



Thurrock Council

Report on Local Geological Sites



‘Thurrock has a geological history remarkable not only for its diversity, particularly in such a relatively small area, but also because of its importance internationally. Few other authorities have such a rich geological endowment.’

Prepared for Thurrock Council by:

Gerald Lucy FGS

GeoEssex

Dr. Peter Allen

GeoEssex

Ros Mercer BSc.

GeoEssex

Revised: 14 December 2020



Contents

1. Introduction

GeoEssex

Geodiversity

Local and National Geodiversity Action Plans

2. The Geology of Essex

Geological map and cross section through Essex

Essex through geological time

3. Background to Geological Site designation in Thurrock

What is special about Essex geodiversity?

Geodiversity's influence on Essex's development

Geodiversity and National Planning Policy

Site designations

4. Objectives of this report

Supporting local planning authorities

5. The geology of Thurrock district

6. Site selection

Site selection and notification to planning authorities

Site protection

Site assessment criteria

Land ownership notification

7. Additional Sources of Information

8. List of Geological Sites

SSSIs in Thurrock district

LoGS in Thurrock district

Proposed LoGS in Thurrock district

Other sites of geological interest in Thurrock district

Appendix 1:

Citations for individual Local Geological Sites (LoGS) approved by the Local Sites Partnership

Cover photographs:

View of Wouldham Chalk Cliff from Devonshire Road, part of Chafford Gorges Nature Park.

The chalk was laid down in a tropical sea some 80 million years ago during the time of the dinosaurs. The photo was taken in 2005. *Photo: © G. Lucy*

A set of paw bones of a brown bear from an early nineteenth century collection of fossils from the Grays brick pits. The bones have cutmarks (just discernable in this photograph) which were made by early humans removing the flesh with flint tools. The cutmarks were only recently noticed when the collection was re-examined. *Photo: © Natural History Museum.*



1. Introduction

The rocks beneath the Essex landscape are a record of the county's prehistory. They provide evidence for ancient rivers, volcanoes, deserts, glaciers and deep seas. Some rocks also contain remarkable fossils, from subtropical sharks and crocodiles to Ice Age hippos and mammoths. The geology of Essex is a story that stretches back over 100 million years.

GeoEssex

GeoEssex is the primary source of information about the geology and physical landscape of Essex. The GeoEssex team, or 'Steering Group', consists of professional and amateur geologists, representatives from local authorities, geological and natural history societies, and from Natural England, the Government's nature conservation body.

GeoEssex promotes geology in all its aspects, from quarries, cliffs and boulders to spas, springs and building stones. It also promotes the county's rich geological heritage of mineral extraction, scientific research and fossil discoveries. The fascinating and often magical world of geology is all around us, if only we know where to look.

A primary task of GeoEssex is to identify the best places in Essex to find out about the Earth's distant past and the landscape processes going on today. These sites are called Local Geological Sites, or LoGS (formerly called Regionally Important Geological Sites or RIGS). It also advises and assists landowners with the management of sites.

GeoEssex aims to advocate and represent geodiversity in planning processes and other initiatives.



A tropical sea floor

A magnificent block of Oldhaven sandstone found in 1979 during excavations for the M25 Mar Dyke interchange.

It contains a large number of fossil shells and represents a shallow tropical sea that covered Thurrock some 55 million years ago.

Photo: © G.R. Ward



Geodiversity

What is geodiversity and why is it important?

Geodiversity is an integral part of the natural environment. It is the variety of rocks, fossils, minerals, landforms and soil, and all the natural processes that shape the landscape.

The only record of the history of our planet lies in the rocks beneath our feet. Here, and only here, can we trace the cycles of change that have shaped the Earth in the past, and that will continue to do so in the future. This is particularly true in Essex, where the record of climate change during the Ice Age is preserved in our quarries and coastal cliffs. The record is unique and much of it is surprisingly fragile.

Apart from the obvious benefits of providing mineral resources such as sand, gravel, chalk and clay, the diversity of the geology is what shapes the landscape, influencing soils and, in turn, influencing all of our habitats and species. Geodiversity also has a cultural role to play, influencing the character of our built environment through building stones, providing inspiration to art, and helping to define where we live and our 'sense of place'. It is the link between geology, landscape, nature and people.

And, of course, it must not be forgotten that ***almost everything we know about the Earth's distant past has been learnt by studying geological sites.***

Local and national Geodiversity Action Plans

The UK Geodiversity Action Plan (UKGAP) sets out a shared framework for geodiversity action across the UK. It establishes a common aim, themes and targets which link national, regional and local activities. It encompasses how geodiversity can inspire people and what needs to happen to conserve Britain's geodiversity. The Plan for Essex has been drawn up within this framework.

The Local Geodiversity Action Plan (LGAP) for Essex sets out a framework for geodiversity action. It is an essential document to conserve the County's geodiversity.

The Essex Local Geodiversity Action Plan aims to:

- *Identify, conserve and enhance the best sites that represent the geological history of an area in a scientific, educational, recreational and cultural setting;*
- *Promote geological sites and make geoconservation relevant to people;*
- *Provide a local geodiversity audit (an audit of sites and skills);*
- *Influence local planning policy.*



2. The Geology of Essex

Compared to most other parts of Britain the rocks of Essex and adjoining counties are young in geological terms. Even the oldest surface rock in Essex (the Chalk) is only about 80 million years old. Much older rocks are, however, present at depth. We have some idea about these ancient rocks because of the records of boreholes that have been sunk, particularly in the search for water, coal and oil.

The surface rocks of Essex that were formed before the Ice Age (from the Chalk to the Red Crag) are described as the 'bedrock' or 'solid' geology. Much of this bedrock geology is concealed beneath the deposits left behind by glaciers and rivers during the Ice Age. The materials laid down during the Ice Age are known as 'Superficial' or 'drift' deposits.

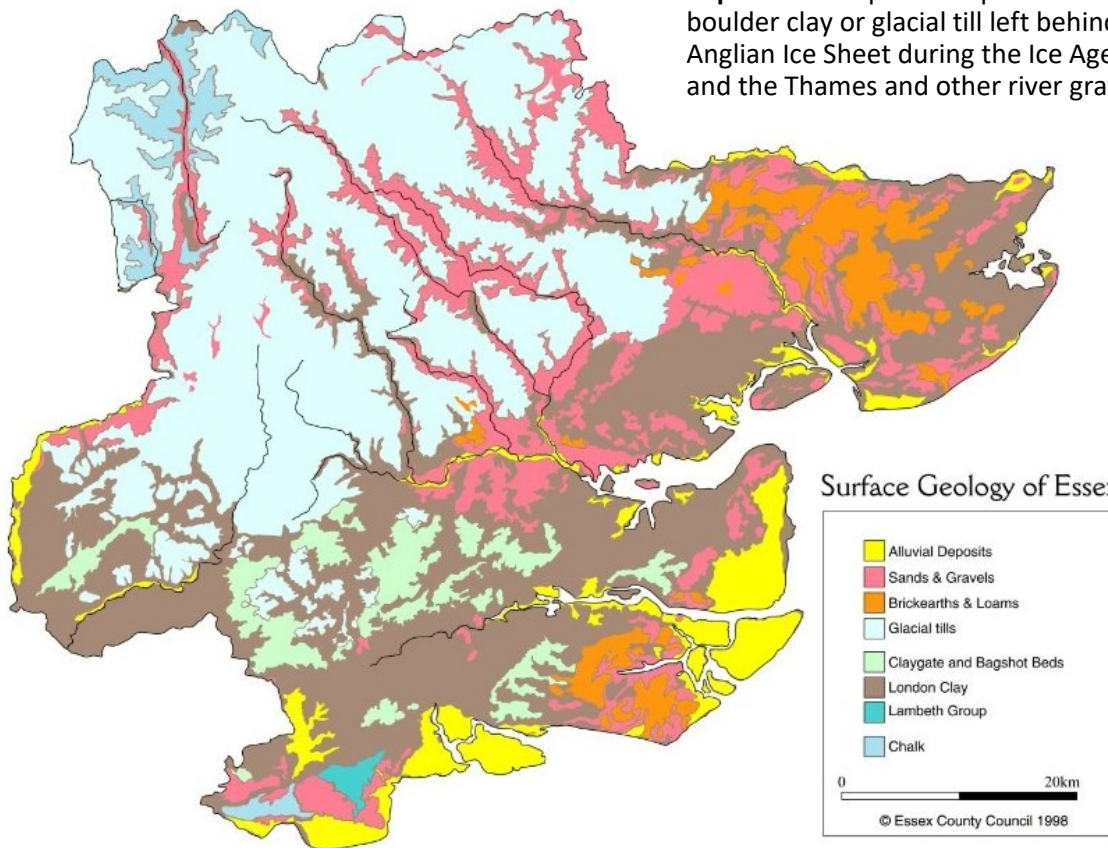
Geological timescale for Essex (not to scale)

Era	Period or Epoch		Approx. age in millions of years	Geological formations in Essex
Caenozoic	Quaternary Ice Age	Holocene	0.01	Recent peat and alluvium
		Pleistocene	0.45 1 2.4	River terrace deposits and brickearth (loess)
				Boulder clay (till) and glacial gravel
				Kesgrave (Thames) sands and gravels
				Norwich Crag (Chillesford Sand)
				Red Crag
	Pliocene		10	No evidence of deposits of this age in Essex but derived Miocene and Pliocene fossils are found in the Red Crag
	Miocene			
	Oligocene		20	
	Eocene	50	Bagshot Sand	
			Claygate Beds	
			London Clay (includes the Harwich Formation)	
Palaeocene	55	Lambeth Group (Woolwich and Reading Beds)		
		Thanet Sand		
Mesozoic	Cretaceous	80	Chalk	
		100	Gault and Upper Greensand (beneath Essex)	
	Jurassic	150	No evidence of rocks of these ages beneath Essex with the exception of Jurassic Oxford Clay in a graben (a sunken part of the crust bordered by faults) beneath East Tilbury.	
	Triassic	220		
Palaeozoic	Permian	250		
	Carboniferous	300		
	Devonian	400	Shales and mudstones dating from these periods occur at depth (about 300 metres) beneath Essex	
	Silurian	420		
	Ordovician	450	No evidence beneath Essex, however, boreholes have not been drilled deep enough to confirm.	
	Cambrian	500		
Pre-Cambrian	Precambrian	Age of Earth 4,600		



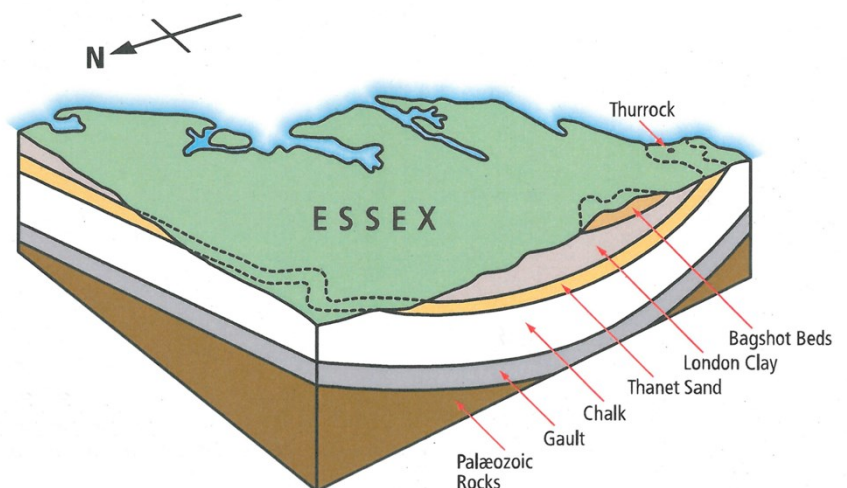
Geological Map of Essex

Geological map of Essex showing all the rocks exposed at the surface - **bedrock** and **superficial deposits**. Examples of superficial deposits are boulder clay or glacial till left behind by the Anglian Ice Sheet during the Ice Age (pale blue) and the Thames and other river gravels (red).



Cross section through Essex (bedrock only)

The layers of rocks that make up Essex are folded so that the Chalk, which is present beneath the whole county, comes to the surface in Saffron Walden and in Thurrock. The Chalk is about 80 million years old and was formed as a white mud on the floor of a tropical sea. The rocks below the Chalk are older, and the rocks above are younger.



Beneath the Chalk is a blue clay called the Gault and below that is the basement of Essex consisting of hard sandstones and shales from the Palaeozoic era, over 360 million years old.

This section is much simplified. The Bagshot beds (the youngest bedrock on this section) make up the high ground in a number of areas of south Essex, including the Langdon Hills.



Essex through geological time

It is difficult to know where to begin with our geological story but the earliest evidence we have is the hard rocks deep beneath Essex that were formed some 400 million years ago in the Silurian and Devonian periods (part of the Palaeozoic era) and form what is known as the 'Palaeozoic basement' of Essex.

Deserts to Dinosaurs

- For a very long time (and before the age of the dinosaurs) these hard Silurian and Devonian rocks formed the surface of the land that was eventually to become Essex. During the Permian and Triassic periods Essex was a desert upland in the middle of a vast continent known as Pangea.
- By 200 million years ago, at the start of the Jurassic period, tropical seas had spread around this land forming a dinosaur-infested, forested island.

Buried Island

- If you could dig down 1000 feet (300 metres) under Essex you would reach the hard rocks of that dinosaur island.
- All trace of forests and animals from this time have been swept away from the eroded surface of the island, so there are no dinosaur fossils in Essex.
- By 100 million years ago, in the Cretaceous period, the sea flooded across the island to spread **Gault Clay** and **Greensand**. The sea then deepened to deposit hundreds of metres of soft white limestone known as **Chalk** all over the island as well as much of what is now Britain.

Pebbles and Clay

- The North Atlantic Ocean, which did not previously exist, began to open out to the west, the land of Essex lifted, chalk hills were worn down and flints were eroded out. Billions of these flints were tumbled on beaches to form layers of sand and beautifully-rounded pebbles across our area.
- Around 50 million years ago, in the Eocene period, a deep, sub-tropical sea fed by muddy rivers spread across what is now Essex and London depositing a great thickness of clay known as **London Clay** on the sea floor, together with the remains of many plants such as palms and cinnamon, and animals including birds, sharks, turtles, and horses no larger than a fox. Atlantic volcanoes showered their ash into this sea.

The Alps and the Thames

- Colliding continents pushed up the Alps, and in south and mid-Essex the Earth's crust was compressed to form a vale or syncline - the London Basin, occupied by an arm of the sea. About 2.4 million years ago, the western part of the London Basin began to rise and rivers poured vast amounts of material in the sea, forming offshore sandbanks which became red shelly sandstone layers across north-eastern Essex known as the **Red Crag**.
- Global cooling led to the Ice Age (the Pleistocene epoch), with many warm as well as cold periods. With further uplift, the Red Crag sea retreated and was replaced by the ancestral River Thames, spreading a succession of flint-rich river gravels across the middle of Essex, through Harlow, Chelmsford and Colchester, and out across the area where the North Sea is now.

Ice and people cover Essex

- During an exceptionally cold stage 450,000 years ago a gigantic ice sheet covered most of Britain and Essex as far south as Hornchurch. The moving ice diverted the Thames towards its present-day course and dumped its load of boulder clay, or glacial till, on top of these old Thames gravels.
- During the past million years of the Ice Age, there have been numerous cold and warm stages (right now we are in a warm period known as the Holocene) and humans have migrated to and from Essex, together with the animals they have hunted. They have left thousands of flint tools and tool-making debris on the banks of the ever-changing Thames and its tributaries. Thus, in south Essex we have the best geo-environmental and archaeological record in Europe of the last half a million years.



3. Background to Geological Site designation in Thurrock

What is special about Essex Geodiversity?

Essex is an area of predominantly subdued relief with gentle slopes, the result of its underlying geology of soft, relatively young rocks. These generally yield fertile soils. The result is an attractive 'lived in' landscape dominated by arable agriculture, but still retaining forested and heathland areas, particularly where gravels and sands, many of glacial and fluvial origin, have yielded poorer soils.

Although lacking the more dramatic geology and landforms of many 'hard rock' areas, Essex geology and geomorphology is still of great interest, possessing abundant evidence of the huge environmental and biodiversity changes that our area has witnessed over the last 100 million years. Among the key themes are dramatic and sometimes long-lasting changes in the distribution of land and sea, major shifts in climate, and mass species extinctions. Many of these phenomena are of great relevance today, and so an understanding of our past is essential in interpreting the challenges to come.

Geodiversity's influence on Essex's development

Essex's geodiversity has exerted a major influence on land use, agriculture and landscape.

The distribution of less fertile ancient river and glacial gravels has been a major influence on historical land use, resulting in the preservation through to the present day of extensive tracts of woodland and to a lesser extent heathland, in a predominantly arable county. These are of great significance both for biodiversity and recreation.

The chalky boulder clay, or glacial till, found north and west of Chelmsford is highly suitable for cereal cultivation, especially wheat. London Clay outcrops south of Chelmsford, providing soils less suitable for arable agriculture and more suited to pasture. The brickearth of the Tendring district is the basis of the rich agricultural land of this peninsula.

In earlier times rivers penetrating deep inland, together with proximity to the Continent, provided a succession of invaders and colonisers – from Stone Age peoples, through to Roman, Viking and Saxon - with easy access.

Chalk for the manufacture of Portland cement and clay for brick-making has brought wealth and employment to south Essex, and the deposits of the ancestral Thames and its tributaries have provided Essex with a source of gravel and sand for construction since Roman times. A special kind of gravel naturally cemented by iron called ferricrete was used extensively as a building stone and is found in many medieval churches.

Geodiversity and National Planning Policy

The importance of geodiversity as an integral part of nature conservation and the planning system is reflected in The National Planning Policy Framework (NPPF), and in legislation – Wildlife & Countryside Act 1981 and Countryside and Rights of Way Act 2000.



The NPPF states that:

“Planning policies and decisions should contribute to and enhance the natural and local environment by protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils” (Paragraph 170);

“Plans should protect and enhance biodiversity and geodiversity” (Paragraph 174).

Site designations

The most important geodiversity sites have been declared as **Sites of Special Scientific Interest** (SSSIs) which are statutorily protected for their scientific importance (there are four geological SSSIs in the Thurrock district).

The next tier of geodiversity sites are known as **Local Geological Sites** (LoGS) These have replaced the earlier ‘Regionally Important Geological Sites’ (RIGS) terminology in line with government guidance.

Local Geological Sites (LoGS) are broadly equivalent to Local Wildlife Sites (‘LoWS’) but have a broader remit as they can be designated for their scientific, educational, historical and recreational benefits. Typical Essex LoGS include quarries, pits, walls, boulders, cliffs, springs, and river meanders. Local Wildlife Sites and Local Geological Sites are both designed to provide a system of locally-valued, non-statutory sites.

Most importantly, the NPPF gives Local Geological Sites a weighting equal to Local Wildlife Sites, and both are collectively referred to as ‘Local Sites’. However, in actuality the attention and priority afforded to the designation and management of LoGS has historically lagged, and continues to lag well behind that of LoWS.



A cliff section through the famous Grays brickearth in a pit south of Orsett Road. The photograph was taken during a visit by the Geologists’ Association in 1901.

Thurrock has been host to visits by geologists since the birth of the science.

Photo © British Geological Survey (Geologists’ Association Archive).



4. Objectives of this report

Supporting Local Planning Authorities

Biodiversity protection is familiar to planning authorities but geodiversity less so. This report will assist planning authorities in meeting their obligations under the National Policy Planning Framework and helping them identify potential development impacts on LoGS.

GeoEssex is therefore seeking to help Local Planning Authorities fulfil their responsibilities with respect to geodiversity.

“Local and neighbourhood plans and planning decisions have the potential to affect biodiversity or geodiversity outside as well as inside designated areas of importance for biodiversity or geodiversity” (extract from: www.gov.uk/guidance/natural-environment)

Further guidance on statutory obligations is given in Circular 06/2005 (*Biodiversity and Geological Conservation*). Geodiversity should be therefore included alongside biodiversity in local authorities' Local Plans. Identifying these non-statutory sites therefore helps local authorities to meet their obligations.

LoGS can also contribute to *sustainability* programmes by providing information about a key element of the environment that contributes to our natural heritage. In addition, the *awareness raising* and *education* functions fit well with the principle of community involvement and enabling people to regain their sense of place.

Chalk quarrying in Thurrock

Chalk has been quarried in Thurrock for hundreds of years for making lime. One of the oldest quarries is Grays Chalk Pit (now known as Grays Gorge), which extracted chalk largely for the manufacture of whiting, a powdered chalk used to make putty, paint and other products.

The invention of Portland cement in the 19th century gave a new impetus to chalk quarrying and several giant cement works were built, the first being Gibbs & Co., which opened the Thames Works in 1872. To make cement, chalk was mixed with river mud and fired in rotary kilns and it was here that the first rotary kiln in the world was used. After 1930 mud was replaced with liquid London Clay piped from clay pits at Aveley. The Lion Works opened in 1874, which in 1900 became the Wouldham Cement Co. All these quarries were eventually taken over by Blue Circle Industries and the last quarry finally closed in 1976.



A Thurrock chalk quarry in operation in the 1920s.
In this particular quarry the chalk was excavated from sloping faces and directed down channels into waiting railway wagons for transporting to the cement works.

Photo: © Thurrock Museum.



5. The geology of Thurrock district

Thurrock has an extraordinary abundance of sites and features of geological interest, some of national and international importance. But these sites are often hidden and more often neglected. So what is so special about Thurrock's geology? It is partly because the rocks of the area have been exploited extensively, leaving a remarkable legacy of disused quarries, often with vertical chalk cliffs. Another reason is the variety of different rock types of varying ages. The geological history of the Thurrock area dates back about 80 million years. At one extreme we have rocks laid down in the tropical heat of the age of the dinosaurs, and at the other extreme there is a wide range of sediments deposited during the Ice Age, sometimes in a very cold climate when glaciers covered most of Britain.

The following is a description of the surface rocks, emphasising what can be seen today of our geological heritage. Much older rocks are, of course, present at depth and these were revealed in a deep borehole, or well, sunk at Fobbing in 1924. The well penetrated through the total thickness of the Chalk, Upper Greensand, Gault, and Lower Greensand before terminating at a depth of 352 metres in hard shales, sandstones and quartzites, from the middle Devonian period, about 390 million years old.

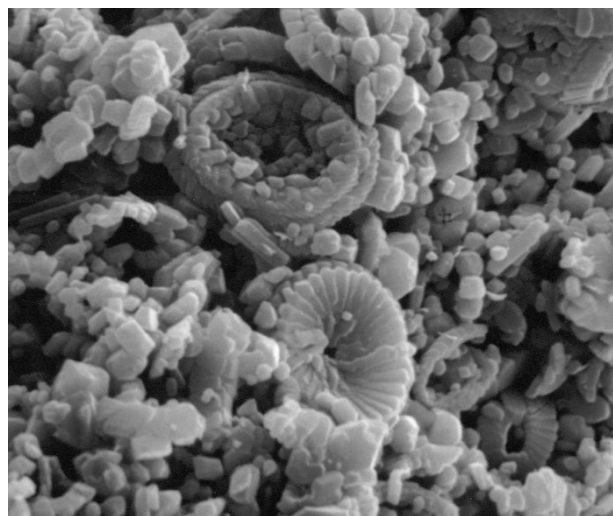
THE CRETACEOUS PERIOD: *TROPICAL THURROCK* 80 million years ago

The surface geology of Thurrock starts with **the Chalk**, a soft, white limestone that was laid down in a deep tropical sea some 80 million years ago at a time when the Atlantic Ocean did not exist. The Chalk Sea is thought to have covered most of northern Europe, the purity of the Chalk being evidence that coastlines were then far away, sea level was very high and that the planet was in a 'greenhouse' state with probably no ice at the poles.

What is chalk?

Chalk is almost entirely made up of coccoliths, tiny disks of calcium carbonate that formed the protective covering of microscopic marine algae. These coccoliths fell to the sea floor like continuous snowfall to form the white mud that was to become chalk. Chalk is therefore made almost entirely of fossils but they are so small that only with the aid of an electron microscope is it possible to see them.

Although a considerable thickness of chalk is present under south-east England, the average rate of deposition must have been extremely slow. Some geologists have estimated this to have been as little as one centimetre (less than half an inch) every 1,000 years.



Coccoliths can be clearly seen in this highly magnified image of a piece of chalk produced by an electron microscope. Each coccolith is only about 1/200 millimetre (1/5000 inch) in diameter. *Photo provided by J. M. Hancock.*



Southern Britain lies at the edge of the area affected by the formation of the Alps, with the result that the Chalk, which is hundreds of metres thick, was buckled into a major basin, called the London Basin syncline. Thurrock is situated at the southern edge of this basin and here the Chalk has been locally uplifted in an arch-shaped fold called the Purfleet Anticline. The Chalk of the Purfleet Anticline now forms an east-west ridge running through Purfleet, Chafford Hundred and Orsett Heath. The higher ground created by the Chalk gives the area landscape interest, particularly the views over the Thames from West Tilbury, Chadwell St Mary and South Stifford (Warren Lane).

The Chalk contains fossils of creatures that lived in the Chalk Sea, the largest being mosasaurs (giant marine reptiles), sharks and giant clams and the smallest being the fragments of microscopic marine algae (coccoliths) that accumulated on the sea floor in their billions. Bands of flint are prominent in places; some bands seen in the Chalk faces such as at Wouldham Cliff on Devonshire Road (part of Chafford Gorges Nature Park) can be traced right across southern Britain to Dover and across into France. Bands of flint are also prominent in the old Dolphin Chalk Quarry between Stonehouse Lane and Canterbury Way (the Dartford Tunnel approach road). On the west side of Dolphin Way is a high vertical chalk face that shows bands of flint nodules about one metre apart which represent cycles of climate change during the Cretaceous period some 80 million years ago.

The Chalk is of great economic and historical importance. The oldest sites of human occupation in Thurrock occur where the meanders of the Thames touch against the Purfleet Anticline, at Purfleet and Grays, giving access to the river from dry land. Greenhithe and Gravesend occupy similar sites in Kent. The cement industry is another example; its economic importance and heritage are fundamental to Thurrock's recent history. Over 5 billion cubic metres of chalk were extracted from the quarries around Devonshire Road and Warren Lane alone, mostly for the cement industry.

THE PALAEOCENE AND EOCENE PERIODS:

A TIME OF PALM TREES AND CROCODILES

55 - 50 million years ago

Within the London Basin, the strata on top of the Chalk are various clays, sands and pebbly sands, sometimes fossiliferous, which accumulated in a subtropical sea.

The junction between the Chalk and the overlying sands is extremely important geologically and represents a time gap of about 25 million years. During this period, the biodiversity of the world changed dramatically. The dinosaurs, mosasaurs and other giant reptiles as well as millions of smaller creatures became extinct. Although there are over 300 metres of Chalk under south-east England it is thought that originally there was probably twice this thickness, the remainder being stripped off by erosion during this time interval. Billions of flint nodules from this chalk were transported by rivers and ground down by the pounding of the waves to form virtually all the pebbles that we now find in the gravel pits and on the beaches of southern England. Some of these flint nodules were left behind to form a distinctive layer known as the **Bullhead Bed**, seen, for instance, in Chafford Gorges Nature Park by the steep footpath leading up from Devonshire Road to Warren Lane.

The first of these deposits to be laid down was the **Thanet Sand**. Up to 30 metres of this marine sand was deposited about 55 million years ago. The Thanet Sand can be seen overlying the Chalk



in the Chafford Gorges Nature Park, around the Arena Essex complex and at Orsett Heath. Two examples in the Nature Park are the Mill Wood Sand Cliff, off Saffron Road, and the Sandmartin Cliff behind the Sandmartin Pub in Drake Road (see photo below). Following deposition of the Thanet Sand the sea shallowed and lagoonal sands, known as the **Woolwich Beds** (part of the **Lambeth Group**) were laid down. These can be seen in the Buckingham Hill Sand Quarry (also known as the Tarmac Quarry) at Orsett. At the base of the Woolwich Beds is an extensive thickness of beautifully well-rounded, black flint beach pebbles with occasional seams of sand known as the **Upnor Formation**. This is well exposed in the Orsett Cock Quarry (also known as Southfields Quarry) at Orsett where the sections stand as vertical cliffs of pebbles. These cliffs represent a section through the sea floor about 55 million years ago, probably part of an offshore barrier in fairly shallow water. The Woolwich Beds were also encountered in excavations for the M25 at the Mardyke Interchange at Aveley where there was a thick seam of lignite (a type of coal) which indicates emergence from the sea and growth of vegetation.



The Sandmartin Cliff in 1996 during construction of the Chafford Hundred housing (left), and after it was completed (right). The junction of the Thanet Sand and the Chalk soon became obscured which is unfortunate as it represents the Cretaceous/ Palaeocene boundary, a time in Earth's history which marks the extinction of the dinosaurs. It could easily be re-excavated.

Photos: © G. Lucy

In humid tropical conditions, the silica of the sand can partially dissolve and re-form as large masses or boulders of extremely hard sandstone, known as **sarsen stones**, of which there are several fine examples in Thurrock.

Sarsen stones

Sarsens are boulders of extremely hard sandstone that occur on the Chalk land surface in Southern England, particularly in Wiltshire where they have been used to build Stonehenge. They were formed at a time of great warmth, about 55 million years ago, when sandy strata on top of the Chalk was raised above sea level and cemented by silica (quartz). This layer was extremely resistant to erosion but it eventually broke up into boulders we now call sarsens.

Sarsens can be found in several parts of Thurrock such as in the Arena Essex complex, around the rim of Grays Gorge, and in Brickbarn Wood west of the Davy Down Riverside Park. The most easily accessible example, however, is the Davy Down Sarsen Stone outside the Davy Down Pumping Station. These sarsens have been rescued from local gravel pits, having been swept into the Thames gravel during the Ice Age (see below). These are some of the best-preserved examples in the UK and most have curious rounded protuberances on their surfaces ('mammilated'), which are growth structures formed as the quartz slowly crystallised between the sand grains.



The next geological formation to be laid down in the region is the Harwich Formation which is represented in Thurrock by a sand known as the **Oldhaven Beds**. It is not currently exposed at the surface but it has been encountered in excavations for the M25 at the Mardyke Interchange at Aveley. Here the sand was, in places, cemented into blocks of sandstone that were packed with fossil shells.

About 50 million years ago, there was a return to tropical marine conditions with the sea bed as deep as 200 metres, during which the **London Clay** was deposited. A remarkable range of fossils have been found locally, particularly from the clay pits at Sandy Lane, Aveley. The fossils from Aveley, several species of which were found to be new to science, included, molluscs, corals, sea lilies, turtle and crocodile bones, sharks' teeth, skulls of fish, nautilus shells and magnificent specimens of crabs and lobsters. There were also numerous plant remains, from fruits, seeds and twigs to large logs, all of which must have floated long distances from the coastal rainforest out into the London Clay Sea. Apart from the fishing lake at Bretts Farm (Aveley Lake), all the Aveley clay pits have now been infilled. London Clay was also worked at South Ockendon until recently.

After two or three million years, the deep muddy sea became shallower and the clay deposited on the sea floor became sandy producing the sandy clay of the **Claygate Beds**. As the sea became shallower still, the Claygate Beds pass up into pure fine yellow sand called the **Bagshot Sand**. The Claygate Beds and Bagshot Sand have been removed by erosion over the whole area except on the high ground of the Langdon Hills.



Fossilised lobster from the London Clay of Aveley. It was collected from the clay pits in the 1980s. This little creature inhabited the subtropical sea that covered Thurrock in the Eocene period, 50 million years ago. The environment is thought to have been similar to present-day Maylasia.

Photo: © G. Lucy

Again, these geological formations were, and some still are, of great economic importance. The London Clay was as important as the Chalk for the cement industry, while sand quarries at Orsett Heath are still serving the construction industry.

THE PLEISTOCENE PERIOD OR ICE AGE

2.6 million - 10,000 years ago

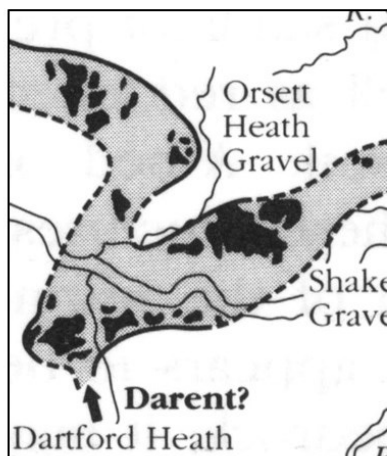
Once again there is a big time gap in the geological record. The time gap here is between the end of the deposition of the Eocene sands and clays, about 50 million years ago, and the Quaternary period (the Ice Age). The Quaternary period is divided into the Pleistocene epoch (the Ice Age proper) and the Holocene epoch (our current post-glacial warm stage).



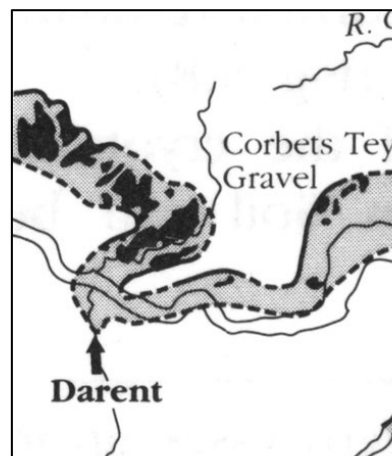
The earliest Ice Age deposit in Thurrock is known as **Stanmore Gravel** (formerly called 'pebble gravel'), the origin of which is still not fully understood. In the early Ice Age the Thames flowed through central Essex until a major ice advance about 450,000 years ago, called the Anglian Glaciation, blocked the Thames upstream and diverted it into the present Lower Thames valley. These enigmatic, high level gravels are found on the summit of the Langdon Hills and may have been laid down by northward-flowing, south bank tributaries of the pre-diversion Thames up to a million years ago, but research is continuing.

The next evidence we have of the Ice Age geography of Thurrock is after the diversion of the Thames. Within its new valley, at first the river followed a very unusual course, eastwards through Ilford, Romford, Hornchurch, and southwards through Ockendon before flowing south-westwards (back towards London) through North Stifford, Purfleet and Aveley (on the north side of the Purfleet Anticline). It then passed into what is now Kent and turned eastwards past Dartford and back into Essex through South Stifford, Grays and Little Thurrock. Eventually it took on a straighter course through East London, Dagenham and Aveley to Grays.

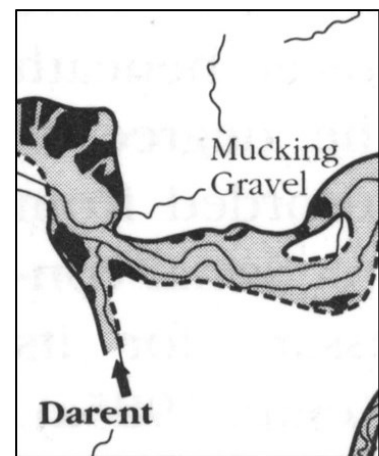
Evidence for this complex history of the Thames is to be found in the many former gravel quarries and in the gravels found resting on the Chalk and Thanet Sand in other quarries mentioned already. The oldest of these post-diversion Thames gravels is about 400,000 years old and can be seen at the top of the cliffs in Chafford Hundred Nature Park (at the Mill Wood Sand Cliff off Saffron Road, the Sandmartin Cliff behind the Sandmartin Pub in Drake Road, and at the north end of Lion Gorge) and, flowing westwards, in the Kennington Park Nature Reserve at Romford Road, Aveley. The gravel can also be found at Orsett Heath and has been named **Orsett Heath Gravel** and is part of the Boyn Hill terrace of the Thames.



400,000 years ago



300,000 years ago



200,000 years ago

The route of the Thames through what is now Thurrock during deposition of the Orsett Heath Gravel, the Corbets Tey Gravel and the Mucking Gravel. The outcrops of the respective gravel are shown in black (maps extracted from Bridgland 1994).



The Orsett Heath Gravels are about 400,000 years old and are about 35 metres higher than the modern river. The gravels are found at this level because they were deposited at the altitude at which the river was flowing at the time. Periodically, over timescales of about 100,000 years, the river would have cut down to a lower level and created a new floodplain of gravel (see table below).

A lower and younger series of Thames gravels can be seen at the Belhus Woods Country Park, at the north end of Warren Gorge (by the A1306), and also in the Bluelands and Greenlands Quarries – Botany Pit complex in Purfleet. At these last two sites the gravel shows evidence of the Thames flowing in a westward direction. These gravels are about 300,000 years old and are called **Corbets Tey Gravel** (Lynch Hill terrace). Younger still is the **Mucking Gravel** (Taplow terrace) which represents the floodplain of the Thames about 200,000 years ago. Several pits expose the Mucking Gravel but the finest exposure is the Turners Farm Gravel Pit on Walton's Hall Road, Mucking.



Corbets Tey Gravel overlying Chalk at the north end of Warren Gorge in Chafford Hundred Nature Park. This gravel was laid down by the Thames around 300,000 years ago. The photo was taken in 2006. *Photo: © G. Lucy*

Within many of the quarries referred to there is evidence for great swings of climate within the last 400,000 years, with four temperate stages at least as warm as today, separated by cold stages with arctic conditions. About 30 years ago, only two of these warm stages were known, but the evidence from the Thurrock quarries has been extremely important in unravelling the more complex climate history. The evidence from Thurrock is better than from elsewhere in Europe, making the Thurrock geological sequences of international importance. The most important site is the Greenlands Quarry – Botany Pit complex at Purfleet but other notable sites are the former pit at Sandy Lane in Aveley, the A13 cutting at Purfleet Road in Aveley, the tramway cutting at the south end of Lion Gorge, and the former Globe Pit in Whitehall Lane, Grays. All of these are nationally and internationally important for the evidence they have provided and, except for Sandy Lane, are designated geological Sites of Special Scientific Interest (SSSIs).



Epoch	Stages	Climate	Marine isotope stages	Age in years	Deposits in Thurrock
Holocene	Flandrian Stage	Temperate	1	10,000	Present interglacial
Pleistocene	Devensian Glacial Stage	Glacial	2-5d	50,000	Mucking Gravel
	Ipswichian Interglacial	Temperate	5e	125,000	
	Unnamed cold stage	Cold	6	150,000	
	'Aveley' Interglacial	Temperate	7	200,000	
	Unnamed cold stage	Cold	8	250,000	Corbets Tey Gravel
	'Purfleet' Interglacial	Temperate	9	300,000	
	Unnamed glacial stage	Glacial	10	350,000	Orsett Heath Gravel
	Hoxnian Interglacial	Temperate	11	400,000	
	Anglian Glacial Stage	Glacial	12	450,000	Thames diverted by ice

Timescale of the last 450,000 years of the Quaternary Period, or Ice Age, in Britain (not to scale). We are now living in the Holocene or Flandrian Stage. For ease of reference the ages of each stage are approximate.

Fossils from the warm stages, known as interglacials, include elephants from Sandy Lane Pit in Aveley (receiving substantial press coverage in 1964), lion from Purfleet Road in Aveley, jungle cat also from Purfleet Road (a first for Britain), macaque monkey (Gibraltar/Barbary 'ape') and hyena from Greenlands Pit, and brown bear from the Grays brickearth (see below). These are only a few of the wide range of species found. Many of the species, such as early cattle and horses, and also the lion, were up to 30% bigger than their modern counterparts. Many fossils from Thurrock form an important part of the collections of the Natural History Museum, London.

The two new warm stages are informally named 'Purfleet Interglacial' (about 300,000 years ago) and 'Aveley Interglacial' (about 200,000 years ago), emphasising the geological importance of the Thurrock area.

Among the famous Ice Age fossils for which Thurrock is well known are the spectacular mammals from the **Grays brickearth**. The town of Grays developed around the brick-making industry which was once of great economic importance to the area. The undulating ground in various parts of Grays is the only evidence today of this industry which employed over 500 men at the beginning of the 19th century. The sunken ground of Grays Park, a disused brick pit purchased by Grays Town Council in 1898, is perhaps the best example of this. The low ground either side of Whitehall Lane is due to two former brick pits, covering 30-40 acres. The term brickearth is used here to describe the various layers of sand, silt and clay, some initially blown in by the wind and subsequently reworked by rainwash and other surface processes, and some deposited by the Thames. Most of the fossils collected from the brick pits are now preserved in the Natural History Museum in London. They include bones of straight-tusked elephant, mammoth, lion, wolf, brown bear, hyena, rhinoceros, monkey, bison, beaver and wild boar. These fossils are thought to be mostly from the 'Purfleet' Interglacial Stage deposits, but some, such as the Aveley elephants, are from deposits of the 'Aveley' interglacial. This spread of brickearth has been almost entirely quarried away.



The gravels laid down during cold stages sometimes contain remarkable structures created during periods of freezing and thawing. These structures, like complex contortions, were once very common in the Chalk quarries of the area, but exposures are now very few. A good example can be seen in the former quarry face by Merlin Close in the Chafford Hundred Nature Park, where the Essex Wildlife Trust keep the structures exposed. Also during this cold stage, the freezing and thawing made slopes on the London Clay unstable and landslipping occurred. There are 'fossil' landslips on the west and south sides of the Langdon Hills.

THE HOLOCENE PERIOD: POST-GLACIAL THURROCK 10,000 years ago to the present day

During the last cold stage, sea level was about 120 metres below modern sea level. Since then there has been recovery, but the rise in sea level over the last 10,000 years has not been constant, with periodic minor falls of sea-level. During periods of higher sea-levels, muds were deposited along the Lower Thames. During the lower periods, vegetation, including trees, spread on to the mud-flats. In the next high sea-level, the vegetation would die off and be sealed beneath a new layer of mud. Today, this is represented by a sequence of clays (the mud flats) and peats (the vegetation). One of the peat beds (a 'submerged forest'), with tree trunks over 5,000 years old, can be seen by the sea wall close to the RSPB visitor centre at Purfleet.

THE ARRIVAL OF HUMANS

Human occupation of Thurrock during the Ice Age

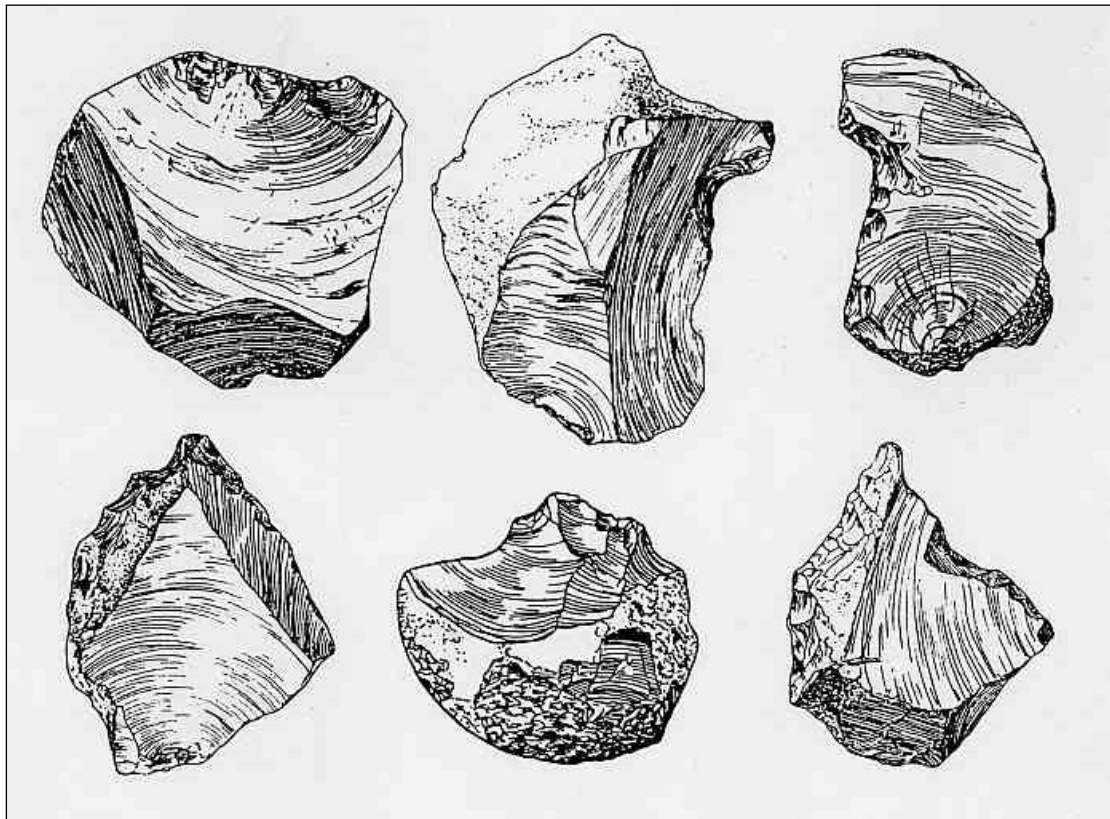
The Quaternary (Ice Age) Thames deposits are also important for old Stone Age (Palaeolithic) flint tools, indicating that early species of humans were in Thurrock during various interglacials, competing for food with other carnivores such as lion, bear and hyena. Most of the Quaternary sites mentioned have yielded artefacts. Two sites are of particular importance.

In the Bluelands – Greenlands – Botany quarry complex in Purfleet a large number of humanly struck flints have been found in the Thames gravels and interglacial deposits. Those found at the base of the sequence are struck flakes of a simple form, described as a **Clactonian** industry. Higher in the sequence, the artefacts include more elaborate forms such as hand-axes, but still created by a simple striking technique; this industry is termed **Acheulian**. In the highest levels a more advanced technique is used in which a flint is prepared by striking off flakes to create a flat surface and further flakes are struck off from the flat surface in a more controlled fashion; this is termed the **Levallois** industry. This is the only site in Britain, possibly Europe, where this progression occurs. Recent research suggests that these changes reflect the arrivals of peoples from different parts of Europe with different cultural 'tool-kits'. During this time there was probably a gradual evolution from *Homo heidelbergensis* to *Homo neanderthalensis*.

In the tramway cutting at the south end of Lion Gorge, there is a section through what was originally a chalk cliff, against which later deposits have been banked up. A number of humanly struck flint flakes have been recovered from gravels at the base of the cliff, some of which could



be fitted back together to form part of the original stone. The refitting of the flakes means that they are still at the spot where they were created, that early humans actually knapped the flint on the river beach at the base of this cliff to create tools. This is a very poignant insight into human life in Thurrock 200,000 years ago.



'Clactonian' flint tools from the brickearth at Globe Pit SSSI that were produced by human workmanship about 300,000 years ago.

Clactonian tools were once considered to be 'primitive' and therefore earlier than the more 'advanced' industries that produced hand-axes but the position of the Globe Pit gravel in the terrace sequence meant that it was clearly younger than other gravels that contained hand-axes (e.g. Swanscombe in Kent). As a result of the evidence from Globe Pit we now know that the Clactonian flint knapping tradition is not restricted to a particular period of time and the early humans that embraced this method of working flint must have colonised Britain from continental Europe several times, and were followed on each occasion by humans from other parts of Europe with different traditions.

Illustrations © J. Wymer



6. Site selection

Site selection and notification to planning authorities

LoGS in Essex are identified by **GeoEssex**, a largely voluntary group composed of representatives from the major Essex geological and conservation bodies and supported by the Essex Field Club, Essex Rock and Mineral Society, Essex Wildlife Trust, Natural England and Essex County Council (Place Services). The site selection process is based on clearly defined criteria (see below) and includes scientific, educational, historical and aesthetic values. When selecting sites GeoEssex aims to gain the support of landowners whenever possible. The majority of LoGS are on private land and site selection does not infer any right of access.

Like LoWS (Local Wildlife Sites), proposed LoGS are presented to the Local Sites Partnership (chaired by Essex Wildlife Trust) for endorsement and then passed to local authorities for inclusion in their Local Plans. Local authorities receive a citation and boundary map.

The sites selected as LoGS in the Thurrock district are summarised below, together with a list of other sites which are proposed LoGS. Other sites may be identified in the future, occasioned by housing or other development and restoration following mineral extraction.

Site protection

Like their biodiversity counterparts, LoGS have no statutory protection and the conservation and management of individual sites relies heavily on the support of landowners. Inclusion within local plans also forms a vital role in the protection of LoGS. An example of a comprehensive natural environment policy incorporating geodiversity can be provided on request.

It is recommended that the Local Sites Partnership (c/o Essex Wildlife Trust) and the Essex Field Club Datasearch Service should be consulted if any development is proposed that would affect a LoGS site.

Site Assessment Criteria

The assessment criteria used for identifying LoGS are based on DEFRA document *Local Sites: Guidance on their identification, selection and site management* (2006). The guidance states that assessment is a matter of judgement but must be based on an understanding of geological principles and processes, and the distribution and abundance of the resource (national, regional and local). Those sites selected must be 'of substantive importance to the geodiversity of the local area'.

There are four value categories: scientific, educational, historical and aesthetic. A site qualifies for notification as a Local Geological Site if it fulfils the criteria under one or more of these categories. Each site is also given a site assessment score. This score is not a measure of the site's value or importance but a relative assessment of the usefulness of the site in promoting geodiversity.

Land Ownership Notification

Where the landowner is identified as a public body e.g. a local authority, Forestry Commission etc., notification is by letter to that authority. For sites under private ownership, where the landowner can be identified, they will be informed by letter.



7. Additional Sources of Information

Scientific literature

If a LoGS has been referred to in the scientific literature (e.g. a paper in a recognised scientific journal) these references are given in the LoGS citation. Such reference means that the site is at least of historical interest and some of these sites will have potential for research.

Site interpretation

If a site is accessible or simply visible to the general public, it is the aim of GeoEssex to provide interpretive information where possible and practical. This could be in the form of interpretive boards or leaflets. Such interpretation will be with the cooperation of landowners and other interested parties.

Organisations

GeoEssex www.geoessex.org.uk GeoEssex is the primary source of information about the geology and physical landscape of Essex. Background geological information for Essex can be found on its website, together with a selection of sites in each district (SSSIs and public accessible sites).

Essex Field Club www.essexfieldclub.org.uk The Essex Field Club, founded in 1880, exists to promote the study of the county's natural history and geology. The club has a centre for Biodiversity and Geodiversity in Wat Tyler Country Park at Pitsea, near Basildon, with extensive collections. It is open to the public most weekends. Their website provides comprehensive data on a large number of wildlife and geological sites which can be searched in a number of ways. Details of several hundred geological sites across Essex can be found here which includes LoGS and potential LoGS.

British Geological Survey www.bgs.ac.uk Other geological resources, maps and borehole information are available on the website of the British Geological Survey.

Essex Rock & Mineral Society www.erms.org. The Essex Rock and Mineral Society, founded in 1967, is the club for Essex geology enthusiasts.

GeoEast GeoEast is the East of England Geodiversity Partnership. It is a partnership of organisations active in conserving and promoting Earth heritage in this region.

Earth Heritage Magazine www.earthheritage.org.uk Earth Heritage magazine is produced for the geological and landscape community by Natural England, Scottish Natural Heritage, the Countryside Council for Wales.

Geologists' Association www.geologistsassociation.org.uk The Geologists' Association, founded in 1858, is Britain's largest society for amateur geologists.

Quaternary Research Association <https://www.qra.org.uk> The Quaternary Research Association researches 'Ice Age' geology, palaeobiology and Palaeolithic archaeology and has published several field guides covering many sites in southern and eastern Essex.

Tertiary Research Group <https://www.trg.org> A London-based, specialist geological society, which brings together amateur and professional geologists with an interest in the Tertiary period worldwide.



Books and articles relating to the Thurrock district

- ALLEN, P. 1998. **The geological history of the Lower Thames in Essex – a review.** Essex Naturalist. Volume 15 (New series). Pages 5-21.
- ALLEN, P. 1999. **The Anglian cold stage in Essex – a review.** Essex Naturalist. Vol. 16 (New series). Pages 83-100.
- BLEZARD, R.G., BROMLEY, R.G., HANCOCK, J.M., HESTER, S.W., HEY, R.W. and KIRKALDY, J.F. 1967. **Geologists' Association Guide No. 30A. The London Region (North of the Thames).** Geologists' Association.
- BRIDGLAND, D.R. 1994. **The Quaternary of the Thames.** Chapman and Hall. Geological Conservation Review Series.
- BRIDGLAND, D.R., ALLEN, P. and HAGGART, B.A. (Editors). 1995. **The Quaternary of the Lower Reaches of the Thames – Field Guide.** Quaternary Research Association.
- BRIDGLAND, D.R., BRIANT, R.M., ALLEN, P., BROWN, E.J. and WHITE, T.S. 2019. **The Quaternary Fluvial Archives of the Major English Rivers – Field Guide.** Quaternary Research Association.
- CHASE, M. 1979. **A Victorian scientist at Grays: 1872-1876.** *Panorama: The Journal of the Thurrock Local History Society.* Vol. 22. Pages 8-17.
- CHRISTY, M. 1907. **Victoria History of the County of Essex. Vol. 2 (industries).** Pages 450, 492 & 493.
- CLEMENTS, D. (editor). 2010. **The Geology of London.** Geologists' Association Guide No. 68. Geologists' Association.
- DINES, H.G. and EDMUNDS, F.H. (1925). **The Geology of the Country around Romford.** Geological Survey Memoir. Explanation of sheet 257. HMSO.
- ELLISON, R.A. 2004. **Geology of London.** Special Memoir for 1:50,000 Geological sheets 256 (North London), 257 (Romford), 270 (South London) & 271 (Dartford). British Geological Survey.
- GEORGE, W.H. 2007. **Some Essex elephants.** *Essex Field Club Newsletter.* No. 52. Pages 8-14.
- GIBBARD, P.L. 1994. **Pleistocene History of the Lower Thames Valley.** Cambridge University Press.
- GOODE, W.J. 1982. **East Anglian Round Towers and their Churches.** Friends of the Round Tower Churches Society. Pages 111 – 113.
- HOSE, T.A. (ed). 2016. **Geoheritage and Geotourism: A European perspective.** The Boydell Press.
- JUKES-BROWNE, A.J. 1904. **The Cretaceous Rocks of Britain.** Memoirs of the Geological Survey. Vol. 3.
- LISTER, A. and BAHN, P. 1995. **Mammoths.** Boxtree Ltd.
- LUCY, G. 2003. **Essex erratic boulders: a gazetteer.** *Essex Naturalist* (New Series) No. 20. Pages 115-134.



- LUCY, G. 1999. **Essex Rock: A look beneath the Essex landscape**. Essex Rock and Mineral Society.
- LUCY, G. 2009. **The geology of Chafford Gorges Nature Park, Thurrock**. *Essex Naturalist*. Volume 26 (New series). Pages 99-112
- LUCY, G. 2011. **Geological sites in Thurrock**. *Essex Naturalist*. Vol. 28 (New Series). Pages 74-93.
- LUCY, G. 2012. **The minerals of Essex**. *Essex Naturalist*. Vol. 29 (New Series). Pages 113-128.
- LUCY, G. and ALLEN, P. 2011. **Thurrock's Geological Heritage**. *Panorama (Journal of the Thurrock Local History Society)*. No. 50. November 2011.
- MORIGI, A., SCHREVE, D.C., and WHITE, M. 2011. **The Thames through Time: The Archaeology of the Gravel Terraces of the Upper and Middle Thames. Early Prehistory to 1500 BC. Part 1 – The Ice Ages**. Oxford Archaeology.
- POWELL, W.R. (editor). 1983. **Victoria History of the County of Essex. Vol. 8. A History of Essex (Chafford Hundred)**. Pages 35-74.
- PROSSER, C., MURPHY, M. and LARWOOD, J. 2006. **Geological Conservation: A Guide to Good Practice**. English Nature.
- RAYNER, D., MITCHELL, T., RAYNER, M. and CLOUTER, F. 2009. **London Clay Fossils of Kent and Essex**. Medway Fossil and Mineral Society.
- SCHREVE, D.C. (editor). 2004. **The Quaternary Mammals of Southern & Eastern England**. Quaternary Research Association, London.
- SMITH, A.B. and BATTEN, D.J. 2002. **Fossils of the Chalk**. Field Guide to Fossils No. 2. Second edition. Palaeontological Association.
- STRINGER, C. 2006. **Homo Britannicus: The Incredible Story of Human Life in Britain**. Penguin Books.
- SUMBLER, M.G. 1996. **British regional geology: London and the Thames valley**. British Geological Survey. Fourth edition. HMSO.
- SUTCLIFFE, A.J. 1995. **The Aveley Elephant Site, Sandy Lane Pit (TQ 553807)**. In Bridgland et al. 1995 (Pages 189-199).
- WHITAKER, W. 1889. **The Geology of London and of part of the Thames Valley. Volume 1: Descriptive geology**. *Memoirs of the Geological Survey*. HMSO
- WHITAKER, W. & THRESH, J.C. 1916. **The water supply of Essex from underground sources**. Memoir of the Geological Survey of Great Britain.
- WOODWARD, H.B. 1903. **Victoria History of the County of Essex. Vol. 1 (geology)**
- WYMER, J. 1968. **Lower Palaeolithic Archaeology in Britain as Represented by the Thames Valley**. Humanities Press.
- WYMER, J. 1999. **The Lower Palaeolithic occupation of Britain. Vol. 1**. Wessex Archaeology.



A selection of scientific and more specialist papers relating to the district

- ALLSOP, J.M. and SMITH, N.J.P. 1988. **The deep geology of Essex.** *Proceedings of the Geologists' Association*. Vol. 99(4). Pages 249-260.
- DALEY, B. and BALSON, P. (1999). **British Tertiary Stratigraphy.** Geological Conservation Review Series. Joint Nature Conservation Committee.
- BRIDGLAND, D.R. 1999. **'Wealden Rivers' north of the Thames: a provenance study based on gravel clast analysis.** *Proceedings of the Geologists' Association*. Vol. 110. Pages 133-148
- BRIDGLAND, D.R. and HARDING, P. 1993. **Middle Pleistocene Thames terrace deposits at Globe Pit, Little Thurrock, and their contained Clactonian industry.** *Proceedings of the Geologists' Association*. Vol. 104. Pages 263-283.
- BRIDGLAND, D.R., SCHREVE, D.C., ALLEN, P. and KEEN, D.H. 2003. **Key Middle Pleistocene localities of the Lower Thames: site conservation issues, recent research and report of Geologists' Association excursion, 8 July, 2000.** *Proceedings of the Geologists' Association*. Vol. 114. Pages 211-225.
- BRISTOW, C.R., ELLISON, R.A. and WOOD, C.J. 1980. **The Claygate Beds of Essex.** *Proceedings of the Geologists' Association*. Vol. 91 (4). Pages 261-277.
- DEWEY, H., PRINGLE, J. and CHATWIN, C.P. 1925. **Some recent deep borings in the London Basin. Summary of Progress for 1924.** Geological Survey of Great Britain.
- GEORGE, W.H. 2014. **A Thames foreshore exposure at Purfleet, Essex, showing a Neolithic Submerged Forest resting on the Cretaceous Seafood Chalk formation, Middle Coniacian.** *Essex Naturalist*. Vol. 31 (New Series). Pages 128-140.
- GEORGE, W.H. and VINCENT, S. 1978. **Notes on the London Clay of the Ockendon Clay Plant, South Ockendon, Essex.** *Tertiary Research*. Vol. 2(1). Pages 5-8.
- HOLMES, T.V. and COLE, W. 1887. **Report on the Denehole Exploration at Hangman's Wood, Grays, 1884 and 1887.** *Essex Naturalist*. Vol. 1. Pages 225-276.
- MOORLOCK, B. and SMITH, A. 1991. **S W Essex- M25 Corridor: Applied Geology for Planning and Development.** British Geological Survey.
- MORTIMORE, R., NEWMAN, T., ROYSE, K. R., SCHOLLES, H., and LAWRENCE, U. 2011. **Chalk: its stratigraphy, structure and engineering geology in east London and the Thames Gateway.** *Quarterly Journal of Engineering Geology and Hydrogeology*. Vol. 44. Pages 419 - 444.
- ROYSE, K.R. et.al. 2012, **Geology of London, UK.** *Proceedings of the Geologists' Association*. Vol. 123, Pages 22-45.
- SCHREVE, D.C. et.al. 2002. **Sedimentology, palaeontology and archaeology of late Middle Pleistocene River Thames terrace deposits at Purfleet, Essex, UK.** *Quaternary Science Reviews*. Vol. 21. Pages 1423-1464.



- SCHREVE, D.C. et.al. 2006. **A Levallois Knapping Site at West Thurrock, Lower Thames, UK: its Quaternary Context, Environment and Age.** *Proceedings of the Prehistoric Society*. Vol. 72. Pages 21-52.
- WILLIAMS, R.J. 2002. **Observations on the London Clay excavation at Aveley, Essex.** *Tertiary Research*. Vol. 21(1-4). Pages 95-112.
- WOOLDRIDGE, S.W. 1924. **The Bagshot Beds of Essex.** *Proceedings of the Geologists' Association*. Vol. 35. Pages 359-383.
- WOOLDRIDGE, S.W and BERDINNER, H.C. 1922, **Notes on the geology of the Langdon Hills, Essex.** *Proceedings of the Geologists' Association*. Vol. 33. Pages 320-323.



A magnificent flint hand axe photographed in 1981 shortly after it was found during construction of the M25 motorway cutting at Belhus Park, Aveley. It is one of the largest ever found in the UK. This hand-axe is only a few thousand years younger than the Clactonian implements illustrated on page 19, yet it demonstrates a completely different method of flint working by a different group of early humans.

Photo © G.R. Ward



8. List of Geological Sites

The following is a representative list of geological sites in the district. For completeness, it includes the geological SSSIs but such sites are statutory sites and do not form part of this report.

The list gives an idea of the range of sites that can qualify as Local Geological Sites (LoGS). It includes those LoGS that have already been approved by the Local Sites Partnership and those that are proposed.

Note: *Not all of the sites here described are accessible. Some sites are on private land and can only be viewed from footpaths that pass through or alongside the site. Inclusion of a site on this list does not, therefore, imply any right of access.*

Sites of Special Scientific Interest (SSSIs)

A13 Road Cutting SSSI, Aveley (TQ 556 799)

During excavation for the A13 trunk road to the south of Aveley in 1997 a sequence of Ice Age sediments were found that were equivalent to those that contained the fossil elephants at Sandy Lane Pit directly to the north. Excavations for the cutting beneath the Purfleet Road bridge provided a revealed a cold-climate gravel at the base overlain by fossiliferous sands and clays (known as the Aveley Silts and Sands). The upper part of the interglacial sequence was represented by two layers of clay rich in vertebrates, molluscs, insects, plant remains and pollen indicating that the climate was at least as warm as the present day. The whole sequence is capped by sand and gravel indicating a return of very cold conditions. This interglacial, the Aveley Interglacial, is so-named in recognition of the site here and that at Sandy Lane Pit nearby, and is about 200,000 years old. Bones of a range of mammals were found such as brown bear, wolf, giant deer, mammoth, straight-tusked elephant, rhinoceros, horse, bison and a very large lion. Of particular interest was the first discovery in Britain of the bones of a 'jungle cat'. Although grassed over, the road cutting can be seen from the Purfleet Road bridge.

Lion Pit Tramway Cutting SSSI, Chafford Hundred (TQ 598 781) (part of Chafford Gorges Nature Park – see below)

This site, part of an old tramway cutting created in the nineteenth century to transport chalk from Lion Pit to the riverside wharves, provided an excellent section through Ice Age sediments which are banked up against an ancient riverside chalk cliff that existed here about 200,000 years ago. These river deposits span a period of deposition from one glacial stage through to the next which includes the intervening interglacial stage, at the beginning of which there were early humans here, making stone tools on the gravel beach below the cliff. Evidence of human occupation has been flint knapping debris in the lower gravel which is undisturbed. Remarkably it has actually been possible to refit some flakes together, which proves that humans were actually manufacturing stone tools here. The humans occupying the site were Neanderthals. The tramway cutting has also produced the fossil bones of several species of mammals such as brown bear, rhinoceros, bison, mammoth and straight-tusked elephant. The sides of the cutting are now grassed over.



Globe Pit SSSI, Grays (TQ 625 783)

Globe Pit in Whitehall Lane is of geological importance because of the occurrence, on the eastern side of the pit, of Corbets Tey Lower Gravel containing abundant Palaeolithic flint tools, above which is a brickearth that was formerly very fossiliferous. The gravel and the brickearth were deposited by the River Thames when it flowed through here about 300,000 years ago. These Thames deposits sit on top of the Thanet Sand, which in turn lies on top of the Chalk which is exposed on the floor of the quarry. The flint tools in the gravel are known as 'Clactonian' and represent an industry that was first recognised in the cliffs at Clacton and that is based on flint flakes and cores rather than hand-axes. Globe Pit is also important because the brickearth is virtually all that remains of the celebrated 'Grays brickearth', a fine grained silt containing fossil shells which was a rich source of spectacular Ice Age fossil mammals. Surviving remnants of this deposit are valuable as no modern studies of its small vertebrate fossils has ever been carried out, studies which could yield much information about the fauna and climate of this little understood period of the Ice Age. There is no access to the site for casual visitors but visits are sometimes arranged for organised groups.

Purfleet Chalk Pits SSSI (Greenlands Quarry), Purfleet (TQ 569 786)

Greenlands Quarry at Purfleet (sometimes called Dolphin Pit) is of critical importance for interpreting the sequence of events in the Lower Thames valley during the middle of the Ice Age. Here, sediments are banked up against the northern side of the Purfleet anticline, an east-west ridge formed by a fold in the Chalk strata, and contain a record of three separate periods of early human occupation that makes this site unique in Britain. The first is a cold climate gravel at the base followed by warm climate sediments and capped by gravel representing a return to cold or glacial conditions. Based on the fossils and other evidence geologists have concluded that the warm climate sediments were laid down by the Thames during the 'Purfleet Interglacial' (named after this site) that is thought to be about 300,000 years old. Fossils found include the bones of deer, bison, monkey, beaver and straight-tusked elephant, and a coprolite (fossilised faeces) of a hyena. Three adjacent disused quarries (Bluelands Quarry, Botany Pit and Esso Pit) also form part of the Purfleet Chalk Pits SSSI. For safety and security reasons the Greenlands Quarry section is not accessible to the public and is only accessed via a locked gate in Armor Road. Visits, however, are periodically arranged for organised groups.



Local Geological Sites (LoGS)

Sites agreed by Local Sites Partnership to date

ThG1 - Arena Essex Sand Pit, West Thurrock (TQ 587 797)

On the south side of the A13, in a large sand pit that was formerly the Arena Essex Motor Sports Complex, is a fine collection of at least 20 large sarsen stones with exceptionally well-preserved surface structures. The largest stone is over three metres long and is almost certainly the largest sarsen in south Essex. Most of the stones were piled up in one place close to the car park at TQ 5875 7967 but others were scattered about. One stone was sticking out of a bank of what appears to be Thanet Sand. This may be a unique in-situ example.

ThG2- Belhus Woods Country Park, Aveley (TQ 565 825)

Straddling the border between Thurrock and the London Borough of Havering, Belhus Woods Country Park contains many lakes that were originally gravel pits. The area is situated on the Lynch Hill terrace of the Thames, which contains Corbets Tey Gravel, deposited by the river about 300,000 years ago. The old gravel workings, formerly known as Hunts Hill Farm and Whitehall Wood Pits, have fortunately been spared 'landscaping'; therefore most of the pits here retain their original profiles, with some gravel and sand still visible in the banks.



Belhus Woods Country Park.

300,000 year old Thames gravel (Corbets Tey Gravel) exposed at Hunts Hill Farm.

Photo: © P. Harvey

ThG3 - Bluelands Quarry (north and east faces), Purfleet (TQ 570786)

The south and west faces of Bluelands Quarry are part of the Purfleet Chalk Pits SSSI (see above). The north and east faces are not included in the SSSI and so are proposed as a Local Geological Site. Bluelands Quarry is currently (2020) being infilled and the gravels, sands and clays overlying the Chalk are becoming accessible as the infilling proceeds. The sediments overlying the Chalk were laid down by a former course of the Thames about 300,000 years ago and are part of the Corbets Tey Formation. The central part of the sequence was deposited during an interglacial period informally known as the 'Purfleet' Interglacial, after these sites.



ThG4 - Brickbarn Wood, South Ockendon (TQ 586 799 to 589 799)

One of the finest collections of sarsen stones in the UK is situated in Brickbarn Wood and the adjacent Combe Wood on the south side of the Mardyke Valley adjacent to the cutting of the A13 trunk road. It is estimated that as many as 40 stones may be present, most of them partially buried in soil from old gravel pits. Many of the stones are over 2 metres long and have fine mammilated surfaces. Private woodland. Access is available with permission of the landowner. The two woods are a local Wildlife Site.



Brickbarn Wood

One of the many remarkable sarsen stones in Brickbarn Wood. The photo was taken in 2007.

Photo: © G. Lucy

ThG5 - Buckingham Hill Sand Quarry (Tarmac Quarry), Orsett (TQ 673 803)

The disused Buckingham Hill Pit, north-west of Walton's Hall, was formerly operated by Tarmac and is often referred to as the Orsett Tarmac Pit. It provides very fine exposures of the Woolwich Beds sands. Of particular interest is the preservation in the cliff faces of burrows of crustaceans that lived on the sandy sea floor some 55 million years ago. The cliff face profiles should be retained in any future development scheme.



The Buckingham Hill Sand Pit

Exposures of 55 million year old marine sands called the Woolwich Beds. The photo was taken in 2007.

Photo: © G. Lucy



ThG6 - Davy Down Sarsen Stone, South Ockendon (TQ 592 800)

Davy Down Riverside Park forms part of the Mar Dyke Valley, a delightful valley with steep, wooded sides and a grazed floor that can be seen from the M25 motorway. The valley runs along the northern side of the Purfleet Anticline, an east-west trending ridge of chalk between Purfleet and Grays. The pumping station was built in 1928 with a 50 metre deep borehole down into the Chalk. It is still used today for pumping water for use in the local area. Outside the pumping station is a remarkable sarsen stone - probably the finest example in Essex. The sarsen is 1.6 metres square and has fine mammillated surfaces. It formerly stood outside Marley's works on the south side of Stifford Road, South Ockendon and is understood to have been found in the gravel pit south of the works.



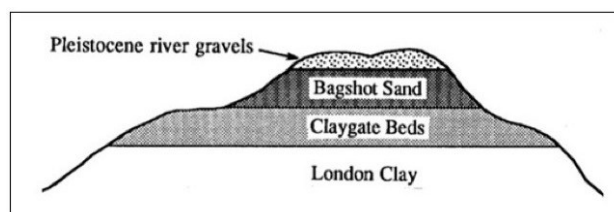
The Davy Down sarsen stone

Sarsens are boulders of extremely hard sandstone that occur on the Chalk land surface in Southern England, particularly in Wiltshire where they have been used to build Stonehenge. This is a particularly fine example.

Photo: © G. Lucy

ThG7 - Gravelhill Wood (part of Langdon Hills Country Park) (TQ 6775 8637)

The Langdon Hills consist of London Clay overlain by Claygate Beds with Bagshot Sand capping the highest ground. This in turn is capped by Stanmore Gravel (formerly called 'pebble gravel'), the origin of which is still not fully understood but may have been laid down by northward-flowing south bank tributaries of the pre-diversion Thames up to a million years ago. Gravelhill Wood, south-west of the church, contains at least two large gravel pits, very overgrown, but with plenty of gravel visible here and there, especially where trees have toppled over or badgers have been at work. There are fine views from the highest ground here over the Thames Estuary, although some viewpoints have been lost due to uncontrolled tree growth. The Country Park is run by Thurrock Council's Ranger Service.



Section through the **Langdon Hills** showing the bedrock strata overlain by river gravel. The gravel is known as Stanmore Gravel (formerly called pebble gravel) and may be as much as a million years old.



ThG8 - Chafford Gorges Nature Park, Chafford Hundred (TQ 599 793)

Chafford Gorges Nature Park is the finest area for geology in south Essex. Spectacular cliffs of Upper Chalk can be seen which are a legacy of quarrying for the Portland Cement industry. The Chalk is overlain by Thanet Sand and gravels from former routes of the Thames during the Ice Age. There are also several fine sarsen stones around the rim of Grays Gorge. The park consists of seven geological sites (**Grays Gorge, Lion Gorge, Lion Pit Tramway Cutting SSSI, Millwood Sand Cliff, Sandmartin Cliff, Warren Gorge and Wouldham Cliff**), which are under the control of Essex Wildlife Trust. Lion Pit Tramway Cutting SSSI is one of the most important of the County's SSSIs, yielding evidence of human occupation on the banks of the Thames 200,000 years ago. The visitor centre has fine views overlooking Warren Gorge. A geological trail guide is available.



Mill Wood Sand Cliff

55 million year old Thanet Sand overlain by 400,000 year old Thames gravel (Orsett Heath Gravel) at Mill Wood Sand Cliff, Chafford Hundred Nature Park. The photo was taken in 2005.

Photo: © G. Lucy

ThG9 - Gun Hill Gravel Pit (also known as Broom Hill), West Tilbury (TQ 656 780)

The ridge of high ground between West Tilbury and Chadwell St. Mary is a high terrace of the present Thames and to the south the land falls steeply down to the Tilbury Marshes. On this ridge, at the high point known as Gun Hill (also known as Broom Hill) is a disused gravel pit with exposures of Orsett Heath Gravel, the oldest and highest of the Thames terraces. Up to 2 metres of sand and gravel is visible in the sections in various places, some showing current bedding. The gravel is now some 25 metres above the level of the present Thames, an example of the erosion that has taken place over this period of time. There is a fine view from here across the Tilbury Marshes to the modern river. The site is, in effect, a fossil cliff line and is well placed to explain the loop of the Thames around Tilbury. The pit is part of Broom Hill Local Wildlife Site.

Gun Hill Gravel Pit, West Tilbury

400,000 year old Thames gravel (Orsett Heath Gravel) exposed in the northern section of the pit in about 1999.

Photo: © G. Lucy





ThG10 - Kennington Park, Aveley (TQ 560 812)

Kennington Park was created from gravel pits alongside the Romford Road and the former pits are now publicly accessible fishing lakes. When the park was created there were several exposures of gravel, particularly alongside the path on the northern edge of the park where it formed low cliffs up to 2 metres high. The best of these exposures is unfortunately now contained within a members only fishing area known as Back Lake. The gravel is Orsett Heath Gravel which forms the oldest and highest terrace of the Lower Thames and about 400,000 years old.



Kennington Park, Aveley

400,000 year old Thames gravel (Orsett Heath Gravel) exposed in the northern section of Kennington Park. The photo was taken prior to 2003 and a few years after the park was created

Photo: © G. Lucy

ThG11 - One Tree Hill Brick Pit (part of Langdon Hills Country Park) (TQ 6959 8610)

One Tree Hill is one of the high points of the Langdon Hills. The hill is capped with Claygate Beds and an isolated patch (an outlier) of Bagshot Sand on the very highest ground. The pit was worked by the former Corringham Brick and Tile Company. The pit still exists in a fenced off area although it is much overgrown. The Bagshot Sand is sometimes visible in heaps thrown out from animal burrows. It would be possible to create a section in one of the steep banks. The Country Park is run by Thurrock Council's Ranger Service.



The former pit on **One Tree Hill** (part of the Langdon Hills) in 1907, showing what was then a fine section through the Bagshot Sand with its resident sand martins. The Bagshot Sand was formed on the floor of a sub-tropical sea some 50 million years ago.

Photo © British Geological Survey (P252671).

ThG12 - Orsett Cock Quarry (also known as Southfields Quarry), Orsett (TQ 657 811)

The quarry is situated behind the old Orsett Cock public house and once provided a magnificent exposure of the basal part of the Woolwich Bottom Bed (the Upnor Formation). It consists mostly of extremely well-rounded pebbles representing a cross section through an ancient sea floor some 55 million years ago. The pebbles are black and many have crescent-shaped percussion or 'chatter-marks', indicating that they have been pounded together on a beach in a high-energy environment. This bank of pebbles was an impressive sight, forming a vertical cliff. It was the best inland exposure of this particular formation.



ThG13 - Purfleet Submerged Forest, Purfleet (TQ 5445 7871)

Part of a submerged forest, between 5,000 and 6,000 years old, consisting of fallen tree trunks and roots, is exposed on the Thames foreshore. This site and other submerged forests along the Thames (e.g. at Rainham nearby) have been studied since 1665. This site has educational importance in the interpretation of sea level changes since the end of glacial conditions some 10,000 years ago. The forest can be seen only at low tide.



Purfleet Submerged Forest

Part of a submerged forest, over 5,000 years old, consisting of fallen tree trunks and roots, is exposed on the Thames foreshore at Purfleet. The photo was taken in 2011.

Photo: © G. Lucy

ThG14 - Sandy Lane Pit (site of), Aveley (TQ 553 807)

To the west of Kennington Park is the famous Sandy Lane Clay Pit where, in 1964, the remains of a mammoth and a juvenile straight-tusked elephant were discovered in Ice Age deposits channelled into the London Clay. The discovery received considerable publicity in the national press. The fossils are now in the Natural History Museum, London. Attempts to conserve part of the Sandy Lane Pit (also known as Aveley No. 2 pit) as a Site of Special Scientific Interest (SSSI) unfortunately failed as planning consent for landfill had already been granted. The pit has therefore now been infilled. However there may be some undug land on the edges of the pit that could provide scope for future investigation (Bridgland et al. 2003). An interpretation board could be provided in the vicinity about the Aveley elephants, perhaps in the car park of Kennington Park nearby.

The Aveley Elephants

The Sandy Lane Clay Pit, Aveley in 1964, as the remains of a mammoth and a straight-tusked elephant were being transported out of the pit prior to their journey to the Natural History Museum. Fossils found with the skeletons clearly indicated that the elephants were living during an interglacial period but the exact age of the sediments has long been the subject of controversy. They are now attributed to the penultimate interglacial and therefore about 200,000 years old. In recognition of this site this interglacial stage is now informally known as the 'Aveley Interglacial'.

Photo: © G. R. Ward





ThG15 - Stanford Warren Sarsen Stone, Mucking (TQ 6856 8117)

To the east of the former church a very large sarsen stone at about 2.2 x 1.3 x 0.6 metres in size, with a mammillated surface, is sitting by the path at the entrance to Stanford Warren Nature Reserve (Essex Wildlife Trust). The boulder was rescued from the large Mucking Gravel Quarry nearby which was landfilled in 2007.

ThG16 - Turners Farm Gravel Pit, Mucking (TQ 677 801)

A disused gravel pit on private land next to Turners Farm on Walton's Hall Road (opposite Walton's Hall Museum) has a fine section through the Mucking Gravel, representing the bed of the Thames some 200,000 years ago. The east face of the pit is about 5 metres high and provides one of the best vertical sections through Thames Terrace gravel to be seen in the Thames Valley.



The gravel cliff at Turners Farm Pit

200,000 year old Thames gravel (Mucking Gravel) exposed as a cliff in a former gravel pit.
The photo was taken from the road in about 2007.

Photo: © G. Lucy

Other sites of geological interest in the district.

For completeness, the following sites also contribute to the geodiversity of the district.

Chadwell St. Mary sarsen stone (TQ 646 785)

In the churchyard is a sarsen stone (1 x 0.5 x 0.35 metres in size) with mammillated upper and lower surfaces.

The Fobbing borehole (TQ 7127 8435)

The Fobbing Auxiliary Well, north-west of Fobbing church, was sunk in 1904 by the Southend Waterworks Company and terminated in the Upper Chalk at a depth of 551 feet. However, what made this well of great geological interest was the water company's decision two decades later, in 1924, to deepen it by sinking a borehole at the bottom which more than doubled its depth taking it right down to the ancient Palaeozoic basement rocks.

The Palaeozoic basement consists of shales, sandstones and quartzites dating from the middle Devonian period, about 390 million years old (see table – page 5), and probably of similar age to the Devonian rocks encountered in the nearby Canvey Island borehole. The borehole revealed that lying directly on top of these ancient rocks is the Lower Greensand, a much younger deposit from the Cretaceous period. A considerable period of geological time – over 250 million years – is therefore missing from the rock record at this point which means that this was an ancient land surface. During the Jurassic and early Cretaceous periods there must have been inundations of this land by the sea but the sediments deposited have been removed by subsequent erosion. At this



time dinosaurs were the dominant land creatures, there were no flowering plants, and Essex would at various times have been covered by forest dominated by huge conifers such as the monkey puzzle. At Fobbing, this ancient land surface was recorded as being present at a depth of 1,128 feet below the well house floor.

Deepening the well must have been a success for the water company. At the base of the Lower Greensand water rushed in and rose to a height estimated at the time to be 83 feet above sea level. As the well house floor was only 65 feet above sea level this well must have been an 'artesian' well which means that water fills the entire well or borehole and overflows at the surface. Today the borehole has a cast iron cover and is situated on land still in use by the water company but there is no public right of way to the site. A drawing of the borehole with descriptions of the strata is held by GeoEssex (produced by the water company in 1966 at a scale of 24 feet to one inch).

Hangmans Wood Deneholes, Grays (TQ 631 794)

Hangman's Wood contains the most extensive a best preserved set of deneholes in existence. Deneholes are thought to be medieval chalk mines and consist of vertical shafts through the Thanet Sand and end in branching chambers cut into the underlying chalk. The Hangman's Wood deneholes are particularly deep, the shafts being over 20 metres deep before the Chalk is reached. There are up to 70 deneholes here but almost all are infilled. Those that are open are fenced. The site is a biological SSSI for the bat colony.

The Dell, Grays

Former home of Alfred Russel Wallace (1823-1913), zoologist, botanist, geologist and anthropologist, was one of the greatest scientific minds in Victorian Britain. He is most well known as the co-discoverer, with Charles Darwin, of the laws of evolution by natural selection. Wallace built the house and lived here from 1872 to 1876. The house is still in existence at the very end of College Avenue and is part of the adjacent convent school. It is provided with a heritage plaque to commemorate its famous former resident.

Thurrock Museum Sarsen Stone, Grays (TQ 6153 7814)

The report of a visit by the Geologists' Association to Globe Pit in Whitehall lane in September 1959 records the finding of a large sarsen stone, described as 'six feet long and four feet wide' at the southern end of the pit. This stone, which is a fine example of a sarsen stone, is now in the grounds of the library and museum in Orsett Road. It was originally proposed to be positioned in the garden at the front of the Museum but this never happened. Thurrock Museum contains a number of interesting fossils from the local neighbourhood including the Boatman collection, a small but historically important Victorian fossil collection which was donated to the museum in 1964. Boatman was a jeweller and watchmaker in the old Grays High Street, south of the present railway crossing.



Thurrock College Sarsen Stone, Grays (TQ 635 788) (current whereabouts unknown)

A fine sarsen stone (1.3 x 1.1 metres in size) was formerly standing upright on the grass in front of Thurrock College in Woodview. Before that, it was lying flat on the paving by the college entrance (see photograph). According to a former lecturer at the college the stone was found during nearby road construction work in the late 1960s. The stone has fine mammillated surfaces on both sides. Thurrock College has now been demolished and replaced with a housing estate. Unfortunately, the stone has been moved by the contractors and its current whereabouts is unknown. This is unfortunate as it would have made a fine monument of scientific interest standing upright at the entrance to the housing estate.

The **Thurrock College Sarsen Stone** outside the college in the 1980s. It was subsequently erected in the garden in front of the college. Since demolition of the college the stone appears to have been lost.



Grays Town Park, Grays (TQ 618 781)

The town of Grays developed around the brick-making industry which was once of great economic importance to the area and produced spectacular fossils of Ice Age mammals such as mammoth and straight-tusked elephant, lion, brown bear, hyena, rhinoceros, monkey, bison, and beaver. The undulating ground in various parts of Grays is the only evidence today of this industry. The sunken ground of Grays Park, a disused brick pit purchased by Grays Town Council in 1898, is a good example of this.

Rainbow Shaw Quarry, Linford (TQ 665 801)

Rainbow Shaw Quarry on Holford Road, north-west of Linford, is currently an active quarry working Thanet Sand. Lying on top of the Thanet Sand is Orsett Heath Gravel.

Stanford Warren Angling Lakes, Mucking (TQ 689 815)

The type section of the Mucking Gravel, representing the bed of the Thames some 200,000 years ago, is situated on private land used as angling lakes adjacent to Essex Wildlife Trust's Stanford Warren Nature Reserve. The former gravel pit is now Stanford Warren Angling Lakes, which are an important fishery and habitat for birds. Public access to the lakes is restricted to the car park but views can be obtained when following the short circular walk. Close to the edge of the site is a fine, though small, exposure of gravel.



Vange Mineral Well, Langdon Hills (TQ 7002 8627)

In the parish of Fobbing, not far from the Five Bells interchange at Vange, are the remains of a curious domed structure, which originally resembled a temple. Although the building was originally built on open land, it is now situated in Martinhole Wood, which is part of the One Tree Hill Section of Langdon Hills Country Park. Known as Vange Mineral Well No. 5, it is now sadly a ruin but in the early twentieth century it was the centre of a widely publicised mineral water business. The site is on the slopes of One Tree Hill and the water originated from the junction between the sandy Claygate Beds and the impervious London Clay below. The building is in danger of collapse and requires urgent repairs.



The remains of the pump house of **Vange Mineral Well No.5** in Langdon Hills Country Park in November 2020. Sadly, the building is in a ruinous condition and requires urgent repairs.

Photo: © J. Seward

North Stifford Church Puddingstone. (TQ 6044 8031)

St. Mary's Church contains a remarkable variety of local stone types, particularly the boulder (0.75 x 0.6 metres) supporting the north-west corner. The boulder consists of layers of black-coated flint pebbles set in a sarsen matrix. Similar to 'Hertfordshire puddingstone', this boulder is unique in south Essex.

Dansand Quarry, Orsett (TQ 651 810)

The Dansand Quarry on the Stanford Road (west of Brentwood Road) currently provides exposures of the sands of the Woolwich Beds. They take the form of very steep to almost vertical cliffs on the northern faces which mark the edges of the original quarry. The Woolwich Beds sands are capped by Orsett Heath Gravel in places. These cliffs could be easily retained in any future use of the site.

Purfleet foreshore Chalk outcrop, Purfleet (TQ 54931 78340)

A small outcrop of Upper Chalk can be seen at low tide on the foreshore at Purfleet just a few hundred metres north-west of the Royal Hotel. This is the oldest rock exposed on the Essex coast. The Chalk contains numerous flints and occasional fossils. Additionally, at very low Spring tides, the feather edge of a Neolithic Submerged forest can be seen resting on the underlying Chalk (see also Purfleet Submerged Forest LoGS).



The Dipping (Church Hollow), Purfleet (TQ 551784)

Former chalk quarry on the south-west slope of Beacon Hill with fine vertical chalk face on its northern boundary. Much of the quarry floor is occupied by residential development. The quarry was also called Tank Lane Quarry. Church Hollow is the name of the western part of the site originally occupied by a chapel, school and schoolmaster's house built by the Whitbread family (owners of the quarries) for its estate workers. Chalk was quarried here from as early as the 16th century and therefore this quarry is of great historical as the site of the earliest commercial chalk workings in Thurrock.

St Nicholas Church, South Ockendon (TQ 5949 8290)

An example of an unusual building style with a geological connection. The construction of round church towers came about because of the difficulty of making satisfactory corners with natural unknapped flints.

The round flint tower of St. Nicholas, South Ockendon. There are six round tower churches in Essex and this is one of the best examples.

Photo: © G. Lucy



Dolphin Chalk Quarry, West Thurrock (TQ 571 780)

Formerly known as the Metropolitan Works Quarry, the Dolphin Chalk Quarry is situated between Stonehouse Lane and Canterbury Way (the Dartford Tunnel approach road) and contains a cement manufacturing plant and an industrial estate. The 20 metre high vertical chalk face that forms the western side of the quarry is the most remarkable chalk cliff in Essex as it shows regularly spaced bands of flint nodules which represent cycles of climate change (Milankovitch climate cycles) during the Cretaceous period some 80 million years ago. These flint bands are better displayed here than anywhere else in Essex and, due to aspect and differential weathering, are not even clearly visible in the adjoining quarry.



Dolphin Chalk Quarry

On the west side of Dolphin Way is a high vertical chalk face that shows bands of flint nodules about one metre apart which represent cycles of climate change during the Cretaceous period. Based on the extremely slow rate of chalk deposition on the Cretaceous sea floor, each cycle represents a time period of between 20,000 and 40,000 years.

Photo: © G. Lucy



Lakeside (Tunnel Cement Works Quarry), West Thurrock (TQ 585 780)

Lakeside Shopping Centre occupies the floor of the former giant Tunnel Cement Works chalk quarry. In 1968 the Tunnel Cement Works was the largest in Western Europe with 1,200 employees. Steep and vertical faces of chalk are still visible today around the edges of the old quarry with clear bands of flint nodules. However, several faces are covered in geotextiles to prevent falling rock and most are fenced off or otherwise inaccessible. Currently the best and most accessible chalk face is on the south side, off Motherwell Way (behind IKEA). Access is best through the Cliffside Trading Park, open to the public during office hours, where the face can be seen between Units 6 & 7 (TQ 585 780).

Tesco Distribution Centre Quarry, West Thurrock (TQ 570 781)

Tesco's distribution centre occupies the southern part of Greenlands Quarry and is accessed from Dolphin Quarry via Dolphin Way through a tunnel under the A1090 (Stonehouse Lane). Fine chalk cliffs encircle the building but the cliff on the north side is of particular interest as the top third is coombe rock, a shattered chalk which is direct evidence of extremely cold climate during the last glacial period.

Tesco Distribution Centre Quarry

The top section of the chalk cliff to the north of Tesco's distribution centre consists of coombe rock, proof of an arctic climate in Thurrock, about 15,000 years ago.

Photo: © G. Lucy



Low Street Pit, West Tilbury (TQ 672 775)

A disused, wooded sand and gravel pit south of Station Road between east Tilbury and West Tilbury. It is situated on a patch of Mucking Gravel, which is the down-stream equivalent of the Taplow terrace of the Thames and was laid down about 200,000 years ago. The gravel has been excavated down to the Thanet Sand below which is exposed on the floor of the pit. The pit has been designated as a Local Wildlife Site.

West Tilbury Hall Well (TQ 660 777)

The 16th century West Tilbury Hall and former church sit near the summit of a steep-sided, gravel-topped hill. In the early 18th century there was discovered here a medicinal spring or well which afterwards became famous – more so than any other Essex well. It retained its fame, too, for a long period and appears to have been the only Essex medicinal water to have enduring commercial value. The well was first sunk in 1724 and its medicinal value was discovered some three years later. The fame of Tilbury Water increased throughout the 18th century and was advertised extensively in London newspapers. It was promoted by prominent doctors and physicians at the time including Sir Hans Sloane, who was “so well convinced of the great efficacy of the Tilbury water that he frequently recommended it to his patients”. Despite refurbishment at West Tilbury Hall, the original well has not been rediscovered. Thurrock Museum, however, has in its collection one of the original two pint glass bottles stamped with the words ‘West Tilbury Hall’. The water from the wells owes its chemical composition to filtering through Thames gravel (Orsett Heath Gravel) and Thanet Sand, which caps the hill at West Tilbury.