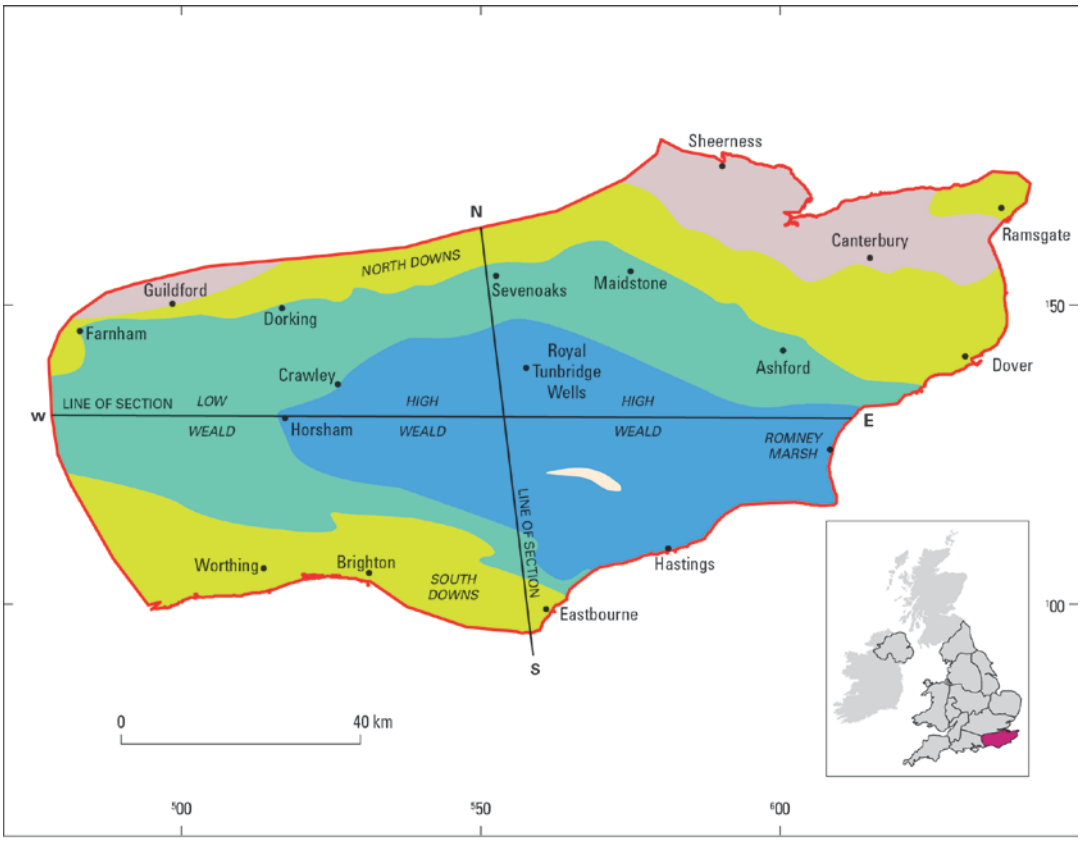
The Wealden district

This account provides a broad perspective of the geology of the Wealden region of southeastern England, which extends from Kent westwards into Surrey and Sussex, and includes the eastern part of Hampshire. The area is predominantly rural. The principal towns and cities include Dover, Folkestone, Canterbury, Maidstone, Eastbourne and Brighton. Figure 1 provides a geological sketch map of this region showing the rock types occurring in relation to the major towns and cities. This account outlines the geology to a depth of at least a kilometre and summarises the current and historical use of the geological resources in the region.

The region is mainly formed of rocks laid down in seas that covered the area in the past. The relatively flat landscape is typical of areas underlain by these sandstones, clays and limestones. Even in the downlands and the High Weald, where the highest land rises to more than 200 m above sea level, the rocks are very rarely exposed at surface: the principal exception is the sandstones of the High Weald (Figure 2). Nevertheless, the surface geology is well-known from quarries and other surface excavations, seacliffs, shallow boreholes, water wells and changes in soil type.

At depths greater than about 300 m below surface, however, our knowledge depends largely on deep boreholes drilled in the search for water, coal, oil, gas or gypsum resources. There are about 200 such deep boreholes in various parts of the region, of which about half are more than 1000 m in depth. Most are in either the central or western parts of the region, where prospects for oil or gas are most promising, or in east Kent within the area of the coalfield that is concealed beneath that part of the North Downs. There are few deep boreholes in northern Kent. Numerous geophysical seismic surveys have been conducted, covering most of the region except for parts of the extreme northeast (broadly speaking eastwards from the Medway towns), which provide information on the rocks by sending sound waves through the ground. The results of these investigations are complemented by interpretations of the patterns of variation in the Earth's gravity and magnetic fields shown by regional geophysical maps.

Coal was mined from depths between about 300 and 950 m at several sites in east Kent during the late 19th and the 20th centuries, with the last colliery closing in 1989. Oil and gas are currently extracted at several sites in the west of the region, typically from depths of more than 1 km, and other parts of the region may have oil or gas in sufficient quantities to make extraction economical. Gypsum, which is used as a fertiliser and the main constituent of many forms of plaster, is mined at depths of about 300 m in a small area of East Sussex.



Age (My)	Map/Section Descriptor	Geological sub-units	Text sub-units	Text Descriptor
40-45	Palaeogene Sediments	London Clay Lambeth Group and Thanet Formation	Low permeabilty clay, Varied sediments	Younger Sedimentary Bedrock
80-145	Upper Cretaceous Sediments	Chalk Group	White Limestone major aquifer	
	Lower Cretaceous Sediments	Upper Greensand, Gault Clay, Lower Greensand and Wealden Clay	Low permeabilty clay and sandstone aquifer	
		Wealden Group (High Weald)	Sandstones interlayered with low permeability clays	
145-200	Middle-Upper Jurassic Sediments	Portland and Purbeck Groups, Kimmeridge and Ampthill clays, Corallian Group, Oxford Clay Oolite groups	Shelly limestone aquifers and low permeability clays	
	Lower Jurassic Sediments	Lias Group	Mudstones	
200-250	Triassic Sediments	Mercia Mudstone Group Sherwood Sandstone Group	Red desert mudstones and sandstone (aquifer)	
310-350	Carboniferous Rocks	Coal Measures	Sandstones and mudstones, minor coals	Older Sedimentary Bedrock
		Carboniferous Limestone	Grey Limestone aquifer	
360-420	Devonian Rocks		Sandstones, siltstones and mudstones,	Basement Rocks
420-500	Lower Palaeozoic Rocks			

Figure 1 *Geological sketch map and key showing the range and distribution of different rock types in the Wealden District in relation to major towns and cities. The extent of the Wealden district is identified on the inset map of the United Kingdom.*

Figure 2 *Sandstone exposure in the High Weald, at Stone Hill Rocks, near East Grinstead, the exposure is about 5 m high.*

Geologically recent surface deposits

Throughout the region, there are locally widespread, but generally rather patchy, geological deposits of relatively recent origin formed over the past 2 to 3 million years and spanning the Ice Ages and Interglacial periods. These are known as superficial deposits, the most common of which were laid down by the local rivers or in coastal areas. These superficial deposits mainly comprise gravels, sands, clays and peat layers, which are soft and easily eroded as they have not been deeply buried and consolidated to form strong rocks. The most extensive are the river terrace and flood plain deposits of the main rivers and tributaries, and the coastal deposits of Romney Marsh -Dungeness and the Pevensey Levels. The thickness of these deposits is generally less than 10 m, and exceeds 30 m only locally. This region lay beyond the extent of the ice-sheets that have dominated the evolution of the British landscape over the past 2-3 million years.

Geology at depth

Beneath the superficial deposits, or with just a cover of soil where such deposits are absent, are older rocks which geologists broadly split into two distinct types:

- The *sedimentary bedrock geology* is composed of quite hard rocks which were originally deposited from 350 to 40 million years ago as layers of sediments in shallow seas, deserts and vast river systems in times when Britain lay closer to the Equator and the climate and landscape were very different from those of today.
- The *basement geology,* which underlies the bedrock, is over 360 million years old and mainly comprises harder, denser rocks which have been strongly compacted and folded. They include both rocks originally deposited as sediments and others that are products of volcanic activity.

In the course of the past 500 million years there have been periods when the area of the UK formed a landmass and was being eroded, and other periods when it was sinking and new layers of sediment were being deposited. The history of erosion and deposition has not been the same in all parts of the UK. In the Wealden region the oldest sedimentary bedrock, which occurs in the central and southern parts, is similar to rocks occurring at the surface in parts of northern England and Wales. They include limestones, sandstones, and shales, and were buried and deformed by the forces of continental plates moving against each other. They are referred to here as the *older sedimentary bedrock*.

Subsequently, a younger sequence of sedimentary rocks, including limestones, sandstones and clays, was laid down and are known as the *younger sedimentary bedrock*. These include Jurassic rocks, comparable to those seen along the coast of Dorset and north Yorkshire. Under the North Downs, however, deposition stopped and instead uplift and erosion took place for hundreds of millions of years. When deposition restarted the Chalk Sea flooded the landscape and the Gault Clay and then the Chalk were laid down on a variety of different older sediments. This situation where younger rocks rest directly on rocks of different older ages because of uplift and erosion is referred to by geologists as an unconformity.

The younger sedimentary bedrocks occur at the surface and dictate the broad variations in the geography and land-use across the region. It is composed of varied rocks formed from about 250 to 40 million years ago, mainly as sediment layers in shallow seas, as deltas, in lakes or on extensive coastal plains. While generally harder and more consolidated than the superficial deposits, much of the younger sedimentary bedrock is quite soft and easily eroded. Figures 3 and 4 are vertical sections through the geology, referred to as geological cross-sections, and illustrate the variations across the region.

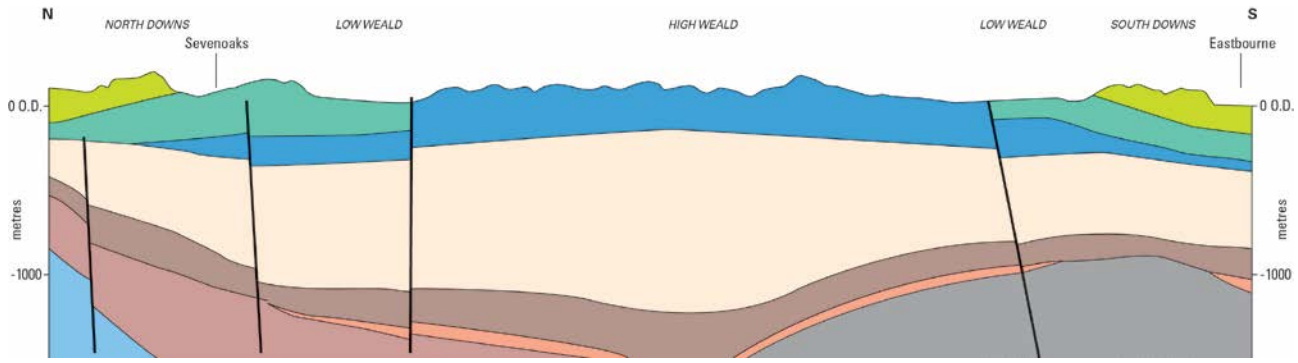


Figure 3 *Schematic cross-section through the Wealden region from north to south. The alignment of the section and key are shown in Figure 1.*

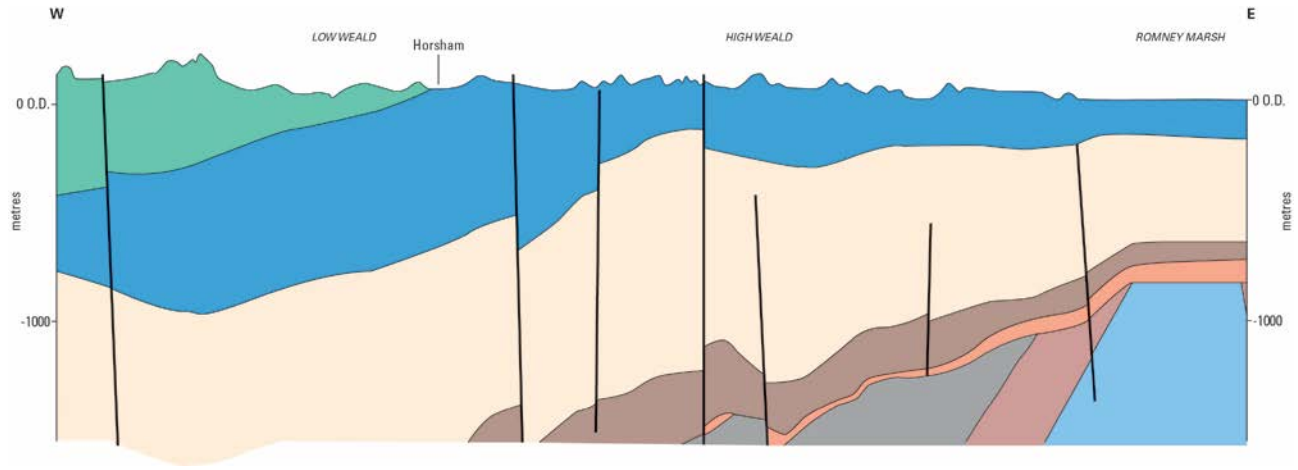


Figure 4 *Schematic through the Wealden region from west to east. The alignment of the section and key are shown in Figure 1.*

The youngest, uppermost layers of the bedrock (Palaeogene sediments) occur on the northern flank of the North Downs and on the southern slopes of the South Downs. The Chalk, which underlies the North Downs, Hampshire Downs and South Downs, forms an outwards-tilted rim around the Weald, which outlines an elongated arch or dome-shaped structure that is open to the east but closed westwards. Within this dome, which geologists term an anticline (see Figure 3), the layers become gradually older towards the centre, so the oldest rocks that appear at the surface in this region (Purbeck Group) can be found in central East Sussex.

The lower parts of the sequence of younger sedimentary bedrock do not occur at surface anywhere in the Wealden region but can be seen to the west, especially along the 'Jurassic Coast' in Dorset. However, these concealed rocks can be treated as a downwards continuation of the rock layers found at the surface, and so it is convenient to treat them as part of the same sequence.

In the central and southern parts of the region the younger sedimentary bedrock rests on much older sedimentary bedrock (Carboniferous rocks). The latter are rocks from about 350 to 310 million years old and whilst most are sedimentary they have undergone periods of deep burial and deformation during ancient earth movements.

Beneath the North Downs, however, even older basement rocks (Devonian and pre-Devonian rocks) form the southern edge of an uplifted block called the London Platform, where these rocks occur less than about 500 m below the surface. This block has been an area of geological stability for at least 250 million years. There is a significant regional variation in the nature and thickness of the younger sedimentary bedrock, which over most of the region comprises all the uppermost kilometre of the subsurface. To describe this variation and that of the deeper lying rocks the region can be divided into three geographical areas: the North Downs, the Weald including the coastal lowlands of the Pevensey Levels and Romney Marsh, and the South Downs (Figure 1).

North Downs

The North Downs are a range of hills extending from mid-Surrey eastwards through northern and eastern Kent. They are bounded to the south by a steep slope but fall away gently to the north. This area of downland is formed by the Chalk, which is composed mainly of a very fine-grained white or pale grey limestone. The Chalk often contains nodules of flint, a very hard form of silica. It is best seen in the cliffs near Dover (Figure 5) and Margate. The Chalk is generally about 250 m in thickness in this area, reaching about 280 m in northeast Kent. The Chalk is the most important aquifer, or source of underground water, in southern England. Most of the water flow in the Chalk is not through the pore spaces between the grains of the rock but along fine fractures within it. These fractures are both horizontal and vertical and connect together to make pathways for water to flow through. Because the Chalk is composed of calcium carbonate which can be slowly dissolved by groundwater, the fractures become wider over long periods of time leading to the quite rapid flow of water through some parts of the Chalk.

Figure 5 *Chalk with layers of flint nodules in cliffs near Dover; these cliffs are up to 100 m high.*

In the generally low-lying ground along the northern Kent coast, the Chalk is overlain by younger sedimentary bedrock layers comprising silt and fine-grained sand, beneath clay (Palaeogene sediments). Up to 200 m of these layers are present in places along this coast.

The Chalk is underlain by a layer of mudstone called the Gault Clay, which is about 40 to 50 m in thickness. This comes to the surface from beneath the Chalk at the foot of the North Downs. Other layers forming the younger sedimentary bedrock in the Weald (Cretaceous, Jurassic and Triassic sediments) also extend northwards under the Chalk of the North Downs, but these layers rapidly thin out in this area. This reflects the fundamental difference in the structure beneath the North Downs compared with that of the remainder of the region.

Beneath the younger sedimentary bedrock layers there is a down-fold or trough beneath east Kent that contains a coal-bearing sequence of sandstones and mudstones, similar to those found in the South Wales coalfield, and probably reaching more than 1000 m in thickness. The coalfield rocks (Coal Measures) are underlain by several hundred metres of hard Carboniferous Limestone beneath which lie basement rocks. As noted above most of the North Downs overlie the southern edge of the London Platform. However, the depth to the basement increases southwards rapidly falling to several kilometres depth in the Weald, and in places along the southern edge of the North Downs it is already more than 1 km below ground level.

These basement rocks are generally harder and denser than all the overlying sedimentary bedrock and they are also more strongly folded, in places tilting at steep angles. While the rocks themselves are less porous than the younger sediments they are cut through by fractures that do contain groundwater and include geological faults, where the rocks on each side of a fracture have moved relative to one another. These rocks are mainly between 500 to 360 million years old and comprise grey and red mudstones, siltstones and sandstones.

The Weald

The Weald is a broad area of ridges, separated by clay valleys of various widths. It occupies the southern parts of Kent and Surrey, and the northern parts of Sussex, extending into the eastern fringe of Hampshire. The area is underlain by varied deposits that originated as sediments on the ancient sea-floor, or in low-lying coastal areas, and which now form successive layers beneath the Chalk. The parts of the younger sedimentary bedrock that can be seen at the surface in the Weald largely comprise mudstone (Gault Clay, and Weald Clay of the Low Weald), alternating with sandstones or with mixed sequences of sandstone, siltstone and mudstone (Upper Greensand, Lower Greensand and the Wealden Group of the High Weald).. The individual layers vary from a few centimetres to tens of metres in thickness. Some of the younger sandstones are notably lime-rich, giving rise to local building stones such as ‘Kentish ragstone’ (Figure6). Some of these intervening layers also provide aquifers of local importance. The water in these aquifers either flows between the rock grains or through cracks in the rock, and sometimes both.

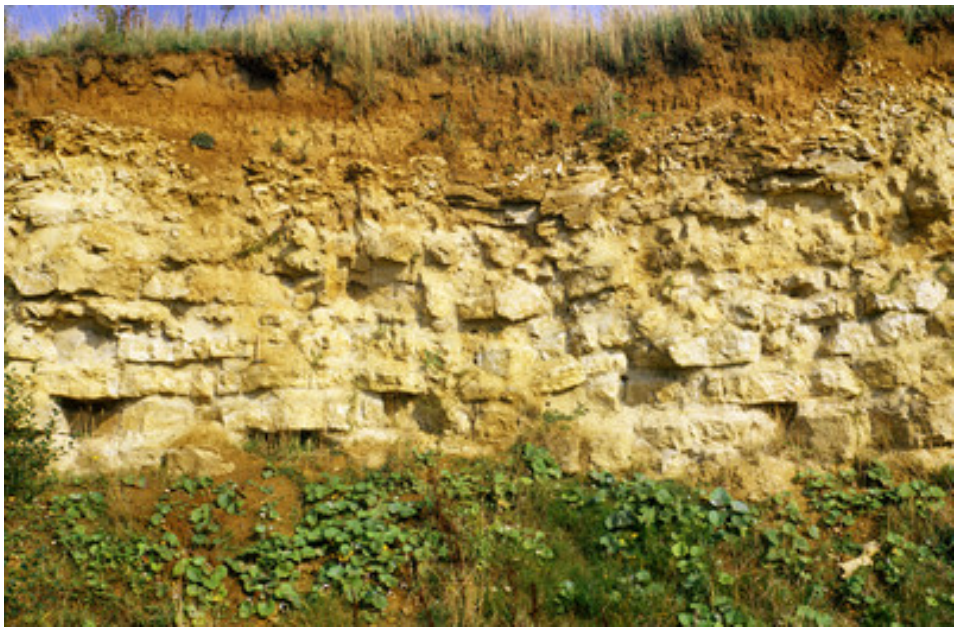


Figure 6 *Kentish ‘ragstone’, as seen in a small quarry near Ashford; the rock face is about 2 m high.*

The mudstone intervals can be as little as a few metres thick. The thickest, known as the Weald Clay (Figure 7), which forms the clay lands of the Low Weald, is up to 460 m thick in the west of the area but thins to as little as 122 m in the east. It was deposited in a broad shallow lake or coastal lagoon, with meandering rivers.

Figure 7 *The Weald Clay, seen in a brick pit near Horsham.*

Deeper levels of the younger sedimentary bedrock include some thick limestones (Portland, Purbeck, Corallian, Great and Inferior Oolite groups). These alternate with further thick mudstone sequences (Kimmeridge, Ampthill and Oxford clays, and the Lias and Mercia Mudstone groups) and some sandstones (in the Wealden Group and the Sherwood Sandstone Group) ; the complete sequence reaches 2km thick in the centre of the Weald. The thicker limestones and some of the sandstones are more porous and therefore act as reservoirs for the region's oil and gas resources, while the dense clays act as barriers to the flow of oil, gas and water.

Beneath the younger sedimentary bedrock lie older sedimentary rocks (Carboniferous and Devonian rocks) that have experienced considerable folding and faulting over a long period culminating in a period of mountain building about 300 million years ago. Rocks representing this same zone may be seen in the cliffs of Devon and Cornwall, but in the Weald they usually occur at depths greater than 1 km.

The South Downs

The South Downs form a range of hills similar to the North Downs, except that they are bounded by a steep slope facing to the north and slope away gently towards the south (Figure 8). Like the North Downs, they are composed of Chalk, but here it is up to 425 m in thickness.

Figure 8 *The South Downs at Ditchling Beacon, looking northeast to the High Weald.*

The Chalk in Sussex is overlain by a relatively thin succession of younger bedrock layers (Palaeogene sediments), but unlike those found in Kent, these are composed largely of clay, with only minor sand, and they are mostly confined to a narrow belt within a down-fold or structural trough around Chichester. This clay succession is up to 130 m in thickness. Unlike the North Downs, the Chalk of the South Downs is underlain by thick sedimentary deposits that are a continuation of those making up the younger sedimentary bedrock in the Weald. Deformed older sedimentary bedrock similar to that found at depth beneath the Weald also occurs but mainly at depths of more than 1 km.