# Green Chain Walk
# GEOTRAIL






LONDON GEODIVERSITY PARTNERSHIP

# GREEN CHAIN GEOTRAIL

Welcome to the Green Chain Geotrail. Learn about the tropical seas and kilometre high glaciers that have covered London in the past. Our capital has suffered all this and more. Learn about them and how the present London was built by walking over this trail based on the Green Chain Walk which happens to connect some of London's most interesting geological sites.

The trail is a seven mile walk from the Thames Barrier to Lesnes Abbey. It is shown on the map on page 3 and covers parts of three sections of the Green Chain Walk. We have selected 12 geologically interesting stopping points along the way.

Most of the geological strata of this part of London were laid down between 50 and 60 million years ago and the chart sets out the current names and provides alternative commonly used informal names.

| Age (m years) | Period | Stage | Group | Formation | Informal names | Thickness in area | Description and how they were deposited |
|---|---|---|---|---|---|---|---|
| 51-54 | Palaeogene | Eocene | Thames Group | London Clay Formation | Claygate Beds | 15-18m | Sandy clays deposited in shallow seas |
| | | | | | London Clay | Up to 70m | Grey clay that weathers brown, sandy at top. Five cycles of marine transgression |
| 55 | | | | Harwich Formation | Blackheath Beds | 5-27m | Fine-grained sand, rounded black flint pebbles & shelly lenses, occasionally cemented, deposited in a marginal marine environment |
| | | | Lambeth Group | Woolwich Formation | Woolwich Beds | 0-7m | Layered grey clay and sand with shell beds. Deposited in estuaries and lagoons |
| 56 | | Paleocene | | Upnor Formation | | 0-5m | Greenish-yellow sandy silts deposited in a shallow marine environment. |
| 58 | | | | Thanet Sand Formation | Thanet Sand | 5-14m | Fine-grained sand, very clean in some horizons, deposited in a shallow marine environment |
| 84 | Cretaceous | Santonian | | Chalk | Upper Chalk | Up to 18m exposed | White chalk with courses of nodular flints. Chalk is a limestone formed entirely from the skeletons and shells of marine organisms that lived in warm seas |

Unconformity between Chalk and Thanet Sand when there was a break in deposition


*The Thames Barrier is easily accessible by train to Charlton from where it is about a 10 minute walk to the east, or there are buses along Woolwich Road. Lesnes Abbey is close to Abbey Wood station. The walk may be done in sections; public transport is close or crosses the Green Chain Walk at many places. Note that a few stopping points are a short detour from the Green Chain path.*

## 1 Thames Barrier

Serious floods occurred on the Thames in 1928 and 1953 and many people were drowned. In 1953 approximately 160,000 acres of farmland were flooded and over 300 people lost their lives. The floods were caused by the concurrence of three events:

- Spring high tides
- A storm surge in the North Sea caused by low atmospheric pressure raising sea level
- High flows in the River Thames

The flooding problem has become more acute with time as sea level has risen in the estuary. This results from polar ice melting and thermal expansion of the sea as average sea temperatures increase. The estuary is also sinking as the Earth readjusts to the melting of the Ice Age. Combined, these effects mean that sea level is rising up to 4mm per year.

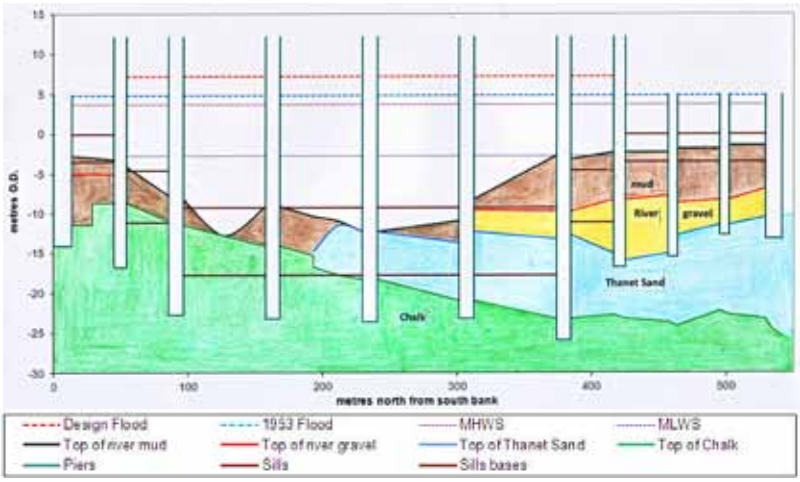
Without the Barrier, which became operational in October 1982 and first used in February 1983, the flooding that could be caused by a 1953 type of flood would directly affect 1.25 million people in London. The barrier closes when a flood incident is likely, isolating the upstream low lying land from the high sea level in the estuary.

A recent review has confirmed the barrier will be capable of providing protection against rising sea levels until at least 2070. Currently it is operated up to 15 times per year, which is expected to increase to 30 times per year by 2030.

For more information on the Thames Barrier look at the Environment Agency's website:
*http://www.environment-agency.gov.uk/homeandleisure/floods/38353.aspx*

It was built as far downstream as practicable; where the Thames is relatively straight and where the Chalk has been brought to the surface by earth movements to provide a comparatively strong footing for the structure.

Ahead of the detailed design of the barrier about 50 boreholes were sunk and much other work done to investigate the geology of the site. The chalk here is about 180m thick and provides good foundations for the barrier.




*Cross section along the Thames Barrier showing the position of the piers and the underlying geology*

In the southern part of the channel the Chalk appears in the river bed or beneath about 5m of river gravel and mud. This shows that in the recent past, say 10,000 years ago, when sea level was many metres lower than it is now, the topmost few metres of the Chalk here were exposed to the shattering and softening action of frost. The piers had to be founded on undisturbed Chalk but the builders had problems in draining off water before placing concrete foundations for the piers.

*After crossing Woolwich Road, follow the Green Chain signs to the right. Once in Maryon Park, when you reach the Interpretation Board about Gilbert's Pit take a small diversion from the Green Chain Walk and go up the steps to the top of Cox's Mount. Go back down the steps to get back on the Green Chain Walk.*

## 2 Viewpoint at Cox's Mount in Maryon Park

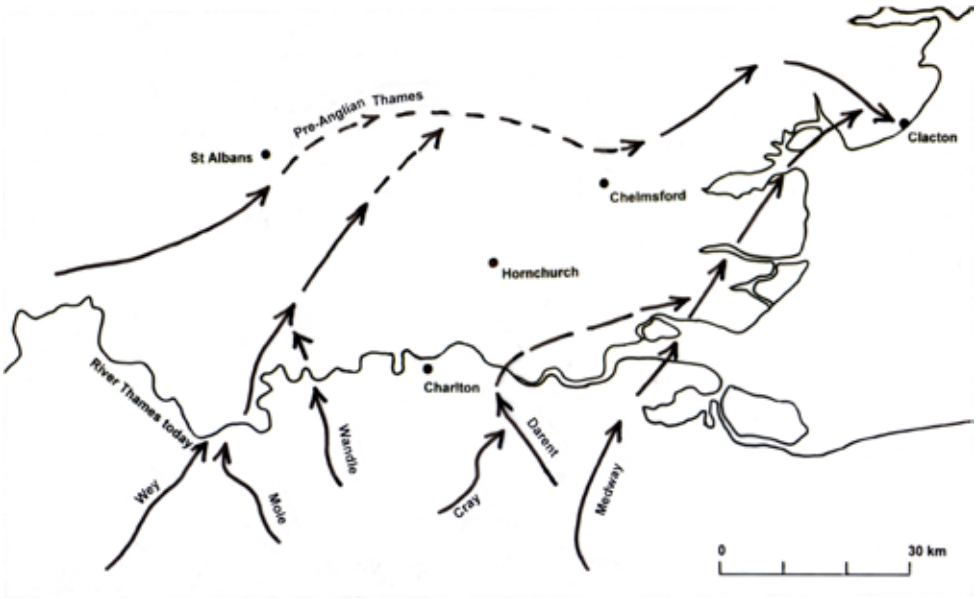
When you arrive at the top of Cox's Mount you will see the remains of an Iron Age hill fort behind the iron railings. Then turn and admire one of the most impressive views of the Lower River Thames to be found In London. From here you can see Charlton Athletic football ground in a former Chalk quarry, the Thames Barrier, the Millennium Dome, the Queens House at Greenwich and the Blackheath Plateau above it.

Discoveries at Boxgrove, Sussex in 1993 suggest early man was established in Britain about 500,000 years ago although the Thames would not have been here. It ran to the north of the present route, flowing into the sea near Chelmsford where the River Blackwater flows today (see first diagram on page 6).

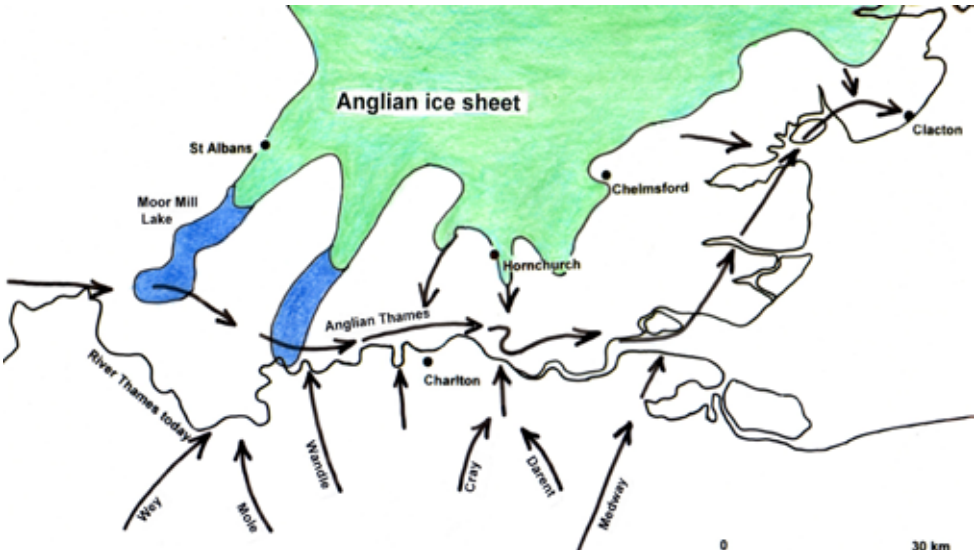
Climate changed rapidly 450,000 years ago in the Anglian Ice Age. Looking north at that time you would have seen a massive glacier reaching as far south as North London (see second diagram on page 6). The glacier was up to 1 km high and effectively blocked the route of the Thames to the sea. As the ice began to melt, two large lakes formed and, when the banks of the lakes burst, the Thames was pushed southwards towards its present course.

Eventually the climate improved and early man became re-established in Britain. At least four subsequent ice ages/interglacials have been recognised in the gravels on either side of the Thames with a consequent flux of animals and humans. Cold conditions but no further glaciers reached southern England. About 200,000 years ago the Thames at Woolwich was almost a mile wide with large marshy areas on both sides; the recent course has been mostly engineered by man.

*Diagrams illustrating diversion of the River Thames by the Anglian ice sheet (after Bridgland and Gibbons, 1997)*



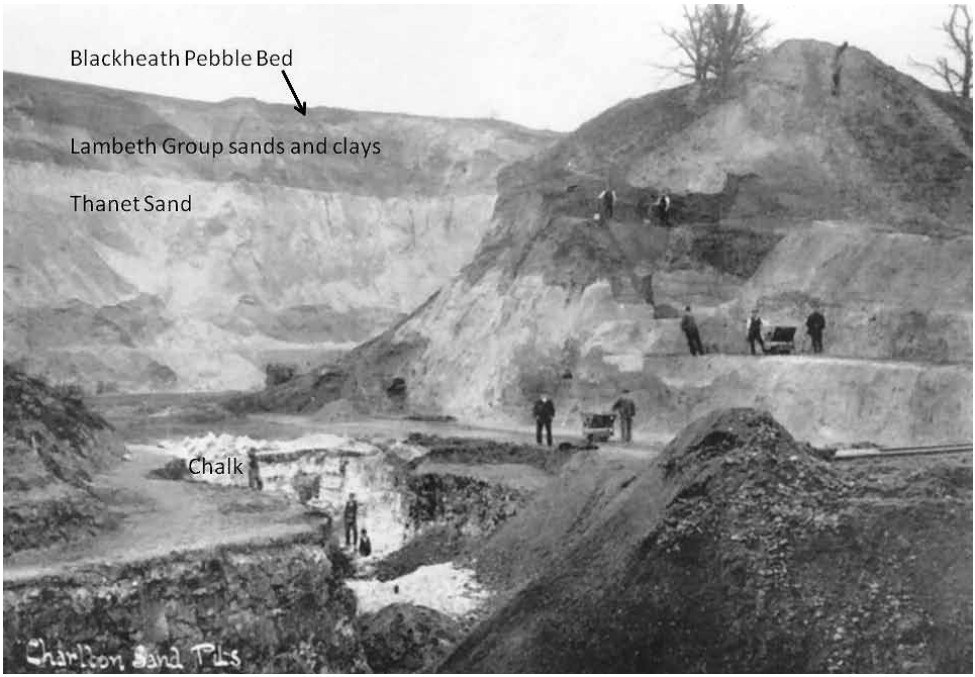

*Route of the River Thames and its tributaries before the Anglian Glaciation*




*Anglian glaciation and the diverted River Thames*

*Return to the route of the Green Chain Walk and stop at the Information Board at the bottom of the steep scree-covered cliff.*

## 3 Gilbert's Pit

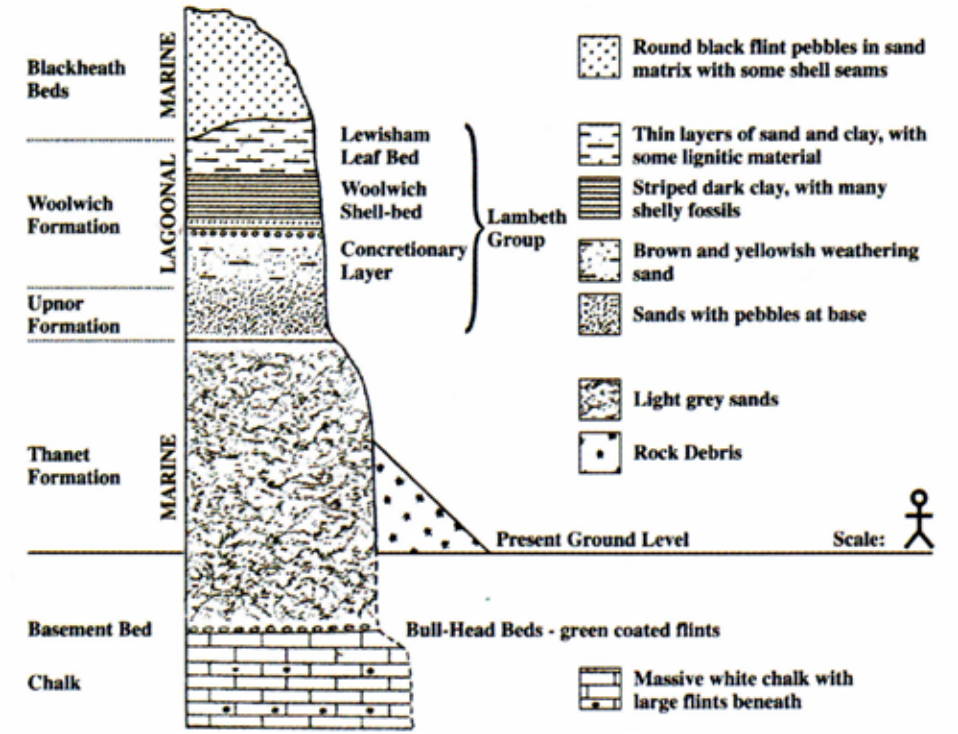



*Gilbert's Pit in 1906*
*(Based upon Plate 8 of the Proceedings of the Geologists' Association, 1950 with permission of The Geologists' Association)*

The photograph shows Charlton Sand Pit being quarried in 1906. There were many pits in the Charlton area exploiting the Thanet Sand and the underlying Chalk. The biggest pit is now home to Charlton Athletic Football Club and another is the landscaped public space on the east side of the slope.

Quarrying operations in Gilbert's Pit ceased in 1938 and the original pit floor is now buried by 10m of wartime bomb damage rubble. Underneath this is the white Chalk, formed by the remains of minute sea organisms when a tropical sea covered Britain. This was some 75 to 100 million years ago. Above this the Thanet Sand, now hidden by slope debris, is composed of uniform very dense light grey sand. Charlton was still beneath a shallow sea when it was laid down about 60 million years ago. It was primarily for the Thanet Sand that the pit was quarried for use in moulding canon shot at the Woolwich Arsenal and for making into glass bottles.

Towards the top of the slope there are sands and fossiliferous shelly clays of the Woolwich Beds, named after this area. Occasional shells can be found at the bottom of the slope where they have rolled down. This sequence is evidence of a transition from marine conditions to mud flats similar to modern mangrove swamps and lagoons, with varying amounts of fresh water. The Blackheath Beds are the highest, and therefore youngest, part of the sequence seen in the pit. They are composed of black well-rounded pebbles of flint in a sandy matrix with occasional seams of shells and were deposited in marine channels that were cut into the underlying Woolwich Beds. Some pebbles have rolled down the slope and piled up behind the fence.




*Section at Gilbert's Pit, Charlton*

This is a very important section as it gives engineers and geologists a rare view of some of the rocks that underlie London, providing information for the many engineering projects. For this reason it is a Site of Special Scientific Interest.

In winter, when the trees are bare, on the steep face on the south side of the old quarry, alternating layers of clay and sand can often be seen more clearly than on the east face.

*Follow the Green Chain Walk through Maryon Wilson Park, noticing the springs near the top of the hill where water percolating through sand meets a clay layer and is forced out at the surface. Before crossing Charlton Park Road turn right to look at the concrete lumps in the wall made with Blackheath Pebbles. Follow the Green Chain directions towards Barrack Field.*

For those interested in looking at the properties of stone and how it weathers, Charlton Cemetery provides some interesting examples. Granite and slate tombstones are the most resistant. Lettering on sandstone blocks can remain sharp but if frost gets behind the surface layer and it peels off, it is completely lost. Limestone dissolves with acid rain and so the lettering tends to become indistinct. Gravestones have the advantage of being dated. For more details of what to look for see: Graveyard Geology" at *http://www.es.ucl.ac.uk/schools/LondonWalks/walks.html*

## 4 Charlton Cemetery Wall, Charlton Park Lane and brickmaking in the area

*Cemetery wall on Charlton Park Lane*

The photograph shows typical London stock handmade bricks in the cemetery wall. Note the 'scrunched' look created when the clod of prepared clay was squashed into the mould. The black patches are the charred remains of organic material (mostly household ash) mixed with the clay so that the bricks became self-combustible, allowing low heat production in a 'clamp' on the fields on which the clay was dug.

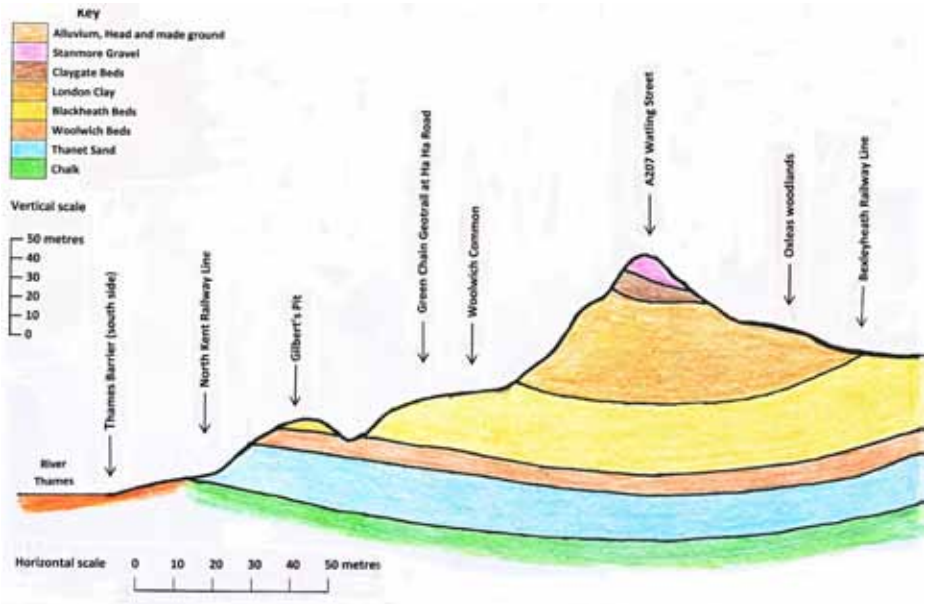
Brickearth was the most important of the clays used in the area. It mostly consists of very fine-grained clay containing a certain amount of ground-up Chalk but there can also be some sand mixed in when it was re-deposited by water on top of the gravels. The London Clay was also used for brickmaking but requires the addition of some sand and Chalk. All of these products can be found close by and brickmaking was formerly an important industry in the area. More evidence will be found along the route.

The 1866 Ordnance Survey map shows 1 Brick Field, 3 Clay Pits, 2 Clay Mills and 2 Potteries within a couple of field widths of the next mile of our route.

*After the wall next to Charlton Cemetery, you enter Ha Ha Road, still on Blackheath sand and pebbles.* [Note that Ha Ha Road will be closed during the Olympic and Paralympic Games; follow the diversion southwards around this area.]

## 5 Ha-Ha and Shooters Hill

Next to the road is a long and deep ha-ha built about 1774 that separates the former Royal Artillery Barrack Field from Woolwich Common. The ha-ha acted as an invisible fence to keep cattle out of the Royal Artillery grounds. The fact that this ditch is usually dry is evidence for the Blackheath Pebbles. You are at the northern end of Woolwich Common, which gently rises southwards where it becomes London Clay. However, much of the southern half of the Common is overlain by imported soil and rubble.




*Cross-section of Shooters Hill showing the geological layers*

Beyond the Common and slightly to the left you can see Shooters Hill and, at 130m, it is the second highest point in London. Shooters Hill is formed of about 70m of London Clay. The hill is capped by sand and flint pebbles, which is the reason that Shooters Hill has not been eroded and a line of springs exists around the hill. These pebble beds are found capping the highest hills throughout London and there is an argument on whether they were deposited on beaches or by earlier river courses over a million years ago.

Where we are standing the London Clay has been removed by erosion but north of the Thames it still provides almost ideal tunnelling medium for the deep tube lines of the Underground. Absence of London Clay in south London explains why, for the most part, the underground system did not extend south of the Thames until recently.

Waters from the London Clay towards the top of Woolwich Common, like those more famous from Epsom, were, in 1673, said to be "medicinal for internal and external griefs: the scent nitrous and bituminous, the taste brisk and partly bitterish". In about 1700 George and Francis Moult at "the Springs on one side of Shooters Hill in Kent" had "made such large Apparatus for evaporating the Water, that they have sometimes boyl'd down 200 Barrels in a Week, from which, in a dry Season, and when the Land Waters did not get into their Drains, they have obtain'd 224 Pound of Salt (Epsom Salts)". [By 1720 all Epsom Salt was obtained much more cheaply from sea water]

*The route of the Green Chain walk continues along Nightingale Place and Plumstead Common Road where road names can give clues to the underlying geology. Look out for Brook Hill and Sandy Hill Road en route.*

## 6 Dog Rocks

*Dog Rocks, Plumstead Common*

The Dog Rocks can be found in the shrubbery opposite the entrance to the Adventure Playground. They are so called from their shape seen in silhouette. They are Blackheath Pebbles that have been naturally cemented and are very similar to those already seen in Gilbert's Pit (Stop 3). For the most part, the Blackheath Pebbles are uncemented but just occasionally small areas of cemented pebbles can be found such as here at Dog Rocks.

The steep bank crossing the common is one side of the former quarry, which was the source of the rocks. Evidence of brick making can be seen in the amphitheatre formed by the quarry. The low walls are made of over-burnt bricks (clinker). Garden walls of clinker are a good indication of former brick works close by as they don't travel far.

*Continue along the Green Chain Walk to view the gorge, known as the Slade (Stop 7) from the top before walking down the steps to the pond at the bottom of the valley*

## 7 The Slade

*Exposure of Blackheath Pebbles on the south side of The Slade*

*Close up of Blackheath pebbles*

The head of the Slade Ponds is close to the site of a spring shown on the 1866 O.S. map. The steep sides of this valley are clearly seen to be cut into the Blackheath Pebbles. The base of the pebble bed here, as in many places in south east London, is marked by a spring where water soaking down through them meets the impermeable clays of the Woolwich Beds beneath them.

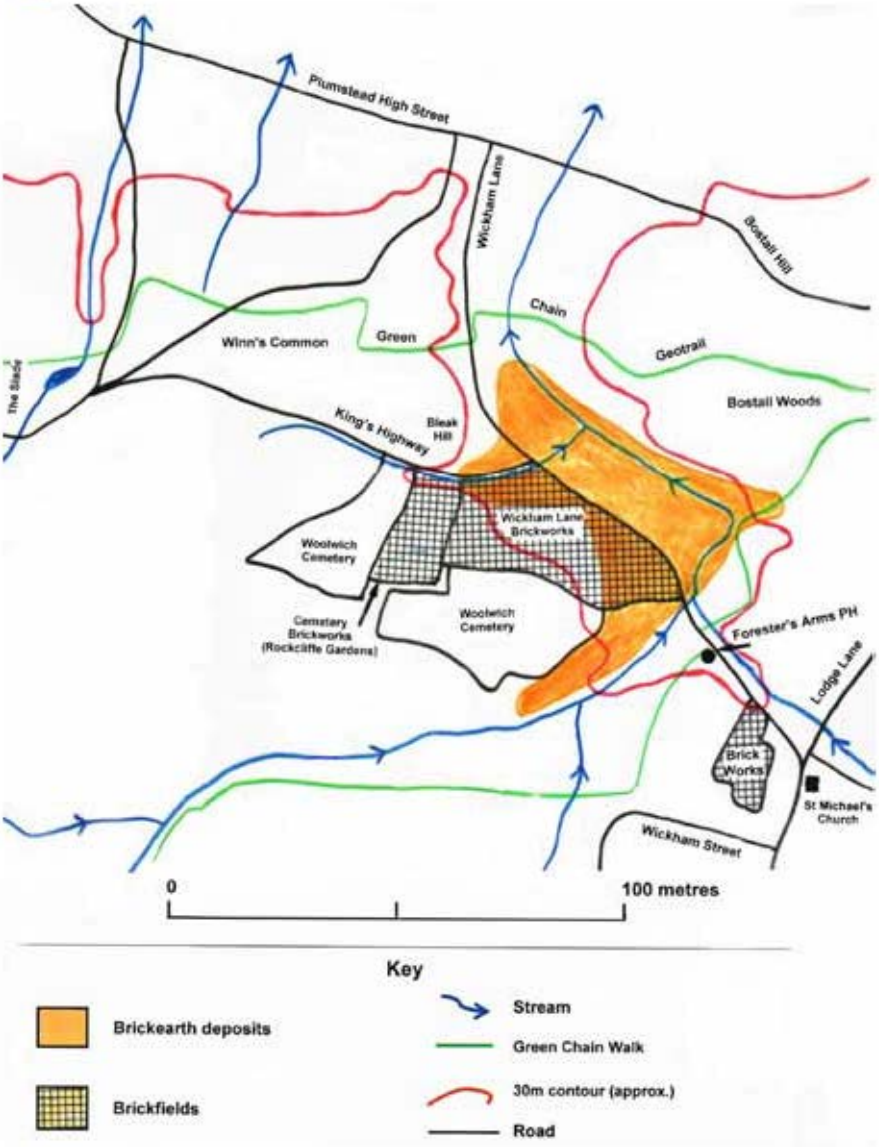
How has this large valley been cut by a very small stream? In the Ice Ages, although the glaciers did not reach south London, the ground would have been frozen and largely impermeable. Surface water flows would have been much stronger in those conditions.

*Follow the fence around to the right and walk up the narrow path at the bottom of the valley. You can see the Blackheath Pebbles in the areas of bare landslip on the left hand side off the path (see photograph).*

The rounded black nature of most of the Blackheath Pebbles is unusual and striking. The pebbles originated from the grey layers of flint that can be seen in the white Chalk cliffs along the south coast. The extreme rounding implies a high-energy environment such as a beach, but without renewal of the flint supply, and it is possible that more than one cycle of erosion and transport may have occurred. All traces of the original white cortex has been removed and if you look closely you can see chatter marks (pits) where they bounced together in fast flowing channels, and white points which are probably solution points where they were in contact with other pebbles in the outcrop.

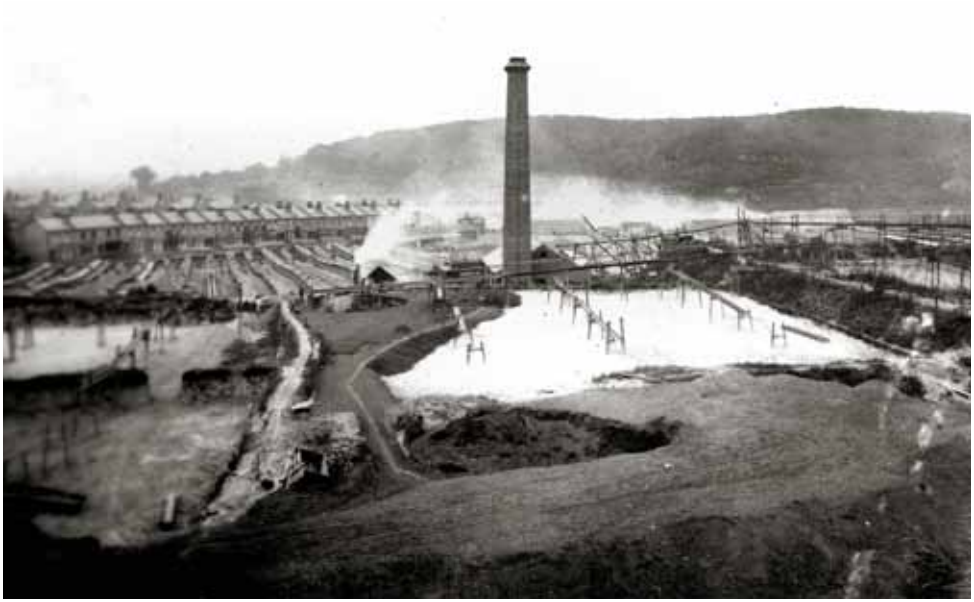
*Turn left at the road until the way-signed Green Chain Walk markers are picked up again to cross the road onto Winn's Common. Continue to wooded Bleak Hill on the side of the Wickham valley.*

## 8 Old Quarries, Winn's Common to Bostall Woods




*Sketch map of former brickfields in Wickham Valley 1860s to early 1900s Based on information from 'Brickmakers Index' by David Cufley*

Leaving the spectacular Slade Valley and walking across Winn's Common you are entering an area that in the late 19th century provided much of the building materials for the major expansion of this part of London. This was energetically proceeding at that time. Although now overgrown and in some cases hard to find, within half a mile of where you are standing a happy accident of geology provided sand and clay for brick making together with flint pebbles useful for aggregate and nearby chalk for lime production. Remember that transport then was by horse and cart making small local brickworks a better proposition than today's centralised factories.



*Wickham Valley brickworks in 1901 looking towards Bostall Woods*
*From http://www.plumstead-stories.com/*
*by kind permission of Colin Weightman*

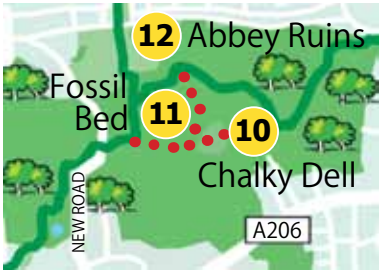
We saw at stop 4 how local clays were used to make bricks. Nearby quarries provided Brickearth for high quality bricks. Geologists call this material loess. During ice ages, the bases of glaciers acted like files with trapped rock acting as scraper teeth. The resulting fine rock flour was deposited here as the glaciers melted. It was subsequently concentrated by water flow into deep deposits in pre-existing valleys.

After crossing the flat Winn's Common, the Green Chain Walk descends a steep wooded slope crossing a very similar geological sequence to that seen in Maryon Park. It is no surprise, therefore, that close by to the south there were, a hundred years ago, similar large sand and clay pits. Here also shafts and tunnels were driven to mine the underlying Chalk

## 9 Bostall Woods

*View towards Bostall Woods from Wickham Lane*

Coming down from Bleak Hill, you cross the Wickham Valley, which has cut deeply through Thanet Sands into the Chalk. You cannot see the stream that made the valley as it has long since been put underground. Storm water from this valley has to be pumped into the Thames to prevent flooding of Thamesmead. As you rise steeply from the Wickham Valley see if you can make out changes in geology through changes in vegetation and steepness of the slope. Much of the open ground near the valley bottom is former chalk pits. At the top of the hill you arrive at Bostall Woods and Bostall Heath. They are the last part of the 7-mile plateau of Blackheath Pebbles from Greenwich Park / Blackheath through Woolwich Common, Plumstead and Winn's Common that have been dissected by steep-sided valleys running north to the flat Thames plain.




*Shortly after crossing New Road, the Green Chain Walk turns left towards Lesnes Abbey. Instead, go straight ahead to the top of the hill and down the other side to Chalky Dell. At the bottom of the hill, on the right, is an entrance through the fence to the exposure.*

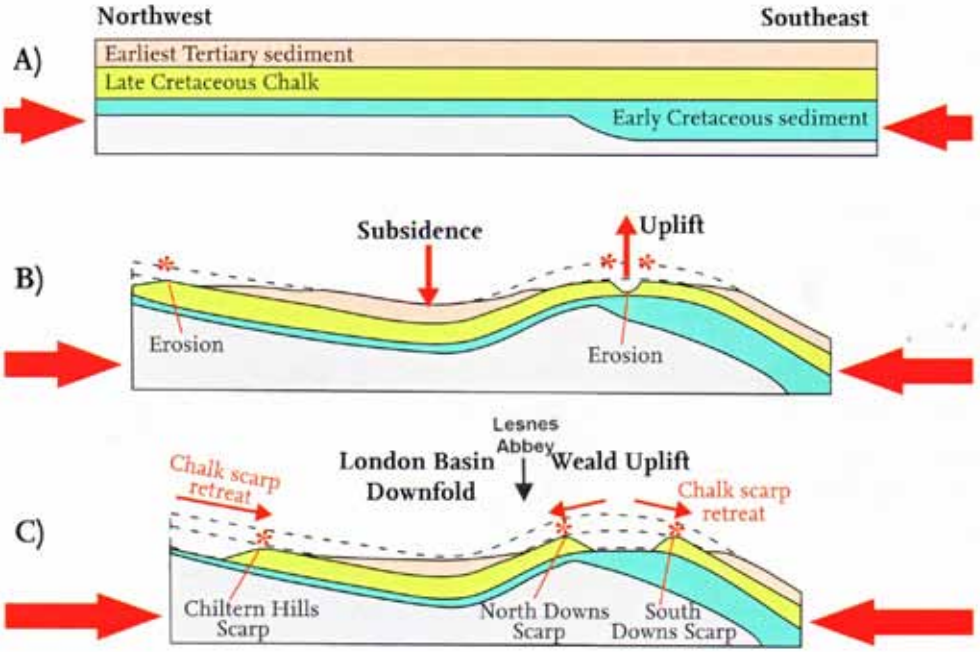
## 10 Chalky Dell, Lesnes Abbey Woods

*Top of the Chalk with the Thanet Sand above*
*From Marriott, 1925*

The quarry was used, initially by the monks and then by farmers, to provide chalk for treating the land. Several small exposures show the underlying chalk although most of the chalk in the quarry is now covered by scree.

It is one of the very few places in the London area that the chalk can be easily accessed. The chalk was laid down when London was covered by a warm shallow sea very similar to the Caribbean today. The chalk is the fossilised remains of tiny sea organisms that thrived in this warm sea. They are so small that a pile of them five high would have the thickness of a human hair. The warm seas retreated to be followed by a shore type of environment that laid down the overlying Thanet Sands.

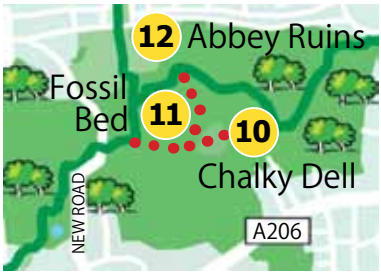
As the northward moving African tectonic plate collided with the European plate the horizontal sedimentary layers were buckled forming hills over what are now the Weald of Kent, the London Basin and Chiltern Hills to the north. With time the single large hill was eroded leaving the North and South Downs as they are today. The chalk here is the eroded stub of the North Downs.




*Evolution of the London Basin and the Weald*

*Movement of tectonic plates folded and tilted the bedrocks from (A) to (B) leading to a downfold (syncline) beneath London and uplift (anticline) in the Weald. Erosion has led to the chalk scarps and basin of today (C).*
*After fig. 10 in Friend, 2008*

In this area many vertical mine shafts were dug to get chalk, some in Abbey Wood. They are known as Dene holes and are widespread in North Kent some dating back to Roman times.




*After visiting Chalky Dell, retrace your steps uphill. At the top turn right towards the fossil bed, this is a short way down on the left-hand side.*

## 11 Fossil Bed enclosure, Lesnes Abbey Woods

The Fossil Bed was discovered by accident when the eminent geologist William Whitaker was out walking his dog sometime in the 1870s. Whitaker went to investigate the rabbit hole that his dog had been digging into and much to his amazement he found fossil marine shells and sharks' teeth amongst the sand. Further investigations were even more remarkable as very occasionally they turned up small bones and teeth of early mammals including rodents, early ancestors of horses, primates and other animals that don't exist at all today. So far 46 species of mammal have been identified and it is one of the richest sites of a similar age (about 55 million years old) to exist anywhere in the world. For this reason it is a Site of Special Scientific Interest.

Dry sieving of the surface material can be quite productive but digging is not permitted except for the annual dig. Not many of the sieving party are interested in the fossil shells and so it is usually easy to find examples within the enclosed area. Small sharks' teeth fossils can still be found quite easily.

Bexley Council permit visits by individuals and small groups at any time. Larger groups, schools and professional digs should contact Bexley Parks and Open Spaces for permission (email: *parksandopenspaces@bexley.gov.uk*) at least one week before the planned visit.

All visitors must adhere to the following guidelines:

- No more than 2 kg (4.4lb) of material should be removed from the site.
- No more than 0.6m (2 feet) should be dug out.
- Any holes should be refilled.

Further information about the Abbey Wood fossils can be found on the Tertiary Research Group website. Go to 'links' on *www.trg.org* and go to 'Fossils of Abbey Wood'

The Fossil Bed is part of the Blackheath Beds and small rounded black pebbles are found alongside the fossils but are much less abundant than other horizons. However, the by-now-familiar pebbles abound on the footpaths in the higher parts of Lesnes Abbey Woods and it has been shown that there are approximately 25m of Blackheath Beds above the shell bed in this locality. Elsewhere the maximum depth of the Blackheath Beds is about 12m. It seems that a channel was formed carving into the underlying Woolwich Beds (seen at Gilbert's Pit, stop 3) and probably as deep as the top of the Thanet Sand as well. As the Fossil Bed has not been located elsewhere along the slopes of Lesnes Abbey Woods it is thought it is a very rare window into a time when mammals began to diversify after the extinction of the dinosaurs at the end of the Cretaceous Period.

*On leaving this enclosure, walk downhill to re-join the Green Chain Walk, turning left towards Lesnes Abbey.*


*Typical fossils found in the Fossil Bed, Lesnes Abbey Woods*

*Photograph by David Ward*
*Reproduced with the permission of The Geologists' Association from Fig. 54 of GA Guide No. 68 "The Geology of London" © The Geologists' Association, 2010*

## 12 Lesnes Abbey

*View of Lesnes Abbey, 2011*

Lesnes Abbey was founded in 1178 by Richard de Lucy. At that time it may have been directly accessible by boat. Built of stone from Normandy, it is now very much a ruin with most of the stones sold for building material after its suppression in 1524. Please do not interfere with this ancient monument.

The abbey lies about 15m above sea level and good views can be had across the Thames floodplain. The marshland was owned by the abbey and the need to repair dykes and river walls partly explains why it was never a wealthy abbey.

In 1279 the abbey enclosed and drained (inned) most of their marshland between here and Crossness, and the rest 12 years later.

Between 1515 and 1551 the river banks were breached several times and some 2000 acres flooded. At this time a number of extra banks were built at right angles to the river bank so as to link it to the high ground and divide up the drained marshes. The bank which the Green Chain Walk follows north from the railway is based on one of these banks, Gravelly Wall. The last 550 acres or so of these flooded marshes were not recovered until 1623 by the Dutchman Joas Croppenbergh. He was paid by being given half the reclaimed land. All these marshes were again flooded by the great surge tide of 1953.

Much of the ground between Lesnes Abbey and the main road has been built up to a higher level as is clear from the form of the footbridges over the road and railway. The early Thamesmead houses built in the 1960s and 1970s were on concrete platforms to keep them above flood-levels. Examples of this "town on stilts" can be found in Rushdene Road on the north side of the railway.

*Flooded houses in Abbey Wood, 1953*

*Photograph from http://www.ideal-homes.org.uk/ - a history of south-east London suburbs*

*Follow the Green Chain Walk directions to Abbey Wood Station: either left along Abbey Wood Road or over the railway footbridge (painted with Green Chain Walk images) and left along Rushdene Road to look at the raised front doors.*

*This Geotrail was devised by the London Geodiversity Partnership in conjunction with the Green Chain Walk.*

This Geotrail was compiled by Laurie Baker, Diana Clements, Vernon Marks and Paul Rainey, all members of the London Geodiversity Partnership.

Other Geotrails in London are:

- A Geological walk around University College London and Bloomsbury
- Geological Walk in the City of London Cemetery
- Thames Path Geotrail

Descriptions of these walks can be found at:
http://www.es.ucl.ac.uk/schools/LondonWalks/walks.html

*Further reading*

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