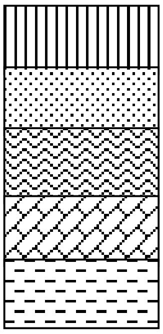
The Geology of the Chilterns

By Geoff Larminie

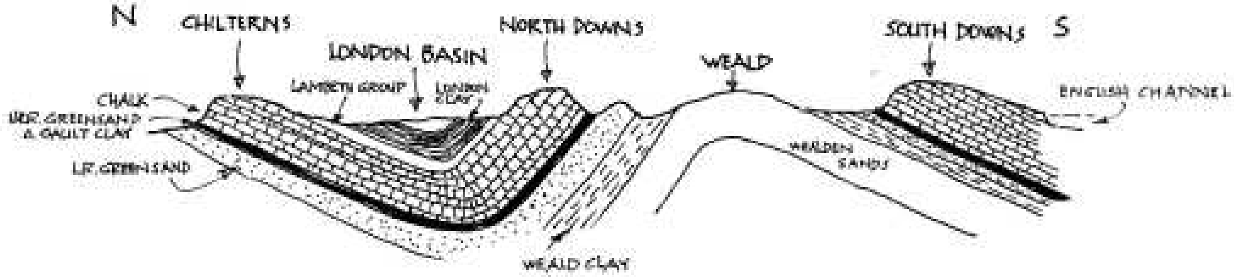
Timescales in geology are very important. The Earth is more than 4 billion years old (i.e.4,000,000,000) and there has been life on the planet for at least 500 million years. Man has been on the planet for 2 million years. The oldest rocks in the Chilterns and surrounding areas were deposited about 100 million years ago, the youngest about 2 million years ago.



2-3 M	Quaternary River Terraces (Pleistocene gravels)
51-57M	London Clay
57-60 M	Reading Beds (now called Lambeth Group)
60-100 M	Chalk
100 M	Upper Greensand and Gault Clay

The rocks comprising the Chilterns were laid down one above the other mainly in marine environments, but since then tectonic forces have brought them to the surface and caused the layers to tilt towards the south-east. This means that as you travel from Aylesbury to London via the Chilterns the rocks you travel over are progressively younger than those at the start of the journey. This uplift and folding was followed by a period of erosion to give the present subdued topography. The hardness of each type of rock also determines how easily it was eroded, so hard rocks tend to stick up as hills (the Chilterns), and soft rocks erode down into valleys.

The type of rock determines many of the surface features. For instance, soil produced by Greensand clay (in Aylesbury Vale) is very fertile so we see agriculture dominating the land use. In areas overlying clays (which are impermeable) there are rivers and streams, e.g. the River Thames in South Bucks, the River Thame and the River Ouzel in Aylesbury Vale. In areas of chalk (which is permeable because it is fractured and jointed) there is no running surface water. Any standing water, e.g. Pallett's pond and other small ponds, are formed on top of small localised patches of clay which are either man-made or natural.



• GENERALIZED CROSS-SECTION FROM THE CHILTERNS TO THE ENGLISH CHANNEL SHOWING THE FOLDED STRUCTURE & THE LONDON ARTESIAN BASIN –

The chalk forms a major aquifer (water bearing rock sufficient to provide a water supply to wells). In London it has been possible in the past to have artesian wells, because the surface of the land was lower than the water table in the hills to the North and South. This caused the water pressure to force water up the well to try to restore the water level to that in the chalk. (This means that it is particularly important not to pollute water in Chilterns since the chalk in this area is a point of input to the aquifer underlying the whole Thames basin.) In Victorian times, the water table fell because of the increase in industrial activity until there was no artesian effect. The reduction in industry over the last 30 years has caused the water table to rise by about 45'. This is having an impact on the deeper sections of the London Underground. It also partly explains the increase in winter flooding around Chesham and other towns in the Thames basin.

Gault Clay has a marine origin. It was formed when mud from large rivers flowed into the sea. The water was very slow moving and was carrying large quantities of very fine mud. It occurred at a time of global warming so the water was warm and full of animal life, now preserved as a rich fauna of marine fossils.

As the sea level rose the whole country along with northern Europe became submerged and chalk was deposited in the deep warm sea (300m deep). Chalk is a very pure form of limestone containing varying amounts of clay. The Upper and Middle Chalk have less than 5% clay, whereas the Lower Chalk has up to 50% clay. When algae and protozoa with calcareous shells or skeletons died, their remains fell to the sea floor. Along with other animal skeletons (such as shells, sponges and sea urchins) the minute coccolith skeletons accumulated in thick layers. Most of the chalk is made up of coccoliths which have a ring and cross-strut structure. The chalk that formed is particularly pure and largely uncontaminated by land-derived sediment and it is believed that the shores of the great chalk seas were largely desert.

While the coccoliths were being deposited, dimethyl sulphide (DMS) was produced and evaporated into the atmosphere. Tiny particles of DMS help damp air turn into tiny droplets causing cloud formation. The amount of DMS influences how quickly clouds are formed, and thus influences how much sunlight reaches the sea, and so how much rain falls. This is now recognised as a critical climate control mechanism. So geological processes can have far-reaching effects on the development of our atmosphere.

The chalk of the Chilterns is very soft, unlike the limestone of the Cotswolds, even though they have the same chemical composition. This is visible in the architecture of the two regions. Limestone is used to build houses in the Cotswolds, whereas in the Chilterns clay was used to make bricks because the chalk was not suitable for building. In many parts of the Chilterns the brick was used in conjunction with flints derived from the chalk, and brick and flint buildings are a feature of the vernacular architecture.

Flints are found in the chalk and are often concentrated in the clay overlying chalk in the Chilterns. It is a form of silica (as is sand), whose origins were the silica-rich organisms such as diatoms (microscopic algae), other plankton and sponges. When these creatures died, their silica skeletons dissolved in the water near the sea floor. The deep quiet waters of the chalk sea became locally saturated with silica which was re-precipitated giving rise to flints and replacing the calcium carbonate which went into solution. Initially this was a sticky jelly-like substance, but over a very short period the gel solidified into the very hard flint we find today. Often fossilized remains of sea-urchins and sponges are found in the core of the flint.

At College Lake, Pitstone, it is possible to see some of the finest examples of the various types of chalk, gravels, clays and flint, all in order of deposition. Exposures like this help geologists correlate these rocks with other places where they occur to obtain a better understanding of how and when the materials were laid down.

By looking at the type of rock deposited geologists can determine what the environment and climate was like when they formed. For instance, limestone and chalk and clay are formed in a marine environment, so we can tell that the sea level was high. This was the case when the polar ice caps had melted releasing the water and raising the sea level. Where there is sandstone, we must examine the rock structure in the field and the laboratory to determine whether it was deposited in a marine, riverine or desert environment.

One interesting feature of the Chilterns is the occasional appearance of Pudding Stones. These are the final remains of a layer of shallow marine deposits. High up on a beach can be found the larger, coarser stones and gravels, rounded by the high energy activity of the waves washing up and down the beach. Over time, as silica rich water percolated through, these sediments were cemented together into the very hard conglomerates and fine sandstones we find today. The action of ice during periods of glaciation, and water during warmer periods has eroded this hard layer and finally left behind isolated blocks. In the past when people were building, these blocks would have been ideal, in an area of otherwise soft chalk, and they may be seen in local buildings along with the local flint (e.g. the sarsens of Windsor Castle).

Sarsen stones are the fine-grained sandstones which are associated with the conglomerate Pudding Stones found in Wiltshire, where they were used to build Stonehenge. They occur scattered all over Salisbury Plain where they are known as "grey wethers" because they look like scattered flocks of sheep from a distance, and like the Pudding Stones they are the remains of strata which were once continuous over a wide area.

At the end of the period of chalk deposition (about 60 Million years ago), London and the Chilterns were where North Africa is today. At that point the Atlantic started to form by the gradual separation of North America and Eurasia. It continues today at about the rate of the growth of a thumbnail. Shallow sub-tropical seas covered the area and in this environment over 100metres of dark bluish grey London Clay were deposited. Around the margins were tropical forests and a swampy coastal plain inhabited by large animals.

About 2 million years ago the temperature fell and the forests were extinguished. Ice dominated Britain. The Ice sheet did not quite reach Aylesbury, although the previous ice sheets had probably reached as far south as the Chilterns.The last ice sheet, however, over-rode the area to the northeast of Dunstable which is why there is no clear scarp at that point.Ivinghoe Beacon shows where the approximate southern edge of the ice sheet would have reached . The edge of the ice sheet was probably 1000 m thick and the ice-front perhaps 250 m high. Beyond this there would have been a frozen desert periglacial tundra environment, (similar to Siberia and northern Scandinavia today) with appropriate vegetation. The ground would have been frozen to a considerable depth; a condition known as permafrost.

About 300,000 years ago the Anglian ice advanced and retreated locally diverting the Thames from its original course which passed through St. Albans and out into the North Sea in the Ipswich area. A new course was cut, which is the one still used today. The river itself deposited vast quantities of sand and gravel which form the terraces above the present course of the river (e.g. near Marlow). The great commercial deposits near St Albans are the "fossil" remnants of the former pre-ice course of the river.

When the ice sheets melted an enormous amount of water was released and these large rivers cut many of the dry valleys in the Chilterns that we see today. Good examples are the valley from Cholesbury Bottom through the Vale to Chesham, and the other valleys between the ridges of Hawridge, Bellingdon, Asheridge, and Chartridge, all leading to Chesham.