CHANGING SEA LEVELS

EFFECTS

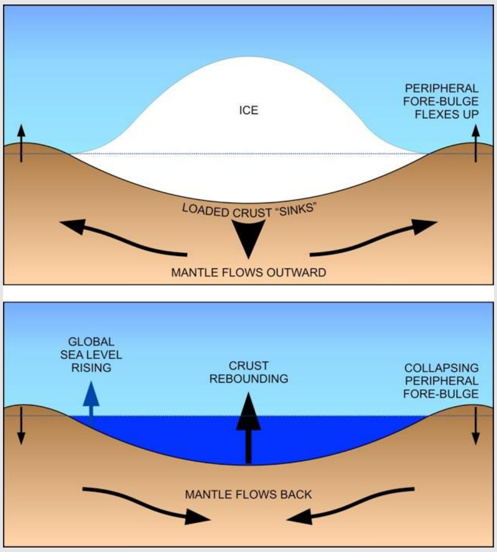
One of the concerns about global climate change is that sea-level rise will lead to coastal flooding and erosion. The majority of the world's major cities are located close to coasts, including London, with large assets at risk.

Sea levels will naturally vary with atmospheric pressure, tides, temperature and salinity variations.

- **Isostatic** changes are changes due to uplift or subsidence of the continental crust. Crust often sinks when loaded with ice or sediment, rising again when such loads are removed. Changes are local to the region.
- **Eustatic** changes are due to changes in the volume of ocean basins or the volume of water within them.

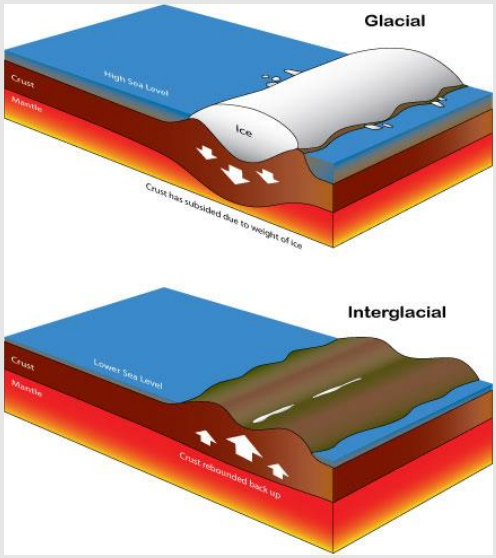
Transgression – sea level rise
Regression – sea level fall
Sea level is generally used to refer to **mean sea level** (MSL), for the surface of one or more of Earth's oceans from which heights such as elevations may be measured. Sea level varies globally by around 2m! due to differences in the Earth's gravitational field strength alone.
In geological terms, sea level now is very near the lowest levels ever. The lowest levels were in the Triassic 250Ma, and the highest in the Cretaceous, 65 Ma.

ISOSTATIC



One of the concerns about global climate change is that sea-level rise will lead to coastal flooding and erosion. The majority of the world's major cities are located close to coasts, including London, with large assets at risk.

Changes in sea level due to local subsidence or uplift are referred to as isostatic.



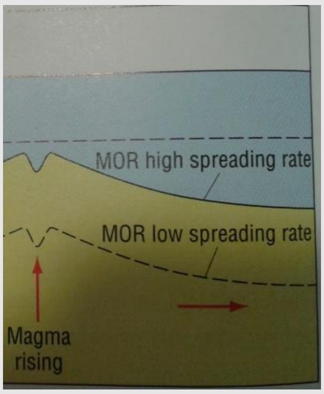
For example, Scotland is rebounding upward while the South Coast subsides because the ice sheets up North during the last glacial have been removed. Ice weighed a lot, so Scotland is rising slowly now it is free from this weight.

EUSTATIC

The effect of the South East subsiding (Isostatic) is worsened by global sea levels rising (Eustatic).

The change in the sea level due to the **volume of ocean basins** or the **water within** them are **Eustatic**. They can be due to the **melting of polar ice caps**, releasing more water into the oceans, or the thermal expansion of water by increasing temperatures. When ice advances, sea regresses as more water is held so sea levels fall.

Eustatic change is also caused by the **rapid rate of sea floor spreading**. This results in the **mid-ocean ridge swelling with magma** and so displacing large volumes of water.



There were **many more MORs during the breakup of a large supercontinent** like Pangea (began breaking up 200 Ma) and this will **raise the ocean floor** and displace large volumes of water. This decreases the volume of the ocean basins.

The **number of MORs** and **the rate of spreading of MORs** are both important factors.

Another mechanism for changing the volume of an ocean basin is **orogenesis** (mountain building). Orogenesis is the **thickening of the crust** and the **formation of fold mountains**. These ranges eventually erode to produce **extensive quantities of sediment** which can **fill ocean basins**, displacing large quantities of water.

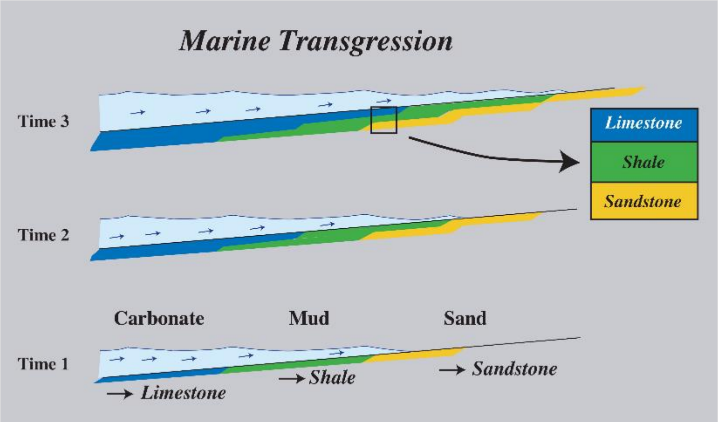
A change in the temperature of the water column will result in **thermal expansion**. By raising the temperature of the top 500m of the sea by just 1^0C produces a global 10cm transgression. Global warming raises the **sea surface temperatures (SSTs)** and as the water's density falls, sea levels transgress.

There is a striking correlation between **mass extinctions and (rapid) sea level change**. However, the survival of life depends on the rate at which animals living in certain climates/environments can move or adapt to the change compared to the rate of the sea level change.

MEASURING PAST SEA LEVEL CHANGE

1. **Using seismic evidence to uncover unconformities**:
   Transgressive seas result in the **sea laying down younger beds** that cover the old strata at a faster rate as the sea deepen. When seas regress there is a **lack of sediment** being deposited and **exposed beds** will be eroded and identified as an **unconformity.**

   Identify terrestrial and marine sediment.



2. **Using exposed geology to estimate the areas of flooded continents through time**:
   The effects of sea level change are seen on the **continental shelf**, and **upper continental slope**.
   - When **seas regress**, there will be **raised beaches and cliff lines**.
   - When **seas transgress**, there will be **submerged landscapes** such as **forests (**forest vegetation **does not grow in high salinity)**. **Marine organisms** may be found in younger sediment too.

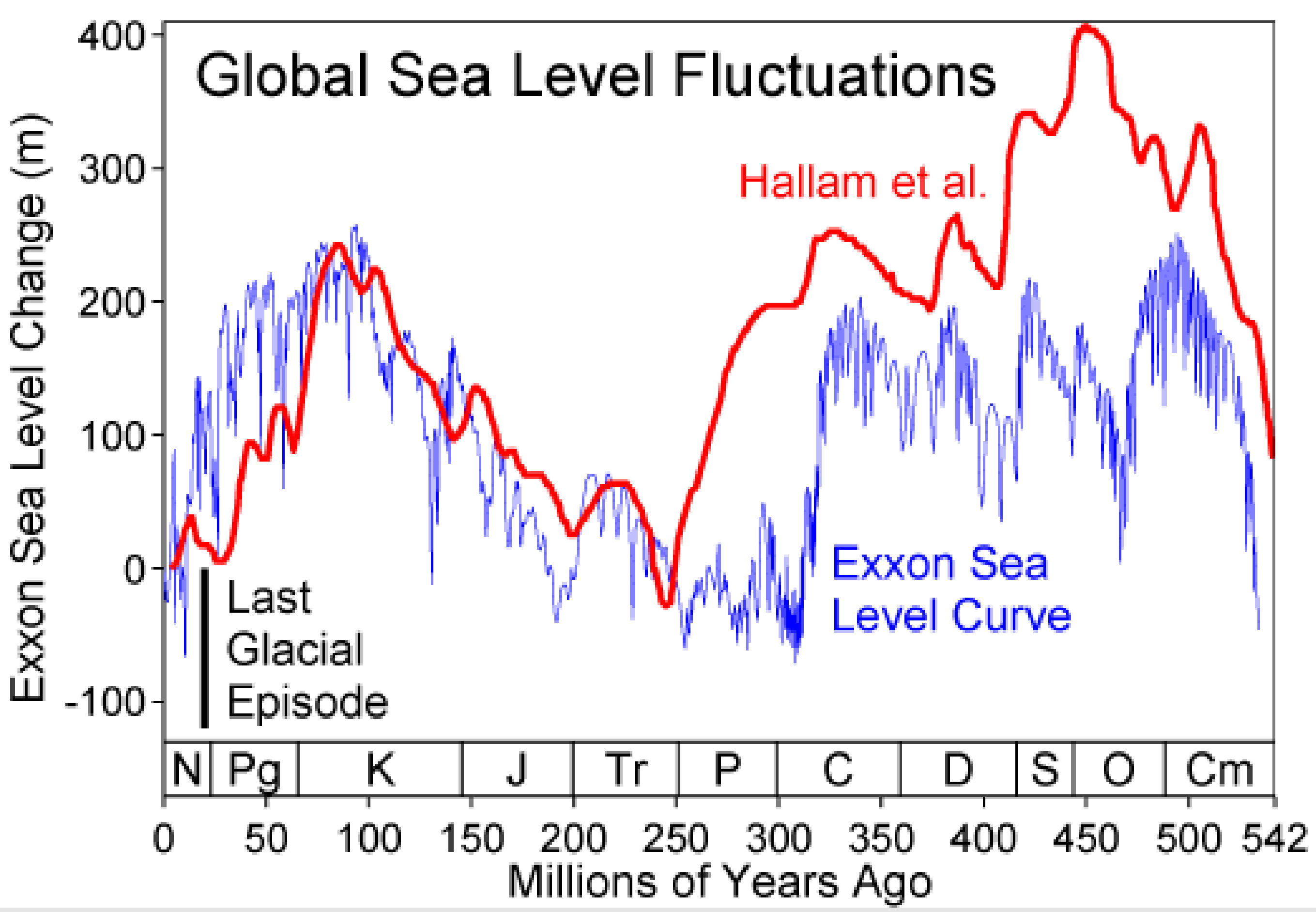
3. **Using oxygen isotope ratios to assess the past temperatures and therefore the amount of ice;** the presence of large ice sheets suggests sea regression, conversely, less ice means raised sea levels and so transgression.

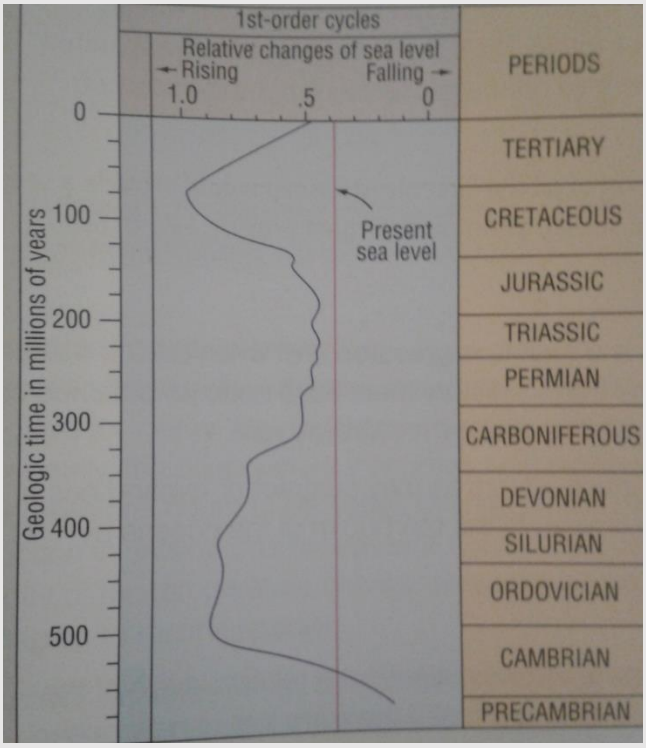
VAIL'S SEA LEVEL CURVES

This is a sea-level curve representing changes of the sea level throughout the Phanerozoic.

The **seismic interpretation of sea-level curves** was pioneered by a team at Exxon, the oil company led by Peter R Vail. The first such curve is the **Vail curve**. Oil companies need to **understand sea-level changes** for **successful oil exploration**. Their sea-level curve was based on **seismic and biostratigraphic data** accumulated **during petroleum exploration**.

From **Triassic to present**, these sea-level curves identified more than 100 **global sea-level changes**. When looked at over millions of years the **combination of all the data** on sea-level changes shows **patterns at many levels**.



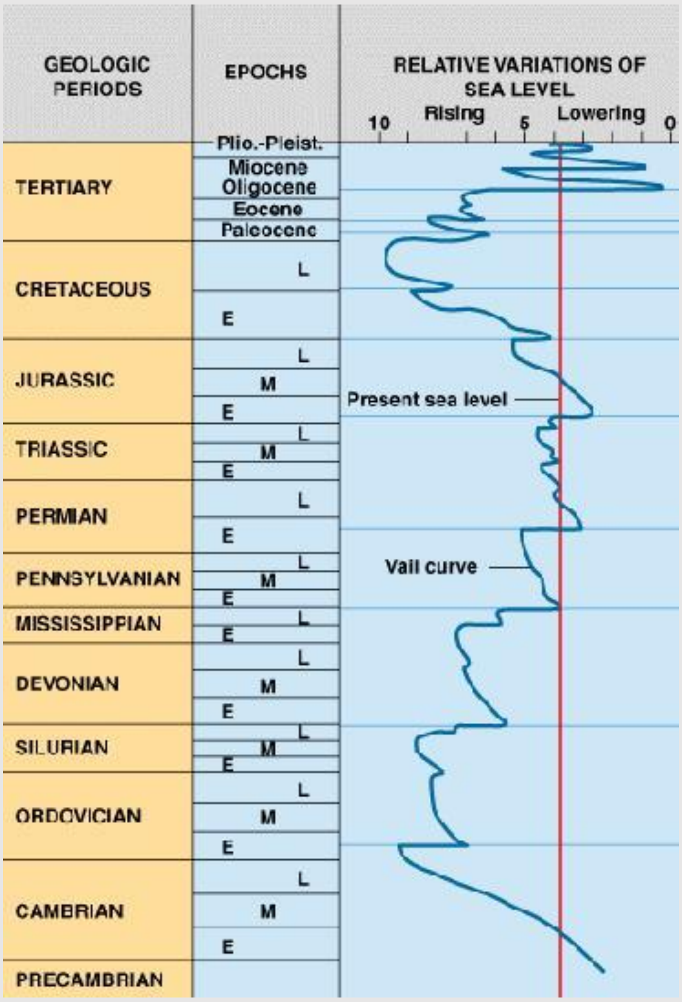


Today's sea level is extremely low, not matched by any other time in the Phanerozoic.

The highest sea level over geological time has been in the Cretaceous.

If the **Vail curve is smoothed out a lot** then it simply shows **broad cycles** lasting **millions of years** where the sea **transgresses and regresses**, known as **first-order cycles**. The first order cycles coincide with times of **major continental plate break up**.

The high sea level that existed in the Cretaceous occurred at the same time as the rate of seafloor spreading was high during the opening of the Atlantic Ocean.



If the graph is **smoothed a little**, it shows a p**attern over tens of millions of year**s of frequent tr**ansgressive and regressive events**, known as **second-order cycle**s. 2nd order cycles are called **super-cycles**; the next diagram makes a good attempt to redraw the **Vail curve** showing 2nd order cycles **superposed** on the first order cycles.

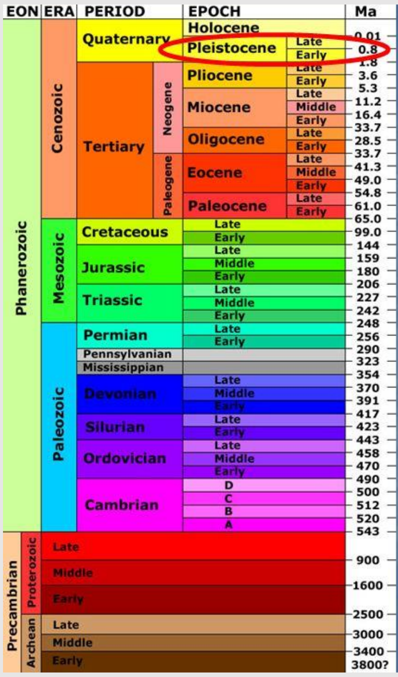
Changes between geological periods are almost always coupled with dramatic/sudden sea level change.
…this suggests **sea level change** is a driving factor in **faunal turnovers** and/or **mass extinctions.**

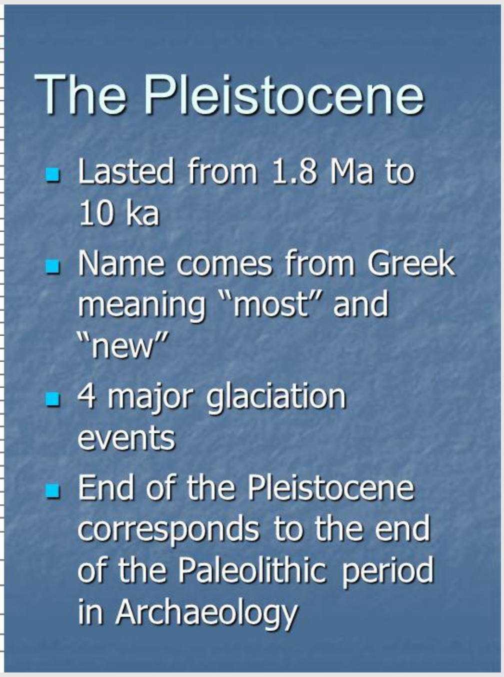
Sea level **oscillations** have continued with a rough **periodicity of 100,000** years linked to astronomical cycles (**eccentricity period**), **superimposed on a gradual rise.**

SEA LEVEL CHANGE IN THE **PLEISTOCENE**

Three different approaches were used in the investigation of the Pleistocene glaciations:

1. Studies of **deep-sea microfossil assemblages** from **Atlantic cores** of **deep-sea sediments** with **palaeomagnetic dating** shows that about **30 glacial events** occurred during the **Pleistocene**.
2. Measurement of **^{18}O to ^{16}O** in the skeletons of **benthonic** foraminifera. These changes cannot be due to deep ocean basin temperature as this remains relatively constant, **0^{0}C to 2^{0}C**. The ^{18}O to ^{16}O ratios in shells show a **volume of ice temporarily removed** from the system.





*Comparing the isotopic ratios in foraminifera shells at the **height of the last glaciation** when **sea level** was at **its lowest**, with those in **modern forms**, when sea **level is higher**, allows us to **calibrate past** records of ^{18}O to ^{16}O with sea level change.*

3. The study of **uplifted coral reef terraces on tropical islands** shows that sea level was higher in the past.