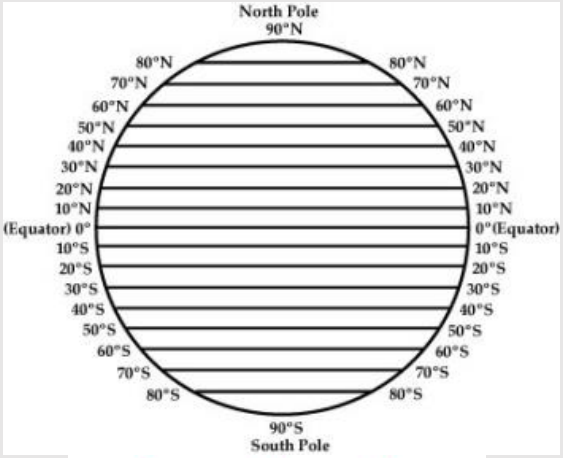
PALAEOCLIMATIC CHANGE

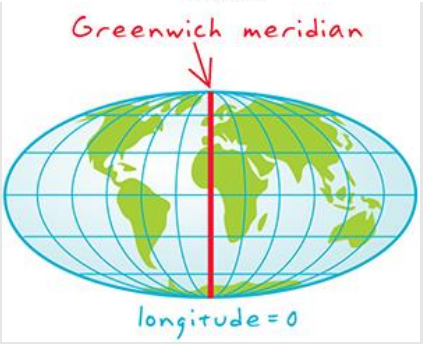
PALAEOLATITUDE



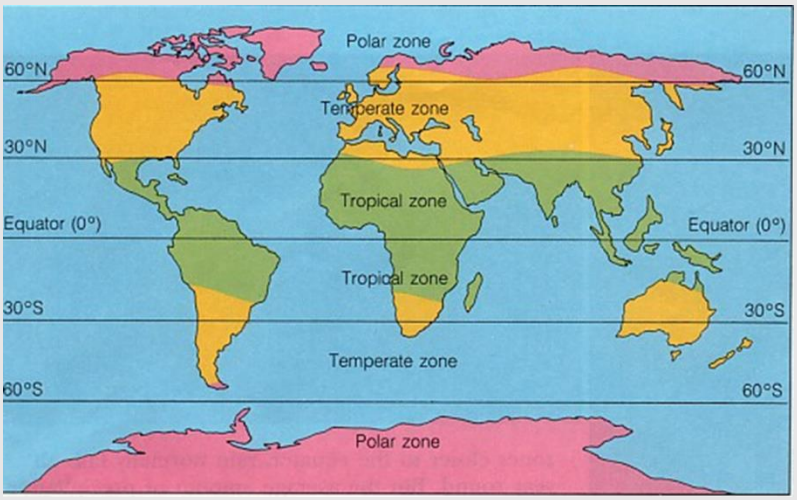
- **Palaeolatitude** refers to the position of a landmass (in this case **the UK**) in terms of latitude over geological time.
- **Latitude** is the **North/South** position of a point on the Earth's surface. It is defined as an angle ranging between **0^0 at the equator** to **90^0 (North or South**) at the **poles**.

Lines of constant latitude, or parallels, run east-west as circles parallel to the equator.

Palaeolatitudes are measured for a place some point in the past relative to the **earth's magnetic poles** in the same period. Differences occur due to tectonic movement.



Today the British Isles are in a **temperate climate**, surrounded by **shallow seas** and **relatively warm temperatures**.



NOTE: Today's climate at certain latitudes is not a good indicator of the past as we are currently in an **Icehouse Earth**, within an **interglacial condition**.

Before the last glacial, the UK was populated with organisms like hippo, lions and hyena with a subtropical environment.

There are many ways to reconstruct past climate. Some we have already looked at are…

1. **Oxygen isotope** ratios in ice cores or calcite shells
2. **Carbon isotope** ratios from calcite shells
3. Knowledge of modern plant and animal habitat environments and environmental conditions. **Microfossils/Macrofossils** as **palaeoenvironment indicators**. **Pollen records. Tree rings.**
4. **Sedimentary structures**
5. **Sediment types**

BIOSTRATIGRAPHIC EVIDENCE: CORALS

Some corals can be found in all oceans and seas (usually the solitary corals which can survive in temperature or tropical waters). Modern corals reefs (scleractinian corals from Permian to present) are thought to have required a narrow window of environmental conditions that are tropical, between 30^0 North and 30^0 South of the equator:

1. Warm temperatures between **23^0C and 29^0C** to increase rates of **photosynthesis and respiration for the algae and polyp** and so high growth rate.
2. Fully marine with a salinity between **30-40 ppt** as polyps can't survive in a varying range of salinities.
3. Shallow waters <**30m depth** and so sunlight can penetrate which is required for **photosynthesis.** Light is filtered out at depth.

4. Water needs to be **clear from terrestrial sediments** such as clay, sand and silt particles as these clog coral polyps. Coral reefs tend to be **offshore and far from river estuaries**.
5. High **energy levels and wave action** to fully **oxygenate** the waters for effective **respiration** and circulates the correct level of **nutrients by upwelling.**

A good example of a location where corals thrive is the **Maldives, in the Indian Ocean.**

Corals can only live where they can successfully exploit their symbiosis with algae. This restricts the corals to an environment of +/- 30^0 of the equator. Fossil coral reefs are found in **Silurian and Lower Carboniferous, forming when the British Isles was in a tropical region.**

Rare colonial corals were found in the Jurassic too.

Period	Diagnostic rock type	Palaeolatitude
Quaternary	Glacial deposits	55°N
Tertiary	Palms and tropical plants	40°N
Cretaceous	Chalk	35°N
Jurassic	Rare colonial corals	30°N
Triassic	Desert Sandstones	31°N
Permian	Desert sandstones and evapourites	12° N
Carboniferous	Reef limestones, corals	0°
Devonian	Desert sandstones	20°S
Silurian	Reef limestones, corals	30°S

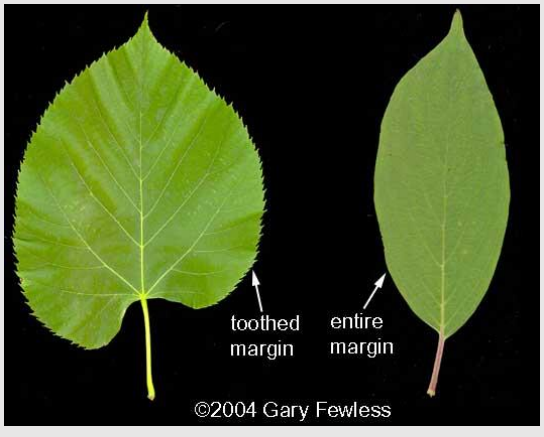
Colonial corals found in the reefs of the **Silurian Wenlock Limestone** suggesting tropical seas. Some colonial corals in the Jurassic mean tropical seas North of the equator (30^0)

BIOSTRATIGRAPHIC EVIDENCE: FOSSIL PLANTS

Plants have specific growth requirements so are good palaeoclimate indicators. Vegetation is restricted to the environments it can thrive (and be fossilised) in.
Tree rings show how the climate conditions varied from year to year, in periods of **good climate, trees have large rings**, in bad climates...**narrow rings** usually correlate with **drier climates**.

1. The presence of rings suggests there was **seasonal variations in climate** and therefore **growth rate.** Many fossil trees from the carboniferous do not show rings, indicating that there was: **No seasonal variation within equatorial regions (tropics).** Upper Carboniferous plants grew to heights of 40m; this high productivity and height indicates a **hot, humid, equatorial climate and latitude.**

Tree rings from Ireland and England span a period of 7000 years. When the tree rings were narrowest, the driest climate, was 5200 years ago.



2. **Leaf shape** will change with temperature/palaeolatitude. In modern leaves, the number of **teeth running along the margin** is an indication of **average** temperature, with **smooth leaf margins equating to warmer temperatures**.

3. **Leaf size** is also correlated with **temperature, humidity and light** levels. Large leaves occur in **humid, dim environments** and decrease in size with increasing temperature or precipitation.

4. Microfossil pollen; pollen grains survive in sediment for millions of years and can be transported into marine sediments. **Pine** and **birch** pollen will indicate **cool conditions** compared to **oak** and **beech pollen**. Indicating **warm conditions**.

   Therefore, in the **quaternary** during a glacial environment of the current Icehouse period, **glacial varves** may have trapped pollen grains of pine or birch.

   If there were petrified wood samples then it would show that the tree rings were relatively large with seasonal variation in the current temperature climate of the British Isles.

   Currently it is quite common to find leaves with serrated edges due to the temperature climate as it is slightly cooler with variation compared to a dry climate with all smooth leafed plants.

LITHOSTRATIGRAPHIC EVIDENCE: COAL SEAMS

Coal seams must originate from peat formation in a sufficient thickness that when it is compressed and matured it forms an economic coal seam. This means the environment must have had a **high rainfall and high temperature** for a high growth rate, this is a highly productive ecosystem for vegetation and is found at a **tropical region (especially rainforests, swamps and deltas) in equatorial latitudes.**

Coal measures of the **Carboniferous** formed at **equatorial rainforests** growing on a huge delta extending from **Scotland to Kent**.

Period	Diagnostic rock type	Palaeolatitude
Quaternary	Glacial deposits	55°N
Tertiary	Palms and tropical plants	40°N
Cretaceous	Chalk	35°N
Jurassic	Rare colonial corals	30°N
Triassic	Desert Sandstones	31°N
Permian	Desert sandstones and evapourites	12° N
Carboniferous	Reef limestones, corals	0°
Devonian	Desert sandstones	20°S
Silurian	Reef limestones, corals	30°S

LITHOSTRATIGRAPHIC EVIDENCE: DESERT SANDSTONE

A desert sandstone is a sandstone restricted to subtropical latitudes (within 30^0 of the equator):

- High purity of quartz (90-99%)
- Well sorted
- Well-rounded to sub-rounded
- Frosted grains
- Hematite coating (red iron oxide, Fe_2O_3)

Desert sandstones in the British Isles formed in the **Devonian, Permian** and **Triassic**.

Period	Diagnostic rock type	Palaeolatitude
Quaternary	Glacial deposits	55°N
Tertiary	Palms and tropical plants	40°N
Cretaceous	Chalk	35°N
Jurassic	Rare colonial corals	30°N
Triassic	Desert Sandstones	31°N
Permian	Desert sandstones and evapourites	12° N
Carboniferous	Reef limestones, corals	0°
Devonian	Desert sandstones	20°S
Silurian	Reef limestones, corals	30°S

Permian and Triassic rocks include red desert sandstones and evaporites of **Cheshire Basin** which formed within **30^0 N of the equator**.

LITHOSTRATIGRAPHIC EVIDENCE: EVAPORITES

These deposits form in an arid environment with a **high rate of evaporation** and **rainfall is low**, most commonly at latitudes of ~ **20-30^0 N or S** of the equator as this is where current evaporites form today.
These are sub-tropical environments. Most commonly where the **desert meets the sea,** such as the Unite Arab Emirates.

LITHOSTRATIGRAPHIC EVIDENCE: TILLITES

Tillites are deposits of **glacial basal till, boulder clay and rock flour**. It is a mixture of clay and fragmented poorly sorted rock with a varying composition, erratics and striations.

It is formed where glaciers dump moraine material into loose, poorly sorted, debris piles.

They are most commonly formed at latitudes greater than **60^0 N/S of the equator,** but some are found at **lower altitudes in high altitude regions** where temperatures are cool enough for glaciers to form.

Period	Diagnostic rock type	Palaeolatitude
Quaternary	Glacial deposits	55°N
Tertiary	Palms and tropical plants	40°N
Cretaceous	Chalk	35°N
Jurassic	Rare colonial corals	30°N
Triassic	Desert Sandstones	31°N
Permian	Desert sandstones and evapourites	12° N
Carboniferous	Reef limestones, corals	0°
Devonian	Desert sandstones	20°S
Silurian	Reef limestones, corals	30°S
Pre Cambrian		

Tillites are found in **Precambrian rocks** in the **west of Scotland**, suggesting a **glaciation** – perhaps **snowball Earth**.

In the Precambrian, the British Isles were probably near the **South Pole in the Southern Hemisphere**.

LITHOSTRATIGRAPHIC EVIDENCE: REEF LIMESTONES

Reef limestones are built of **massive colonial corallum skeletons** and **other reef organisms**. They are whole fossil coral beds so are restricted to the same environmental **parameters as corals (+/- 30^0** of the equator in a tropical shallow sea).
These tend to have formed during the Silurian and lower carboniferous

Reef limestones in the **Lower Carboniferous** in the **Pennines** suggest **tropical seas**.

Period	Diagnostic rock type	Palaeolatitude
Quaternary	Glacial deposits	55°N
Tertiary	Palms and tropical plants	40°N
Cretaceous	Chalk	35°N
Jurassic	Rare colonial corals	30°N
Triassic	Desert Sandstones	31°N
Permian	Desert sandstones and evapourites	12° N
Carboniferous	Reef limestones, corals	0°
Devonian	Desert sandstones	20°S
Silurian	Reef limestones, corals	30°S

LITHOSTRATIGRAPHIC EVIDENCE: CHALK

Chalk forms from carbonate oozes containing skeletal remains of coccolithophores that sank to a low energy anoxic sea bed <4km deep. This is known as the carbonate compensation depth (CCD), below the CCD any carbonate material will dissolve before it reaches the sea floor due to high CO_2 concentrations and lower temperatures.

Pelagic clay containing foraminifera/coccoliths and calcareous material can form at the deep end of the continental shelf, the continental slope and parts of the abyssal plane <4km depth.

Sea levels were very high at the Cretaceous.

Chalk seas of the cretaceous represent **temperature conditions** ad the British Isles move northwards into cooler climates.

Period	Diagnostic rock type	Palaeolatitude
Quaternary	Glacial deposits	55°N
Tertiary	Palms and tropical plants	40°N
Cretaceous	Chalk	35°N
Jurassic	Rare colonial corals	30°N
Triassic	Desert Sandstones	31°N
Permian	Desert sandstones and evapourites	12° N
Carboniferous	Reef limestones, corals	0°
Devonian	Desert sandstones	20°S
Silurian	Reef limestones, corals	30°S

1. **Precambrian Tillites** = Snowball Earth? (at this time the UK was in the Southern Hemisphere, probably near the South Pole)
2. **Silurian Corals** = Tropical position as shallow seas
3. **Lower Carboniferous Reef Limestones** = Tropical position as shallow seas
4. **Carboniferous Coal Measures** = Tropical rain forests and deltas
5. **Permian/Triassic Desert sandstones** = Subtropical deserts
6. **Jurassic corals** = Tropical seas (North of the equator?)
7. **Cretaceous Chalk** = temperate regions, shallow seas
8. **Pleistocene tillites** = temperate/polar climates in the Northern Hemisphere