar block in Bosham Church wall and the sea wall.

#### Quarr Stone, Binstead, Isle of Wight

Quarr Stone is a pale grey to buff, porous, open-textured, shelly limestone with fossils typically present as internal moulds. It was used as quoins in many West Sussex churches, such as Tangmere, Climping, and Yapton. Large amounts of Quarr Stone ashlar was used in the Norman walls of Chichester Cathedral in random chequer pattern with Caen Stone.

# 4 Further Reading

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

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

There is also a separate glossary of geological terms.

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## Figures

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