

The aquifers of the UK

The popular impression is that groundwater flows in subterranean channels such as those in the cave systems of the limestone country of the Peak District, South Wales and the Mendip Hills. There the drainage is entirely underground and the landform is known as karst. It is characterised by swallow holes that feed sub-surface streams and caverns. But this is not the typical style of groundwater; karstic landforms are restricted to areas where hard, compact limestones outcrop and have been subjected to weathering that has dissolved the rock along lines of weakness to enlarge narrow cracks. In contrast, most groundwater used for water supply occurs in sands and gravels, or in consolidated rocks such as sandstones and limestones; the limestones, for example the Chalk, are not so compact or hard as those in karstic areas. These rocks are both porous and permeable and form the principal groundwater reservoirs or aquifers in the UK.

An aquifer is defined as a permeable rock that stores groundwater and allows it to flow readily into a well or borehole. The water flows through the voids, or pore spaces, in the rock. The total volume of the pore space is referred to as the porosity and represents the total volume of water that the rock can store. This may be in the minute spaces between the grains of a sandstone, when it is referred to as intergranular porosity, or in the



An outcrop of the Chalk showing the interconnected network of fractures that gives the aquifer its high permeability.



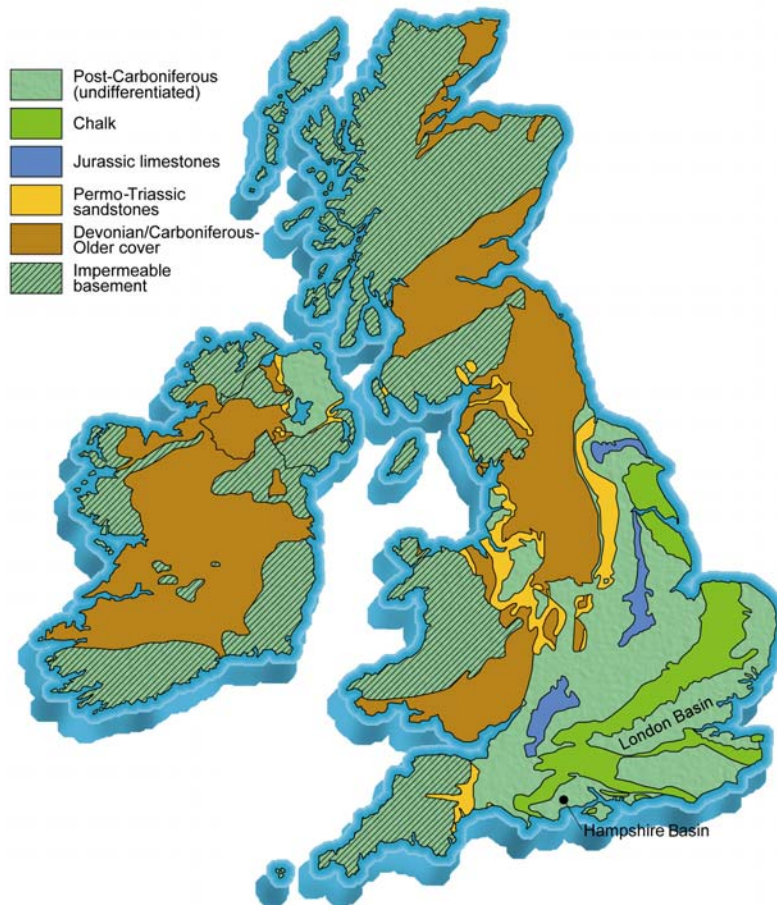
Photograph taken with an electron microscope of a Permian sandstone showing the pore spaces between the grains. The porosity is about 30%.

small cracks and fractures that are more usual in limestones and older compact rocks, which is termed fracture porosity. The pore spaces in an aquifer must be interconnected so that water can flow through the rock, in other words an aquifer must be permeable.

An aquifer's primary functions are to store and transmit water. Most groundwater in an aquifer is slowly circulating in the upper 100 to 200 metres of the saturated zone. But fresh water can penetrate to depths of more than 2 kilometres although at such depths groundwater is generally mineralised with solutes, particularly sodium and chloride, and is too saline for potable use.

The principal aquifers of the UK are found in the lowlands of England. The most important are the Chalk, the Permo-Triassic sandstones, the Jurassic limestones and the Lower Greensand. They occur within the section of the geological sequence referred to as the Younger Cover, which ranges in age from the Permian to the Quaternary. Aquifers do occur in Devonian and Carboniferous strata of the underlying Older Cover but they are much harder and more compact rocks and are regarded as of secondary importance in terms of water supply. The older Silurian, Ordovician, Cambrian and Precambrian rocks generally have low permeabilities and may be regarded as an "impermeable basement" below the strata of the Older and Younger Covers. However, even in these hard rocks, fractures in the upper 50 to 100 metres of the saturated zone do provide small amounts of water to individual wells and springs.

As a result of earth movements, the Jurassic to Palaeogene sequence of eastern and southern England slopes (or dips) either to the east into the

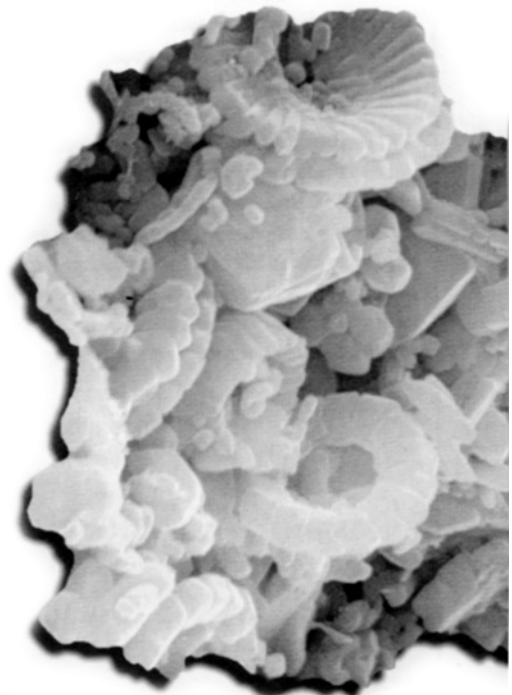


Distribution of the principal aquifers in the Britain and Ireland.

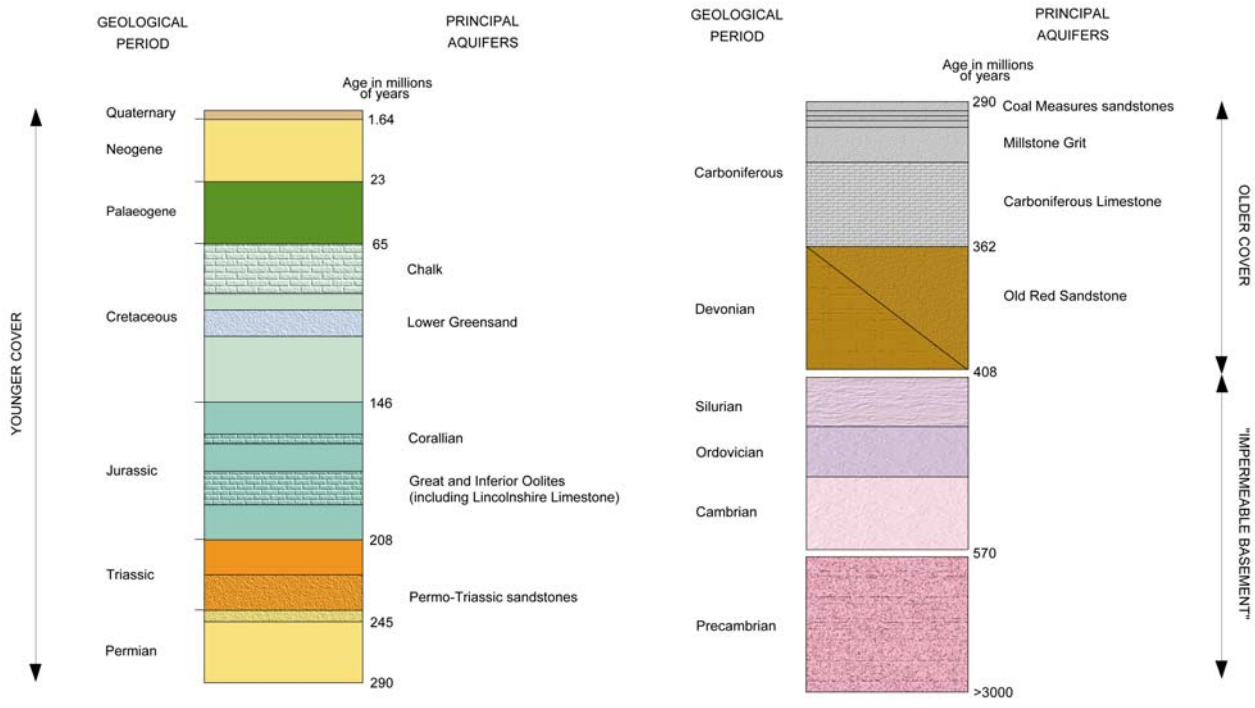
North Sea Basin or to the south into the Anglo-Paris Basin. Within this broad structural pattern the subsidiary London and Hampshire basins are very significant in the hydrogeological context; each contains major aquifers.

The Chalk, which is a soft, white limestone traversed by layers of flint, underlies much of eastern and southern England. It is a unique rock because it consists of minute calcareous shells and shell fragments of plankton. These impart high porosity to the matrix, but are so fine grained that the water contained in the pore spaces of the rock's matrix is virtually immobile, being held by capillary forces. Consequently the specific yield (the water a rock yields when it drains naturally or is pumped) is low, of the order of 1%. The Chalk owes its prominent role as an aquifer to a network of fine cracks that impart a high permeability. Individual boreholes in the Chalk can yield more than 10 million litres per day (Ml/d), sufficient to provide for the needs of about 70,000 people at 150 litres per person per day.

The Permo-Triassic sandstones are mainly red sandstones that originated in a desert environment. They are found in a series of deep sedimentary basins in western England and on



Photograph taken with an electron microscope of a sample of the Chalk showing the tiny shell fragments of algae which make up most of the rock. The porosity is about 45%.



Principal aquifers of the Younger Cover. These aquifers provide most of the groundwater abstracted for public supply and industry. Other limestones and sandstones with less-favourable water-bearing properties provide supplies of local value.

Aquifers of the Older Cover above the 'impermeable basement'. The aquifers are of secondary importance but provide many local supplies. The basement rocks are not entirely impermeable. Where they occur at the surface, small yields of groundwater are obtained from fractures in the upper 50 to 100 metres of the saturated zone.

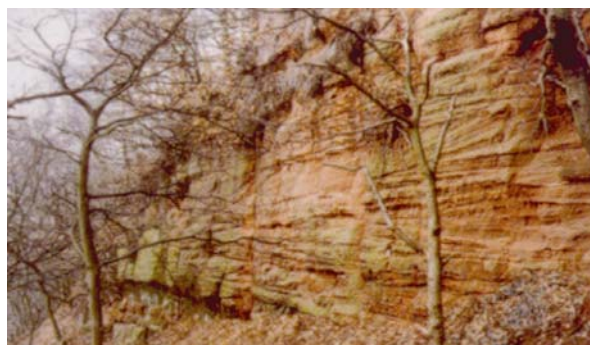
the eastern and western flanks of the Pennines. A deep basin lies below the Antrim basalts in Northern Ireland and small isolated basins are found in south-west Scotland. The packing of the quartz grains in the sandstones imparts a porosity of 30% and the specific yield can be as high as 20 to 25%. Much of the sandstone is a soft, compact rock that is only weakly cemented. Groundwater, therefore, can flow through the matrix but the presence of fractures enhances the permeability considerably. The sandstones are very permeable and yield a high proportion of the water that they store. Yields from large boreholes are as much as 5 to 10 ML/d.

The Jurassic limestones are prominent aquifers in the Cotswold Hills, in eastern England and the North Yorkshire moors. They are represented by the Great and Inferior Oolites, the Lincolnshire Limestone and the Corallian limestones. They are relatively hard limestones with low specific yields but again an extensive fracture network, with fractures enlarged by solution, gives high permeabilities. The largest yields from individual wells in the UK are provided by the Lincolnshire Limestone; the initial natural artesian overflow from one borehole was more than 30 ML/d.

The Lower Greensand flanks the Chalk in eastern England and encircles the Weald in the south-east of the country. The aquifer is not so productive as the sandstones of the Permo-Triassic but despite



The Chalk of eastern and southern England is the most important groundwater reservoir in the UK.



An outcrop of the Triassic sandstones. Water flows through the sandstones between the individual grains of the rock's matrix and more rapidly along fractures.

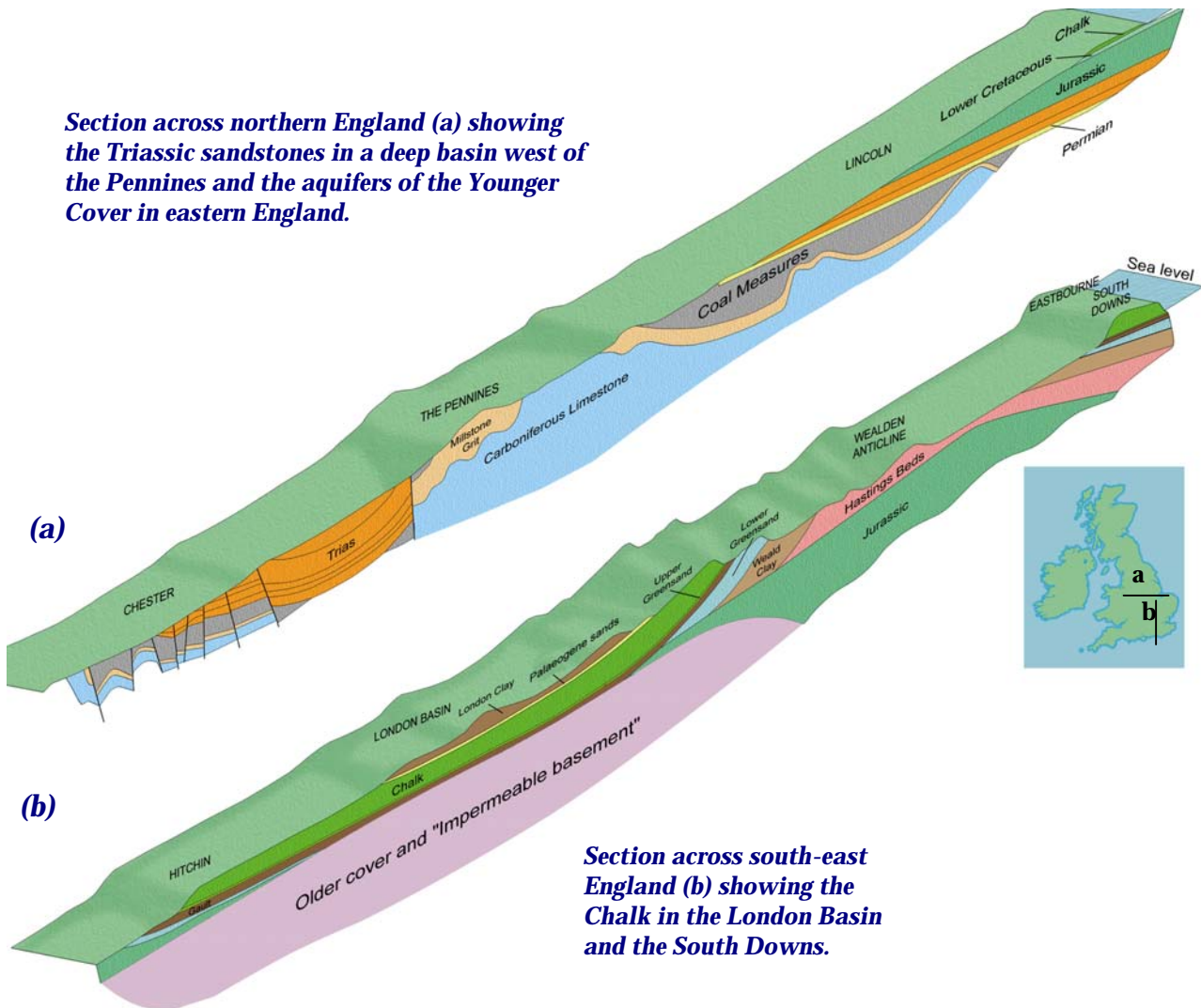
this the specific yield of 10 to 20% and moderate values for permeability make it an attractive source of groundwater.

The sandstones and limestones of the Older Cover have a much longer history and in the past have been subjected to much more intensive earth movements, which are responsible for their lower porosity and permeability. Nevertheless, they do provide many local supplies. Aquifers in the

Carboniferous are important in Northern England and the Central Valley of Scotland while the Old Red Sandstone is valuable in Caithness and along the Moray Firth.

Unlike much of the rest of the world, alluvial sands and gravels are not major aquifers in the UK, although wells and boreholes are sited in these deposits in many parts of the UK and supply individual needs.

Section across northern England (a) showing the Triassic sandstones in a deep basin west of the Pennines and the aquifers of the Younger Cover in eastern England.



Section across south-east England (b) showing the Chalk in the London Basin and the South Downs.

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