MICROFOSSILS

These are simply smaller versions of macrofossils that can only be seen by using a microscope

They are very useful for correlation since they are found whole in large quantities in the chipping from boreholes and are used in oil exploration. Those made from calcium carbonate are used to investigate climate change.

There are 4 main types

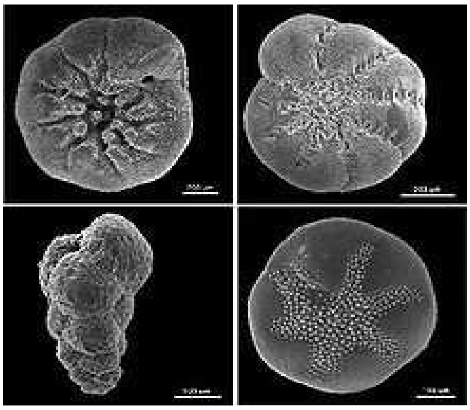
OSTRACODS
FORAMINIFERA
RADIOLARIA
CONODONTS

OSTRACODS

Very small bi-valves made of calcium carbonate. Mainly benthonic they are excellent palaeo-environmental indicators

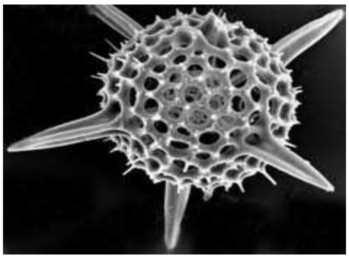
FORAMINIFERA

Single celled creatures with a small calcium carbonate shall/test. Benthonic and planktonic, they are excellent for stratigraphy and to illustrate evolution.



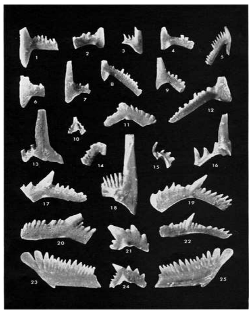
RADIOLARIA

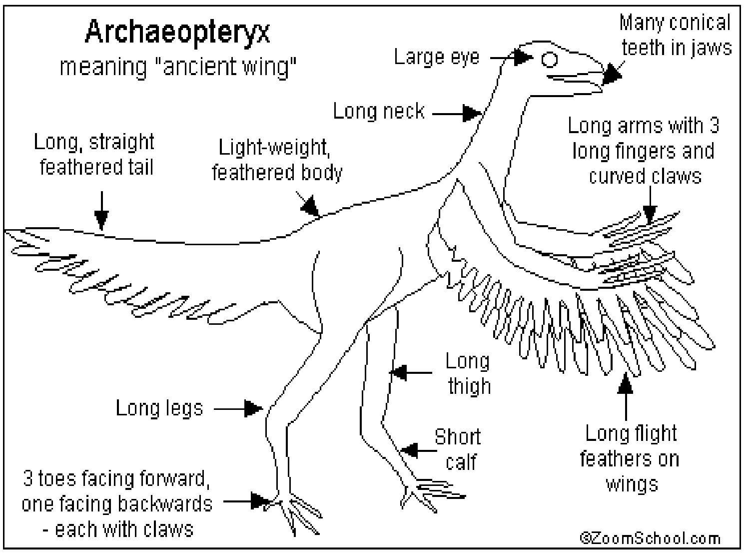
Marine planktonic animals made of silica. They can survive below the Carbon Compensation Depth (CCD) and are therefore very useful for stratigraphy and as palaeo-environmental indicators.



CONODONTS

The teeth of soft bodied animals. Died out at the P-T mass extinction.



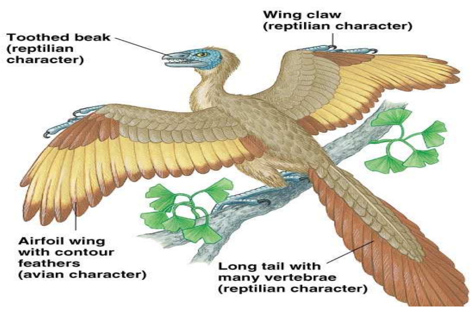


SIMILARITY TO DINOSAURS

LONG TAIL WITH BONES
3 CLAWED HAND
PUBIS (PUBIC BONE) LIKE DINOSAURS
FEET BONES (METATARSELS) NOT FUSED
TEETH

SIMILARITY TO BIRDS

WINGS FOR FLYING
WISHBONE / FURCULA (ADAPTATION FOR EGG LAYING)
FEATHERS WHICH WERE ASYMMETRICAL FOR FLYING
REVERSED BIG TOE
HOLLOW BONES TO REDUCE WEIGHT
NO TEETH
LEGS UNDER THE BODY FOR SUPPORT



geographyjohn

A2 GEOLOGY

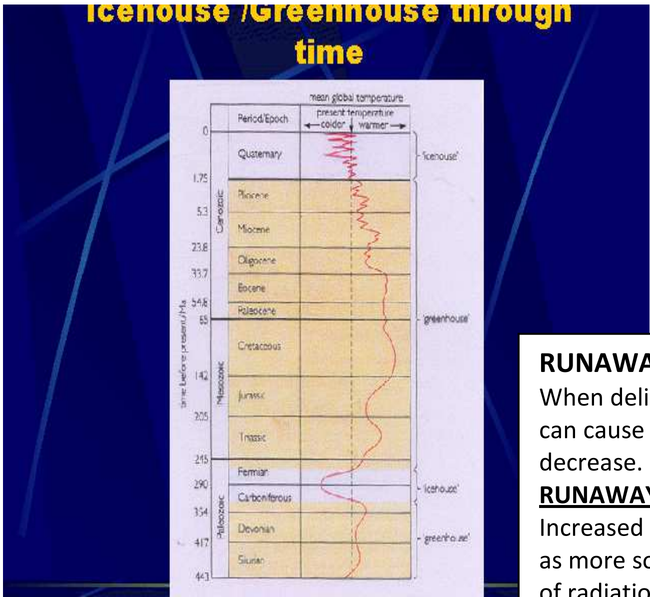
CASE STUDY REVISION BOOKLET

CLIMATE CHANGE AND GEOLOGICAL TIME

CLIMATE

Climate is average weather. It is the state of the atmosphere in terms of temperature, precipitation, wind etc worked out as a mean, such as **Mean Annual temperature**. Climates can be **Tropical** (hot) **Temperate** (mild) **or Arctic** (cold) in relation to **latitude**

Palaeoclimate is the climate that existed in the **geological past.**



Climate change may cause **extinction events** as organisms live in a narrow range of temperatures. The P-T mass extinction may be related to an icehouse or glacial phase.

PALAEOCLIMATOLOGY

The climate has varied significantly in the geological past

There have been periods of:-

<u>GREENHOUSE</u>

Higher global temperatures, lack of ice cover.

Changes in the amount of solar radiation reaching earth or changes is gas content of atmosphere (more carbon dioxide)

<u>ICEHOUSE</u>

Low temperature periods, ice caps, ice sheets and glaciers. Ice ages.

We still have significant ice cover today.

More reflection of solar radiation by ice cover (albedo)

<u>SNOWBALL EARTH</u>

Periods when the whole surface of the earth is covered by ice sheets and glaciers.

RUNAWAY EFFECTS

When delicate balances in the atmosphere are changed positive feedbacks can cause a runaway effect when temperatures continue to increase or decrease.

<u>RUNAWAY ICEHOUSE</u>

Increased snowfall and ice cover causes the albedo of the earth to increase as more solar radiation is reflected back to space. Fresh snow reflects 90% of radiation so the temperature continues to fall.

<u>RUNAWAY GREEN HOUSE</u>

If sea temperatures rise more CO_2 is released which traps more heat in the atmosphere, raising the temperature further which in turn releases more CO_2. Higher sea temperatures may also release methane (also a greenhouse gas) from the sea bed.

MILANKOVICH CYCLES

It is not thought that the level of solar radiation varies over time. In fact it is called the SOLAR CONSTANT. The amount of solar radiation reaching the earth may, however, vary in a predictable way called Milankovich cycles, related to the earth's orbit and the tilt of its axis.

Eccentricity

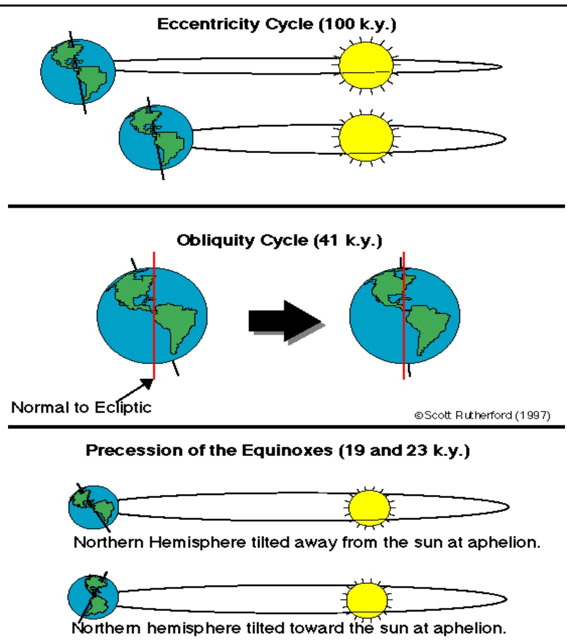
Measure of the noncircularity of Earth's orbit. The orbit of the earth varies from circular to elliptical. This can alter the solar radiation received by 25%. The cycle is about 100,000 years.

Inclination / Obliquity

The changes in the axial tilt (22^{o} to 24.5^{o}) of the Earth. The greater the tilt the greater the contrast between summer and winter temperatures. The cycle is about 41,000 years.

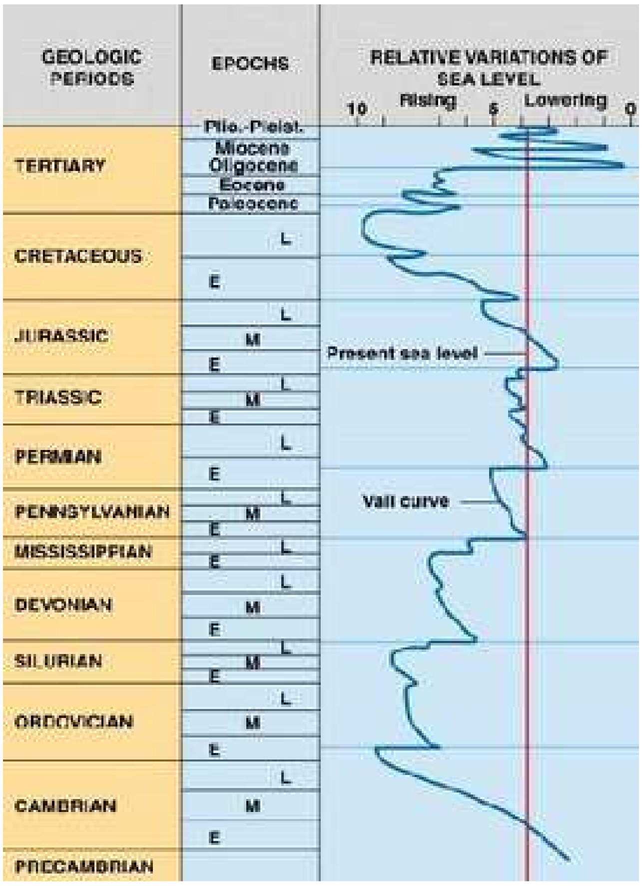
Precession

A combination of the elliptical nature of the earth's orbit around the sun and the changing inclination of the earth's axis. This can affect seasonal contrasts. This has a period of 19,000 years and 23,000 years.



SEA LEVEL CHANGE

Changes in the global climate can have an effect on sea levels, and this has happened many times in the geological past. A fall in global temperatures and the onset of icehouse earth will lower sea levels, whereas a rise in global temperatures and the onset of greenhouse earth will raise sea levels



EUSTATIC SEA LEVEL CHANGES

Global-scale sea level change caused by a change in the volume of water in the ocean store.
A decrease in global temperatures leads to more precipitation occurring in the form of snow.
Eventually this snow turns to ice and so water is stored on land rather than being returned to the ocean store. Consequently there is a global **FALL** in sea level. If global temperatures subsequently rise, glaciers retreat and ice melts causing a **RISE** in global sea level.

ISOSTATIC SEA LEVEL CHANGES

Local-scale sea level change caused by a change in the level of the land relative to the level of the sea.
During a glacial period the weight of ice in ice sheets and glaciers adds weight to the earth's crust. This causes the crust to sink lower into the mantle rock beneath.
At the end of the glacial period the ice melts and weight is lost from the crust causing it to slowly rise (Isostatic rebound or recovery). The sea level will then appear to fall.
Some places on the east coast of Scotland are rising at a rate of 7mm a year.

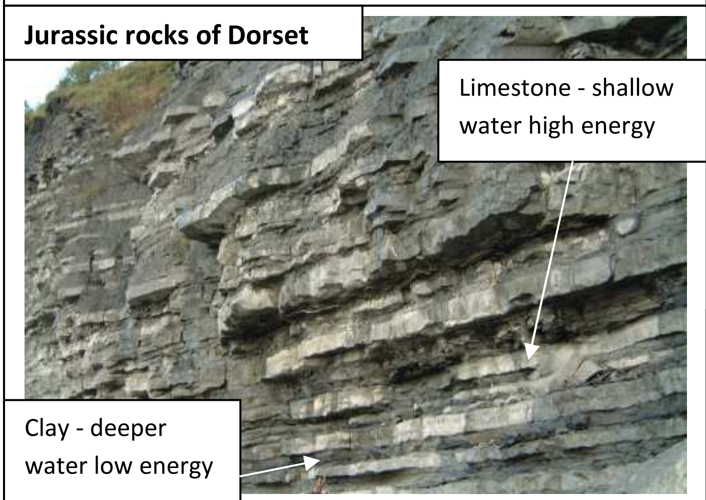
TRANSGRESSION AND REGRESSION

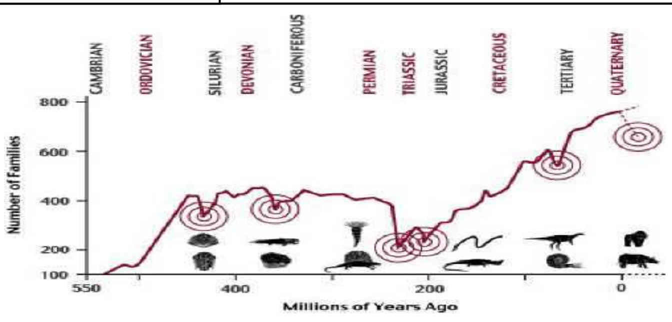
MARINE REGRESSION is a relative fall in the sea level, causing emergence as shallow water areas become land.
MARINE TRANSGRESSION is a relative rise in sea level, causing submergence as land is flooded to increase the area of shallow seas.

VAIL CURVES

Ancient sea levels were discovered by the Exxon oil company using seismic data. This data identified unconformities where transgression (as sea levels rose) covered older beds with younger deposits. Many sea level or Vail curves have been identified which appear to show a cyclical change or oscillations.
The sea level was, for instance, significantly higher in the Cretaceous when much of the chalk was deposited.

Jurassic rocks of Dorset





EVIDENCE FOR TRANSGRESSION AND REGRESSION

Regular alternating layers of limestone and clays/shales relate to periods of regression and transgression which may have been caused by Milancovich Cycles.
Limestones formed in shallow, high energy oxygenated water during periods of regression (sea level fall)
Clays/Shales formed in deeper low energy environments during perods of transgression (sea level rise)

MASS EXTINCTIONS AND SEA LEVEL CHANGE

- Oceanic anoxic events or anoxic events occur when the Earth's oceans become completely depleted of oxygen (O_2) below the surface levels. The geological record shows that they happened many times in the past. Anoxic events may have caused the formation of black shales rich in organic matter and **mass extinctions**. They tend to occur as global temperatures and sea levels rise to give transgression.

- Marine regression (lowering the sea level) will reduce the shallow water, continental shelf habitats where life is abundant leading to a mass extinction.

WHY DO SEA LEVELS CHANGE?

Changing the volume of water in the oceans.

- By climate change (transgression/ regression).
- By changing the temperature of the water causing it to expand.

Changing the volume of the oceans.

- Ocean ridges forming at constructive plate boundaries may displace water onto continents. Variations in the speed of plates and rates of sea-floor spreading and subduction may relate to sea level changes.
- Erosion of major mountain belts built up during major mountain building phases (orogenies) may produce sediment that infills ocean basins raising the sea level.

EVIDENCE FOR PALAEOCLIMATIC CHANGE

Lithological Evidence

COAL

Productive ecosystems such as tropical rainforests need high temperatures and rainfall and an equatorial climate. Vegetation needs to be thick and luxurious for thick layers of coal producing peat to form.

DESERT SANDSTONE

Desert sandstones form at 20 -30 degrees north or south of the equator. They develop a red colour as iron oxidises to haematite.

Wind (aeolian) blown sand dunes may form of fine grained , well sorted, well rounded quartz grains.

EVAPORITES

These deposits also form in dry, desert-like conditions at latitudes of 20 – 30 degrees north or south of the equator. Rainfall needs to be low and evaporation rates need to be high for dissolved salts such as halite, calcite and gypsum to precipitate out.

TILLITES

Tillites are ancient glacial deposits, ancients boulder clays/tills. They are poorly sorted, coarse grained, angular, clastic rocks.

REEF LIMESTONE

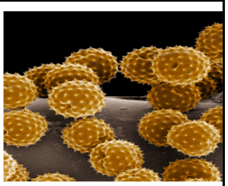
Colonial corals that make up reef limestones need a warm (25-30 C) shallow, well oxygenated tropical ocean environment, this is only found at latitudes between the equator and 30 degrees north or south.

Fossil Evidence

CORALS

Modern corals will only thrive in certain climatic and environmental conditions. Using Uniformitarianism (the present is the key to the past) we assume fossil corals needed the same conditions to build reefs.

PLANTS (flora microfossils)



Pollen grains are very resistant to decay. They are found in extremely large quantities on land and in shallow water environments. Excellent as palaeo-climatic indicators since pine pollen and pollen from more temperate environments are easily distinguished.

EVIDENCE FOR TEMPERATURE CHANGES AND SEA LEVEL VARIATIONS

Oxygen isotopes

- The two main stable isotopes of oxygen are ^{16}O and ^{18}O.
- About 99.8% of oxygen in sea water is ^{16}O
- About 0.2% is ^{18}O
- Normally ^{16}O evaporates and returns quite quickly to the oceans by the hydrological cycle
- During glaciations ^{16}O is trapped as snow falls on land and changes slowly to ice, and the ratio of ^{18}O in sea water increases
- Creatures that produce calcium carbonate shells from sea water, eg. bi-valves, microfossils will show the changes in the ^{16}O / ^{18}O content of the oceans at any given time - can be calibrated with modern specimens.
- Microfossils such as benthonic foraminifera are particularly useful in assessing the $^{16}O/^{18}O$ ratio for a given geological time as they are not affected by temperature changes as they live on the sea bed where temperature is constant.

Carbon isotopes

- ^{12}C is about 99% of the carbon in the world cycle and ^{13}C is about 1%
- The carbon in marine fossils can be used and related to climate change
- The amount of photosynthesis taking place is affected by plant cover which in turn is affected by climate. During a glacial period there will be fewer plants and less photosynthesis, this will affect the $^{12}C/^{13}C$ ratio
- Carbon isotopes are better than oxygen as they are more resistant to change during diagenesis.

THE NORTHWARD DRIFT OF THE BRITISH ISLES

We have all the rocks show to the left so we must have experienced the latitudes and climates indicated.

The rocks indicate a palaeolatitude at a given period and time.

PERIOD	ROCK TYPE	PALAEOLATITUDE
QUATERNARY	GLACIAL DESPOSITS	55^{O}N
TERTIARY	PALMS	40^{O}N
CRETACEOUS	CHALK	35^{O}N
JURASSIC	COLONIAL CORALS	30^{O}N
TRIASSIC	DESERT SANDSTONES	30^{O}N
PERMIAN	EVAPORITES / SANDSTONES	12^{O}N
CARBONIFEROUS	REEF LIMESTONES	0
DEVONIAN	DESERT SANDSTONES	20^{O}S
SILURIAN	REEF LIMESTONES	30^{O}S