GeoEssex
Promoting the geology and landscape of Essex

Castle Point Borough Council
Report on Local Geological Sites

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Cover photographs:

Left: Exposure of Bagshot Sand by the angling lake in Hadleigh Park. *Photo: J. Saward*

Right: A mammoth tooth from Canvey Island on display in Southend Central Museum. It was donated to the Museum in the 1930s and was probably dredged from the bed of the Thames. *Photo: G. Lucy*

1. Introduction

The rocks beneath the Essex landscape are a record of the county's prehistory. They provide evidence for ancient 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. 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).

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

An aerial view of Hadleigh Castle and its famous landslip.

Clearly visible is the large rotational slip which occupies the uppermost part of the slope and has encroached on the south curtain wall of the castle.

Photo © Essex County

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.

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.

A Local Geodiversity Action Plan (LGAP) has been produced for Essex. It sets out a framework for geodiversity action in Essex. 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

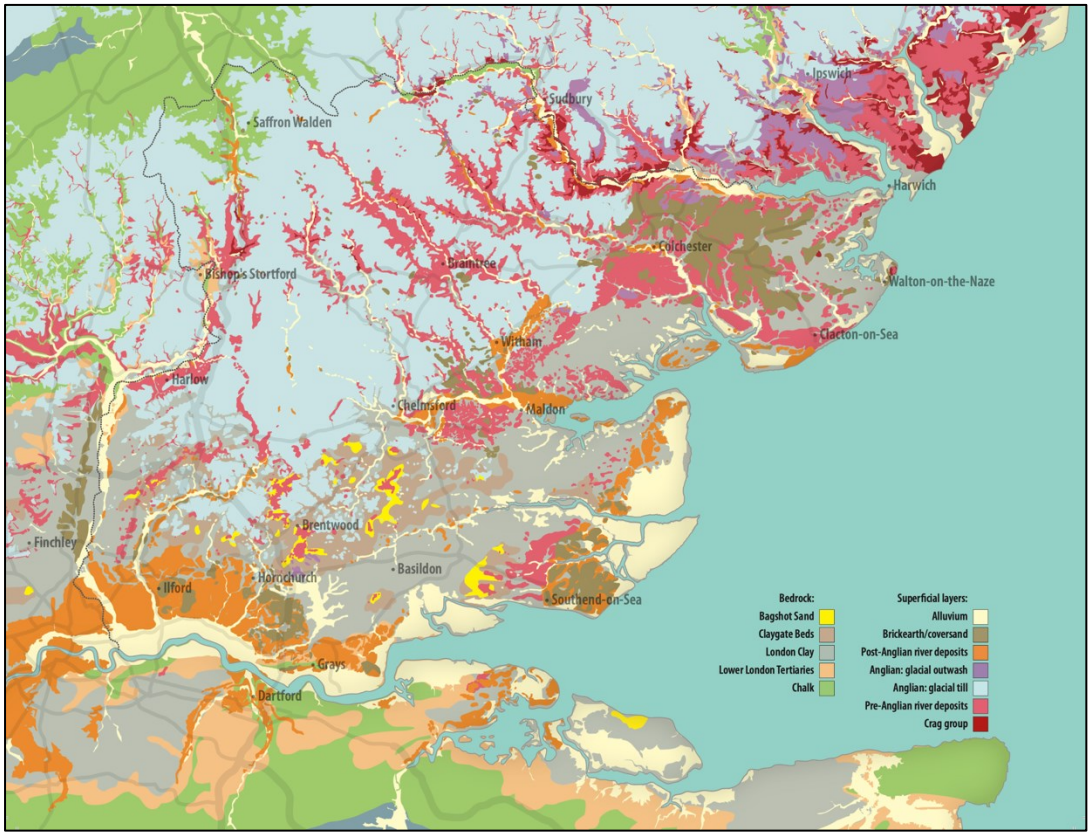
Compared to most other parts of Britain the rocks of Essex and adjoining counties are young in geological terms. Even the oldest surface rock in Essex (the Chalk) is only about 80 million years old. Much older rocks are, however, present at depth. We have some idea about these ancient rocks because of the records of boreholes that have been sunk in search of 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 material laid down during the Ice Age is known as 'Superficial' or 'drift' deposits.

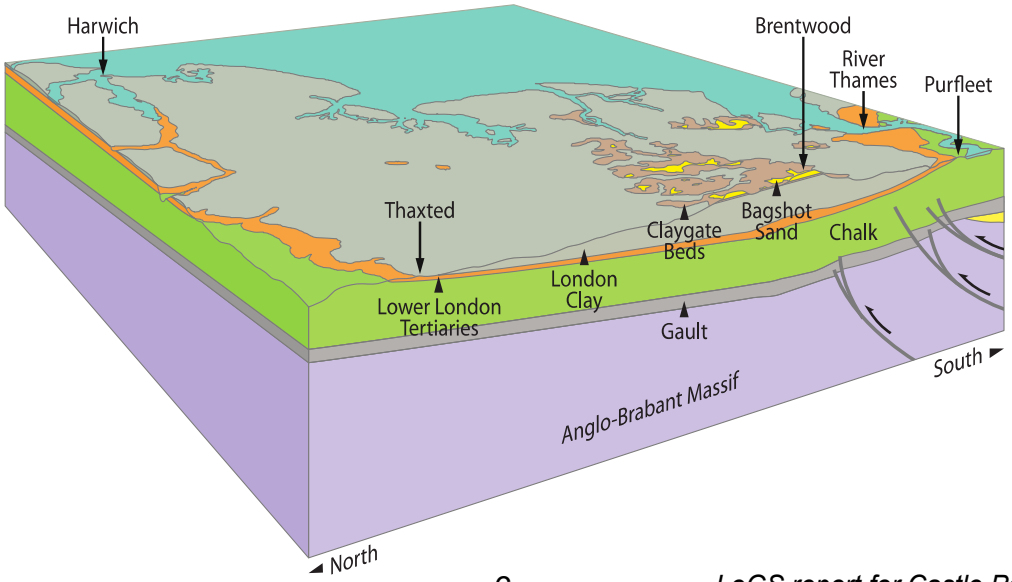
Era	Period or Epoch		Approx. age in millions of years	Geological formations in Essex
Caenozoic	Quaternary Ice Age	Holocene	0.01	Recent peat and alluvium
		Pleistocene		River terrace deposits and brickearth (loess)
			0.45	Boulder clay (till) and glacial gravel
				Kesgrave (Thames) sands and gravels
			1	Norwich Crag (Chillesford Sand)
			2.4	Red Crag
	Pliocene		10	*No evidence of rocks 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 meters) 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.



Cross section through Essex (bedrock only)



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 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 tiny horses. Atlantic volcanoes poured their ash into this sea.

The Alps and the Thames

- Colliding continents pushed up the Alpine mountain chain, bending the crust to form the vale of the Thames river system through mid Essex. About 2.4 million years ago offshore sandbanks formed red shelly sandstone layers across north Essex known as the **Red Crag**.
- Global cooling led to the present Ice Age, with many warm periods such as the one we are in right now. As the sea retreated, the ancestral River Thames spread 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 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 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.

3. Background to Geological Site designation in Castle Point

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.

London Clay outcrops south of Chelmsford, providing fertile soils for arable agriculture, especially wheat. The chalky till found in north and west of Chelmsford is also highly suitable for cereal cultivation.

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

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.

The geology of Castle Point district

The bedrock geology of the district is London Clay, laid down on the floor of a subtropical sea in the Eocene period some 50 million years ago. The Claygate Beds occur above the London Clay and represent a period of geological time when the London Clay Sea was becoming shallower and the clay was becoming increasingly sandy as the shoreline came closer. This culminated in deposition of the Bagshot Sand as the sea became very shallow. Bagshot Sand is therefore considered to be delta and near-coastal sands. Following extensive erosion during the Ice Age, the Claygate Beds and overlying Bagshot Sand are now only exposed on the high ground such as the Rayleigh Hills. These hills are capped by a complex series of gravels laid down at various times by rivers during the Ice Age.

The Rayleigh Hills

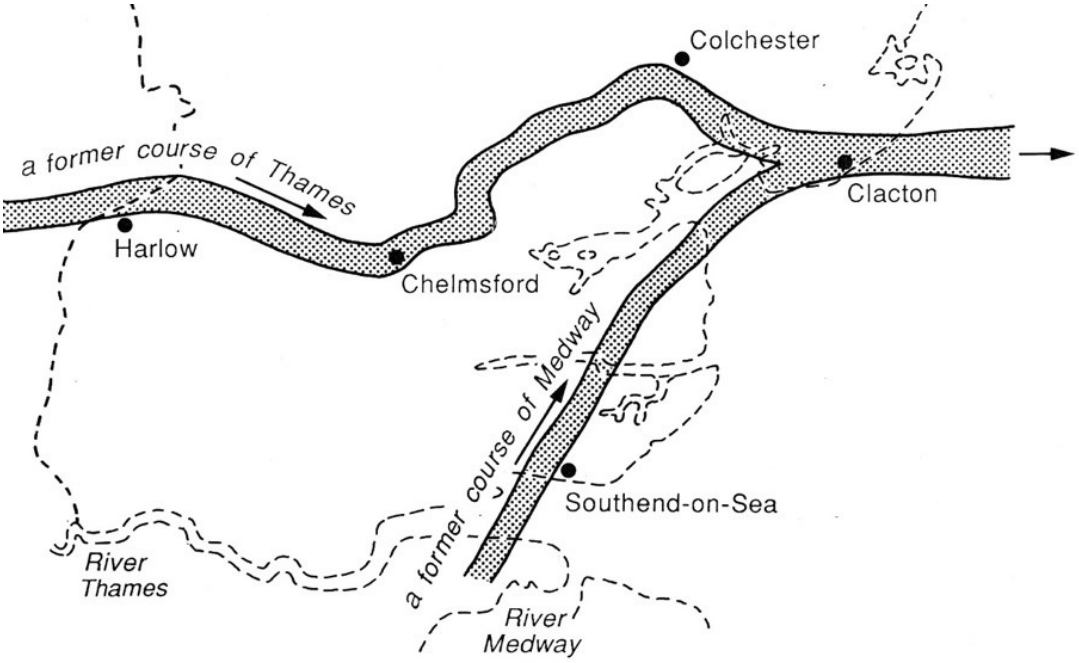
Research has shown that the River Medway in Kent is a very ancient river and before the diversion of the Thames to its present course the Medway flowed across eastern Essex to join the Thames in what is now north Essex. The route of this river has left behind evidence of its existence as layers and patches of gravel between Hadleigh and Bradwell-on-Sea. The higher the altitude of this gravel the older it is, and the highest of this gravel (known as Daws Heath Gravel and Claydons Gravel) is on the Rayleigh Hills between Hadleigh and Hockley which, in places, is over 80 metres (240 feet) above sea level.

It is difficult to believe that this gravel, which caps some of the highest ground in south Essex, was originally the floor of an ancient river valley. However, this must have been the situation perhaps over a million years ago in the middle of the Ice Age. Like the gravel on the summit of the Langdon Hills (which was deposited by another northward-flowing tributary of the ancient Thames), the Rayleigh Hills gravel contains distinctive pebbles of chert from the Lower Greensand of The Weald, together with other rock types that could only have been deposited by a river flowing from the south. It also contains boulders of sarsen stone which must also have originated in Kent.

The existence of this high-level river gravel may even have contributed to the creation of the Rayleigh Hills by protecting the Bagshot Sands and Claygate Beds from erosion while the surrounding areas were slowly reduced to the present lowland. It is a vivid reminder of the immense erosion that has taken place during the ice age and how the land surface can be considerably reshaped in relatively short periods of geological time.

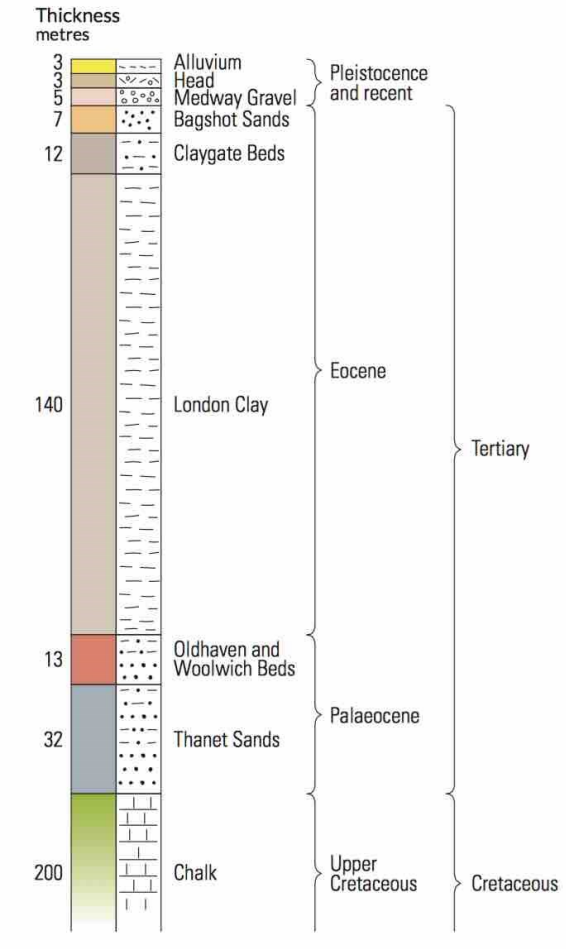
Sarsen stones

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 silca (quartz). This layer was extremely resistant to erosion but it eventually broke up into boulders we now call sarsens. Those in south-east Essex must have originated from the Chalk landscape of Kent and brought here by the River Medway.



Above: Former courses of the Thames and the Medway before the arrival of the Anglian ice sheet in Essex. The ice sheet diverted the Thames to its present course and a combined 'Thames-Medway' river then flowed northeast along the former course of the Medway.

Gravels laid down by the River Medway are found in Castle Point district and enable geologists to build up a surprisingly detailed picture of the Essex landscape during the Ice Age.



Right: Geological column showing the rock strata present in the Castle Point district. The Oldhaven and Woolwich Beds, Thanet Sand and Chalk are not exposed at the surface.

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:

(1) "the planning system should contribute to and enhance the natural and local environment by protecting and enhancing valued landscapes, geological conservation interests and soils" (Paragraph 109);

(2) "local planning authorities should set criteria based policies against which proposals for any development on or affecting protected wildlife or geodiversity sites or landscape areas will be judged" (Paragraph 113); and

(3) "to minimise impacts on biodiversity and geodiversity, planning policies should aim to prevent harm to geological conservation interests" (Paragraph 117).

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 no geological SSSIs in the Castle Point 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 (species and habitats) 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.

4. Objectives of current report

Supporting Local Planning Authorities

"*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)

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.

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* function fits well with the principle of community involvement and enabling people to regain their sense of place.

A large (68 x 42 centimetre) sarsen stone near the corner of St. Peter's Church Hall, Thundersley. This boulder, despite its large size, was carried here from Kent by the River Medway probably over a million years ago.

Photo © Jeff Saward

5. 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 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, 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 Castle Point district are summarised below, together with a list of other sites which are potential 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) should be consulted if any development is proposed that would affect a LoGS.

View looking south-west from Sandpit Hill, Hadleigh, to Canvey Island and the Thames Estuary.

Photo © British Geological Survey

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 eg. 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.

Hadleigh Castle and landslip looking north-east. Photo © British Geological Survey

6. Additional Sources of Information

Scientific literature
If a LoGS has been referred to in the scientific literature these references are of given in the LoGS citation. The fact that a site has been referred to in the scientific literature means that the site is of historical interest and some of these sites will have potential for future research.

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.

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

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 includes geology amongst its many activities. The club has a centre for Biodiversity and Geodiversity in Wat Tyler Country Park at Pitsea, near Basildon. 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 amateur geological enthusiasts.

GeoEast
GeoEast is the East of England Geodiversity Partnership. It is a partnership of organisations active in conserving and promoting Earth heritage in the six counties of the region (including Essex).

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

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

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7. List of Sites

The following is a representative list of geological sites in the district. For completeness it includes geological SSSIs but these 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.

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)

There are no geological SSSIs in the district.

Local Geological Sites (LoGS)

Sites agreed by Local Sites Partnership to date.

CptG1 - Coombe Wood, Thundersley (TQ 783 883)

At the western edge of the Rayleigh Hills the A13 climbs the steep incline of Bread and Cheese Hill. On the left hand (north) side of the road is the steeply sloping ground of Coombe Wood. Coombe Wood is a mostly native woodland situated on the Claygate Beds with Bagshot Sand on the highest ground. The layers of sandy clay that make up the Claygate Beds can be seen in the sides of a stream that cuts through the wood in a very steep valley which is almost a ravine. The underlying geology is also revealed by rabbit burrows and the root plates of fallen trees. Coombe Wood is a public open space owned by Castle Point Borough Council.

CptG2 - Hadleigh Castle Landslip (TQ 810 860)

Hadleigh Castle is situated on the edge of an ancient cliff of London Clay, which was cut by the Thames about 27,000 years ago during one of the coldest periods of the Ice Age. The river appears to have abandoned the cliff at least 10,000 years ago and since then there have been a considerable number of landslips as the ground attempts to regain a stable slope. The ground is still actively land-slipping (the largest slide in historical times occurred in the late nineteenth century) and it may be at least another 10,000 years before it reaches an angle of stability.

The abandoned cliff line stretches all the way from South Benfleet to Leigh-on-Sea and forms the southern edge of the high ground of the Rayleigh Hills. Landslips occur at a number of places but they are most visible at Hadleigh, and the severe effects on the medieval castle can be clearly seen. Hadleigh Castle therefore provides an excellent example of landslipped ground, in an impressive setting overlooking the Thames estuary. The cliff complements the actively eroding London Clay cliffs of Sheppey on the opposite side of the estuary.

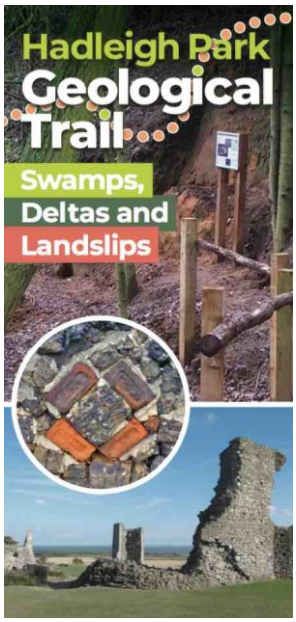
The degraded part of the cliff has an average inclination of over 12° and is still actively landslipping. This indicates that the total time required after abandonment for the cliff to reach the ultimate angle of stability (about 8°) could be several times that which has elapsed so far. Open tension cracks in the ground are evidence of continued movement.

This brief account has been taken from a major paper on the development of this abandoned cliff (Hutchinson and Gostelow 1976) and a report for the Building Research Station on coastal landslides in Essex and Suffolk (Hutchinson 1965).

CptG3 - Hadleigh Park (park entrance TQ 799 868)

Situated only a short distance west of the castle, Hadleigh Park offers some of the best views in Essex and GeoEssex have produced a geological trail guide for the park. The hilly landscape here consists of London Clay overlain by the sandy clay of the Claygate Beds, which in turn passes up into Bagshot Sand on the highest ground. From the car park a track leads downhill to the main part of the country park which is a valley flanked by the steep slopes of Round Hill to the west and Sandpit Hill to the east. Both Round Hill and Sandpit Hill are capped by Bagshot Sand. From here the path continues down to grazing marsh, sea wall, and a narrow strip of saltmarsh alongside Benfleet Creek. There are meanders and oxbow lakes in Benfleet Creek.

The steep ground hereabouts is prone to extensive landslips (Hutchinson 1965). This is particularly evident on the east side of Sandpit Hill (on land owned by the Salvation Army) where successive rotational slips have created a series of sloping terraces separated by small cliffs or 'scarps'. The scarps provide glimpses of the underlying geology with sticky clay at the bottom of the hill and sand at the top, providing a good illustration of the shallowing of the London Clay Sea. The mud laid down on the subtropical sea floor became more and more sandy until it eventually consisted entirely of the fine yellow sand called Bagshot Sand, which was laid down across most of Essex in a great complex of river deltas. In 1973 a borehole was sunk by the British Geological Survey in order to study the complete geological succession in the Hadleigh area for the first time. The site chosen was near the top of Sandpit Hill (TQ 8002 8654) at an altitude of 70 metres above sea level so that the maximum depth of strata could be examined. After passing through 10 metres of Bagshot Sand and 17 metres of Claygate Beds the borehole penetrated the full thickness of London Clay, which here was 132 metres thick. Below the London Clay the borehole continued through 12 metres of Oldhaven and Woolwich Beds (which yielded numerous fossil shells) before terminating in the Thanet Sand at a depth of 176 metres. Beneath the Thanet Sand is the Chalk, which forms the foundations of the London Basin. The borehole results are recorded in detail in the geological survey memoir for the Southend district (Lake et al. 1986). Of particular interest was the discovery of a septarian nodule at the base of the London Clay at a depth of 159 metres which contained particles suspected to have originally been volcanic ash. Bands of volcanic ash, probably from Scottish volcanoes, are common at the base of the London Clay near Harwich but this was the first time it had been identified in this part of Essex.



Hadleigh Park Geological Trail Guide

The best exposure of Bagshot Sand in the park is situated on the side of Sandpit Hill and is publicly accessible by a gate in the fence. It is an excellent vertical section of yellow sand capped by dark earth with some pebbles. The section is dug into a series of delta and near-coastal sands. These are of 'egg- timer' quality, being of very well sorted, 0.1mm, angular quartz grains. The soil at the top of the section contains flint pebbles and chert fragments. These are derived by soil creep from gravel beds higher up in Hadleigh. The chert is from the Lower Greensand of Kent; it was brought to this area by the ancestral river Medway.

CptG4 - Pound Wood Nature Reserve, Daws Heath (TQ 816 888)

Essex Wildlife Trust's Pound Wood Nature Reserve is situated on the northern slope of the ridge of high ground at Daws Heath. Here the ground rises to over 70 metres above sea level and the varied geology of the wood has resulted in a great variation of woodland types (Rackham 1986).

The geology of the area consists of the familiar London Clay, overlain by the sandy clay of the Claygate Beds, which is present at the lowest part (north end) of Pound Wood. As the ground rises to the south the Claygate Beds become increasingly sandy until they pass into fine yellow Bagshot Sand. The Bagshot Sand is overlain by a gravel called Daws Heath Gravel that caps the summit of the ridge. The gravel is therefore present at the surface at the highest part (south end) of the wood and the rounded pebbles can be seen on the paths and in the roots of fallen trees.

Daws Heath Gravel is a remnant of an ancient terrace of gravel deposited by the River Medway when it flowed across eastern Essex in the early part of the Ice Age, perhaps as much as a million years ago. It is one of the oldest of the High Level East Essex Gravels and its Medway origin is demonstrated by the presence of numerous pebbles that originate in the Weald of Kent (Bridgland 2003). In the early twentieth century there were several gravel pits on the Daws Heath ridge and one of these, known as Bramble Hill Pit, is clearly shown on the 1923 Ordnance Survey map just west of Bramble Hall. This pit was visited by the Geologists' Association in 1906 and the report of the visit states that a 'fair sized' boulder of Lower Greensand chert from the Weald was found in this gravel (Cole 1907) but the age of the gravel and the connection with the Medway was not then appreciated. Other rock types from Kent are also present, including sarsens. A large sarsen (nearly half a cubic metre in volume) was reported to be visible on the surface near where the Little Haven Hospice now stands (Lake et al. 1986 p. 26). Its present whereabouts is not known.

CptG5 - Shipwrights Wood, Hadleigh (TQ 795 871)

Shipwrights Wood is adjacent to the recreation ground in Shipwrights Drive and within walking distance of Hadleigh Castle. This fine and varied woodland occupies an area of steeply sloping ground where there have been numerous landslips over the last few thousand years. There are also ridges and ravines formed by stream erosion. The result is the most remarkable wood for natural landforms in Essex (Rackham 1986). The geological succession of London Clay overlain by Claygate Beds and Bagshot Sand is similar to that of other sites nearby such as Hadleigh Great Wood, Pound Wood, Coombe Wood and Hadleigh Park. The strata are horizontal but because of the sloping ground the London Clay occurs at the western end and the Bagshot Sand caps the high ground at the eastern end. Bagshot Sand is often visible in heaps thrown out from rabbit burrows.

An additional aspect of interest is the movement of ground water. Water percolating through the sand seeps out on meeting the impervious clay forming a line of springs, which conveniently mark the junction between the Claygate Beds and the London Clay. The landslips are a feature of the western scarp of the Claygate Beds in this area where the sandy strata, lying on slippery clay, has been lubricated by springs and made unstable.

CptG6 - St. Peter's Church, Thundersley (TQ 782 887)

A couple of hundred metres north of Coombe Wood is St. Peter's Church, which has a steeply sloping churchyard and a fine view to the west. This is a good place to appreciate the remarkable amount of uplift of the land and river erosion that has taken place over the last few hundred thousand years. In response to this uplift the Thames and its tributaries have carved the modern valley leaving remnants of high ground here as the Rayleigh Hills and also further west as the Langdon Hills.

Two fine sarsen stones that were recorded here in the 1930s can still be seen today. One is under a hedge next to Church Road, on the north-east corner of St. Peter's Church Hall and the other is situated in the church porch. The latter stone was apparently discovered while digging a grave around the time of the First World War. These stones must have originated from the Chalk landscape of Kent and brought here by the River Medway, perhaps over a million years ago.

CptG7 - West Wood, Hadleigh (TQ 805 880)

West Wood has a varied geology which has influenced the species of trees that exist from valley floor to hill top. The Prittle Brook flows in the valley in the centre of the wood, which is underlain by a bedrock of Claygate Beds. To the north and south the rising ground gives way to the overlying Bagshot Sands.

On the highest ground, to the north and south, there are overgrown shallow pits where 'exotic' gravel can be found. This is Daws Heath Gravel, which outcrops on each side of the valley just beyond the north and south boundaries of the wood but has migrated here during the coldest periods of the Ice Age by the process of 'solifluction' where saturated ground moves downhill under gravity. Daws Heath Gravel is an ancient remnant of a terrace of river gravel deposited by the River Medway when it flowed across eastern Essex in the early part of the Ice Age (see Pound Wood Nature Reserve).

Other sites of geological interest in the district.

(Some of these sites may be considered as potential LoGS).

Canvey Island Borehole (TQ 8215 8330)

During the Geological Survey's coal exploration programme in the 1950s it was thought that Coal Measures (of Carboniferous age) existed in a concealed depression in the Devonian rocks beneath Canvey Island. This assumption was not unreasonable considering the proximity of a known concealed coalfield in east Kent. Evidence for the existence of this depression came from measuring the variation in the force of gravity over an area and comparing this with an assumed average gravity value, thus producing a contour map with contour lines joining points of equal gravity. The map revealed a 'negative gravity anomaly' at Canvey Island (thought at the time to be due to the low density of Coal Measures sediments present in the depression) and in 1953 a borehole was sunk to test this theory (Smart et al. 1964).

The borehole passed through alluvium, London Clay, Lower London Tertiaries (Oldhaven, Woolwich and Thanet Beds), Chalk, Lower Greensand and Gault. Beneath the Gault the 'Palaeozoic basement' was reached at a depth of 400 metres. Instead of coal, these basement rocks were found to consist of hard Old Red Sandstone of Devonian age and the borehole was abandoned at a depth of 510 metres. Although unsuccessful in its objective, the project nevertheless provided a wealth of information, such as fossil plants from the 380 million year old Devonian rocks, which helped to accurately date the sequence of rocks deep beneath this part of Essex. The borehole was also the first in the United Kingdom in which the direction and degree of dip of sub-surface rocks was measured by geophysical logging (Allsop and Smith 1988). It is an interesting thought that, had the borehole results been different, Canvey Island might have become a coal mining town; an example of how geology affects the character of the landscape.

The site of the borehole is near where Silverpoint Marine, Point Road is now. The entire length of the core (over 500 metres) is available for study at the British Geological Survey's headquarters in Keyworth, near Nottingham. A simplified diagram of the borehole can be found in *Essex Rock* (Lucy 1999, fig. 10).

Hadleigh Great Wood (TQ 820 876)

Hadleigh Great Wood (sometimes called Belfairs Nature Reserve) is the main survivor of a group of ancient woodlands on the southern slopes of the Rayleigh Hills. It lies on the south-western side of the valley of the Prittle Brook, which forms the north-eastern boundary. From the highest point of 64 metres above sea level in the western corner the reserve gently slopes down to 42 metres in the eastern corner. The Prittle Brook itself originally possessed many meanders but unfortunately most of these were cut off by straightening the brook sometime after the 1920s, but the dry beds of some of these former meanders are still visible.

The geology of the wood is similar to other woods in this part of Essex and the fauna and flora of the wood varies with the underlying geology. However, it is not always easy to identify the various rock layers as exposures are rare and the boundaries between the beds are indistinct due to a covering of 'head' (see below). Beneath the entire area is London Clay, which is exposed in the bed of the Prittle Brook, and in places can be seen large fragments of septarian nodules - characteristic

calcareous concretions that occur frequently in the clay. The London Clay is overlain by the sandy clay of the Claygate Beds, and this is overlain in turn by Bagshot Sand. The boundary between the Claygate Beds and the Bagshot Sand is hard to trace on the ground, unlike in other woods where it is often marked by a change in the angle of the slope and by a line of springs. The Bagshot Sand is, however, often seen thrown out of animal burrows in the north-west of the wood where it consists of medium to fine grained sand, in places stained by iron. The whole sequence of rocks is still horizontal but has been uplifted and eroded over millions of years. As the ground surface of the wood slopes down to the valley the London Clay is therefore exposed at the valley bottom, the Claygate Beds in the centre of the wood, and the Bagshot Sand caps the highest ground. Hadleigh Great Wood therefore tells the story of a gradual shallowing of the London Clay Sea as you walk uphill from east to west.

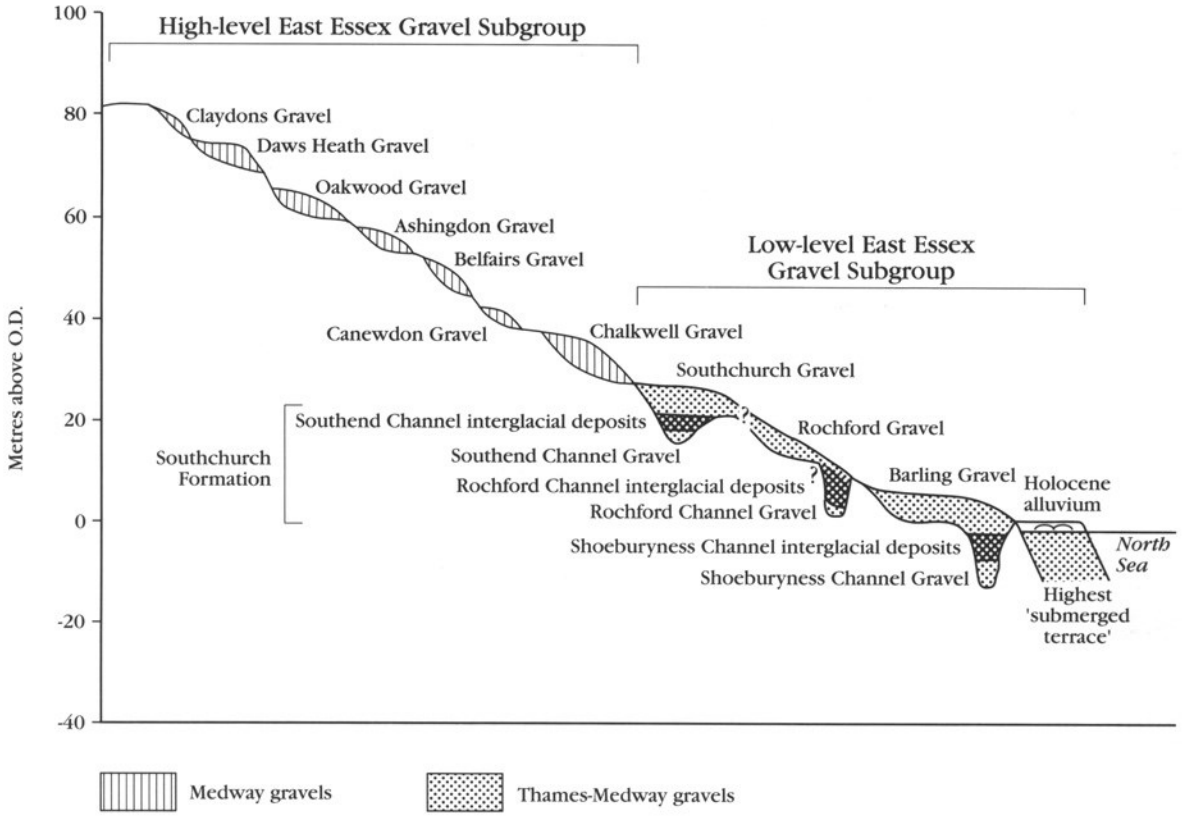
In the south of the wood there are wide, shallow former gravel pits but the origin of this gravel is unclear. It is too thin to be marked on the geological map but is probably ancient Medway gravel that has migrated downhill to this spot from the high ground at Hadleigh during the coldest periods of the Ice Age by the process of 'solifluction'. Much of the surface geology of the wood is, in fact, composed of a thin deposit called 'head' which consists of a mixture of clays and sands from the underlying beds that have been reworked and redeposited by 'freeze-thaw' action during this time. Also present is a large amount of fine silt called loess, which blankets a large part of south-east Essex and was deposited as a wind-blown sediment, again during the Ice Age.

Hadleigh Great Wood and Belfairs Wood are situated either side of the boundary between the districts of Castle Point and Southend but both Woods are owned and managed by Southend Borough Council. Spooner and Bowdrey (1988) have provided an excellent account of the geology of Hadleigh Great Wood.

Kingley Wood Road Cutting, Thundersley (TQ 794 898)

Construction of the A127 Southend Arterial road in the 1920s entailed digging a deep cutting through the high ground of the Rayleigh Hills on the northern boundary of Castle Point district. The cutting, just west of the Rayleigh Weir underpass, was dug through the sandy clay of the Claygate Beds and during the course of the work a layer of clay was found that was particularly rich in fossils.

Among the several species of fossil mollusc found was a pearly nautilus, a creature that lives today in the Indian Ocean. Shark teeth were also found including *Otodus obliquus*, an ancestor of the great white shark (Bristow et al. 1980). Fossils from the Kingley Wood cutting form part of the Essex Field Club's collection.



Idealized transverse section through the gravels of the Southend –Castle Point area.

The highest and oldest gravel terraces (the High-level East Essex Gravel) belong to the River Medway. The lower and younger terraces (the Low-level East Essex Gravel) were formed when the Thames was diverted by the Anglian Ice Sheet, joined the River Medway in south-east Essex and adopted the old Medway valley, flowing north-east as the Thames-Medway River.

(Diagram from Bridgland, 1994).