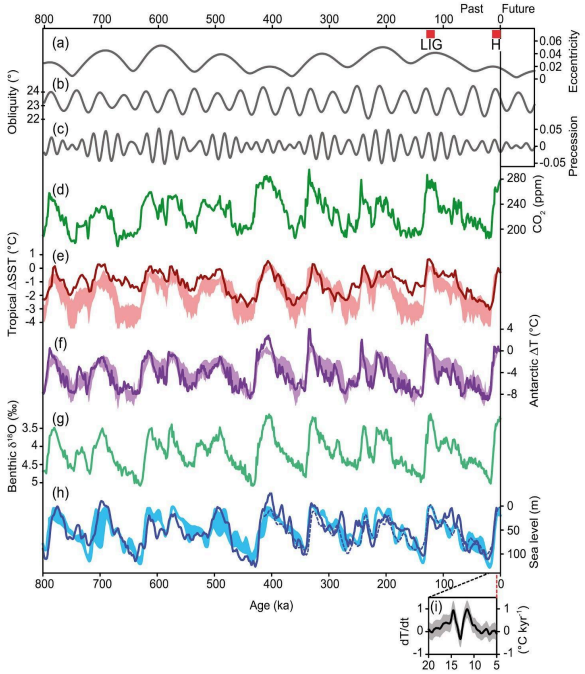
What do we know about
Past Global Conditions and Causes ?
Paleo: Part 2 - The First 4.6 Billion Years (less 50 Million)

Last time, in CSSG-2.2: (Paleo: Part 1), we took a first look at the **last million years-ish**, to see if we can understand more how climates work. The take-aways were:

- We know a **whole lot about the last 800,000 years** because of DIRECT measurements of carbon dioxide (CO_2) and other gases in the atmosphere and in ice cores from Greenland, the Antarctic, and various glaciers.

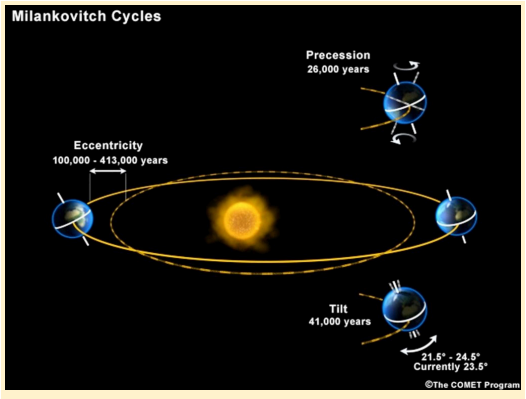
- Ice ages, CO_2 and other greenhouse gas levels, sea levels, and temperatures are all **highly correlated**.



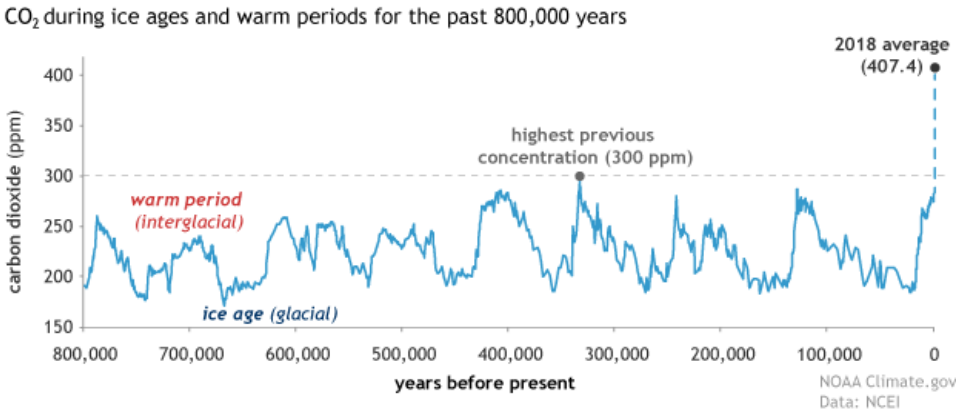
What do we know about Past Global Conditions and Causes ?

Paleo: Part 2 - The First 4.6 Billion Years (less 50 Million)

- **The last million years of ice ages (ice comings and goings) have been driven by characteristics of the Earth's orbit around the sun.** Collectively the perturbations in eccentricity (how close to a perfect circle the orbit is), the tilt of the Earth's axis (which is why we have the summer-winter changes), and the precession of its axis (think of the circular wobble of the top of a spinning top) all add up to more or less ice melting in summers over thousands of years. The cycles of the earth's orbital oddities drive big glaciations which have been (conveniently for getting a feel for this) around 100,000 years long. These cyclical orbital oddities are called **Milankovitch Cycles**. While the very clear data covers the last 800,000 years, there is evidence of around 20 of these ice age cycles over the last 2 or so million years. (Huge ice sheets, like the one we had over a lot of the northern continents 20,000 years ago, tend to wipe out geo records of earlier ice sheets.)



- While the CO_2 levels over the ice ages have averaged around **280 parts per million** (ppm), and never exceeded 300 ppm, it is now dramatically increasing and is around **420 ppm this year (2023)**. Because of this, the earth is expected to be **kicked out of the Milankovitch Cycle behavior** (of cyclical ice ages).

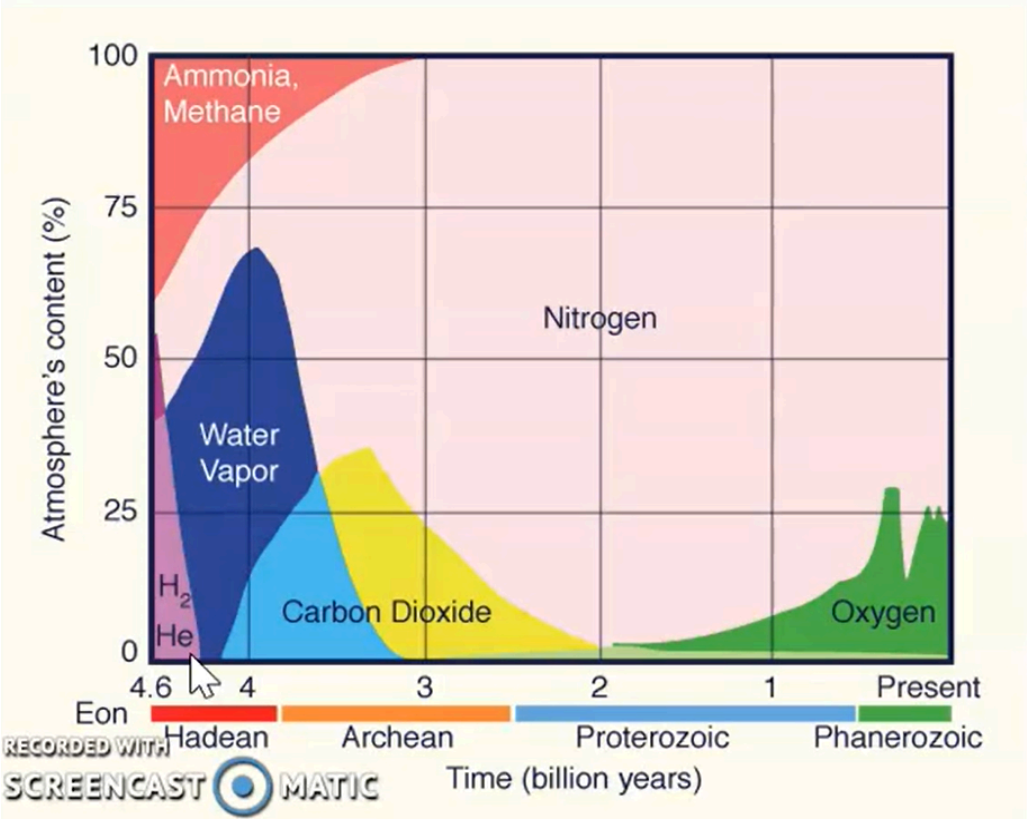


- We will have to **look farther back in time** to see if we can find analogous conditions to this level of CO_2 (and the increased temperatures experienced in the last two centuries).

What do we know about
Past Global Conditions and Causes ?
Paleo: Part 2 - The First 4.6 Billion Years (less 50 Million)

Now for Paleo: Part 2. Before we try to ooch our way back past 800,000 years ago to get insight on our current conditions, it seems reasonable to suggest that we can **ignore conditions prior to 50 Million Years Ago, all the way back to the formation of the planet 4.6 Billion years ago (if our goal is to get a handle on climate science directly relevant to today's issues)!** Since it will be very helpful to simplify things, let's go ahead and understand why I have come to that conclusion. **Part 3 (not this week) will tackle the more relevant times from 50 Million years ago to the present.**

First (and very quickly!), let's look at the entire history of the planet: **4.6 Billion years!** This first chart basically says that only in the last 500 million years (0.5 By) (ish) - at the far right of the chart - was the ***composition of the atmosphere*** similar to the present - mostly Nitrogen (now about 78%), a goodly amount of Oxygen (now about 21%), and a tiny bit of Carbon Dioxide (CO_2) (now about 0.04% = 400 ppm). Argon is around 1% and there are other minor gases which we'll ignore at this point.



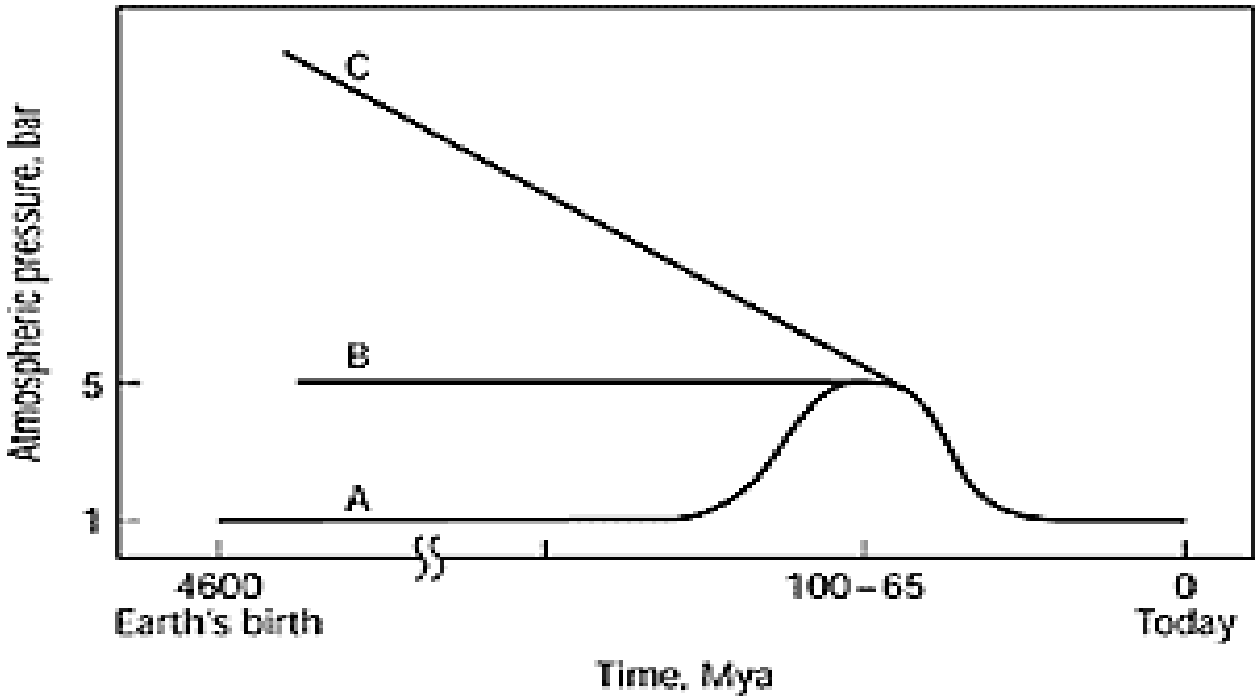
https://www.youtube.com/watch?v=j0evKCTVh2I

Given the above, I think we can **ignore the period 4,600 (4.6 B) - 500 Million (0.5 B) years ago. The composition of the atmosphere was radically different from today.**

What do we know about
Past Global Conditions and Causes ?
Paleo: Part 2 - The First 4.6 Billion Years (less 50 Million)

So, is there a way to whittle this down a bit more?

This next chart is one attempt to figure out what might have been the ***density of the atmosphere***. since the formation of the planet. One of the few things known about this is that the first birds were able to **fly around 100-65 million years ago (65 million years ago is when the dinosaurs were wiped out)**. The density of the air had to be sufficient for that type of bird - about **5 times the current density** we now experience (as shown on the chart). What happened before is the stuff of scientific conjecture, as indicated by lines A, B, and C.



http://pubsapp.acs.org/subscribe/archive/ci/30/i12/html/12learn.html?

So, this doesn't really clarify a lot **before 100 Mya** (Million years ago), but it does imply the atmosphere was far denser than today during the period around 100 - 65 Mya. **This is an argument for not focussing on the period before 65 Mya - the climate could not have been very analogous to ours.**

What do we know about
Past Global Conditions and Causes ?
Paleo: Part 2 - The First 4.6 Billion Years (less 50 Million)

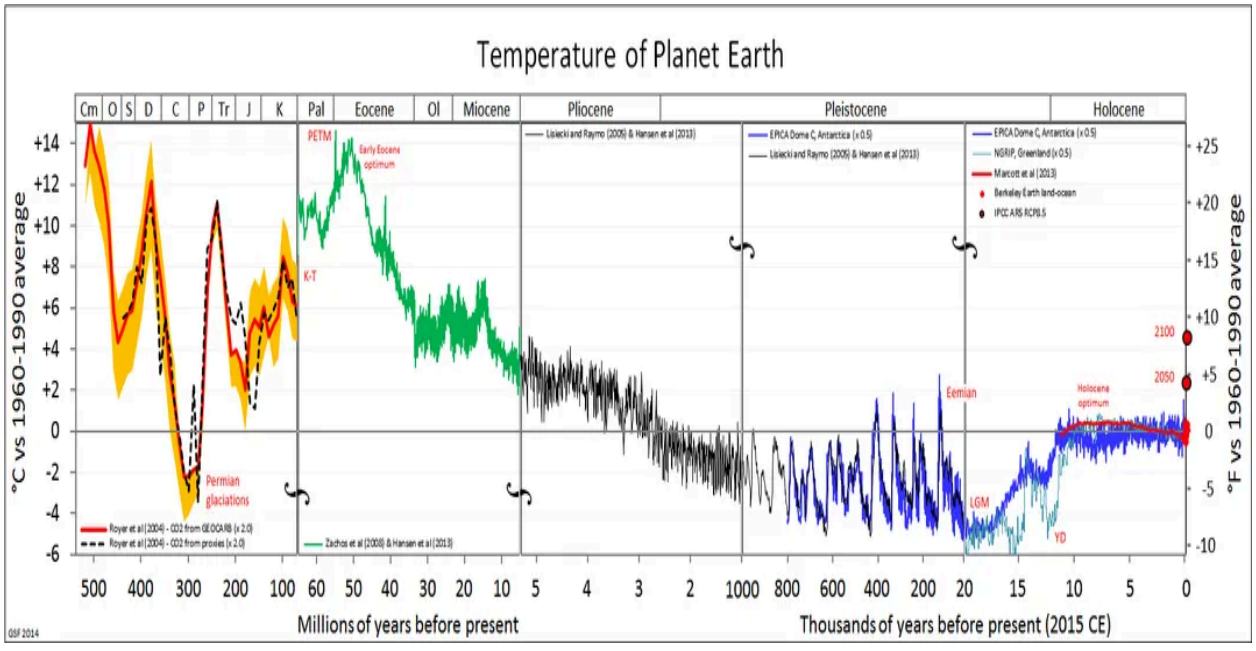
So, what else can we surmise?

For the ***prevailing Temperature of the planet***, during the last half-billion (500 million) years, let's glance at the next chart. Remember, we've decided to ignore times earlier than that because the amounts of **nitrogen, oxygen, and CO_2 were radically different from today**.

[Do note that the scales for years are done in a pretty unusual way! At the left end, we're looking at hundreds of millions of years, while at the right end, we're looking at thousands of years. Look especially at the period from 1000 - 20 thousands of years before present at the right end: these are the ice ages from 800,000 years ago to 20,000 years ago. The final block on the right end is the warm period since the great ice sheets melted from New York north - **These are our times!]**

There seems to be some **orderly (cooling) behavior since around 50 million years ago**, so this can also help us focus our attention to this more recent phase of the Earth's evolution.

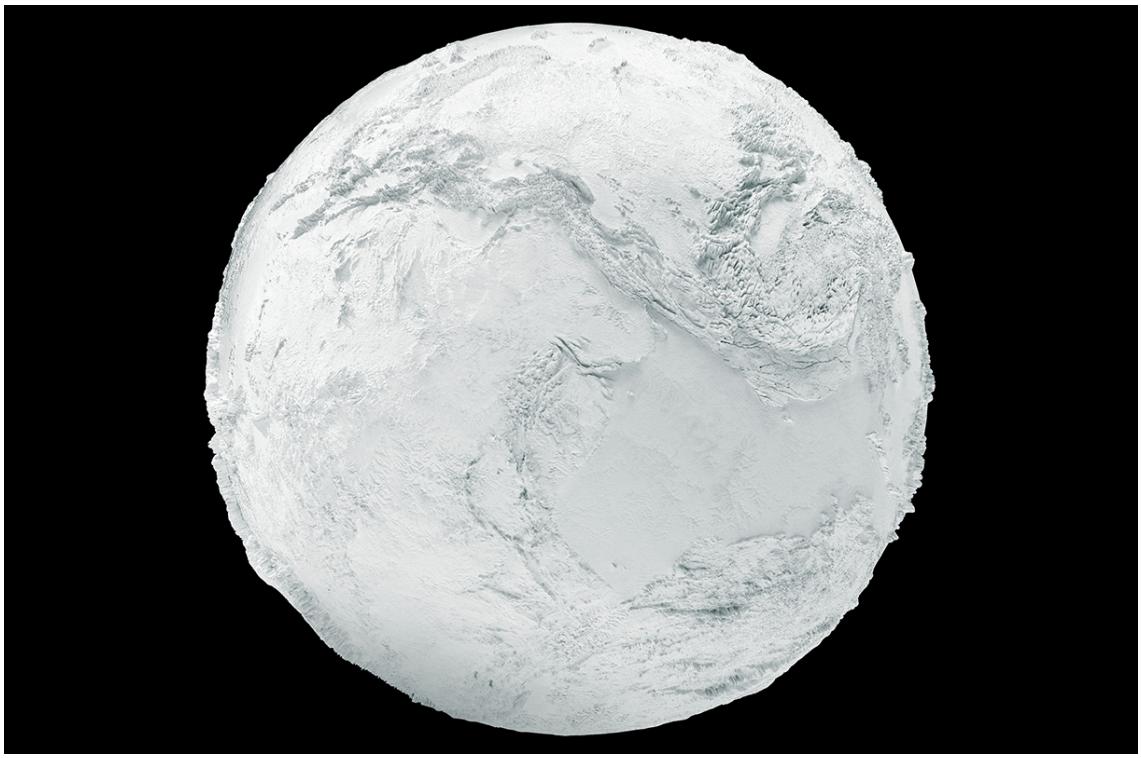
[By the way, that long cooling period from around 50 million years ago until now could be related to the emergence of the Himalayan Mountains. It is hypothesized that this huge amount of bare rock thrust up by the collision of the Indian subcontinent with Asia could have reacted with the CO_2 in the atmosphere - resulting in the cooling of the planet.]



https://www.globalwarming-sowhat.com/warm--cool-/

What do we know about
Past Global Conditions and Causes ?
Paleo: Part 2 - The First 4.6 Billion Years (less 50 Million)

SIDE NOTE: Just for fun, look at the chart above at around 300 million years ago. Enormous amounts of lava flowed to the planet's surface. Similar to the emergence of the Himalayas much later (see above) there is some evidence that this huge amount of new rock may have reacted with the CO_2 in the atmosphere, plunging the entire planet into an ice age. And this may have occurred several times over the earth's history. **Meet the Snowball Earth !**



Punchline for Paleo: Part 2

Given the above, it seems reasonable (and it is definitely convenient!) to just **ignore the Paleo (ancient) record from earlier than 50 million years ago (or so)** as we dig more into the issues facing our own times. The radically different mixes of gases, atmospheric densities, and erratic temperatures (as well as much greater limitations on precise data) of those remote times would make it far more difficult to rationalize an analogy to our current situation.

What do we know about
Past Global Conditions and Causes ?
Paleo: Part 2 - The First 4.6 Billion Years (less 50 Million)

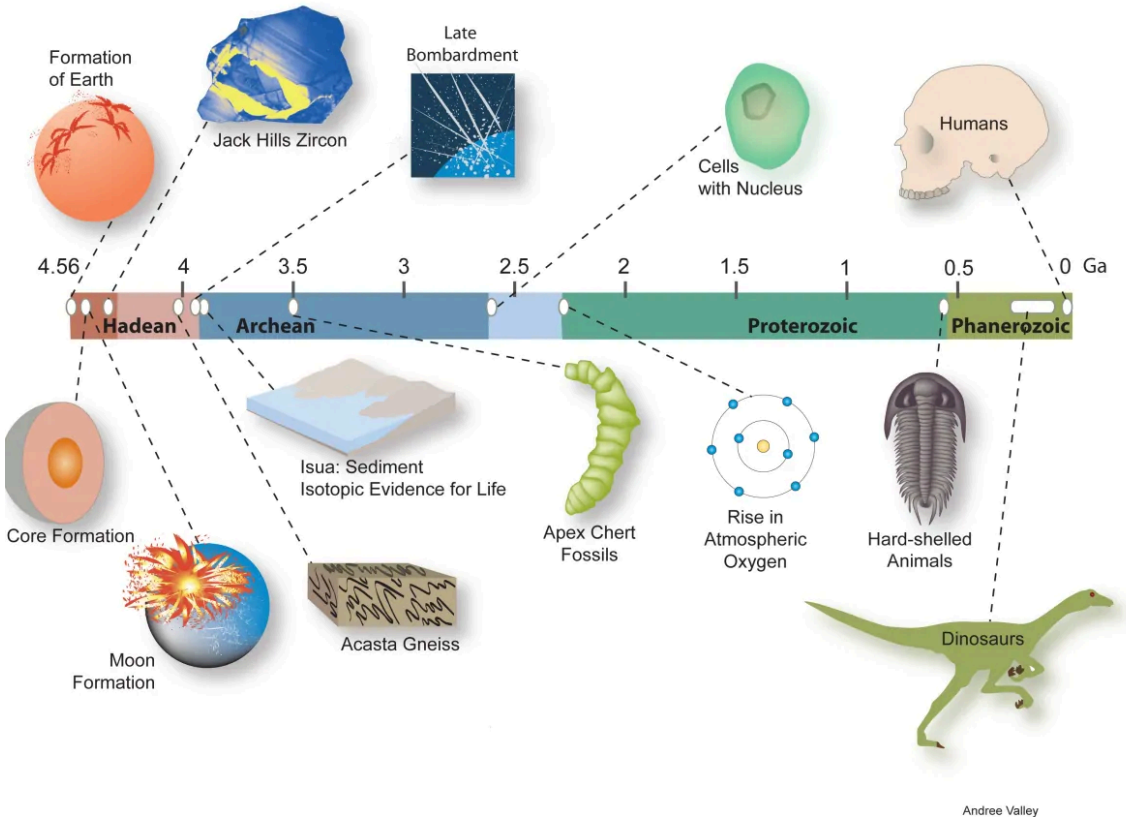
So, in **Paleo: Part 3**, we will give our attention to the most recent 50 million years - and ignore earlier times. Hopefully this more "recent" period will be somewhat relevant to future projections.

BONUS POINTS !!!!

I really recommend fleshing out your visualization of the full history of our planet. It blew my mind, since I had known NOTHING about this. You can just Google History of the Earth and look around, or look this up on YouTube.

An especially good resource is: https://www.youtube.com/watch?v=pN7VQas4OgQ

Here's a general overview of events, worth comparing with the earth's atmosphere chart at the beginning of this CSSG-2.3:



https://www.cbc.ca/news/science/timeline-of-the-history-of-the-earth-1.2550987

Tune in for (Paleo: Part 3) next time!