

# An Introduction to the Geology and Fossils of Essex

## The Foundations of Essex

*The rocks of Essex that were formed before the Ice Age are described as the 'solid' or 'bedrock' geology. Much of the solid geology is concealed beneath unconsolidated sediments laid down during the Ice Age. These Ice Age sediments (sand, gravel etc.) are called 'superficial' or 'drift' deposits.*

### The Oldest Rocks

The geological story of Essex starts with rocks that are between 440 and 360 million years old. Dating from the Silurian and Devonian periods these rocks consist of hard, slaty **shales**, **mudstones** and **sandstones** and are over 300 metres below the surface. These rocks have been encountered in boreholes at many places in Essex and they represent a time in the distant past when the first animals were leaving the sea to colonise the land. Similar rocks can be seen at the surface in the Welsh Borderland.

Lying on top of these ancient rocks is the **Gault**, a marly clay from a muddy sea that dates from the middle of the Cretaceous period. This means that, beneath Essex, there is a gap in the geological record that represents about 250 million years and includes the Triassic, Jurassic and early Cretaceous periods. After deposition of the Gault, sand spread into this sea to form a deposit called the **Upper Greensand**. At this time sea levels were rising leading to widespread flooding of the continents, these are the conditions under which the next rock was formed - the **Chalk**.

### The Chalk

Chalk is effectively the starting point of our geological story as it is the oldest rock exposed at the surface in our county. Chalk also forms the foundations of the London Basin, a great trough-shaped structure beneath London and Essex. A great thickness of chalk forms the Chiltern Hills and their continuation as the hills of south Cambridgeshire; it then passes beneath central London and Essex and comes to the surface again as the North Downs of Surrey and Kent. This layer was originally horizontal, having been laid down as a limy mud on the floor of a tropical sea during the age of the dinosaurs; the folding occurring millions of years later as Britain was squeezed as a result of the African continent pushing into Europe and creating the Alps.

The Chalk sea was in existence between 80 and 100 million years ago (during the Cretaceous period) and the purity of the Chalk means that the water must have been crystal clear and the nearest land a considerable distance away; in fact it is thought that this sea may have covered most of northern Europe. The Chalk sea was teeming with marine life such as molluscs, sponges, corals, sea urchins and fish, and at the top of the food chain were the mosasaurs, giant marine reptiles up to 10 metres long with a long body and tail, paddle-like limbs and heavy jaws armed with sharp, conical teeth. The

smallest creatures were microscopic marine algae with protective shells that accumulated on the sea floor in their billions, in fact it is now realised that Chalk is almost entirely made up of these tiny fragmented shells which are only visible under an electron microscope.

Chalk can be seen in the south of the county in Thurrock where there are many giant disused quarries, the remnants of the Portland cement industry. A number of these quarries are now part of Chafford Gorges Nature Reserve managed by the Essex Wildlife Trust - a bizarre choice of name as these are disused quarries not natural gorges. On the northern limb of the London Basin is Saffron Walden which also has disused chalk quarries but on a much smaller scale.

### **The Extinction of the Dinosaurs**

The end of the Cretaceous period saw the extinction of the dinosaurs and the gradual disappearance of the Chalk sea as sea level fell throughout the world. The next chapter in our story involved further inundations in later geological periods which deposited a great thickness of other rocks over the whole area. Much of Essex is therefore built on these younger rocks but the Chalk is, of course, still present beneath the surface, in some cases as deep as 200 metres below ground level.

The first rocks to be laid down on the eroded chalk surface are a variety of sands clays and shell beds deposited in shallow marine or estuarine conditions. These have now been reclassified and renamed by geologists but they are best known by their old names which describe five distinct types of sediment, namely the **Oldhaven, Blackheath, Woolwich, Reading and Thanet Beds**. These deposits are often collectively referred to as the **Lower London Tertiaries**. Thanet Sand can be clearly seen in many of the Thurrock quarries, lying on top of the Chalk.

### **The London Clay**

The environment of the region was now to change dramatically leading to the deposition of the **London Clay**, a mud laid down on the floor of a subtropical sea some 50 million years ago. The London Clay has yielded fine fossils of the sea's inhabitants such as molluscs, lobsters, crabs and sharks. There are also fossilised fruits, seeds and twigs which provide us with valuable information about the rain forest vegetation which existed on the land at this time. Most remarkable of all are probably the fossil turtles and mammals from the workings of the Harwich cement industry in the 18th and 19th centuries. The cement was made from hard limestone nodules that occur in the clay and in one of these, in 1856, a workman found the skeleton of *Hyracotherium* (also known as Eohippus). *Hyracotherium* was the earliest ancestor of the horse and was no larger than a fox, with toes instead of hooves. This animal lived on the river banks and its bones must have been washed down a river into the sea. This was a time of rapid evolution of mammals following extinction of the dinosaurs.

London Clay fossils, particularly sharks' teeth, turn up all around the Essex coast but the most famous site is at Walton-on-the-Naze where the beach is very popular with collectors. The London Clay here is one of the reasons Walton is a site of international importance, mostly because in it are the best preserved bird fossils of Tertiary age to be found anywhere in the world. The London Clay also contains layers of volcanic ash which may have originated in Scotland where there were active volcanoes around this time.

Lying on top of the London Clay is a sandy clay called the **Claygate Beds**. Above this is a delightful, fine-grained yellow sand called **Bagshot Sand** which indicates a shallowing of

this sea. It formerly covered the whole region but erosion has now reduced it to isolated patches on hill tops in central Essex.

## The Red Crag

A gap in the geological record after the deposition of the Bagshot Sand indicates great time interval and this was no doubt due to subsequent rocks being removed by erosion. This is followed by the two million year old **Red Crag** which occurs across much of north Essex, although it is only at Walton-on-the-Naze that it is well exposed. Laid down just before the present Ice Age, the red, iron-stained sand is teeming with fossil shells and forms spectacular layers on top of the London Clay. The Red Crag also contains the teeth of sharks, the most famous of which is *Carcharodon megalodon*, the largest species of shark that ever lived, weighing in at some 65 tonnes. These teeth, which were derived from rocks of Miocene age and incorporated into the Red Crag, are extremely rare but examples have turned up on the beach over the years.

The 'icing' on the county's geological 'cake', however, is the remarkable variety of deposits laid down during the Ice Age.

## The Ice Age

*The rocks that have been formed during the present Ice Age are described as the 'drift' or 'superficial' geology. They mostly consist of sands, gravels and clays laid down by glaciers, rivers, lakes and shallow seas.*

### The Cooling of the Planet

The story of the Ice Age starts around two million years ago. At this time the climate was probably not too dissimilar to the present day but the temperature had been slowly dropping for tens of million years, ever since the balmy, tropical days of the dinosaurs. The oldest Ice Age deposit in our region was laid down in a shallow sea and is known as the **Chillesford Sand**. This sand occurs at the base of gravel pits in north-west Essex but it is extremely difficult to date due to the absence of fossils for much of its thickness. Following deposition of the Chillesford Sand there is a very fragmentary record of our climate and landscape over the next million years or so. This period, which makes up most of the early part of the Ice Age, is poorly understood but some evidence has been preserved, thanks largely to an early route of the River Thames.

### The Early Thames

During the early Ice Age the Thames flowed to the north of London, through north Essex, Suffolk and Norfolk and out across what is now the southern North Sea to become a tributary of the Rhine; the evidence for this being a substantial thickness of what is called **Kesgrave Sands and Gravels** which, remarkably, was the actual bed of the river. These old Thames gravels contain a variety of unusual pebbles from as far away as North Wales, proving that, at that time, the Thames must have been a huge river draining the Welsh mountains and bringing their characteristic volcanic rocks into the Thames basin. The gravels also contain large boulders of **puddingstone** and **sarsens**, subsequently put to use by man as ancient way markers at road junctions. These gravels have great

commercial value and are worked in numerous gravel pits between Harlow, Chelmsford and Colchester, which was the route of the ancestral Thames at least 600,000 years ago.

During this time the River Medway flowed north across east Essex to join the Thames near Clacton, leaving behind a ribbon of distinctive gravel which can be found between Burnham-on-Crouch and Bradwell-on-Sea. There were also other northward-flowing tributaries of the early Thames, evidence of these are the patches of gravel that are found on the tops of the hills in south Essex, such as the Langdon Hills, Warley and High Beach in Epping Forest.

### **The Anglian Ice Sheet**

The regular pulses of climate change culminated in the **Anglian** glaciation, a severe cold stage about 450,000 years ago that allowed a great ice sheet to spread south into the region across the valley of the early Thames. A lobe of ice from this ice sheet blocked the Thames in the Vale of St. Albans causing a catastrophic change to the route of the river, diverting it south to its present position. Evidence for the existence of this ice sheet is a substantial thickness of **boulder clay**, or **till**, left behind by the ice as it ground southwards across the frozen landscape. The **Anglian till**, lying on top of the old Thames gravels, forms a distinct plateau over the north of Essex, now dissected by modern river valleys. Till can be found as far south as Hornchurch which is known as the most southerly point in Britain that the ice penetrated during the whole of the Ice Age. The till contains rocks that have been carried south by the ice, some of them from as far away as northern England and Scotland, and there are also fossils such as Jurassic ammonites and belemnites, brought here from the Midlands.

### **Glacial Sand and Gravel**

The landscape at this time is almost impossible for us to visualise. As the region was situated at the southern-most limit of the Anglian ice sheet, colossal volumes of melt water would have been continually released and the evidence for this is also preserved beneath our feet. In parts of East Anglia, boreholes have revealed deep, steep-sided valleys cut into the chalk bedrock and now completely filled with sand and gravel and hidden by a covering of till. Known as buried tunnel valleys or buried channels these remarkable natural features were formed beneath the ice sheet and were the main drainage routes for melt water. One of the best examples of a buried channel is the Cam-Stort Buried Channel which is present from Great Chesterford south as far as Bishops Stortford. You can't see it but in Newport it passes beneath your feet and is some 100 metres (300 feet) deep, almost half of this depth being below present sea level.

Glacial gravel is present in many other places in Essex. It is recognisable as an unsorted residue of many rock types, mostly flint, laid down under these exceptional conditions.

### **The Hoxnian Interglacial - The Arrival of Humans**

The Anglian glaciation was followed, about 400,000 years ago, by a warm stage traditionally called the **Hoxnian** interglacial. Early humans made their way north from Europe during this period taking advantage of the retreat of the ice. The Thames now flowed approximately along its present course but in the Southend area it turned north to Clacton along the old valley of the Medway laying down what is known as the Thames-Medway Gravels. These gravels are well exposed in the cliffs at Cudmore Grove Country Park in East Mersea. At Clacton, before the construction of the sea defences, these gravels yielded worked flints which are the earliest evidence of humans in Essex.

Perhaps the most important Hoxnian site is Marks Tey Brick Pit, near Colchester, where lake sediments have revealed distinctive layers containing fossil pollen, revealing to geologists a remarkably detailed record of the vegetation living throughout this interglacial stage.

### **The Modern Thames**

The modern (post-diversion) Thames has numerous bench-like terraces on either side of the valley, the oldest being at the highest elevation. They were formed during cold and warm stages following the Hoxnian Interglacial. Until recently this period of the Ice Age was thought to be a single cold period called the 'Wolstonian'. Terraces are formed by the river slowly cutting down through successive flood plains and creating new flood plains at lower levels. Each terrace contains fossils, some of them spectacular, which tell us what animals were living in this area during each of these periods. The working of brick clay at Ilford in the mid 19th century yielded the bones of hundreds of mammoths and woolly rhinoceroses in the former pits, and the largest complete mammoth skull ever found in Britain (the 'Ilford mammoth') was discovered here in 1864. Downstream, there are numerous other sites such as at Aveley, where a clay pit yielded the famous Aveley elephants in 1964.

### **The Ipswichian or 'Great Interglacial'**

The greatest and the warmest interglacial stage during the whole of the Ice Age was the **Ipswichian**, about 120,000 years ago. This period must have been warmer than the present day with monkeys, elephants and lions in southern England, the bones of which were found beneath Trafalgar Square in the 1950s as a result of building excavations. Downstream, the foreshore at East Mersea is currently one of the best sites of Ipswichian age in Britain. Here there are highly fossiliferous sediments called 'hippo gravels', so called because the hippopotamus was remarkably abundant in our region at this time, but curiously absent during almost all of the other interglacial stages. Fossils indicate that humans and also animals such as the horse were absent from Britain during the Ipswichian. Each interglacial stage has a distinctive fauna, presumably because, in each case, some animals were not quick enough to migrate north as the climate improved and were halted by the reappearance of the English Channel as sea level rose.

### **The Most Recent Glaciation**

Following the warmth of the Ipswichian came the intense cold of the **Devensian** stage when an ice sheet again spread south but this time reaching no further than north Norfolk. Permafrost conditions again gripped this region, providing home for only reindeer, arctic wolf and similar species. Fossils of these animals have been found in a gravel pit at Great Totham and further west in the Lea valley.

### **And finally...**

No review of Essex geology would be complete without a mention of the county's most remarkable geological event. On the morning of 22 April 1884 Essex was shaken by the most destructive earthquake to have affected Britain in historical times. It is known as the Colchester earthquake because the greatest damage was caused to buildings in the Colchester, Wivenhoe and surrounding area. Remarkably no one was killed but there was considerable damage to over 1,200 buildings, including fallen chimney stacks, church towers and roofs stripped of tiles. This event is the more surprising because it occurred in a county otherwise devoid of significant seismic activity.