Earth History from the Bottom of the Ocean

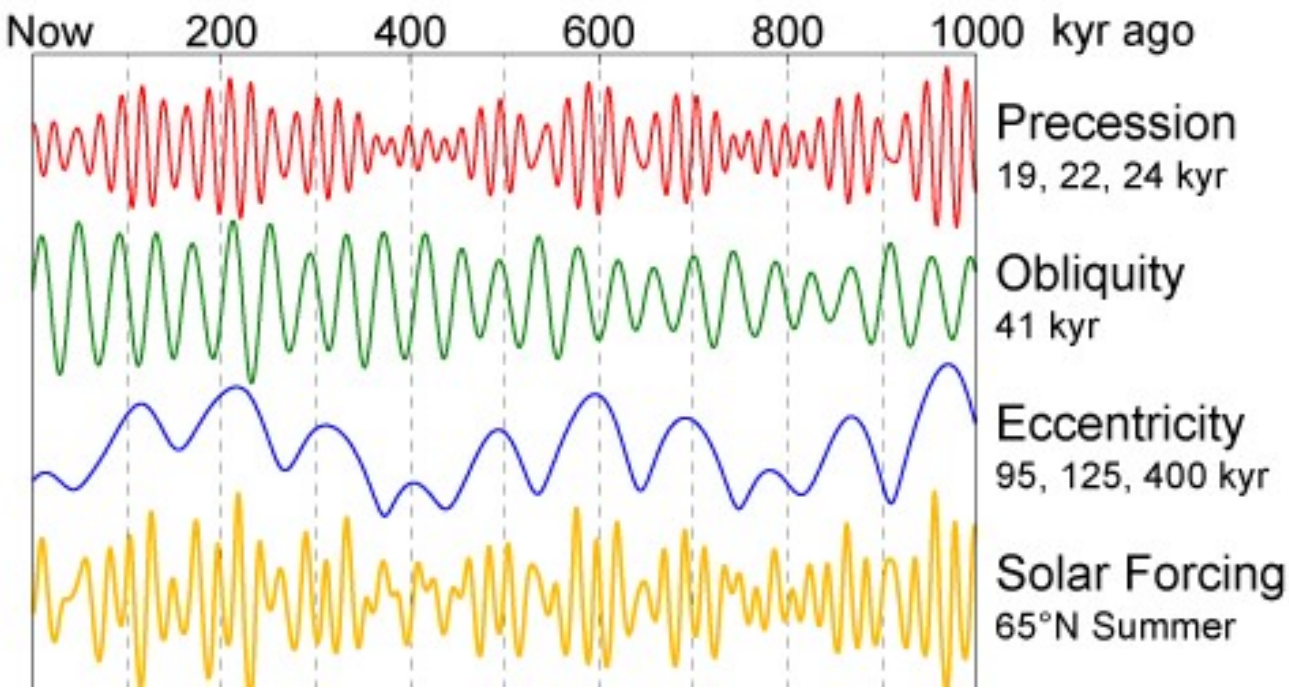
Garry Law

When I was being taught engineering geology it was a terrestrial subject and most geologists did not think of geological processes in world terms

- Other than that they recognized that the major stages e.g. the Pleistocene: the ice age – must have been synchronous around the world.
- The Pleistocene was then thought to of been of about 1M years duration
- The four glaciation stages recognized for glacial deposits in the European alps – Gunz, Mindel, Riss and Wurm were thought to be world-wide.

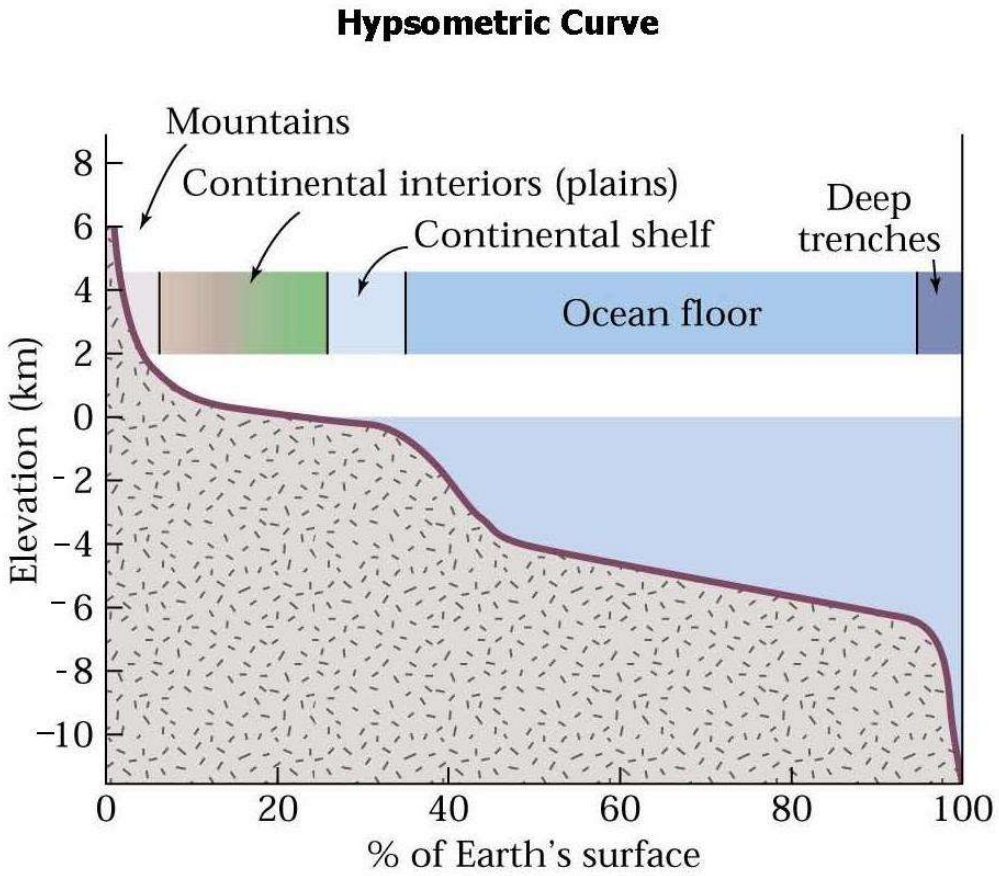
Milutin Milanković, a Croatian polymath in 1922 calculated how variations on the earth's orbit may have been the driver of ice ages.

Never accepted – it seemed too detailed – but not forgotten either.



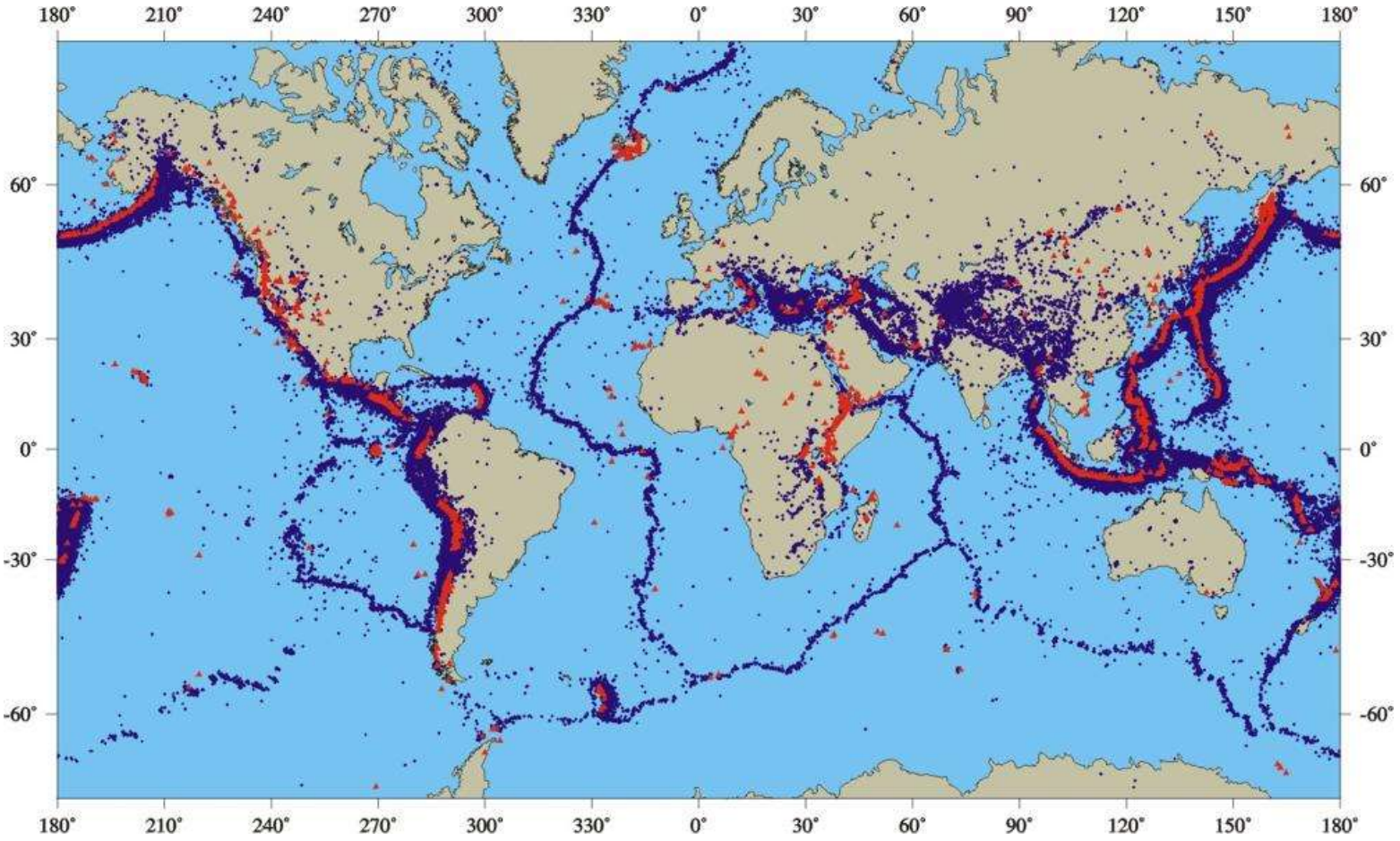
Some indicators then of world processes:

Global distribution of elevation -



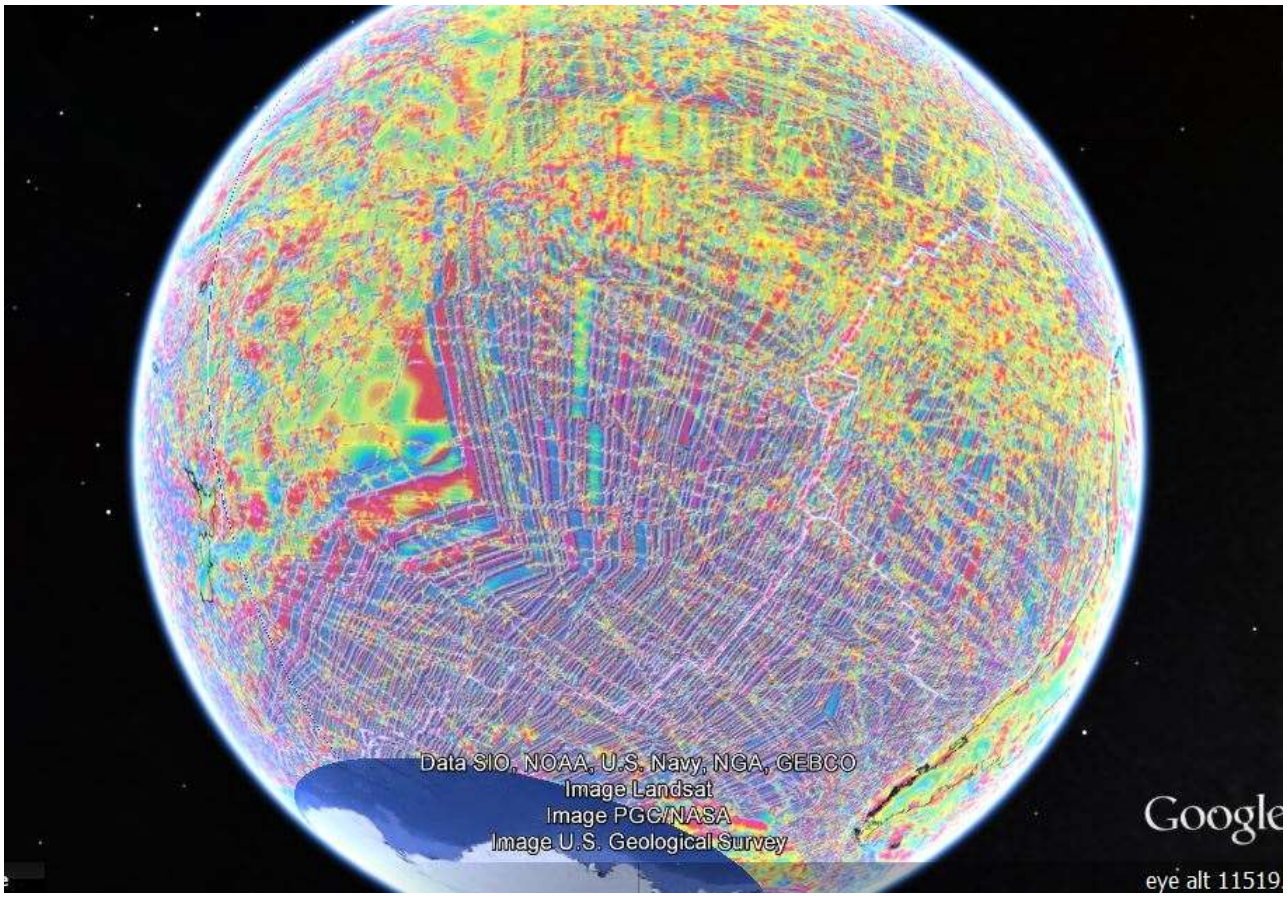
Some indicators then of world processes:

Earthquakes and Volcanoes -



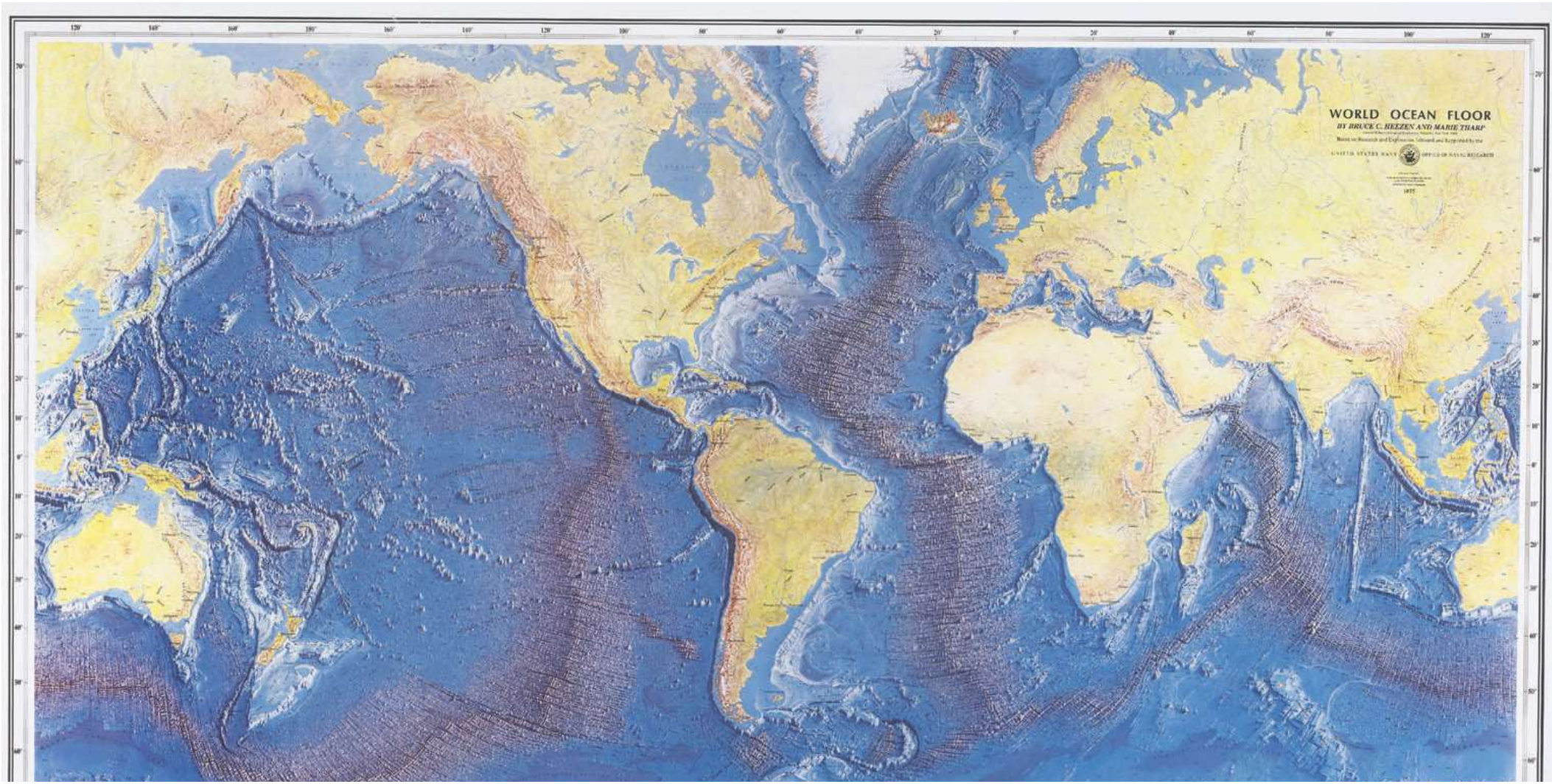
Magnetic anomaly mapping

- Efforts in the oceans completed a mapping process begun on land -



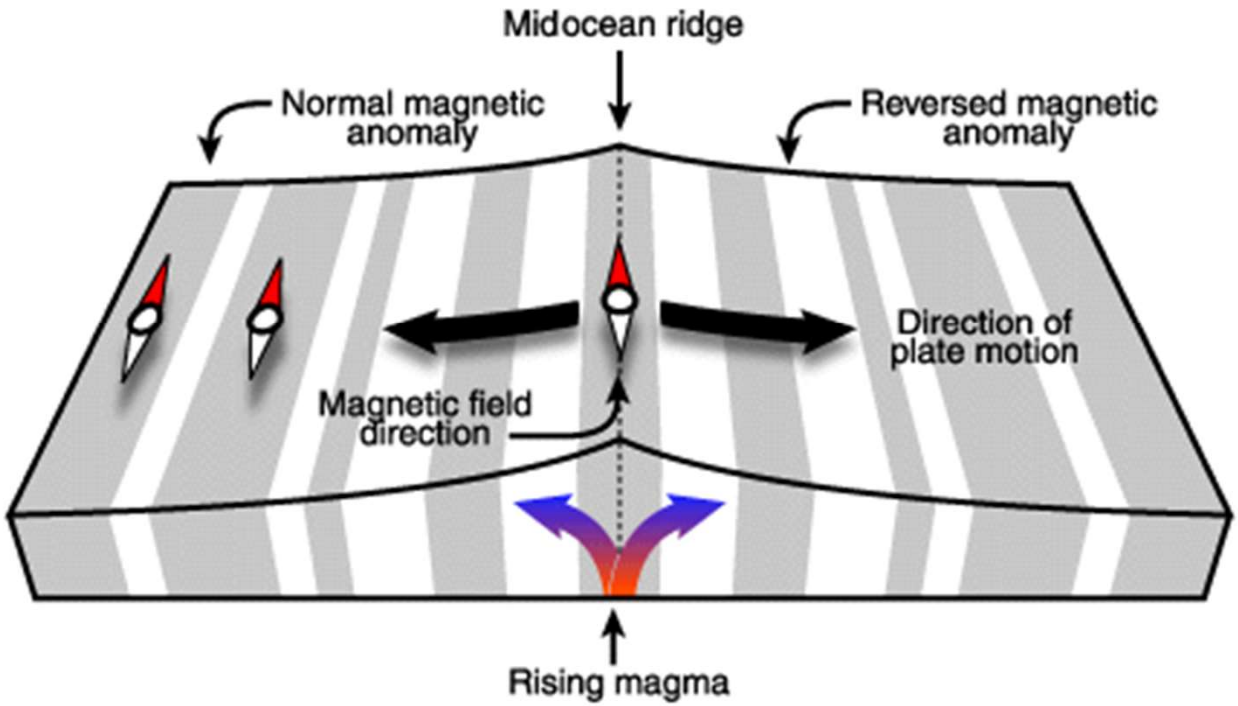
Extraordinary stripes on the ocean bed

At the same time the sea floor was being mapped in ever greater detail:



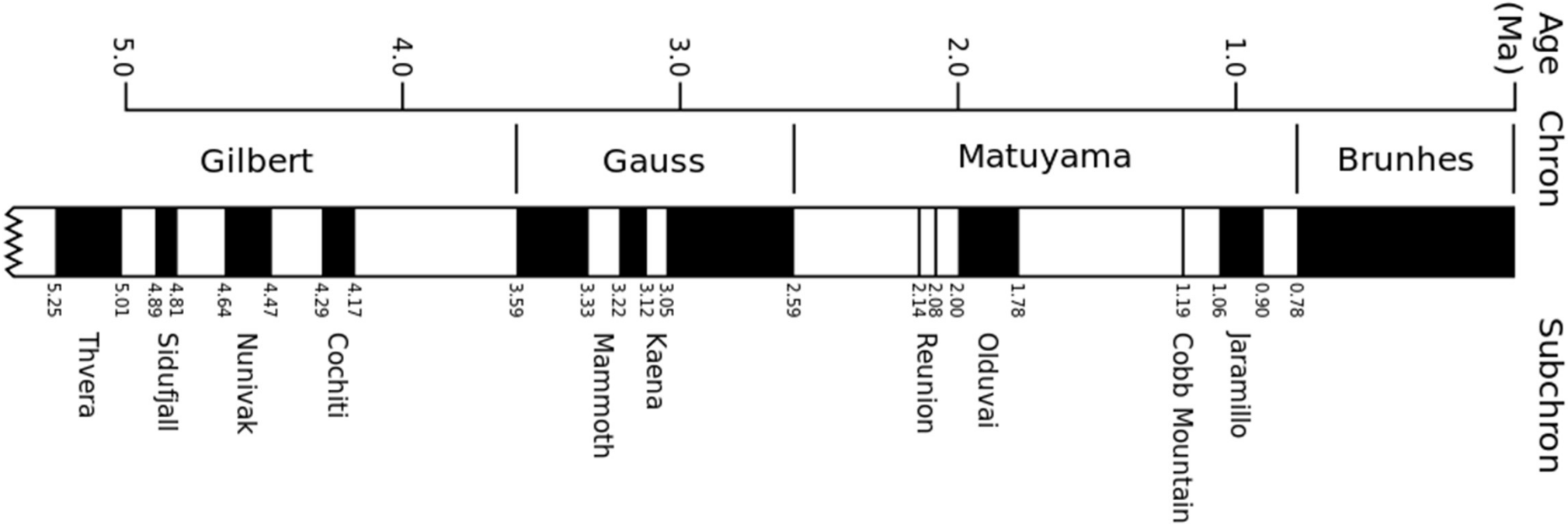
The patterns of magnetic stripes proved to be reflected around the mid ocean ridges.

This proved to be crucial in deriving the theory of plate tectonics.



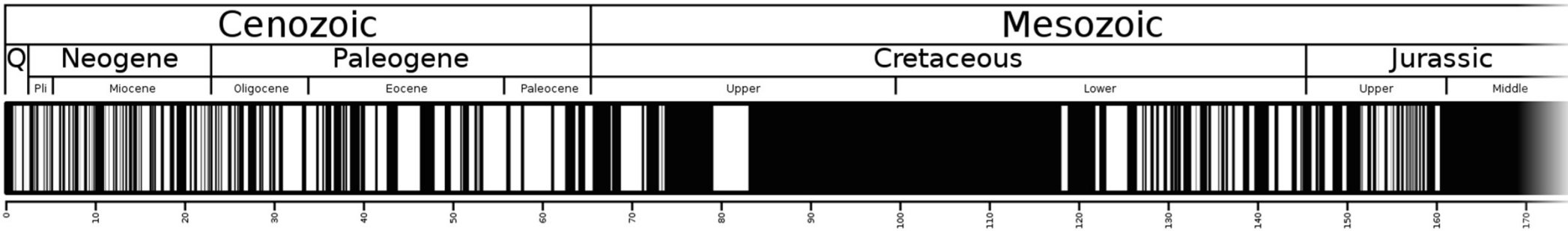
Reversal History:

Largely from terrestrial dating of lava flows (by isotope decay dating) the recent history of reversals is well known:

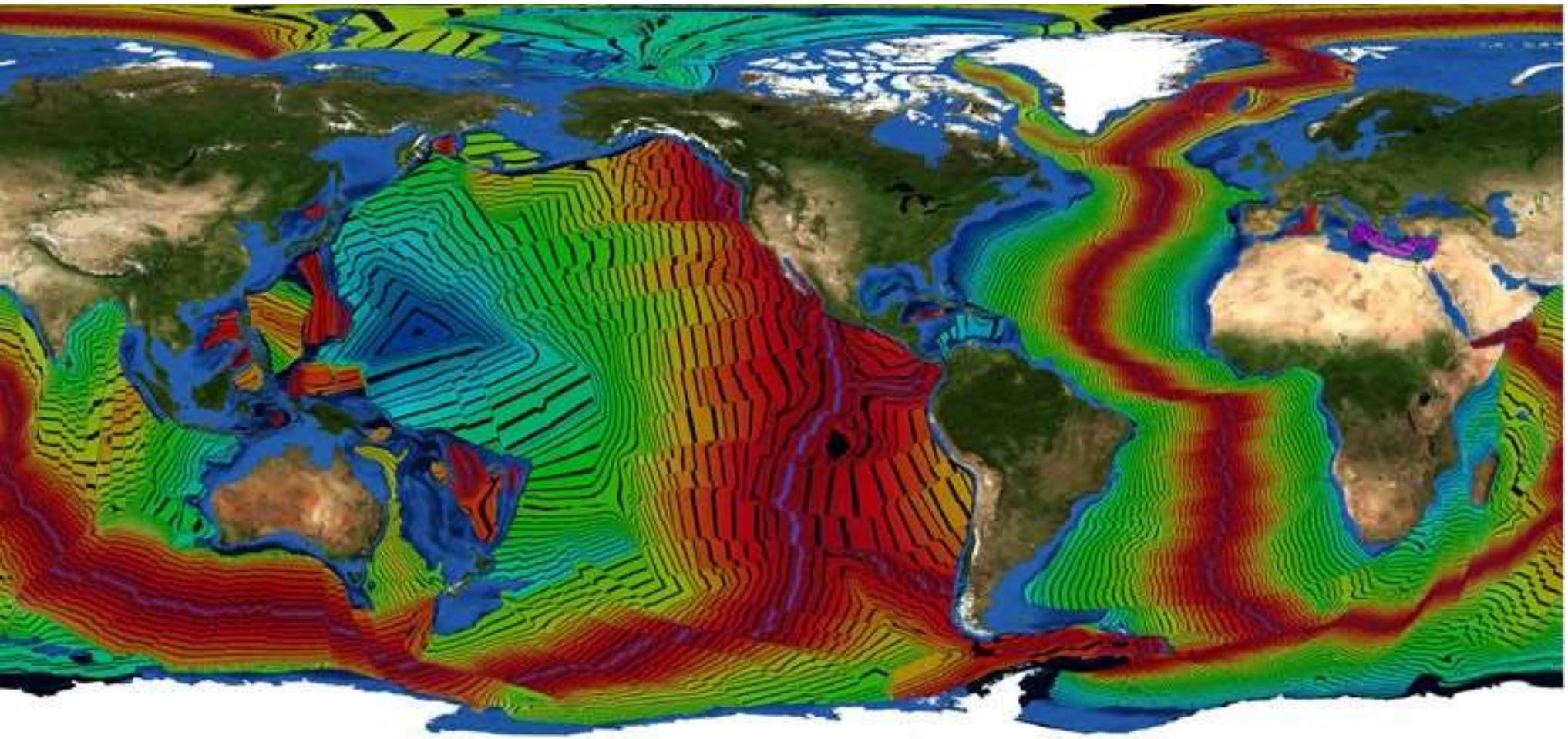


Reversal History:

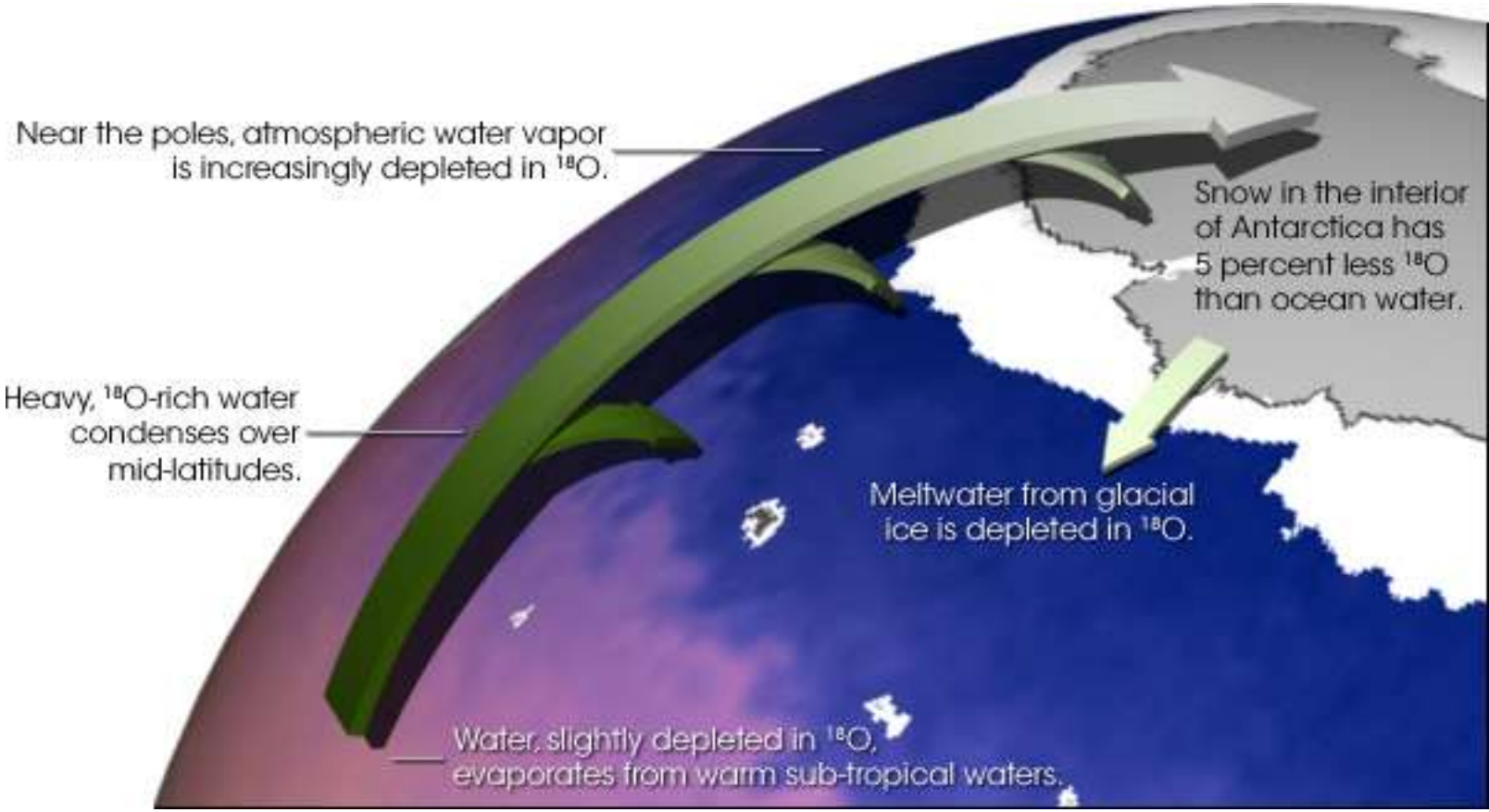
Longer term – back to 170M years ago



From the magnetic stripe pattern the age of the seafloor is well known – but no part is older than ~200M years - despite there being oceans on earth for 20 times that age.



^{16}O / ^{18}O ratios (stable isotopes)



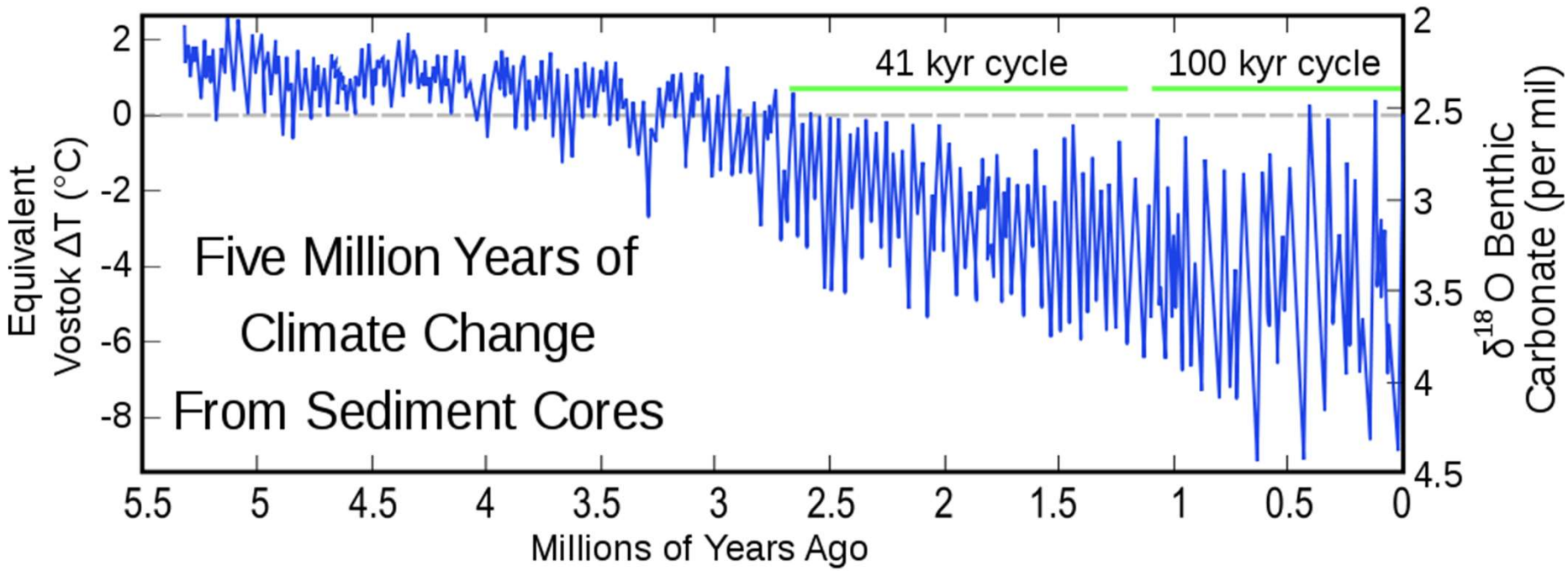
During an Ice age water depleted in ^{18}O accumulates in the polar glaciers affecting ratio in all the world's oceans.

Deep Ocean Cores

- Deep ocean sediments accumulate at about 10mm per 1000 years
- Suffer bioturbation so do not have fine detail
- Are hard to sample
- Now a long history of their collection and analysis for multiple outcomes
- One of long standing is analysing ^{16}O / ^{18}O in the carbonates from things like foraminifera shells (measured by mass spectroscopy)
- Now have a long history of the ratio
- Is an agreed labelling of 104 marine isotope stages back to 2.6M years ago
- Dating is linked to magnetic reversals which can be measured in cores, also global volcanic ash events
- Recent history supported by ice dome cores measuring CO_2 levels in the atmosphere.

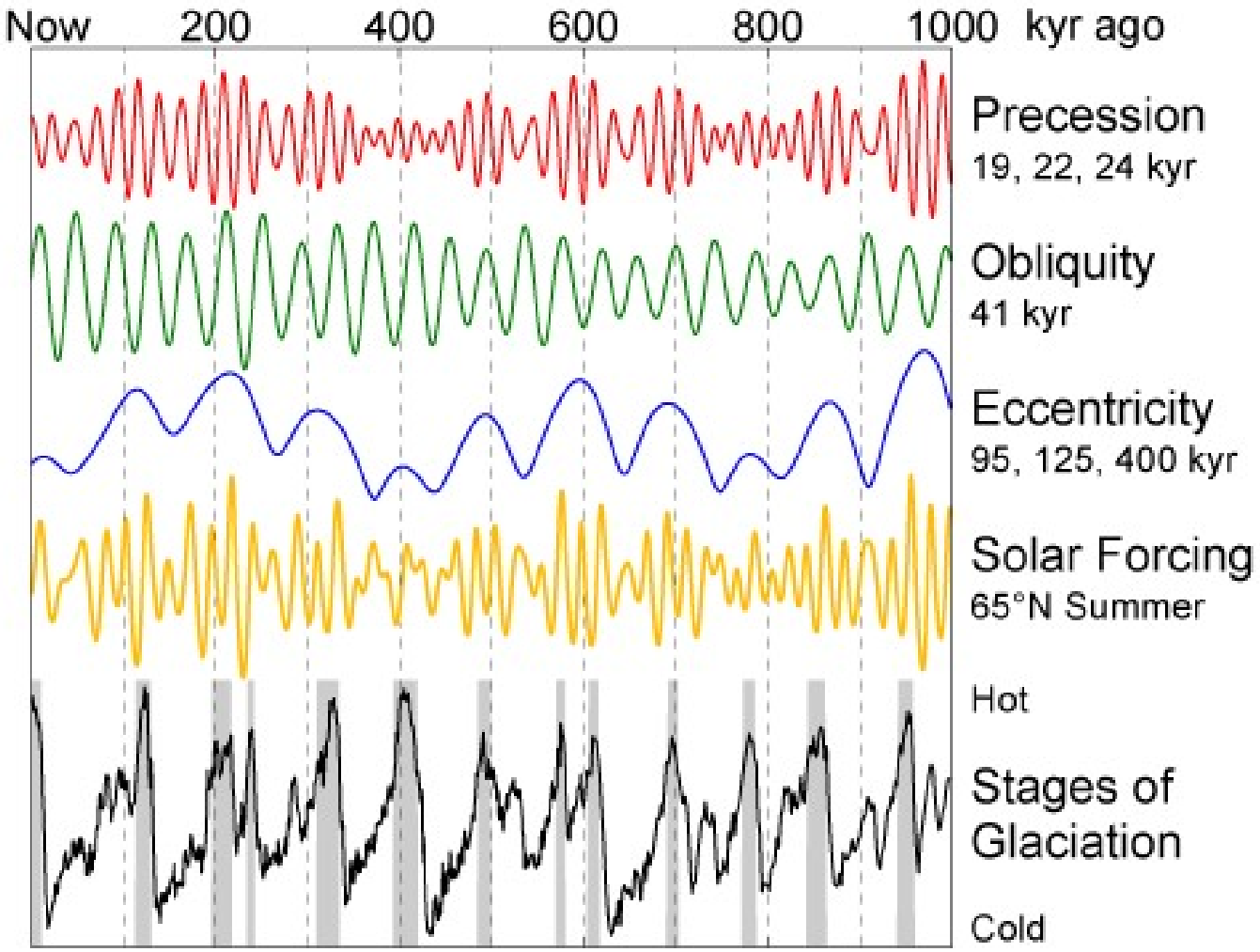
Convert the ^{16}O / ^{18}O isotope ratio to temperature and we have a 2.5M year Ice Age – with many stages.

The cycle changed from 41K years to 100K years a bit over 1M years ago.



Go back to Milanković and add on the temperature record

The cycles he proposed now seem to have some reality as being at least a large part of the story



End

Piston core sampler being deployed