Harrow & Hillingdon Geological Society

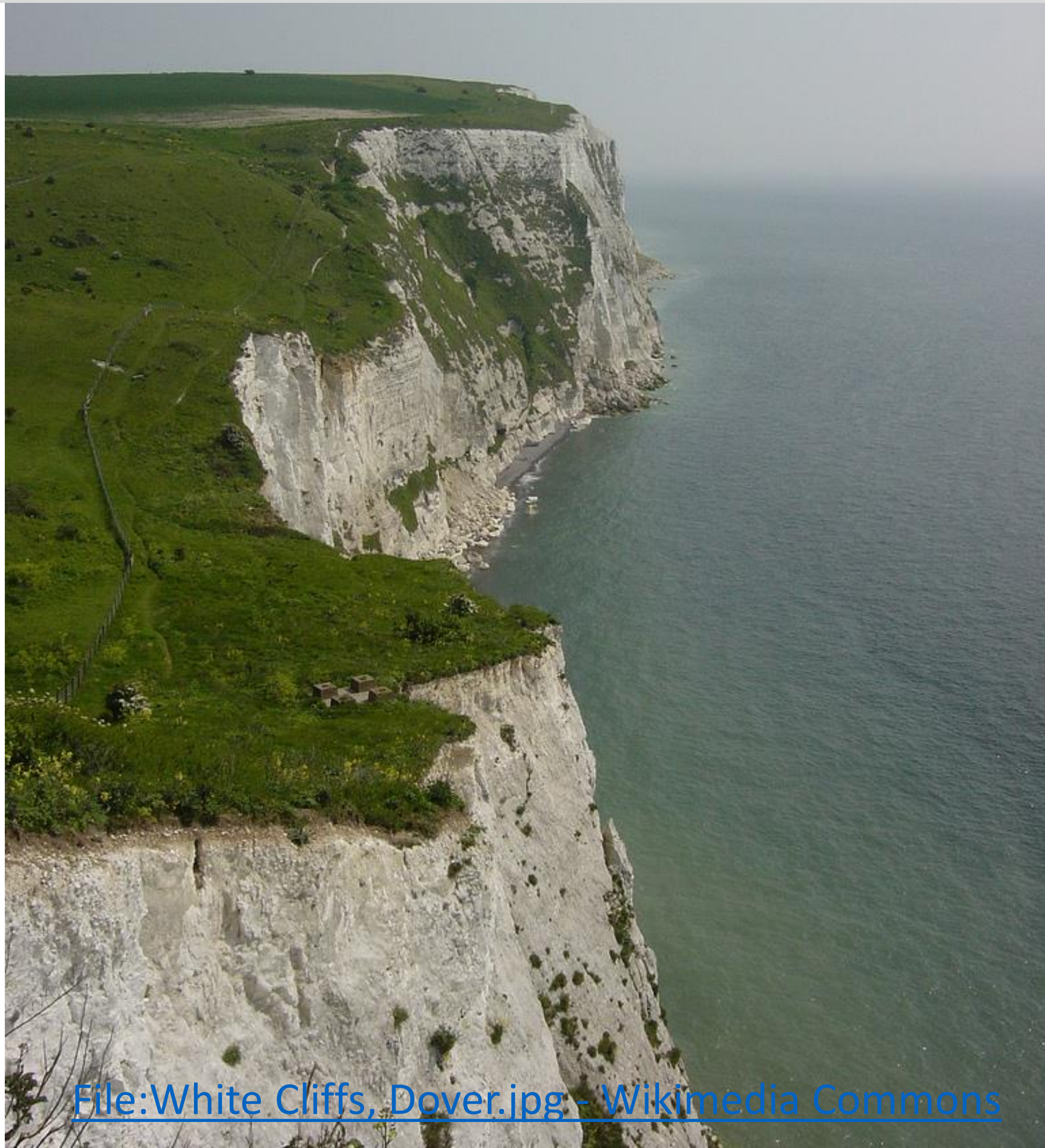
Evidence of past climates
from local rocks

London Boroughs of Harrow and Hillingdon

What can local rocks tell us about climate change?

The Southeast of England is characterised by the great bands of white chalk which form the hills of the Chilterns and the North Downs. Between them is the London Basin with its accumulation of pebbles, silts and clays laid down in shallow seas and coastal plains in a sub-tropical climate. The Thames Valley cuts through the basin carrying young rocks from the Ice Ages in the last 2.6 million years. The geology of London tells the story of the changing climate through time.

File:Alton Barnes White Horse (48744910806).jpg - Wikimedia Commons



File:White Cliffs, Dover.jpg - Wikimedia Commons

Map of London area

showing

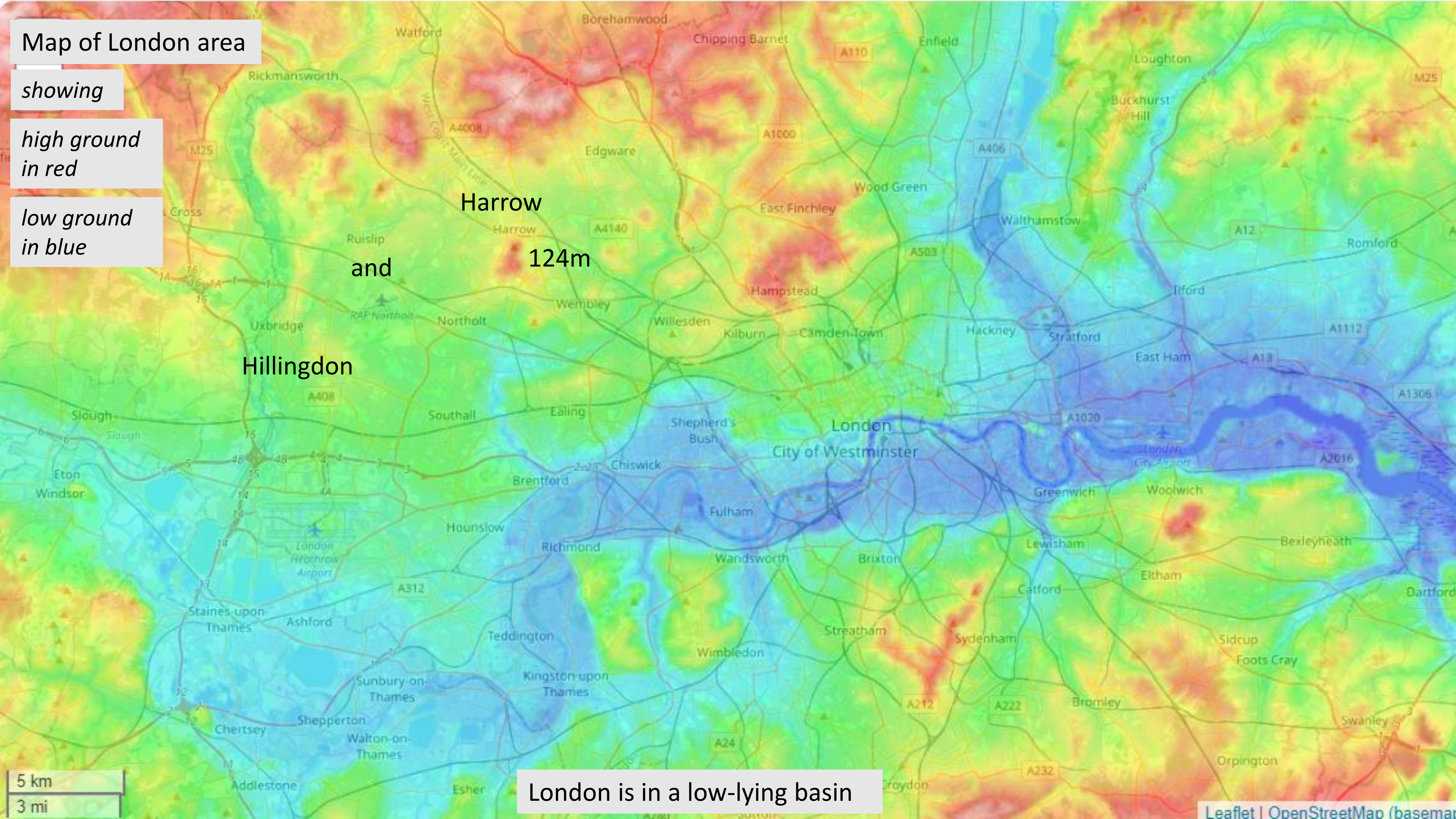
high ground in red

low ground in blue

Harrow and Hillingdon

124m

London is in a low-lying basin



Harrow on the Hill

At 124m, the 13th highest point in Greater London.

From the top of the hill you can see across the London Basin. Central London is approximately 12 miles away.

The London Basin formed as a result of tectonic movements related to the formation of the Alps, 40-60 million years ago. Most of the area is fairly flat and low-lying, and concealed by urban sprawl, making its geological features hard to see.

So how much do we know about the geology under our feet?

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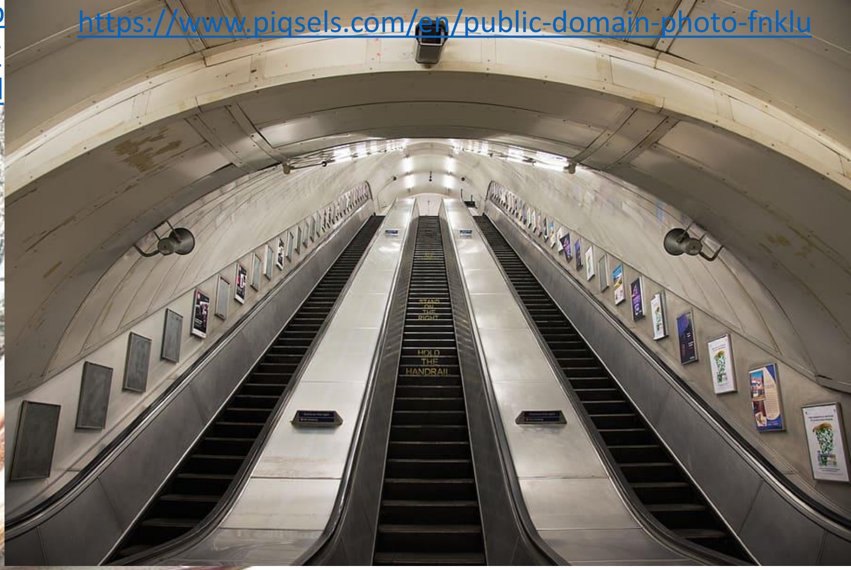
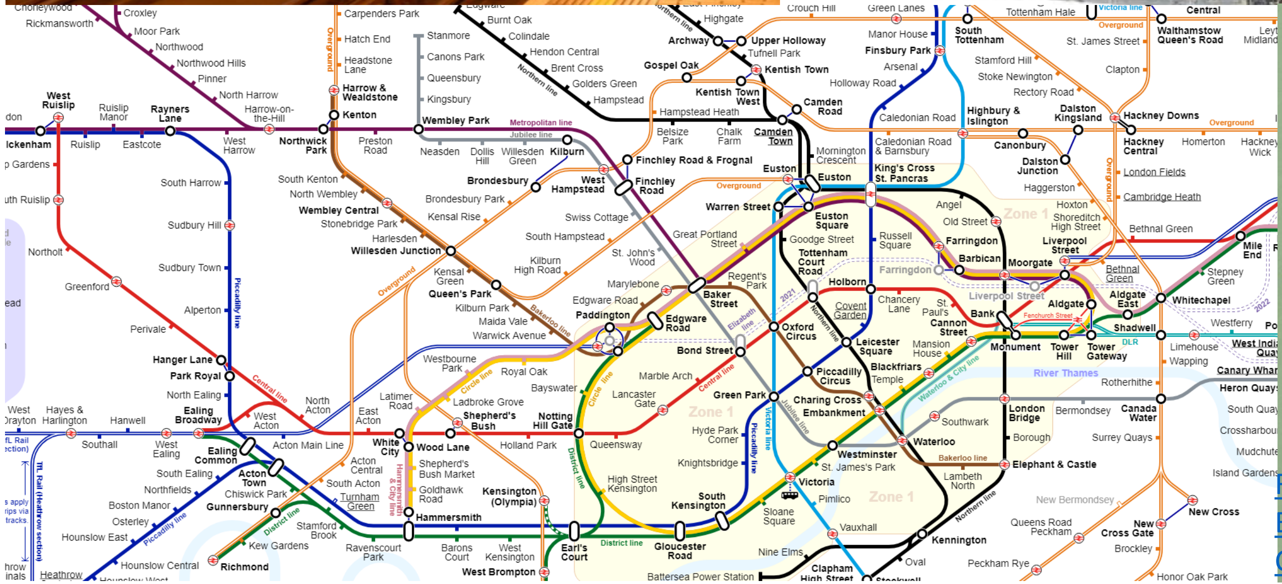
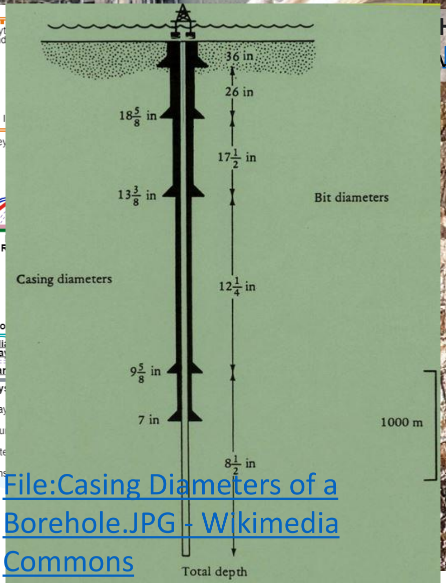


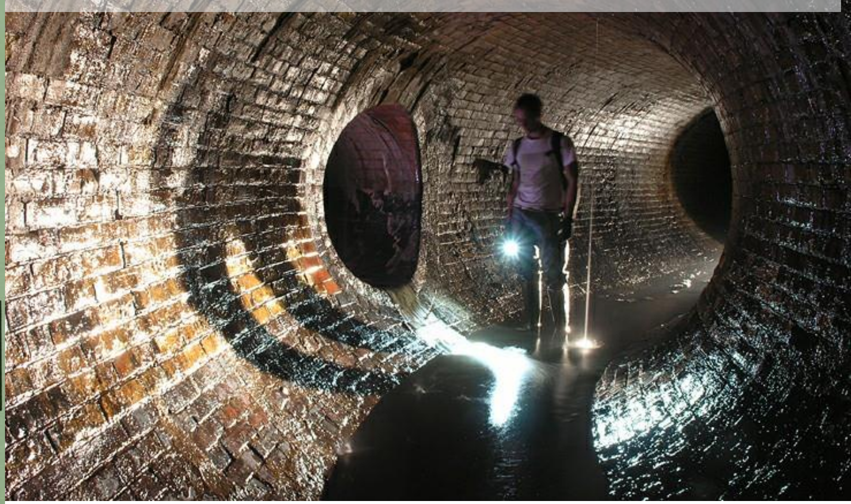




File:Casing Diameters of a Borehole.JPG - Wikimedia Commons

Heavy Mettle - Holloway Storm Relief

https://www.flickr.com/photos/jondoe_264/5306456325 sub-urban.com



We are fortunate that very good records have been kept about London throughout its history and in recent times more tunnel shafts and boreholes have been dug here than under most major cities. We can use these records to trace different rock types that appear at depth and in the same order across the London region and further afield.

Geological Map of the London Basin

Thames Group: Paleogene Period (Eocene epoch) Clays from 52 -48 million years ago

Lambeth Group: Paleogene Period. (Paleocene/ Eocene epoch) 56-55 million years ago

Chalk Group: Cretaceous Period. London's chalk dates from 88 -85 million years ago

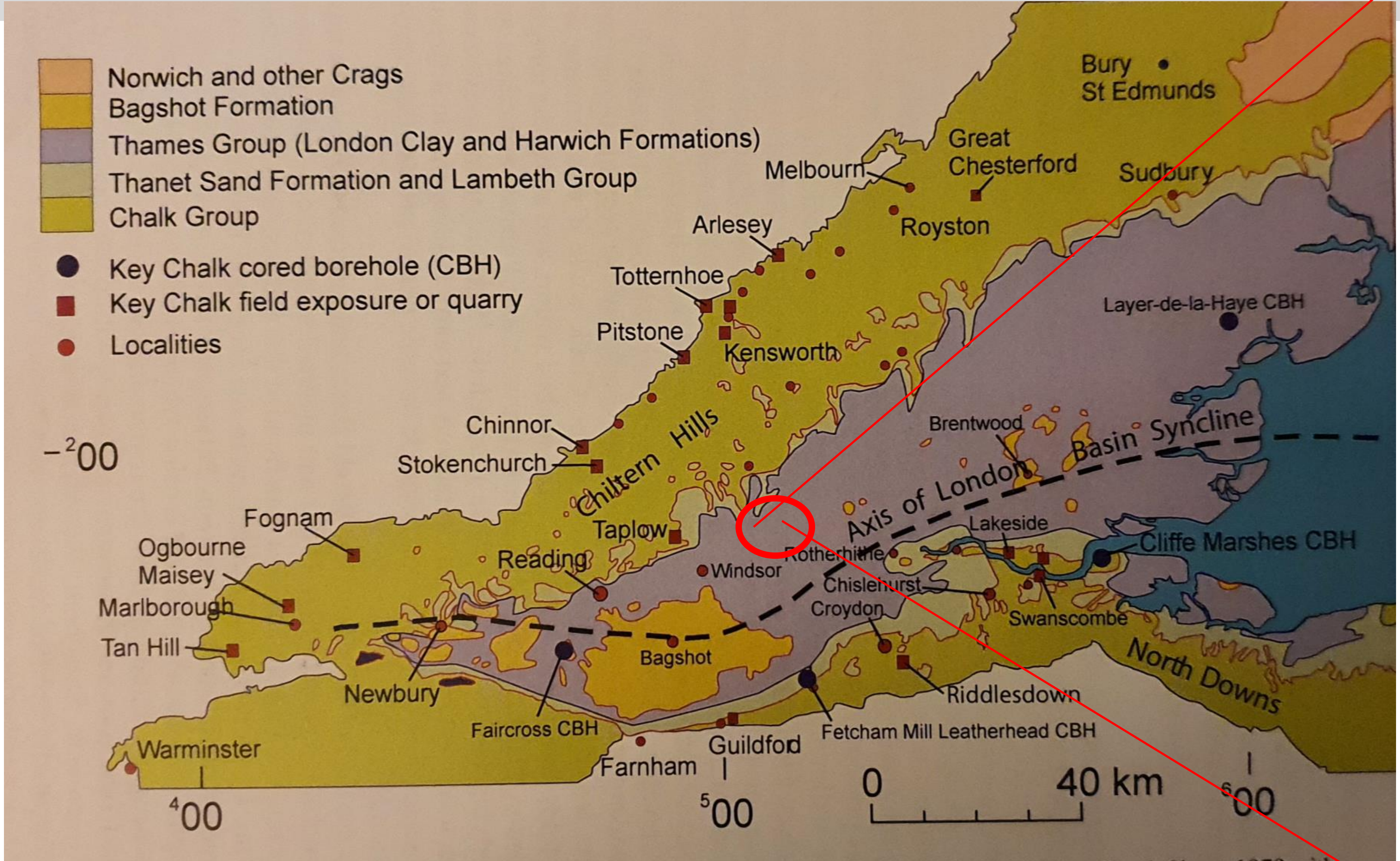


Figure 2. Geological map of the London Basin region (based upon BGS 1: 625 000 Ten Mile Map, South Sheet, 1979 with the permission of the British Geological Survey.) (*R.N. Mortimore*)

Geologists' Association Guide No.68: The Geology of London, compiled by Diana Clements

Harefield Pit in Hillingdon is a Site of Special Scientific Interest (SSSI) because it preserves the succession of rock types above the White Chalk. Layers of pebbles, silts, sand and clay are a record of the changing environment including the time of the last thermal maximum, when temperatures rose by 5-8°C. The same layers of rock are also found in the Pinner chalk mines, Harrow.

Local Rocks through Geological Time

How many million yrs ago	Geological Period: Epoch	Geological Formation	Exposed at	Climate details
c.48 Ma	Paleogene:Eocene (Late Ypresian stage)	Bagshot Fm. (Bracklesham Group)	Harrow Hill	Warm/humid: Fluctuating sea levels. No ice at poles
c.49-48 Ma	Paleogene:Eocene (Ypresian stage)	(Thames Group) Harwich Formation	Exposed only at Harefield SSSI	Warm/humid: Fluctuating sea levels. No ice at poles
c.52-49 Ma	Paleogene:Eocene (Ypresian stage)	(Thames Group) London Clay Fm. & Claygate Member	Claygate Member at Harrow Weald Common	High sea levels. Warm temperatures No ice at poles
56-55 Ma	Paleogene:Paleocene/Eocene (Thanetian-Ypresian stages)	(Lambeth Group) Reading Formation	Harefield SSSI Northwood Gravel Pit; The Dingles, Pinner	Paleocene-Eocene Thermal Maximum (PETM) – Temperatures increased by 5-8°C. This is our nearest analogue to the climate change we are seeing now.
56-55 Ma	Paleogene:Paleocene/Eocene (Thanetian-Ypresian stages)	(Lambeth Group) Upnor Formation	Exposed only at Harefield SSSI	
88-85 Ma	Cretaceous: Upper=Late (late Coniacian / early Santonian stages)	(Chalk Group-White Chalk Subgroup) Seaford Formation	Harefield, Pinner chalk mines	No ice at poles; high sea levels; globally warm, wet and swampy conditions

Cross Section of the London Basin

For the past 56 million years, the London Basin has been accumulating sediments such as clay, gravel and sand. These lie on top of older rocks from the time of the dinosaurs.

These older rocks include the white chalk that is found across southeast England. If you dig deep enough anywhere in London you will find it.

Dig even deeper and you will find even older rocks - such as those found in the southwest of England and Wales. However, we cannot see those at the surface anywhere in London.

In Harrow and Hillingdon we find chalk of the Seaford Formation.

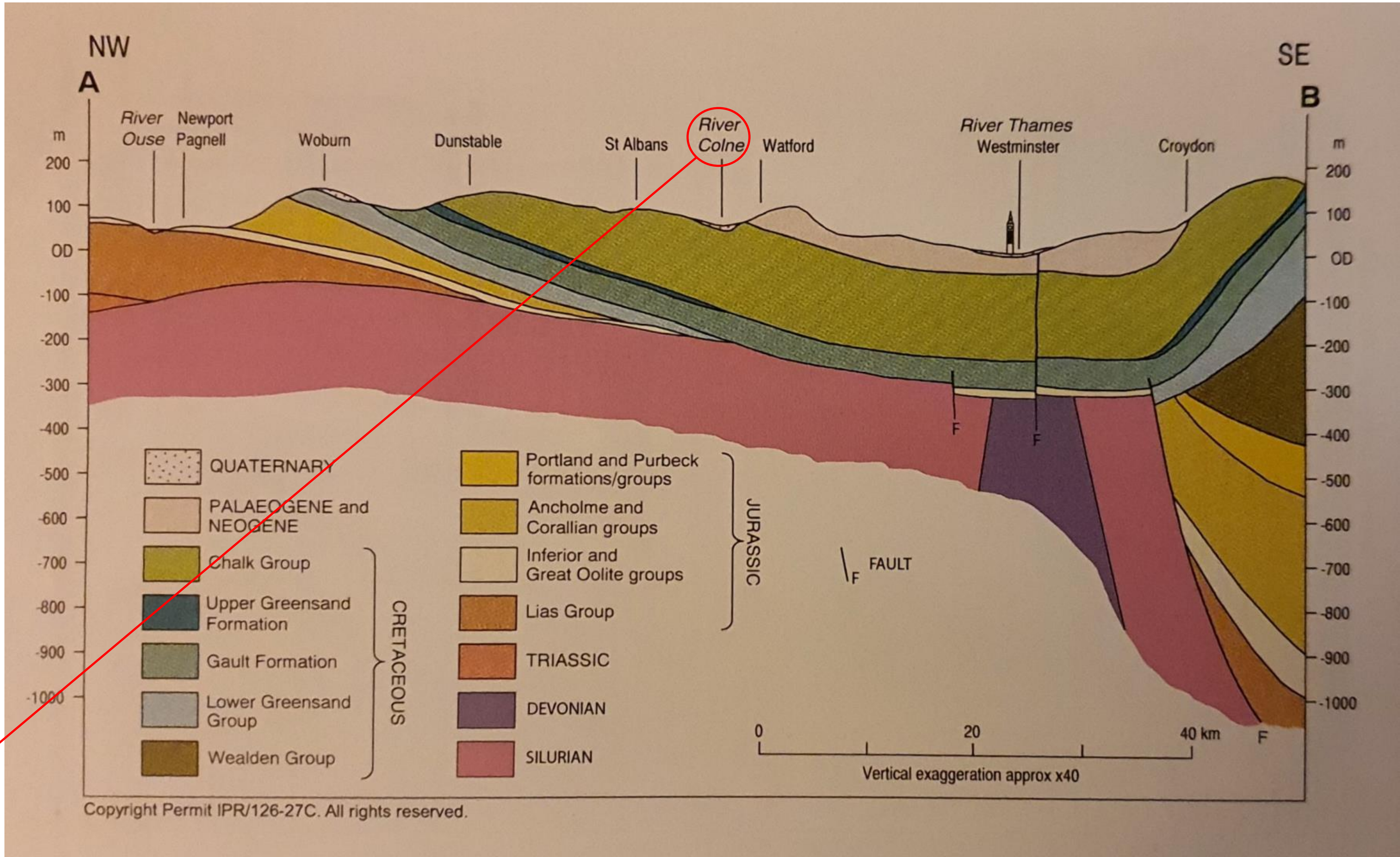


Figure 4. Cross-section of the London Basin showing how the older outcrops can be seen on either side of the Thames Valley. The syncline is superimposed on the older anticline of Palaeozoic rocks. *IPR/126-27C British Geological Survey © NERC. All rights reserved.*

Image from the Geologists' Association Guide No.68: The Geology of London, compiled by Diana Clements

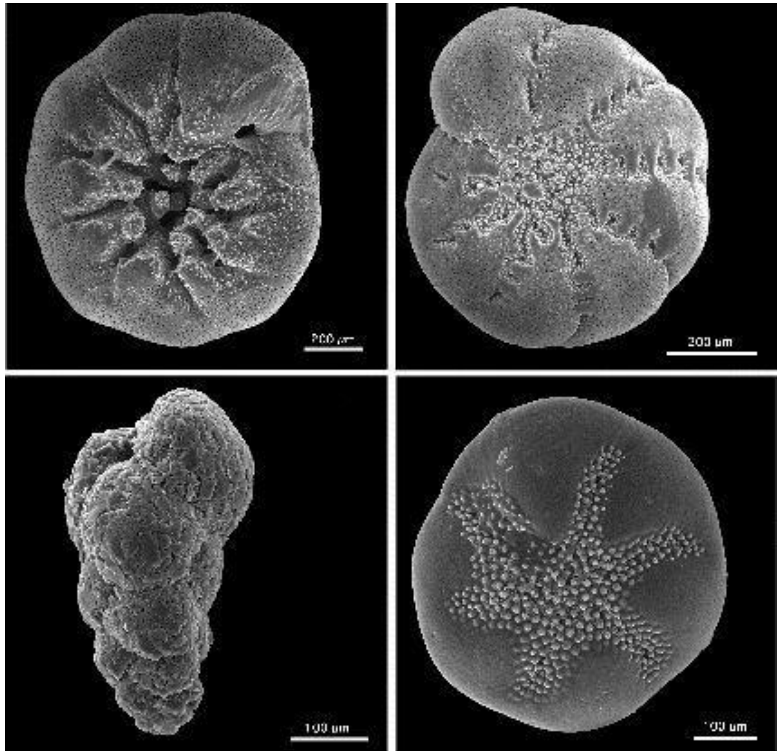
The Seven Sisters Chalk Cliffs at Seaford, East Sussex

What is Chalk?

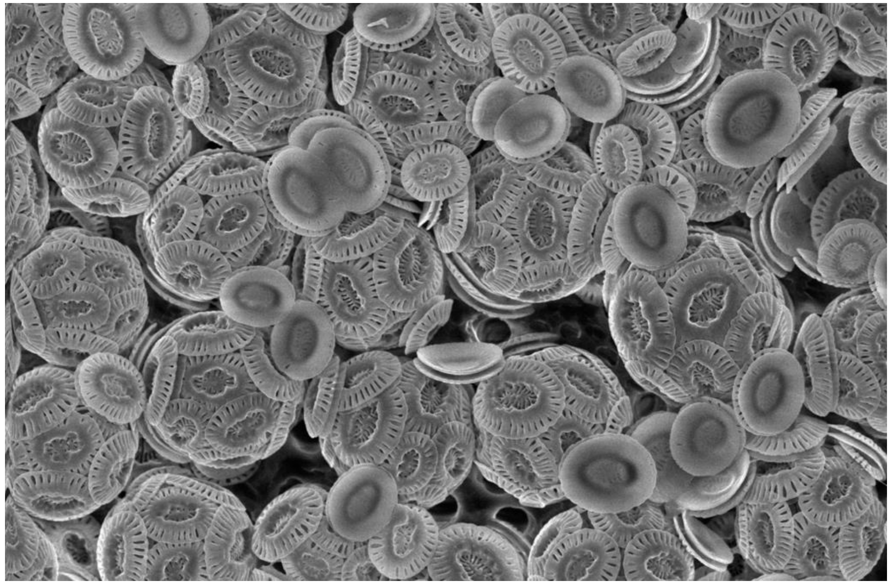
[Read about it on Geology.com]

The remains of tiny micro-organisms in the sea create a marine sediment which accumulates on the sea floor as ooze. If this is high in calcium carbonate ($CaCO_3$) and the sea conditions are just right, chalk will form.

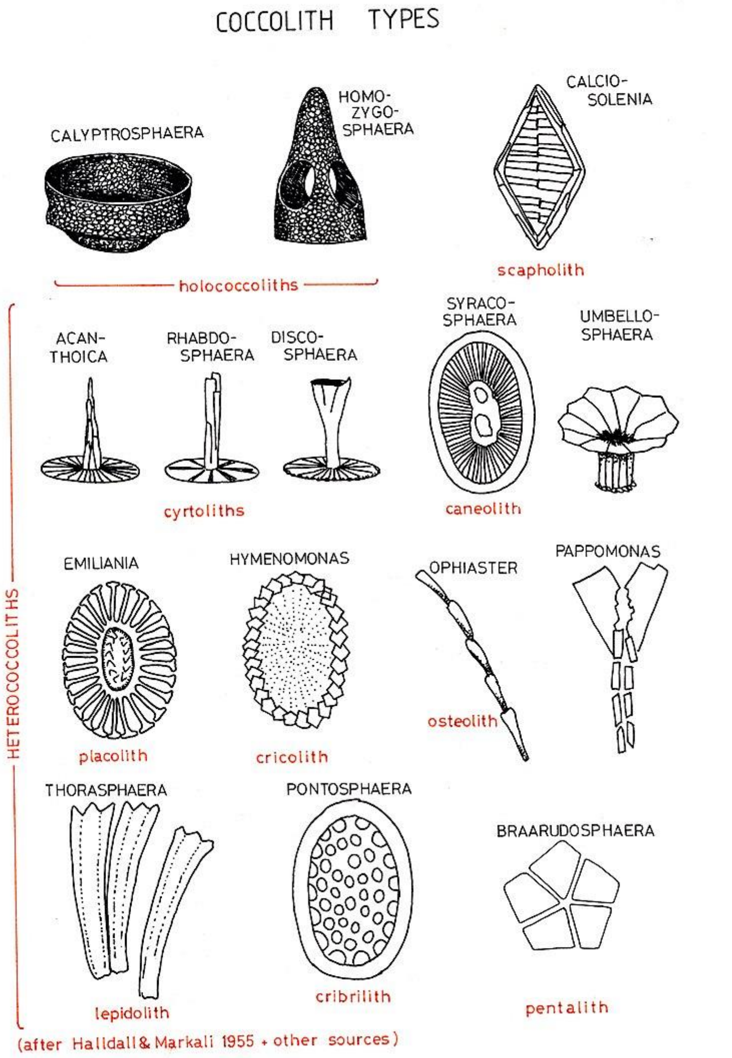
By examining chalk under a scanning electron microscope it is possible to identify plates of calcium carbonate called coccoliths from single-celled algae (coccolithophores), and the shells of tiny marine animals known as foraminifera (also high in $CaCO_3$).



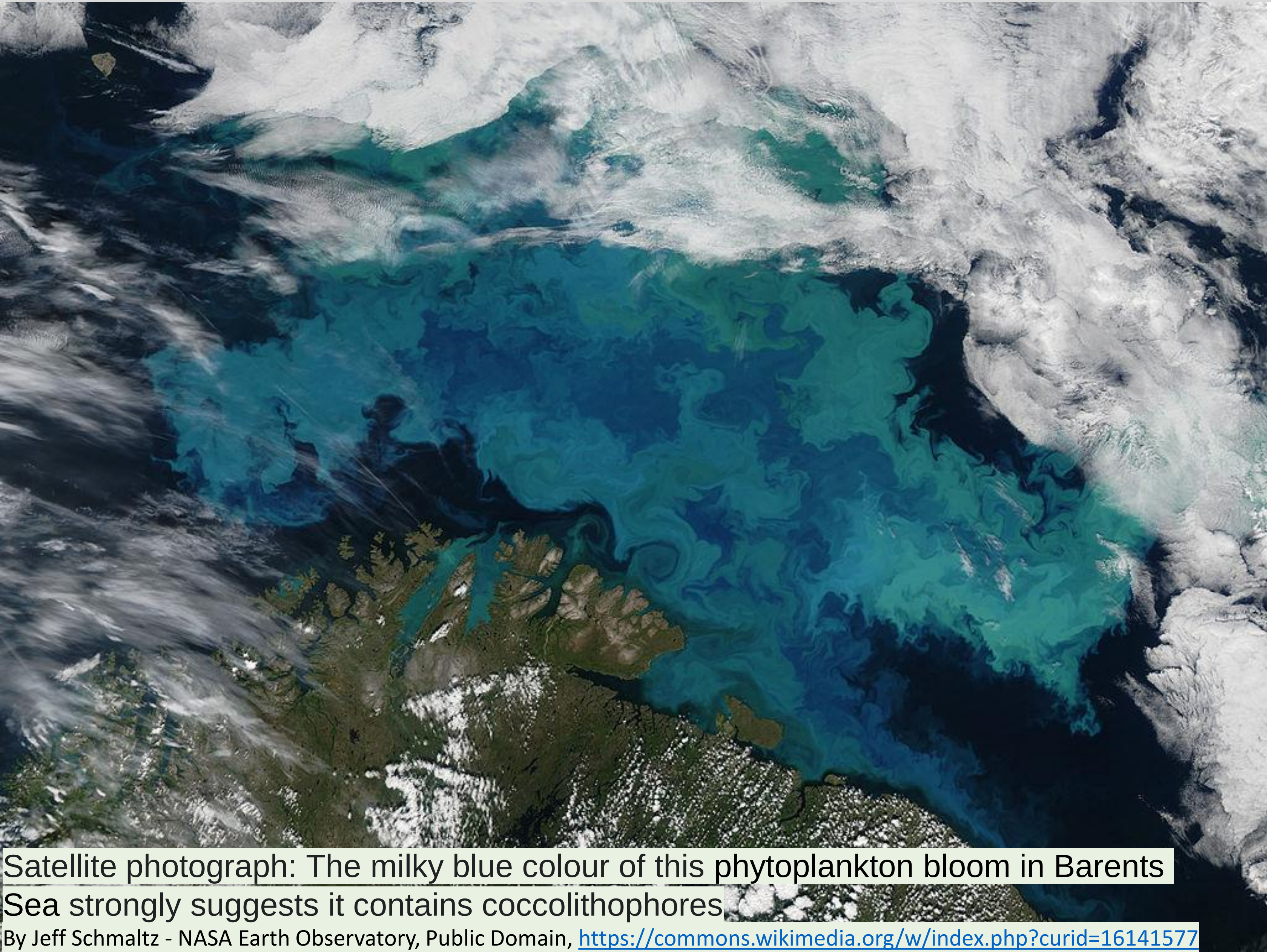
Present day foraminifera shells. Photo by Roger B. Williams – http://www.kgs.ku.edu/Publications/ancient/f06_fusulin.html



Present day coccolithophores. Photo by Robin Mejia.(Dr. Alison Taylor. - [1] doi:10.1371/journal.pbio.1001087, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=99404892



Chalk and Climate



Satellite photograph: The milky blue colour of this phytoplankton bloom in Barents Sea strongly suggests it contains coccolithophores.

By Jeff Schmaltz - NASA Earth Observatory, Public Domain, https://commons.wikimedia.org/w/index.php?curid=16141577

What do we know about the climate at the time when the Chalk was forming?

Sea-levels were particularly high when the white chalk formed, over 150m above the present sea level with no ice at the poles and warm sea surface temperature; southern England lay beneath a warm shallow sea. The chalk formed at depths of 100m-300m and contains few impurities from river sediments due to arid conditions on land.

The level of CO_2 in the atmosphere was high, creating ideal conditions for algae to bloom and create massive quantities of sediment and an ooze rich in calcium carbonate.

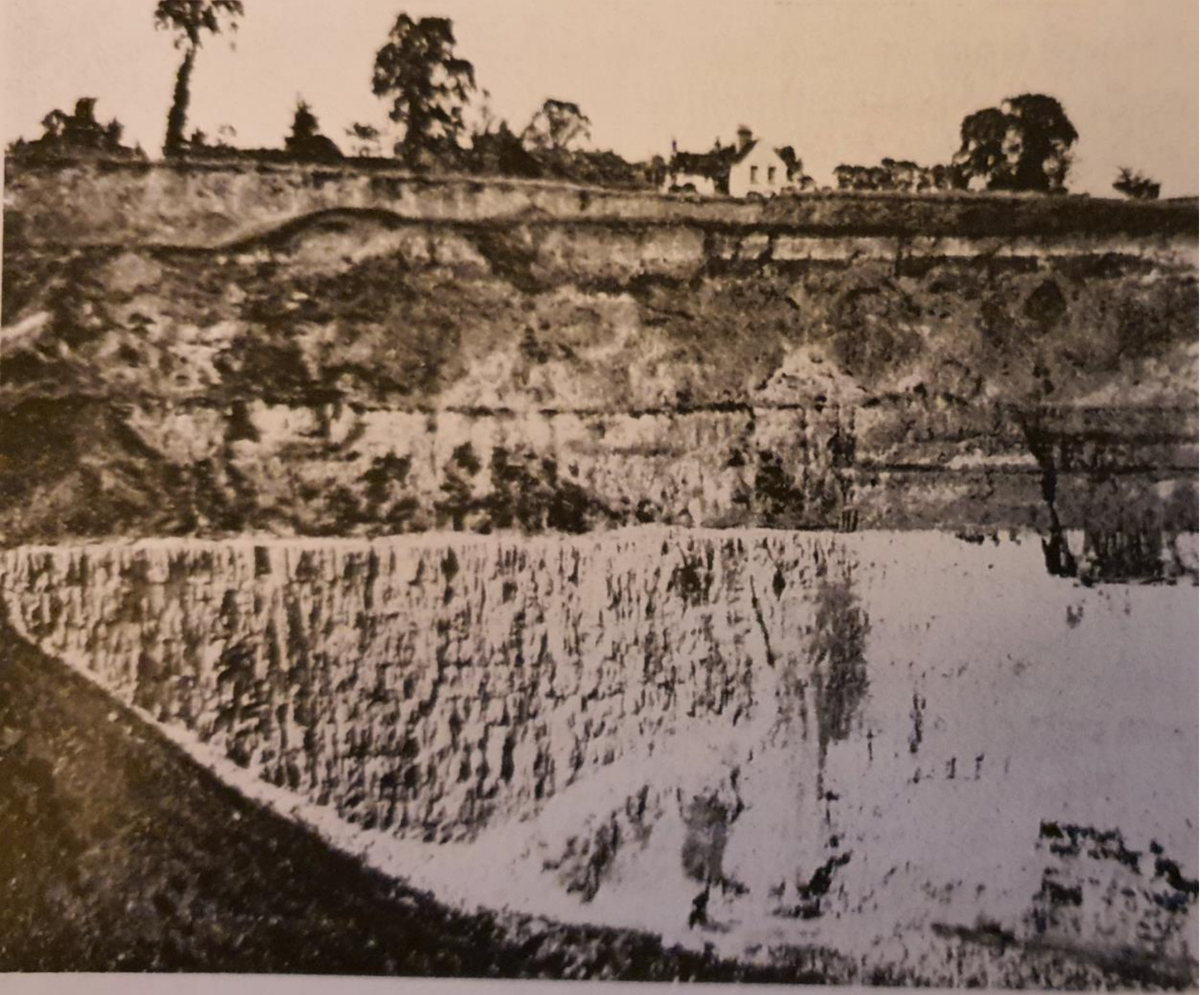


Figure 14. Harefield quarry when operating in 1914. (*Davies, 1914 Pl.IIa*)

Figure 19. Summerhouse Lane Pit in 2005 showing dissolution pipe (centre). This pipe reappears at the base of the pit.

Seaford Chalk is the same White Chalk that is found in Hillingdon at Harefield Pit SSSI and Summerhouse Lane Pit, and also at the Pinner Chalk Mines in Harrow; other outcrops in the London area occur near Greenwich, Bromley and Croydon.

Across London we find layers of sand and clay above the chalk, sediments that were mostly laid down in shallow coastal seas covering the area where London stands. The London Basin had formed after the chalk as a result of tectonic movements.

White Chalk from Harefield Pit SSSI

Chalk Group
White Chalk Subgroup
Seaford Chalk Formation

Dingles Chalk Mine, Pinner

Images from the Geologists' Association Guide No.68: The Geology of London, compiled by Diana Clements

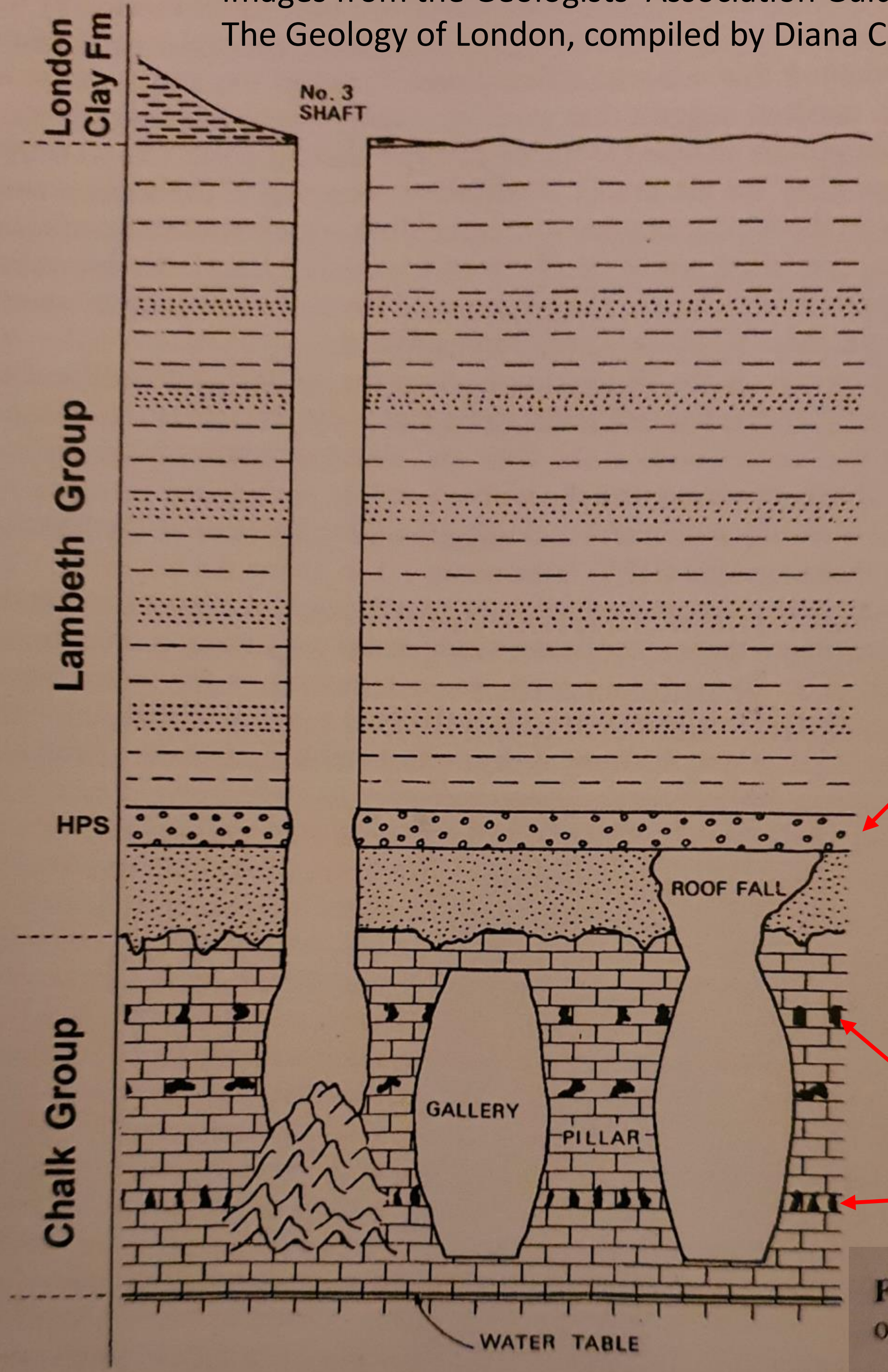


Figure 22. Section through the Dingles Mine showing the geology and method of working. HPS = Hertfordshire Puddingstone. (*After Gallois, 1982*)

Hertfordshire Puddingstone

Above the chalk in Pinner we find a layer of this beautiful rock, 55.6 million years old.

Figure 25. Portion of Hertfordshire Puddingstone from a roof fall in Dingles Mine, Pinner. Length of clast is *c.* 10 cm. (*Collection J. Pester*)

Cementation at the time of formation indicates a warmer climate; this was the time of the thermal maximum.

Find out more.

Flint layers

Dingles Chalk Mine in 2001 *(Photo: Bryan Cozens)*

Chalk Group
White Chalk subgroup
Seaford Chalk Formation

Local Rocks through Geological Time

How many million yrs ago	Geological Period: Epoch	Geological Formation	Exposed at	Climate details
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Dingles Chalk Mine, Pinner

Above the chalk layers of the Pinner mines (Harrow) we find sandy layers that indicate a shallow marine coastal environment.

From gravel to sand to silt, the grain size of the sediment gets progressively finer the higher up the column you look until silt becomes interleaved with clay.

The London Clay was deposited in a sea up to 200 metres deep which became first shallower then deeper again in a cycle that repeated 5 times. Each time, coarser material including some pebbles is succeeded by clay, and the clay then becomes increasingly sandy.

This cyclical deposition indicates changing sea levels and a fluctuating climate.

N.B. simplified text, please refer to original

Reading Formation

- clay
- interlaminated clay and silty clay

?Woolwich Formation

- well sorted sand and rare leaf debris

Reading Formation

- mottled clay with concretions and some laminated silt
- greyish green sand
- reddish pink sand
- dark grey claystone

Upnor Formation

- gravelly sand with some silica cemented areas
- sandy gravel, silica-cemented at base
- clayey gravelly sand, poorly sorted and glauconitic

Chalk Group

- unburrowed chalk

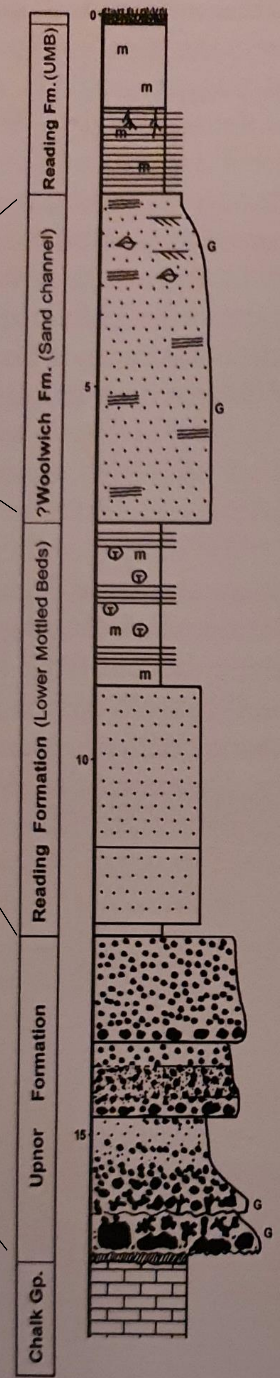

Figure 24. Detailed log of rock overlying Dingles Chalk Mine, Pinner, drawn by Jackie Skipper from exposures due to roof collapse and core obtained by Mark Bradley. UMB = Upper Mottled Beds, G = glauconite (*amended from Gallois, 1998 and reproduced with kind permission of HHGS*).

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The Geology of London, compiled by Diana Clements

Allan Wheeler points out the *unconformity* where there are no rocks to represent a period of about 30 million years.

Above the chalk: Harefield

Lying on top of the chalk is a succession of much younger rocks, recording a gap in time of about 30 million years due to uplift above sea level and erosion. At Harefield we find a rare exposure of the Upnor Formation lying directly on top of the chalk, composed of flint pebbles in a sandy matrix.

Flint only forms in chalk. As Harefield's chalk eroded away over millions of years, the flint was washed out, weathered to pebbles, and then redeposited possibly as a beach.

This was the time when the Alps were forming: ground movements gently folded our region, transforming it from an upland platform to a shallow basin. Once the basin formed, sediments started to accumulate there, about 56 million years ago.

At this period the climate was subtropical and was getting even warmer.

Paleocene / Eocene Thermal Maximum (56-55 million years ago)

This was a period when global temperatures increased by 5-8°C and our region was hot, wet and swampy, similar to Florida today with coastal mangroves.

[The Swamp | This swamp is in Florida and is a good thing, me... | Flickr](https://www.flickr.com/photos/justenoughfocus/) https://www.flickr.com/photos/justenoughfocus/

Local evidence of the Paleocene / Eocene Thermal Maximum

The Coast at Ruislip!

A layer of black clay, thought to have been formed from densely wooded marshes on the edge of a sub-tropical sea, has been found at a depth of 33 metres below the surface at Ruislip.

HS2 workers discover ancient coastline in West London - GOV.UK (www.gov.uk)
HS2 Ground Investigations: Ruislip Bed Discovery – YouTube

Sea levels were still high covering much of what is now land, there was a shoreline from the Wash to the Isle of Wight. The sea depth and shoreline continued to change and we now know that 56 million years ago the coast was located where Ruislip is today, further west than originally thought.

The Ruislip Bed is not found at Harefield or Pinner even though it is situated between them.

Harefield Pit SSSI

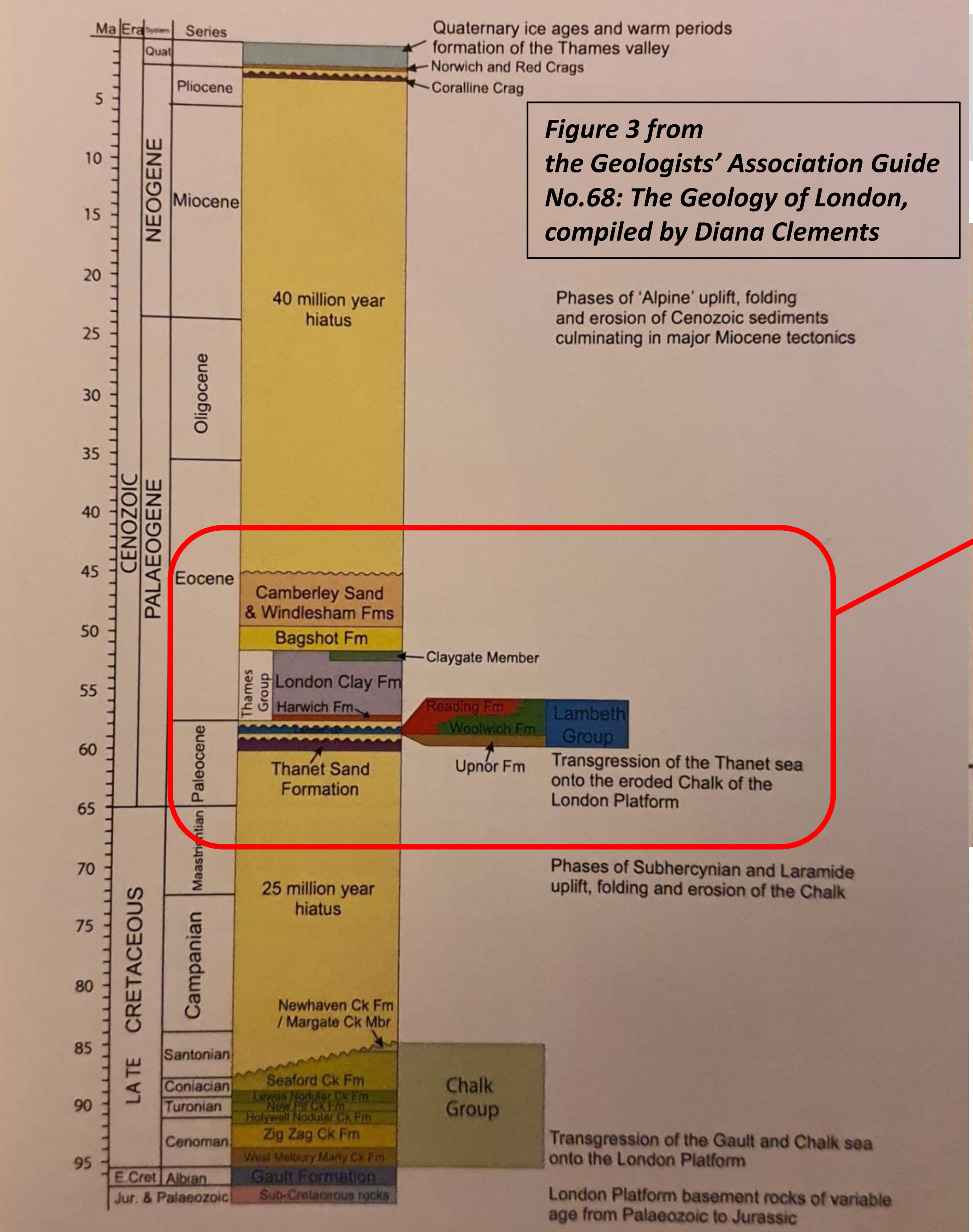
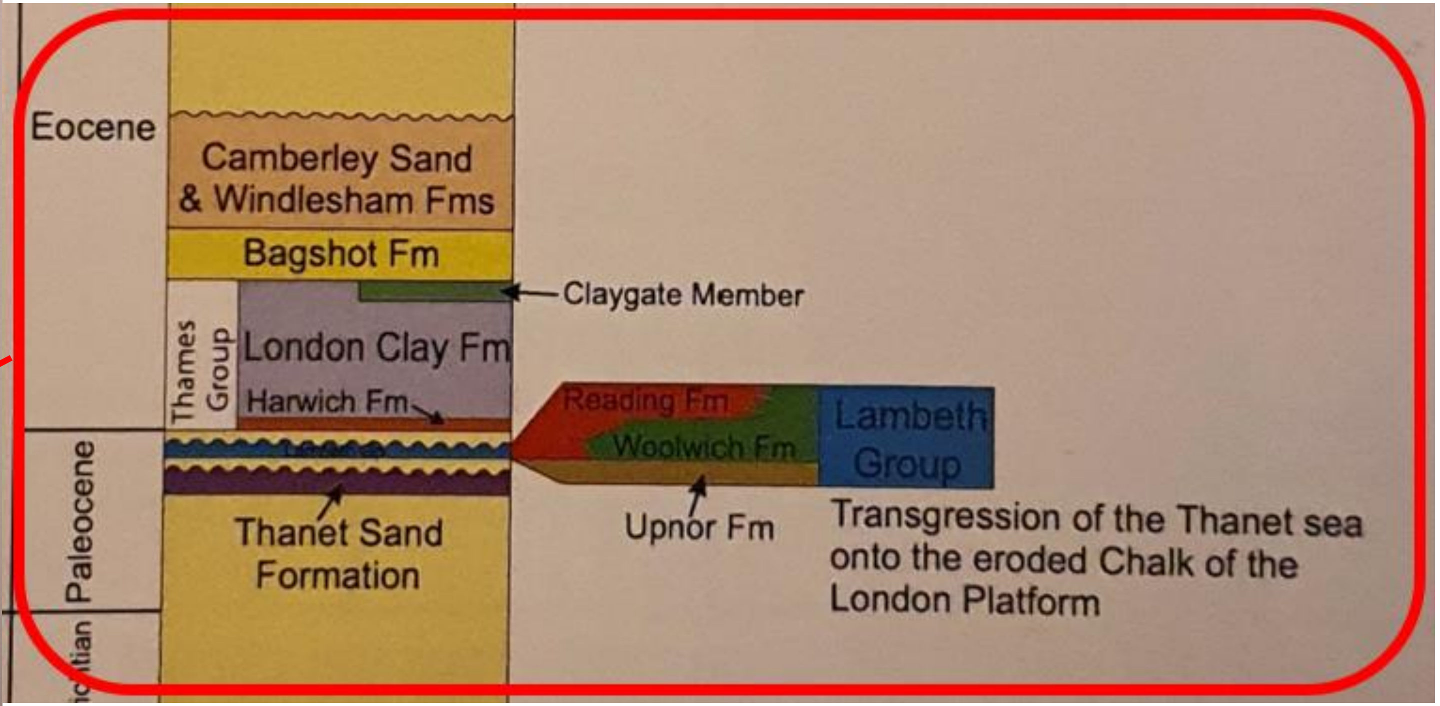


Figure 3. Late Cretaceous and Cenozoic succession and major events in the London Basin. (*R.N. Mortimore*)

Figure 3 from the Geologists' Association Guide No.68: The Geology of London, compiled by Diana Clements



Harefield Pit Site of Special Scientific Interest (SSSI) preserves the geological record of rocks laid down at a most critical period of climate change - the ***Paleocene-Eocene Thermal Maximum***. Particularly important are outcrops of

- Lambeth Group: Upnor Formation
- Thames Group: Harwich Formation

Lambeth Group at Harefield

At Harefield Pit this exposure is of sands within the Lambeth group

The Lambeth Group includes interleaved clays and sands at nearby locations.

The sand was quarried at several pits in Harefield and used in brick making and construction.

Lambeth Group (Reading Formation Sands) at The Dingles, Pinner

These sands lie on the surface above the Pinner chalk mine.

They were probably laid down by a river on a coastal plain. Sand is indicative of higher energy river flow, possibly due to higher rainfall.

This was in the middle of the Lambeth Group, when the PETM occurred.

Harwich Formation

Harefield Pit SSSI.
Thames Group, Harwich Formation. (Palaeogene)

Shell bed, Thames Group (Harwich Formation)

Sarsen boulders at Manor Farm, Ruislip

What are sarsens?

You may be familiar with the giant sarsen stones that form the largest parts of Stonehenge, each 7 metres tall and weighing 20 tonnes. Locally we have more modest examples!

Sarsens are blocks of silcrete, meaning rock that has been cemented by silica, in this case a layer of sandstone that has been hardened by silica dissolved in ground water percolating downwards. While the sandstone may be from the Lambeth Group, the cementation occurred later.

Sarsens often form patches of resistant rock on the ground surface left behind after the rest of the formation eroded away. As the climate cooled, freeze-thaw action moved the blocks by mass-movement downhill, often considerable distances.

That is why we find sarsen blocks strewn around the region today.

Stanmore Gravel at Harrow Weald SSSI

Harrow Weald has been designated a Site of Special Scientific Interest because it provides the most complete exposure of Pleistocene gravel beds above the Claygate Beds, the youngest layer of London Clay.

Climate Change: the last 2.6 million years

Photo: Tom Koerner/USFWS [File:Snowy sage steppe (39829456292).jpg - Wikimedia Commons]

Climate Change: the last 2 million years

The Ice Ages

Permafrost prevailed during this period and Britain would have resembled present-day Siberia. There were many periods of glaciation over Britain, the largest 450,000 years ago (Anglian).
Megafloods carved the English Channel as a result of the ice-sheets melting during warmer periods.
Ice-sheets also formed a land-bridge, covering the North Sea and joining Britain to the rest of the continent again.

http://www.wikigallery.org/wiki/painting_204137/Wilhelm-Kranz/Cavemen-during-the-Ice-Age

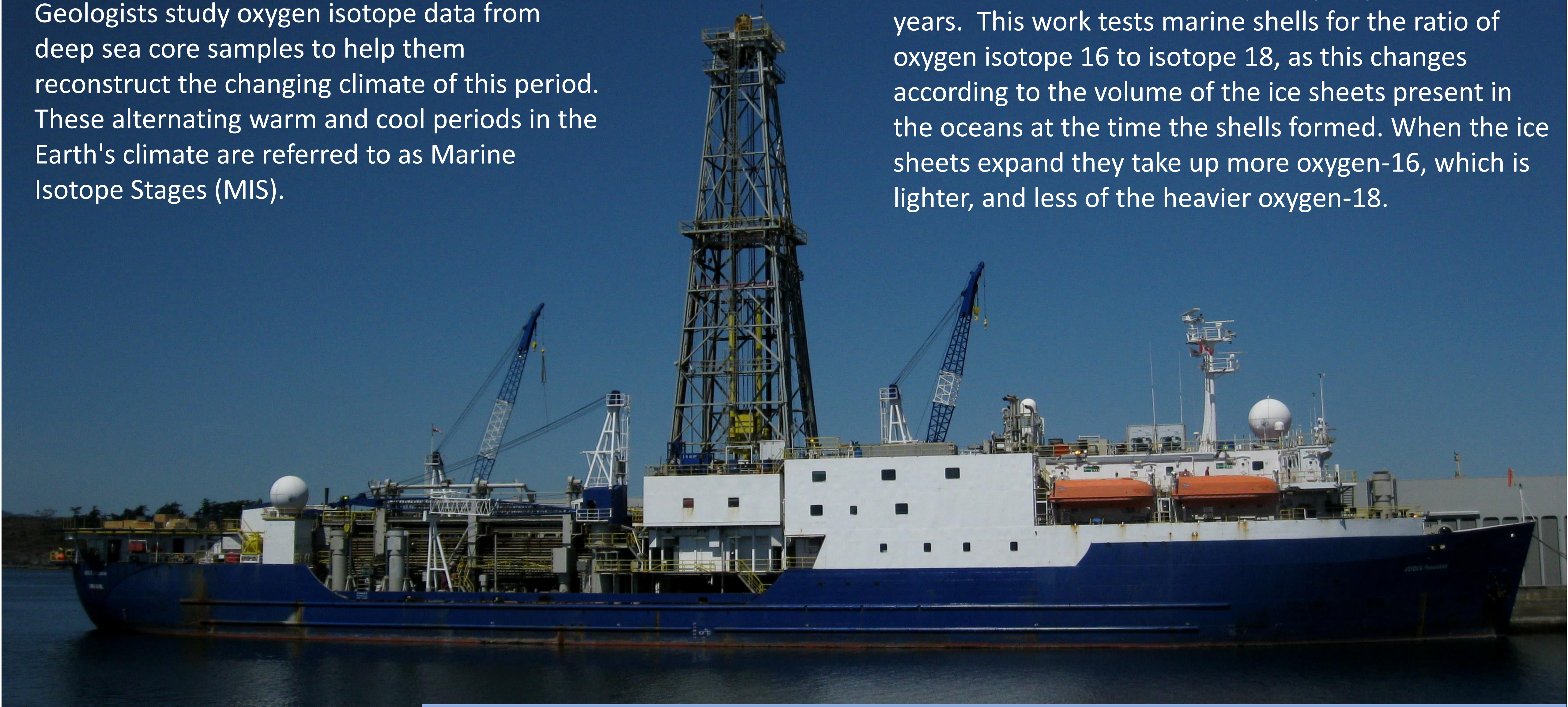
https://en.wikipedia.org/wiki/Pleistocene_megafauna

This is when humans join our geological record. Early humans were able to walk into Britain before it was an island, and footprints have been found in Norfolk from over 800,000 years ago.
At Three Ways Wharf in Uxbridge there were important stone-age settlements 10,000 years ago, at the time when the climate warmed following the last ice-age.

Deep sea drilling

Geologists study oxygen isotope data from deep sea core samples to help them reconstruct the changing climate of this period. These alternating warm and cool periods in the Earth's climate are referred to as Marine Isotope Stages (MIS).

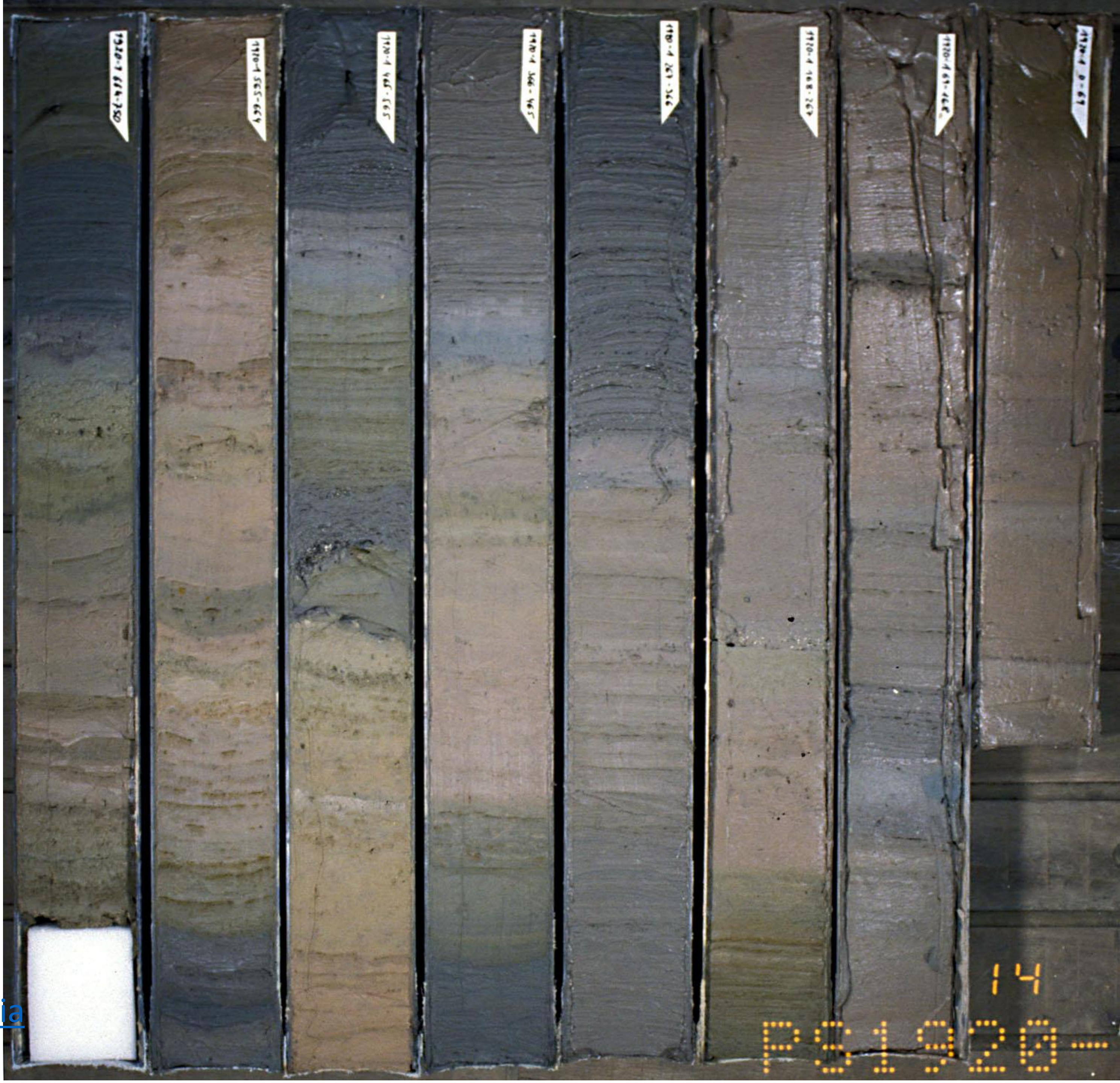
MIS 1 in the scale represents the present time, and records have so far been compiled going back 6 million years. This work tests marine shells for the ratio of oxygen isotope 16 to isotope 18, as this changes according to the volume of the ice sheets present in the oceans at the time the shells formed. When the ice sheets expand they take up more oxygen-16, which is lighter, and less of the heavier oxygen-18.



File:JOIDES Resolution ocean research ship. INFO IN PANORAMIO DESCRIPTION - panoramio.jpg - Wikimedia Commons

Evidence from the deep sea core samples corresponds with the visible records on land, which show how the ice sheets changed through time. Ice-core data also confirms the cold and warm periods of the Quaternary period. The marine isotope data is the most detailed and complete record, so this is used to define the stages of glacial and interglacial (warmer) periods. Marine Isotope Stage 1 (MIS 1) marks the start of the Holocene Geological Epoch, which is the name given to the present geological time. Stages with odd numbers are interglacial warm periods, while even numbers denote glacial periods when ice sheets advanced and the climate was cold.

When we match the Marine Isotope Stages to rock layers in the London area, we find even numbers. Our recent geology has been formed by ice sheets advancing from the north, grinding up rocks, pushing and carrying great boulders and then depositing them when they melted in a warming climate. When the ice sheets grow, sea levels fall; when they melt, sea levels rise.



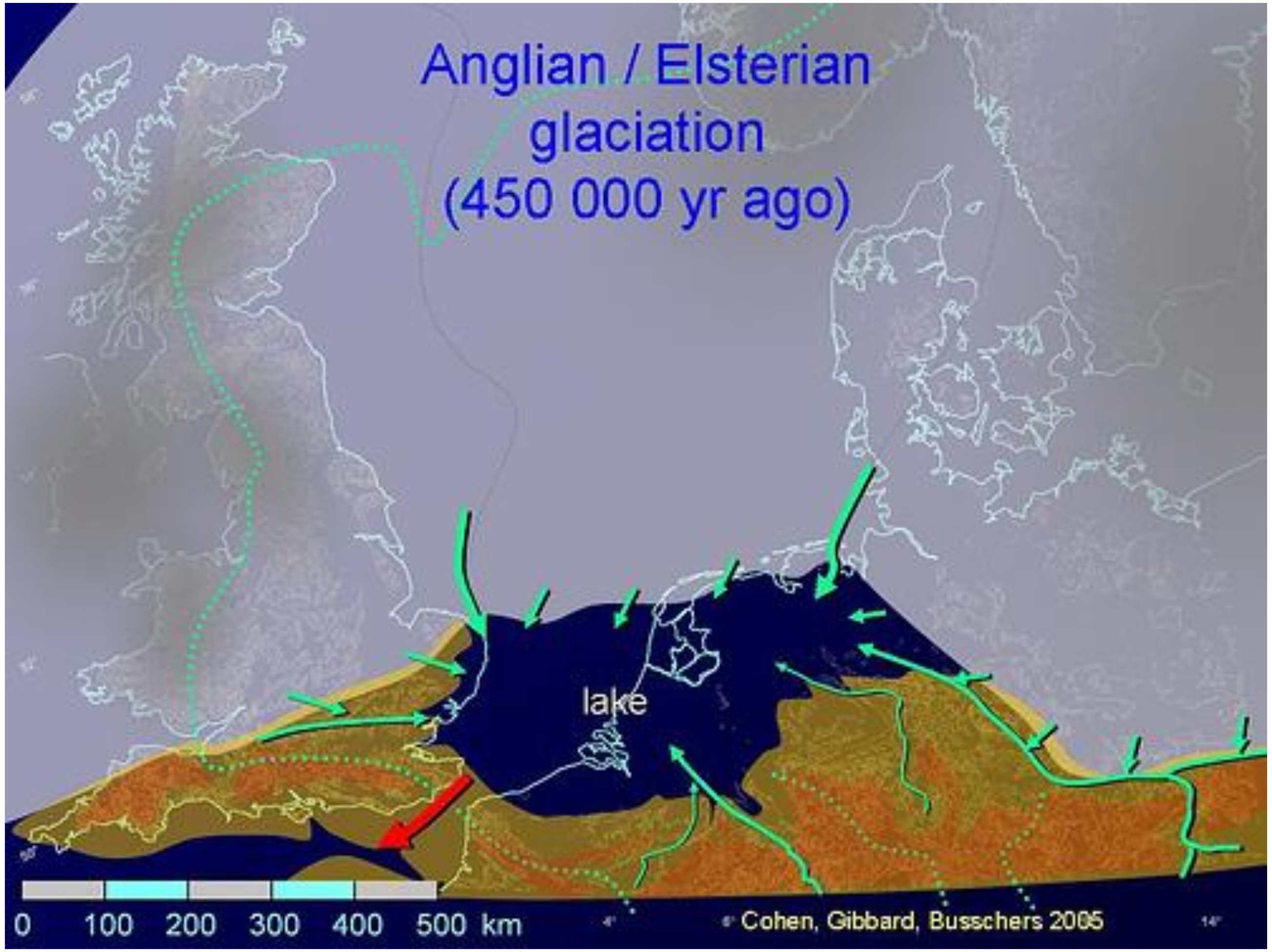
File:PS1920-1 0-750 sediment-core hg.jpg - Wikipedia

Climate Change: the last 2 million years

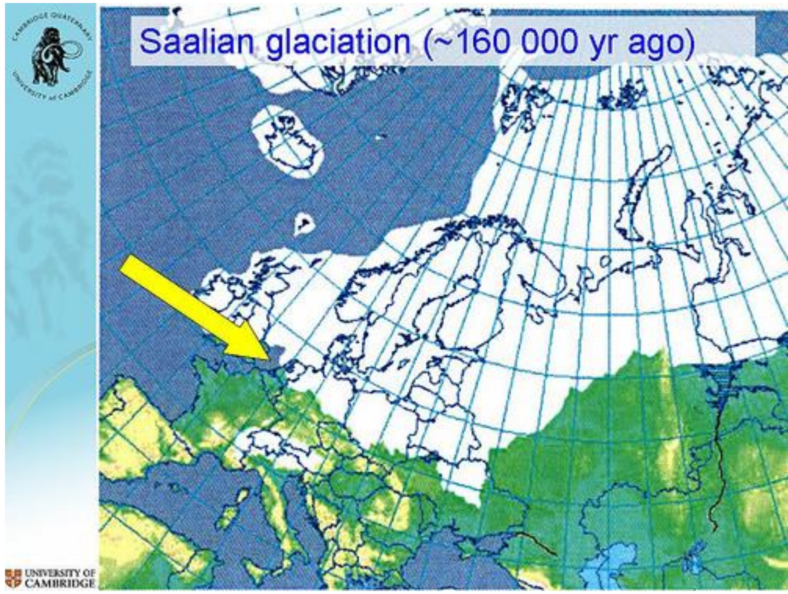
How many years ago	Geological Period: Epoch	Geological Formation	Local exposures at	Marine Isotope Stages
c. 6000-present (Neolithic onwards)	Quaternary: Holocene	Maidenhead Fm. (Alluvium)	Valleys of Colne, Pinn, Yeading Brook, Roxbourne, Wealdstone Brook; Ruislip Lido	(MIS 1)
c. 35,000-10,000	Quaternary: Pleistocene (late)	Maidenhead Fm. (Shepperton Gravel Member)	Colne Valley	(MIS 2, Devensian)
c. 70,000-20,000	Quaternary: Pleistocene (late)	Maidenhead Fm. (Langley Silt Member)	Uxbridge-Cowley-West Drayton, Yiewsley, Harmondsworth, Harlington, Hayes, Yeading	Brickearth (MIS 4-2, Devensian)
c. 240,000 180-140,000	Quaternary: Pleistocene (middle)	Maidenhead Fm. (Taplow Gravel Member)	Harmondsworth to Cranford London Heathrow Airport	(MIS 8, 6, Wolstonian)
c. 340,000-260,000	Quaternary: Pleistocene (middle)	Maidenhead Fm. (Lynch Hill Gravel Member)	Central Uxbridge, Side of Colne Valley to N Yiewsley-Stockley Park-Hayes	(late MIS 10, 8, Wolstonian)
c.350,000	Quaternary: Pleistocene (middle)	Maidenhead Fm. (Boyn Hill Gravel Member)	Uxbridge Cemetery-Hayes End and Botwell	(MIS 10, Wolstonian)
c.420,000	Quaternary: Pleistocene (middle)	Maidenhead Fm. (Black Park Gravel Member)	Hillingdon Hill, Uxbridge Common, Uxbridge Golf Course	(MIS 12, Anglian)
c. 450,000	Quaternary: Pleistocene (middle)	Colchester Fm. (Winter Hill Gravel Member)	Springwell Farm, Harefield	(MIS 12, Anglian)
c. 750,000	Quaternary: Pleistocene (early middle)	Sudbury Fm. (Gerrards Cross Gravel Member)	Watt's Common, Harefield	(MIS 18, cold stage within the Cromerian)
c. 2,000,000	Quaternary: Pleistocene (early)	(Crag Group) Stanmore Gravel Fm.	Harrow Weald Common	(?MIS 103-82)

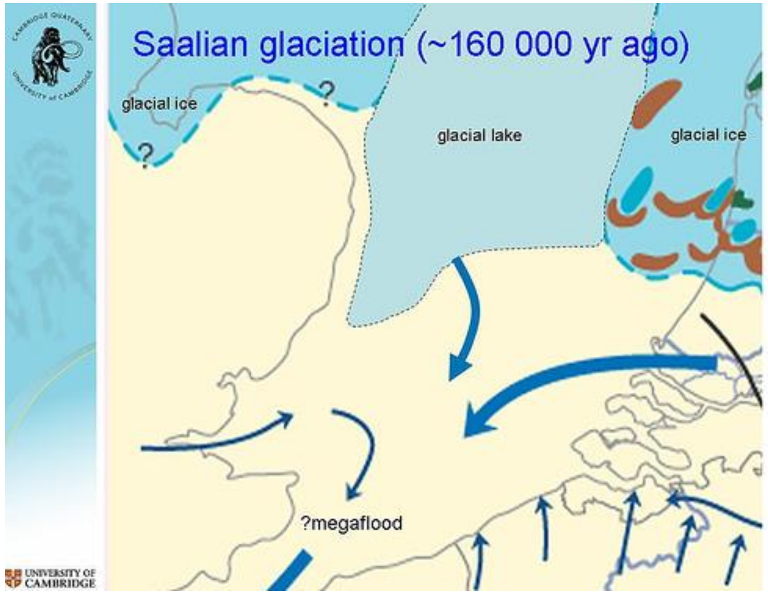
Ice-age Floods

[Quaternary Palaeoenvironments Group (QPG) » How Britain Became An Island]



Two periods of glaciation have been identified as having released massive floodwaters that broke through the chalk that joined England to France at that time. Evidence of megafloods is found on the sea bed from Dover to the Isle of Wight.





Meltwater from the Anglian ice-sheet also found its way south across our region.
The River Thames had to find a completely new route to the sea as a result.

Migration of the River Thames

The Uxbridge Thames!

The Thames was flowing between St. Albans and Chelmsford before the Anglian ice advance. Moor Mill Lake occupied the old Thames Valley when the river was blocked by ice at St. Albans.

The lake overflowed and the water found a route towards Uxbridge and Richmond and then migrated to reach its present route.

Gravel deposits in the area tell the story of where the River Thames flowed at different times. The gravels have been exploited throughout history and we now find extensive gravel pits in the Colne Valley and surrounding area.

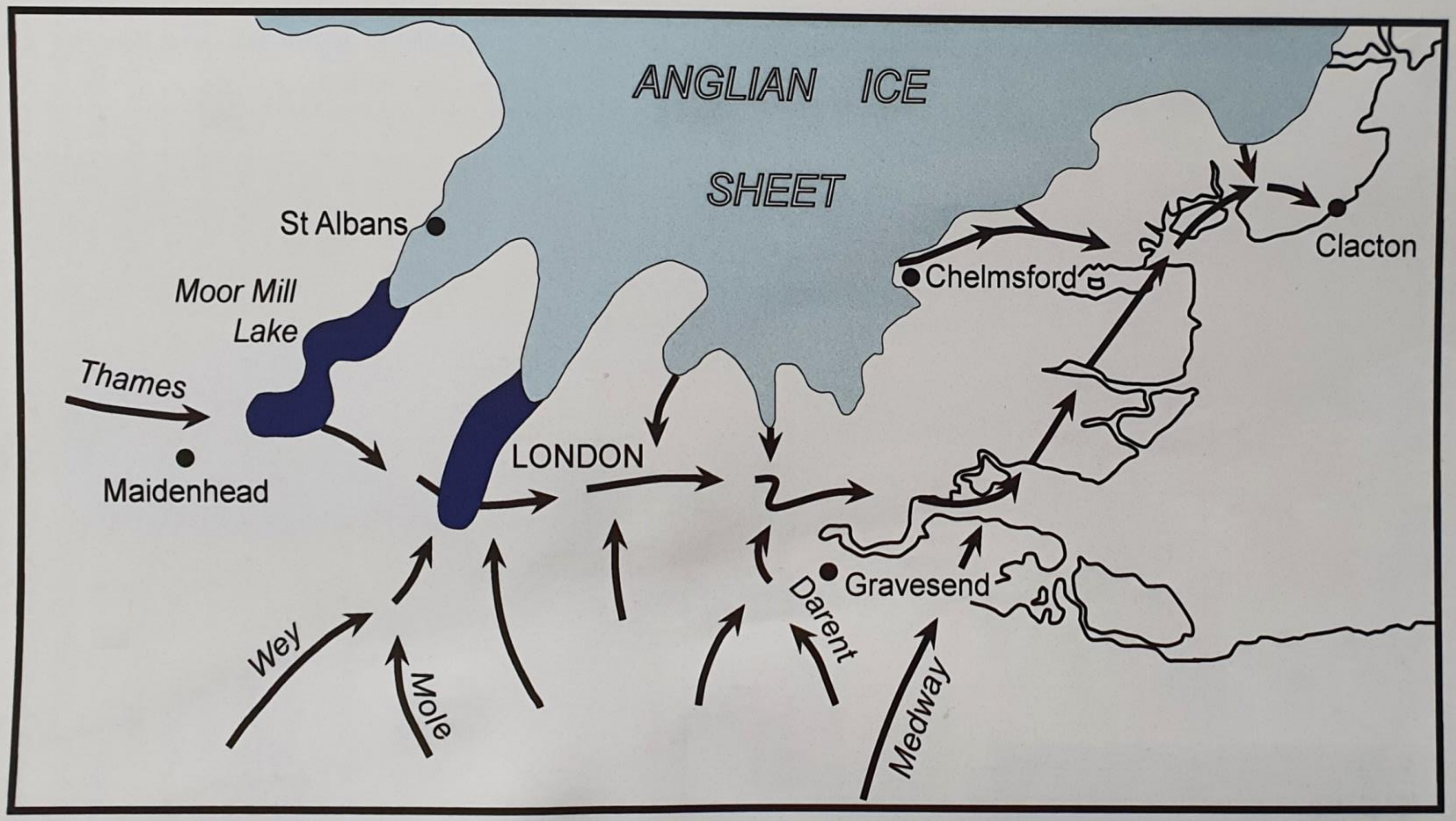


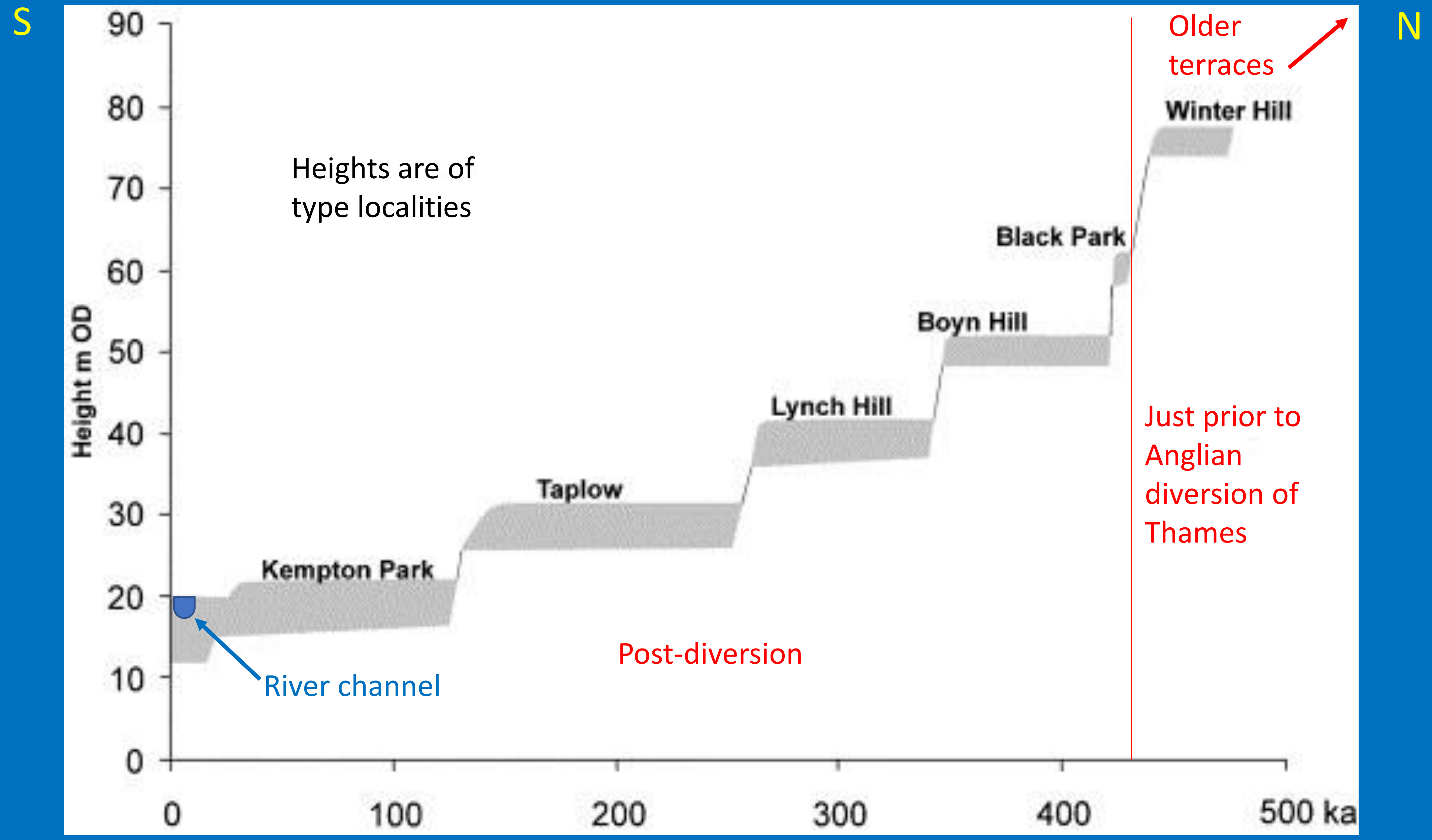
Figure 7. The extent of the Anglian ice sheet and the resultant re-routing of the Thames through Central London. Moor Hill Lake was later to become the Colne Valley. (*After Bridgland* et al., *1995*).

Image from Geologists' Association Guide No. 68 (2010) **The Geology of London** compiled by Diana Clements

Thames Gravel Aggradations and Terraces

There are many different types of gravel in our region which between them record the history of the River Thames from its earliest origins to the present day. The gravels were laid down in a cold climate when the Thames was a braided river carrying very high volumes of water compared to today.

Cross-section through Middle Thames terraces



Gerrards Cross Gravel

The Gerrards Cross gravel was laid down long before the time of the Thames diversion.

It has a fairly high proportion of quartz and quartzite pebbles from the West Midlands, beyond the present source of the Thames (which is in the Cotswolds).

Winter Hill sand and gravel at Springwell Farm, Harefield

This gravel is younger (450ka) than the Gerrards Cross gravel and was laid down just before the diversion of the Thames. The river was still flowing in its old course towards Chelmsford.

In the Harefield area the uppermost Winter Hill gravel was laid down in a delta extending into Moor Mill Lake.

Taplow Gravel and Langley Silt brickearth

Wall Garden Quarry extension in Sipson, near Heathrow Airport

The Taplow gravels records the presence of the Thames in Hillingdon, about 170,000 years ago.

The brickearth layer that can be seen above the gravel in this picture is mostly a wind-blown deposit laid down in the most recent ice-age (the Devensian), roughly 100,000-12,000 years. It was widely exploited locally for brickmaking.

London Boroughs of Harrow and Hillingdon

Visit our area : take a building-stones walk around Pinner