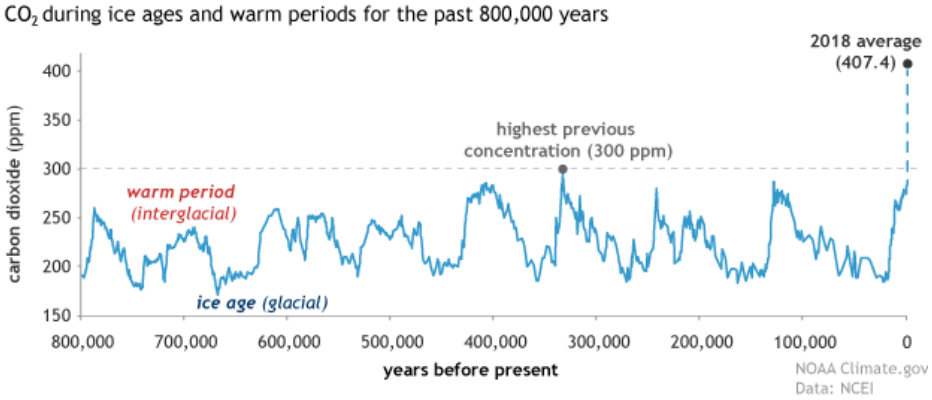
What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

This is Part 3 of our series on the Past (Paleo=ancient), which started in the CSSG-2.2 meeting materials. **[It is likely we will spend more than one meeting on this material, but scanning it a few times should greatly help in getting comfortable with these new concepts!]**

[Always remember that I attempt to paint with a broad but conceptually reasonable (and as accurately as I currently understand things) brush. The science behind these "paintings" is deep and can be complex. Typically, hundreds (if not thousands) of researchers have gathered data and discussed what these data are telling us for decades (if not centuries). On the other hand, all the science can be understood to the degree it is sorted out. As confusions or curiosity arise, be sure to speak up - we are joining this heritage and we may embark on a very interesting study!]

To Recap:

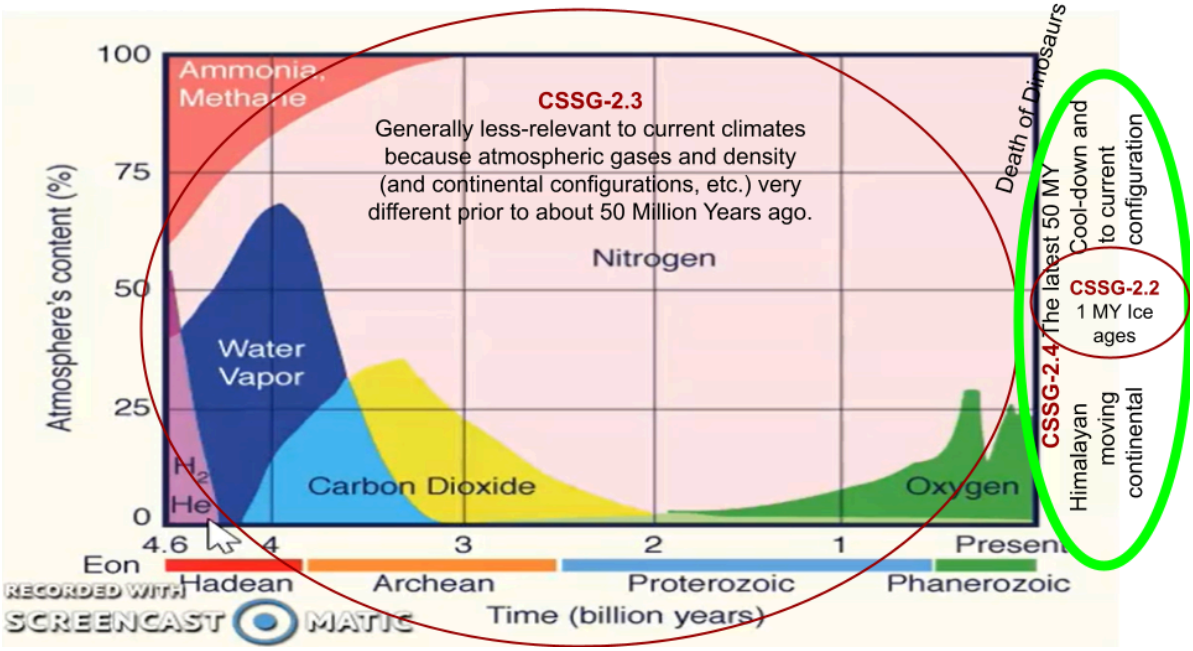
CSSG-2.2 (Paleo: Part 1) Emphasized that we **know a whole lot about approximately the last million years**, with modern instrumentation and ice core data. We noted that recent levels of CO_2 and temperatures are likely above most of what the planet experienced during that time. It seems reasonable to question if today's conditions might break us out of the ice age cycles that were dominated by earth's orbital characteristics.

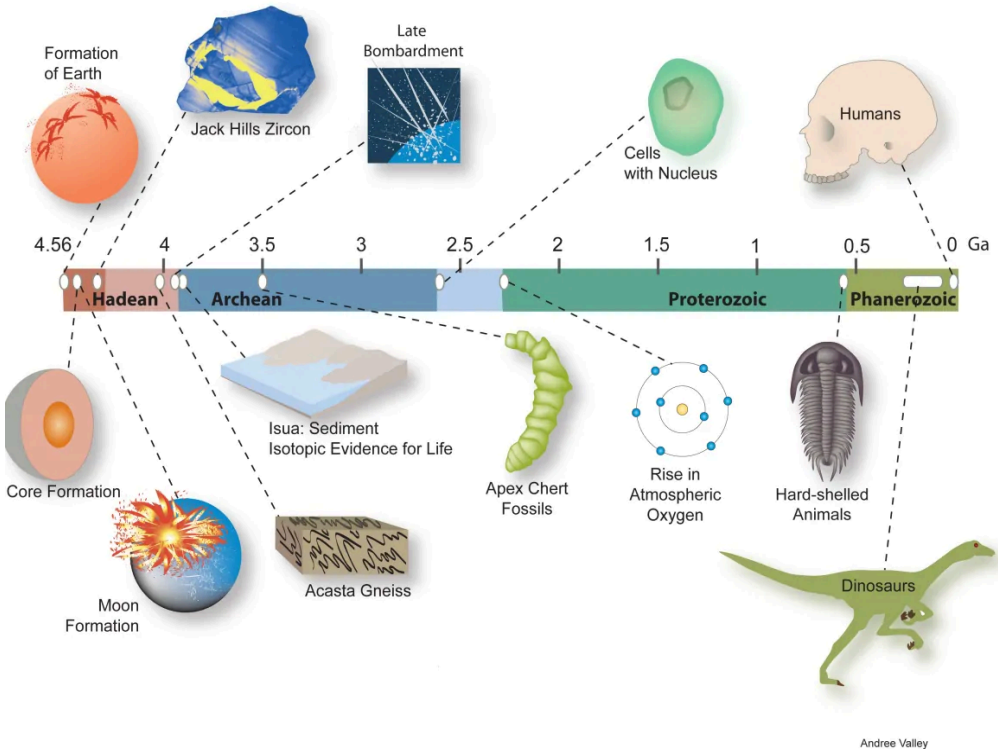


CSSG-2.3 (Paleo: Part 2) Suggested that, over **most of the planet's 4.6 billion years** - until the last 50 million years or so, planetary conditions were so different from today that it may not be likely for us to find conditions which are directly comparable to our present situation. [By the way, we will much later get into some very important data from those early years!]

CSSG-2.4 (Paleo: Part 3) In this new material, we will look at the **most recent 50 million years**. The dinosaurs had been killed off with the asteroid of 66 million years ago. After that, mammals emerged, ultimately leading to humans (mostly in the last million years - coinciding with the ice ages we first addressed in CSSG-2.2). This 50 million year interval set the stage for our current world.

What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown





We've seen the timelines above and below in **CSSG-2.3**. But **<u>before</u> we move on to the latest 50 million years**, please <u>scan</u> the next three pages of "snapshots" of conditions prior to that.

In particular, the key things I'd like you to notice are:

What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

1. The **TEMPERATURE** (today's global temperature is around 15 ^{0}C or 59 ^{0}F)

2. The **TIME** (this is in Millions of years ago = Ma. 1000 million years = 1 billion years, so 4540.0 Ma is about 4.5 billion years ago. Using the .0 at the end of the number is kind of ridiculous. Very few times are known to that degree of accuracy!)

3. The **color of the oceans** radically changes with changing atmospheric chemistry - don't sweat the details, but do note the red oceans. The introduction of huge amounts of oxygen after around 2,500 Ma = 2.5 billion years ago (see above chart) caused the iron in the planet's waters and land to **rust**. Before there was enough oxygen to start changing the atmosphere, these conditions were captured in rocks as Banded Iron Formations .

4. The **very small amount of land in the early years**. This gradually increased, but it wasn't until around 100 Ma (the last two slides in this group) that any resemblance to our current continents was emerging.

5. The occasional **appearance of ice**. Three snowball earths are depicted, but only the first is strongly accepted, from what I can tell.

6. Finally, for fun and a different perspective, notice that the **length of days slowly increases**. I.e., the earth rotation steadily slows, and still does. This is a result of the drag on the earth's oceans (tides) by the moon - which also has slowed the rotation of the moon until it now always shows us only one side.

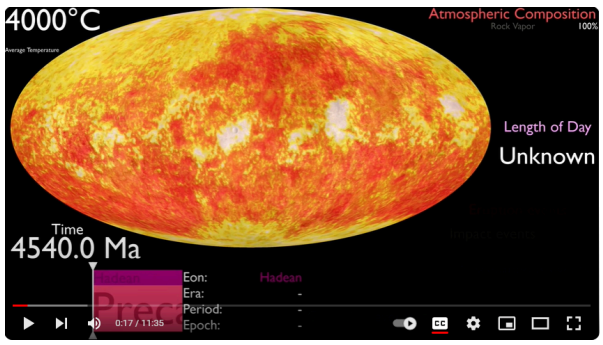
What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

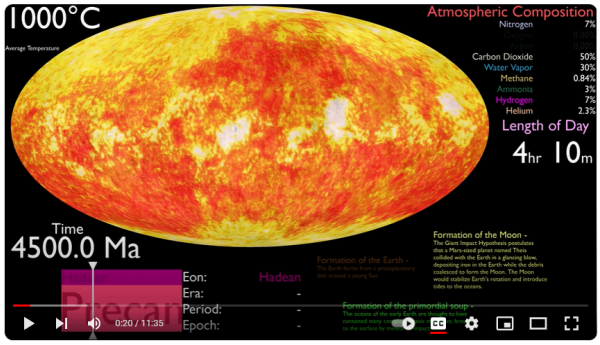
RhAMgYIAhBFGEEyBggDEEUYQdIBCTEzODQwajBqN6gCALACAA&sourceid=chrome&ie=UTF-8#fpstate=ive&vld=cid:85769900,vid:Q1OreyX0-fw,st:0

History of the Earth

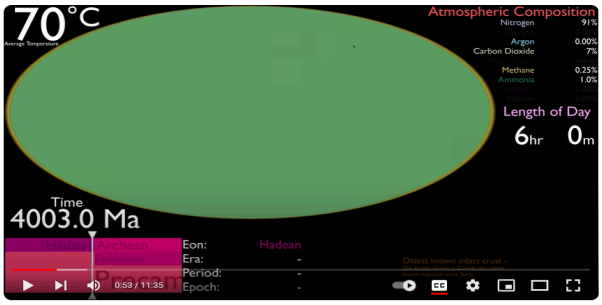
4.6 BY of Planetary Change

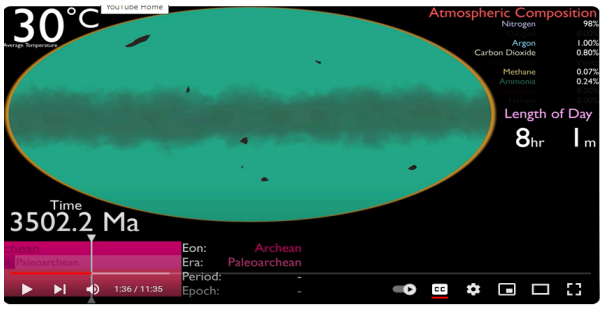
For Reference: Today's Temperature of the Earth is around
15 ^{0}C (or 59 ^{0}F)

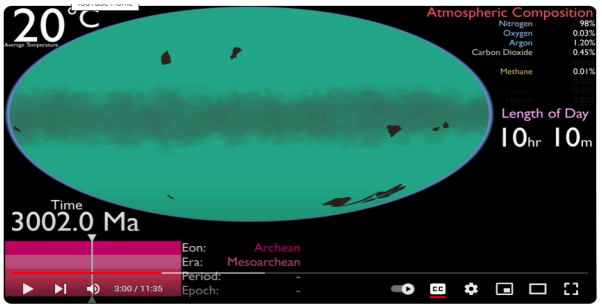


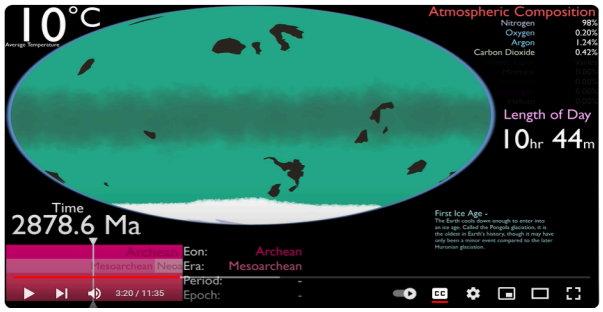


This is in **Millions of years ago = Ma**. 1000 million years = 1 billion years, **so 4540.0 Ma is about 4.5 billion years ago**. Also, it is helpful to remember that 1 ^{0}C is roughly 2 ^{0}F, but starts at + 32 ^{0}F. So, 70 ^{0}C (below) would be around 70 x 2 + 32 = 172 ^{0}F. The proper calculation, important for the lower temperatures, would be: 70 x 9/5 + 32 = 158 ^{0}F.

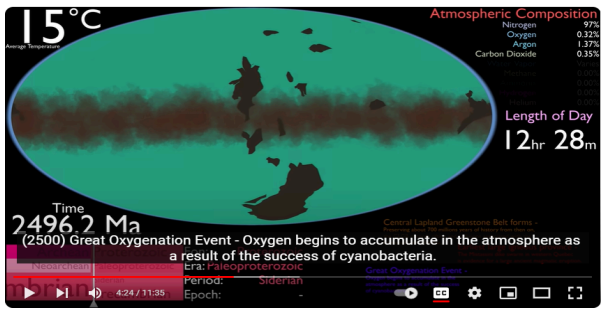


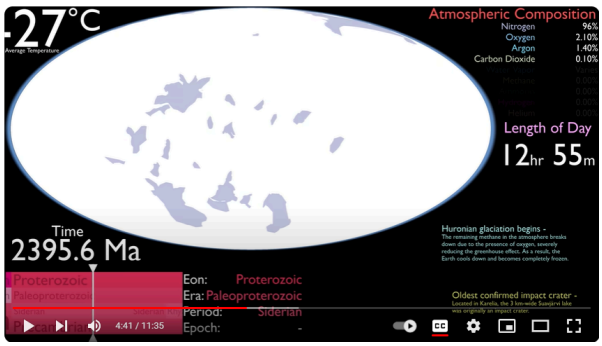


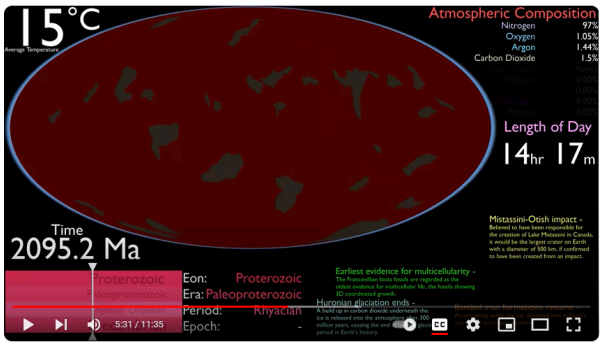


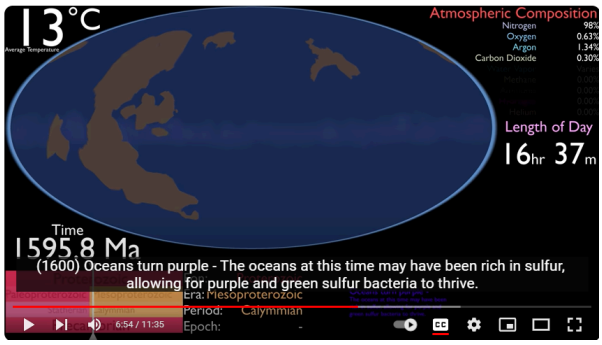


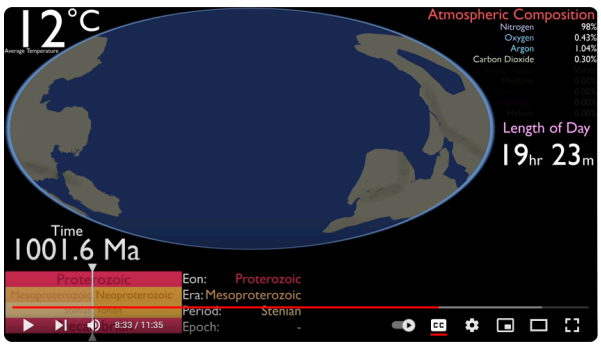
What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

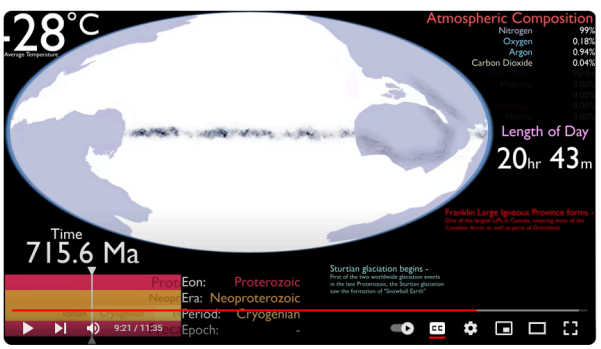


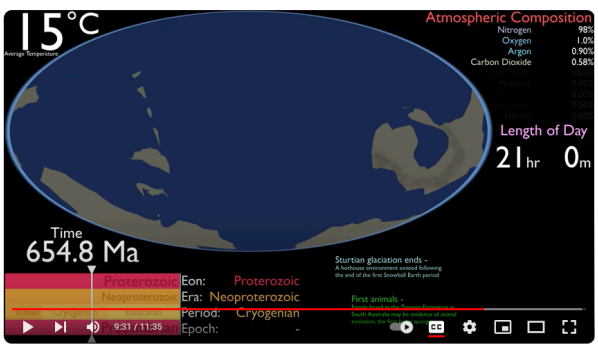




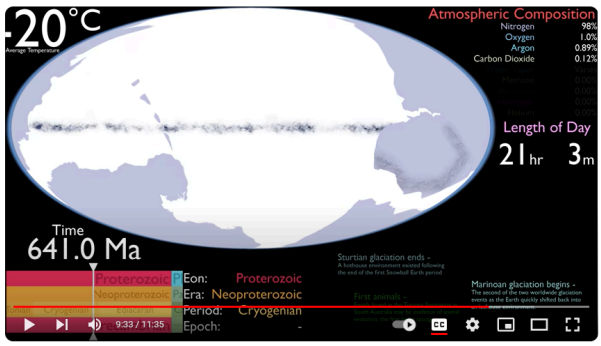


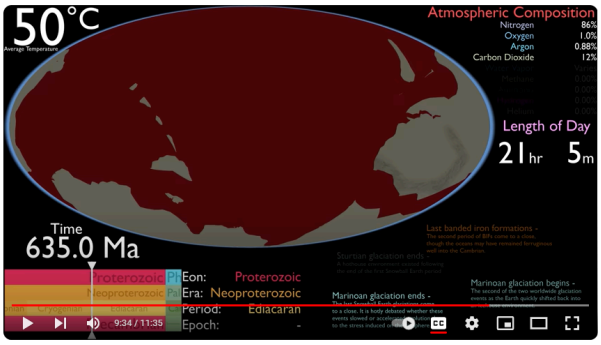


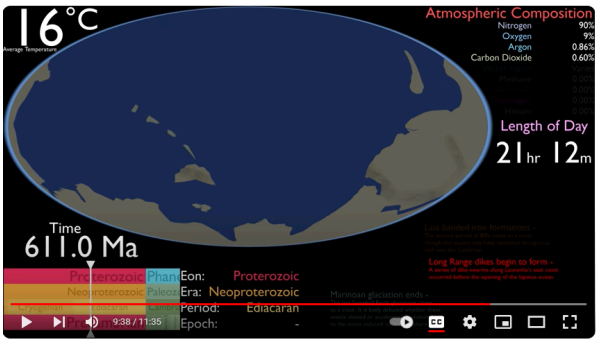


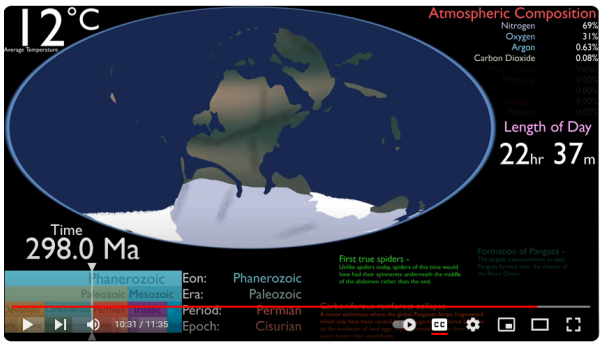


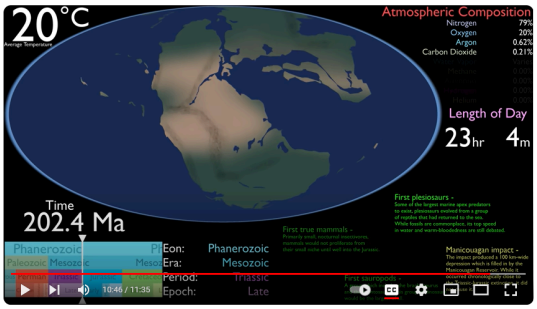
What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

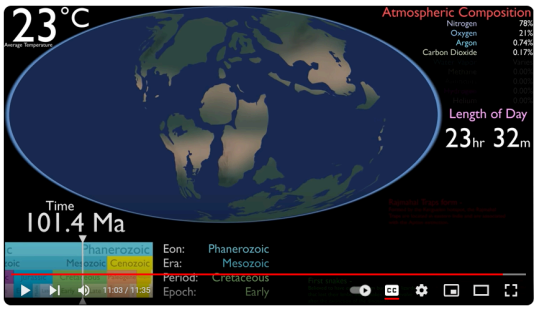


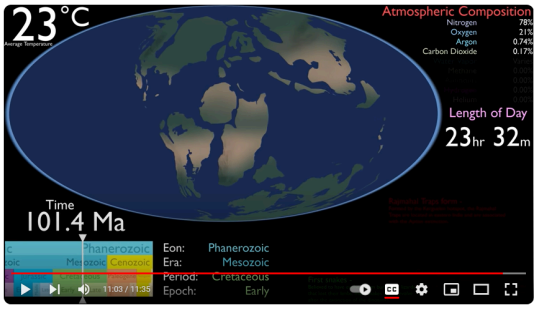


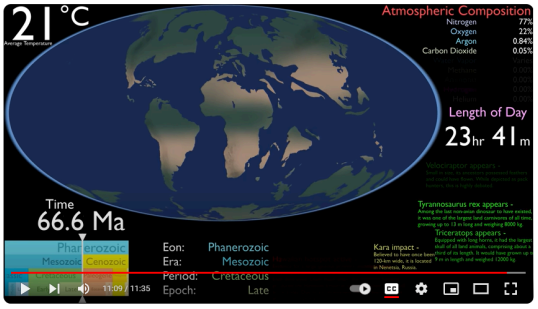












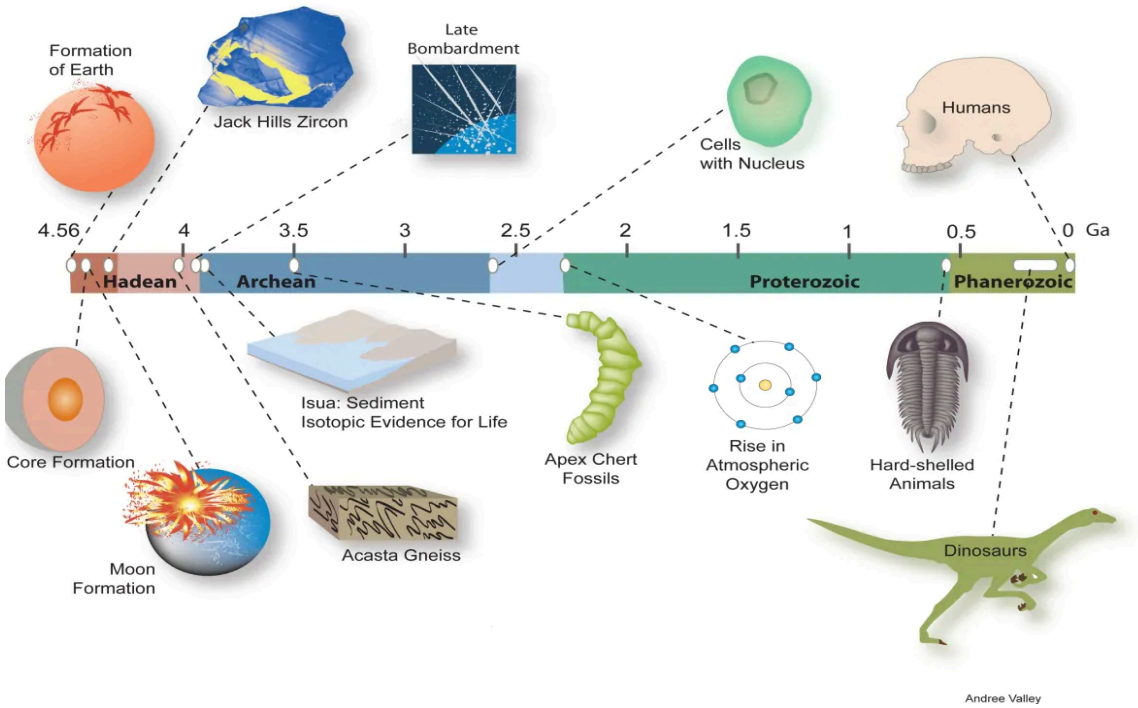
So, at around 66 million years ago, the global average temperature was about **21 ^{0}C =** 21 x 9/5 + 32 = **69.8 ^{0}F**. This may seem pretty moderate, but that is the average, including the polar regions. Today's (2023) global average is approximately **15 ^{0}C or 59 ^{0}F.**

What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

The planet was considerably warmer during the time of the dinosaurs (ended 66 Ma).

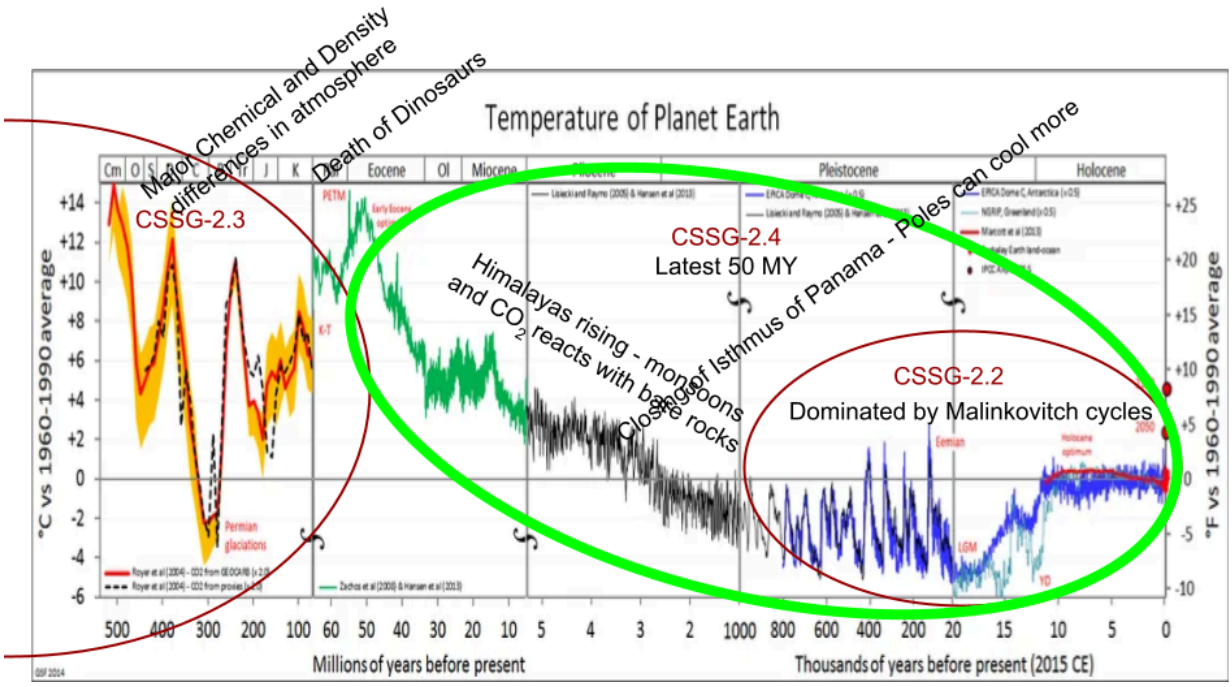
The point of going through the above slides is to bring home:

1. **The world before 100 Ma was radically different from the present**
2. **Radical chemical, temperature, atmospheric, continental, life, etc. changes were seen, but hundreds of millions of years were typically required.**



What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

Let's focus now on the big changes which occurred over the last 50 million years.



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

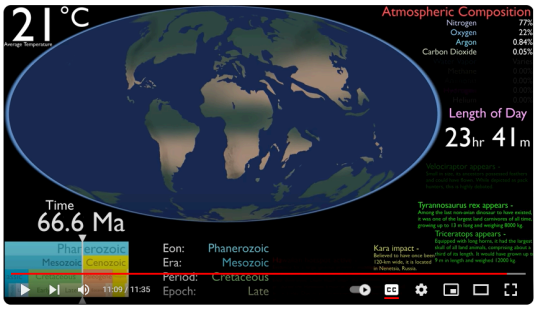
We start at the destruction of the dinosaurs at 66 Ma.

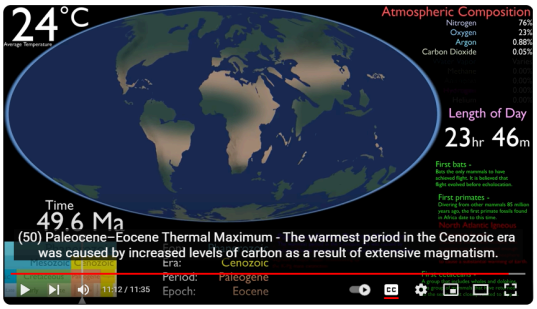
Notice two major configuration changes:

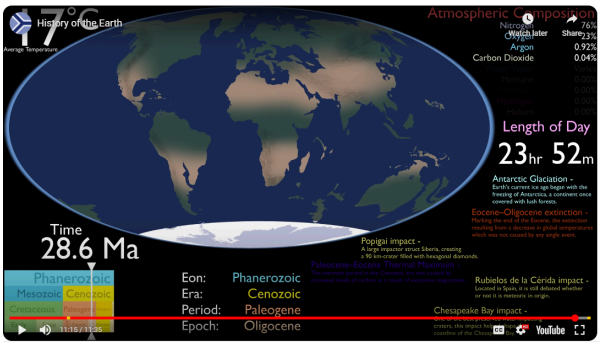
1. The Indian subcontinent smashed into Asia, causing the **uplift of the Himalayas.** This may have been the major cause of cooling of the planet and the formation of the ice sheet in the Antarctic.

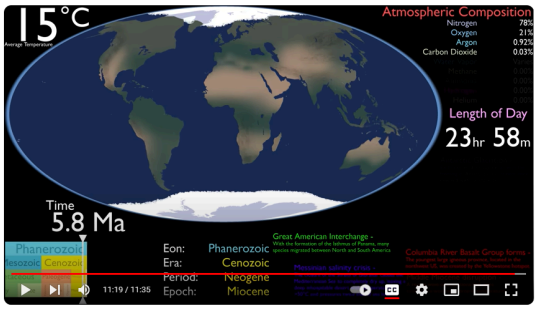
2. The **Isthmus of Panama** closed off the Pacific tropical waters from the Atlantic. This may have allowed even more cooling at the North Pole region.

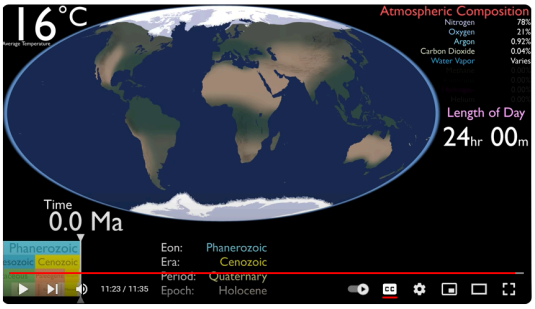
What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown





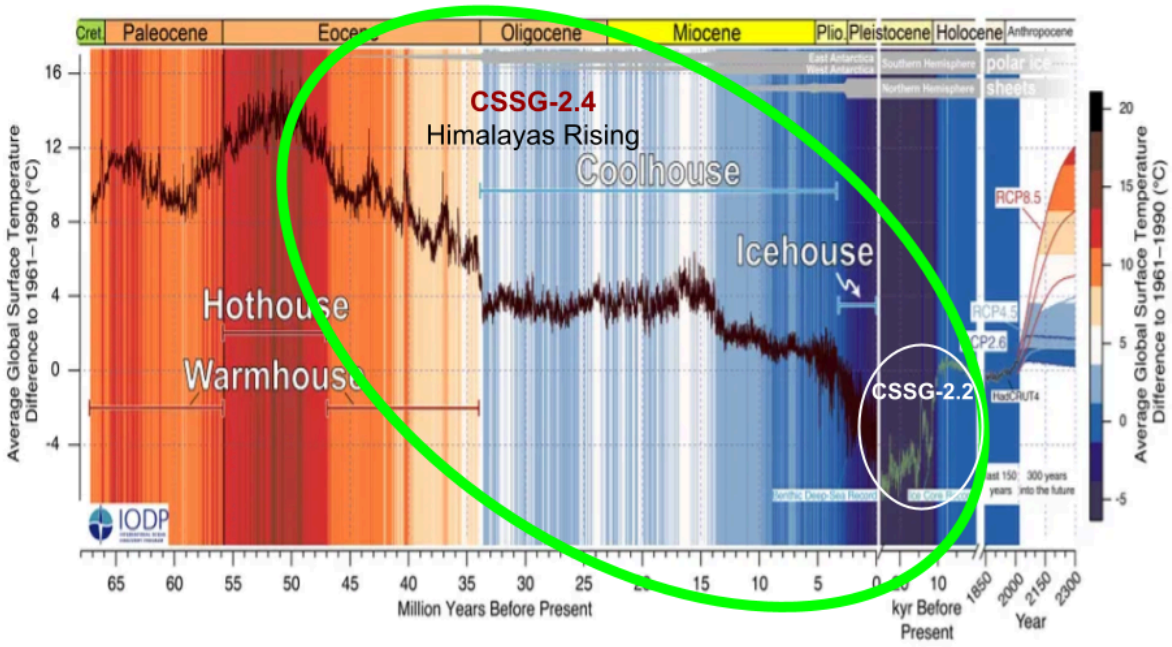




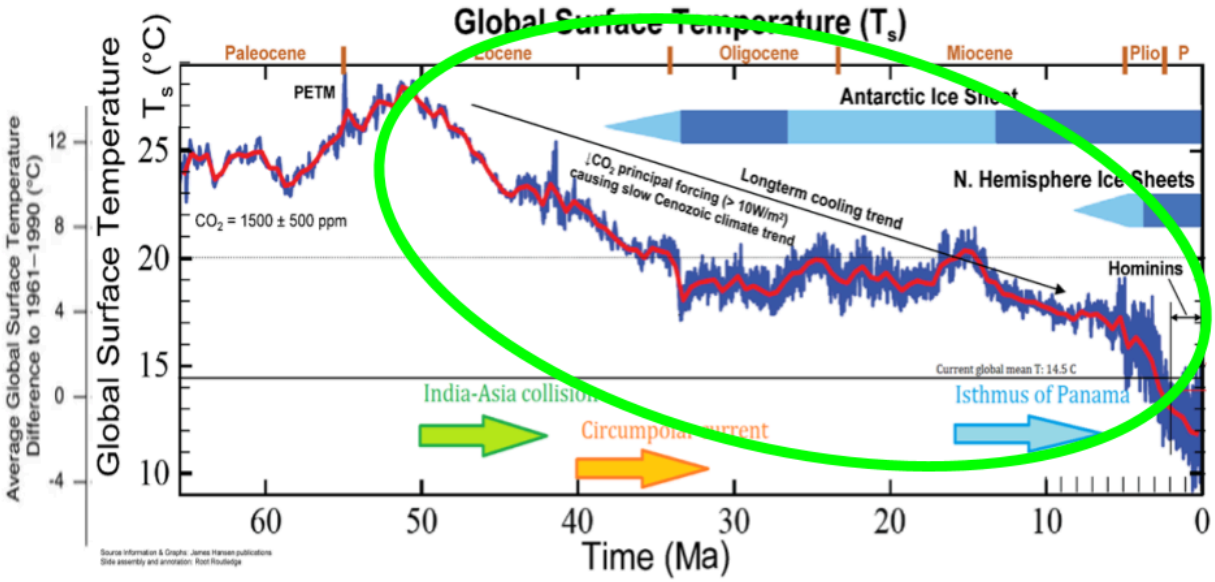


And here's another way to look at these **50 million years**. We talk of the earth cooling down - long before we get to the ice ages of CSSG-2.2, the Antarctic polar ice sheet was forming. Note the cooling seemed to level off from about 33 - 16 million years ago. This is consistent with the cooling being channeled into the new East Antarctic ice sheet formation. Similarly, the slower surface cooling about 13-5 million years ago is coincident with the West Antarctic ice sheet development. The Northern Hemisphere ice sheets seemed to have developed a bit differently (no land at the pole itself) and the major oscillations in glacial conditions emerged as the planet moved into an "Icehouse" phase some 5 million years ago. **It will be in this most recent 5 million years that we will be hoping to find information most relevant to our current situation.**

What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown



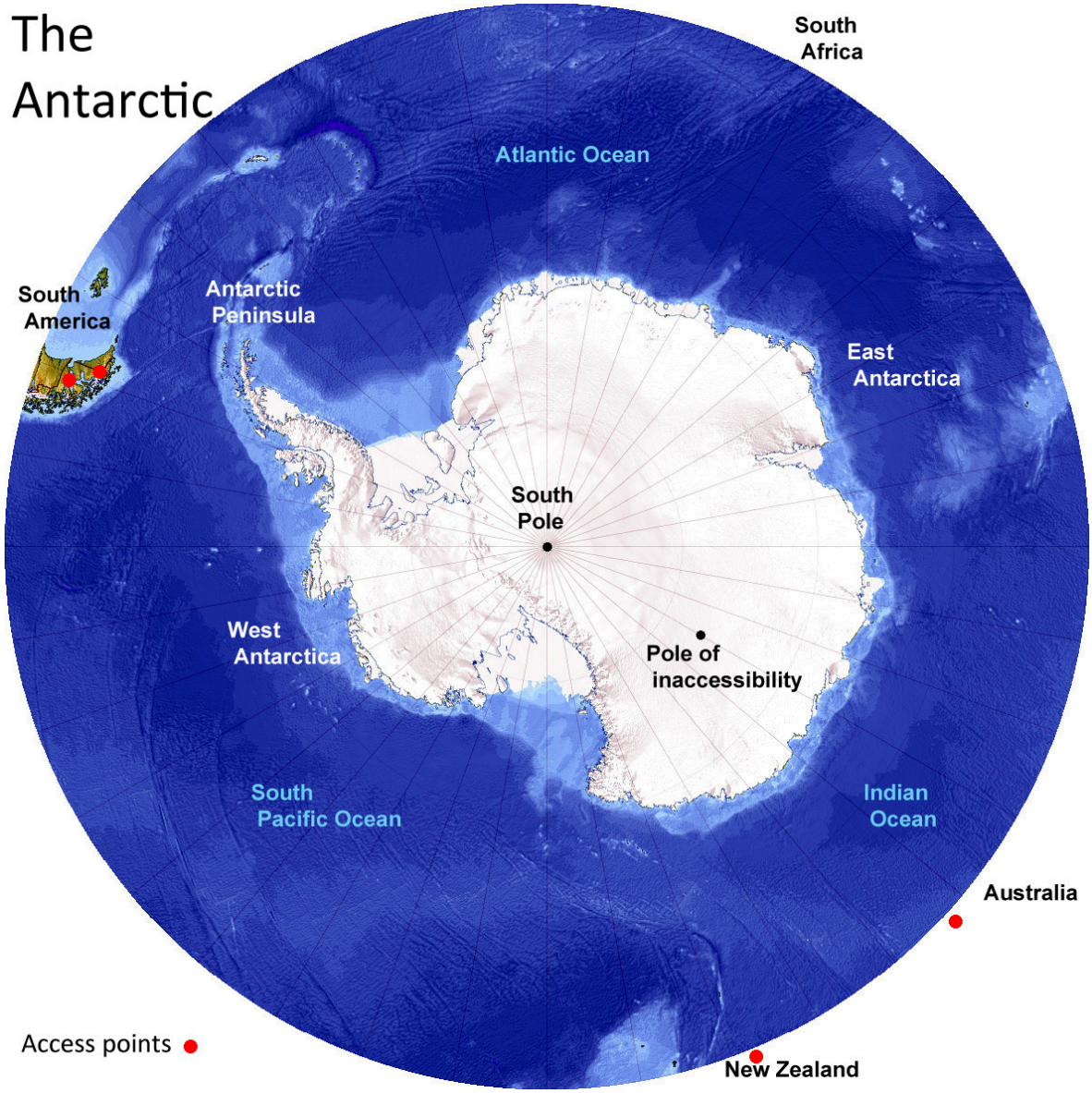
https://www.space.com/oldest-climate-record-ever-cenozoic-era.html



This “Icehouse” condition provides us with some sources of possible substantial sea level rise, should it become warm enough for melting. **Today’s Antarctic ice sheets** (known as West Antarctica and East Antarctica) hold by far the most, with Greenland next. While we won’t dwell on such things at this point, here are some pictures to start getting familiar with that region of the South. The primary feature of **today’s Antarctica** is its division (by a

What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

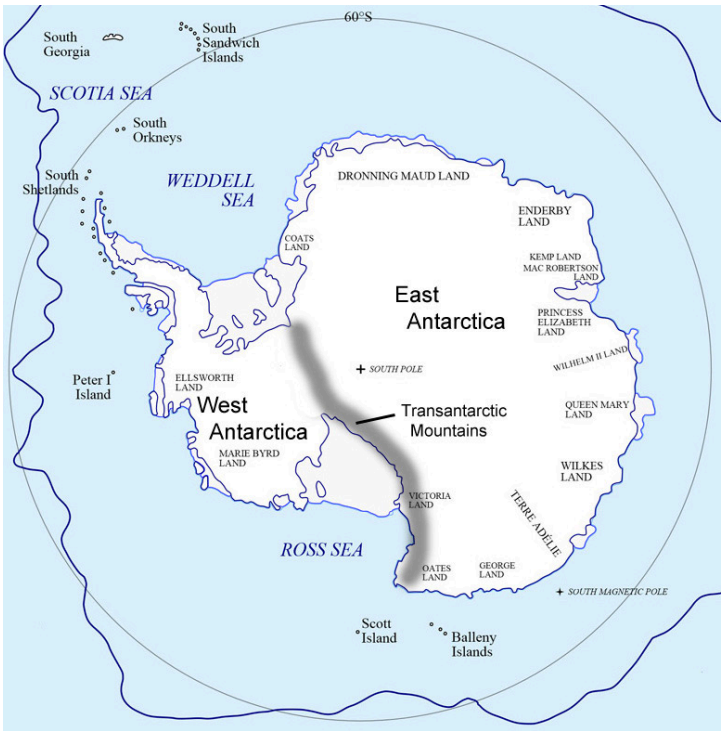
mountain range) into an Eastern and a Western ice sheet. It is the Western ice sheet which may be the more vulnerable to early melting.



This is the Antarctic TODAY.

What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

The Transantarctic Mountains, in places these appear as "nunataks", isolated mountain peaks that show above the surrounding ice with most of the mountains buried. At 3,500 km (2175 miles) long, they are one of the Earth's longest mountain ranges.



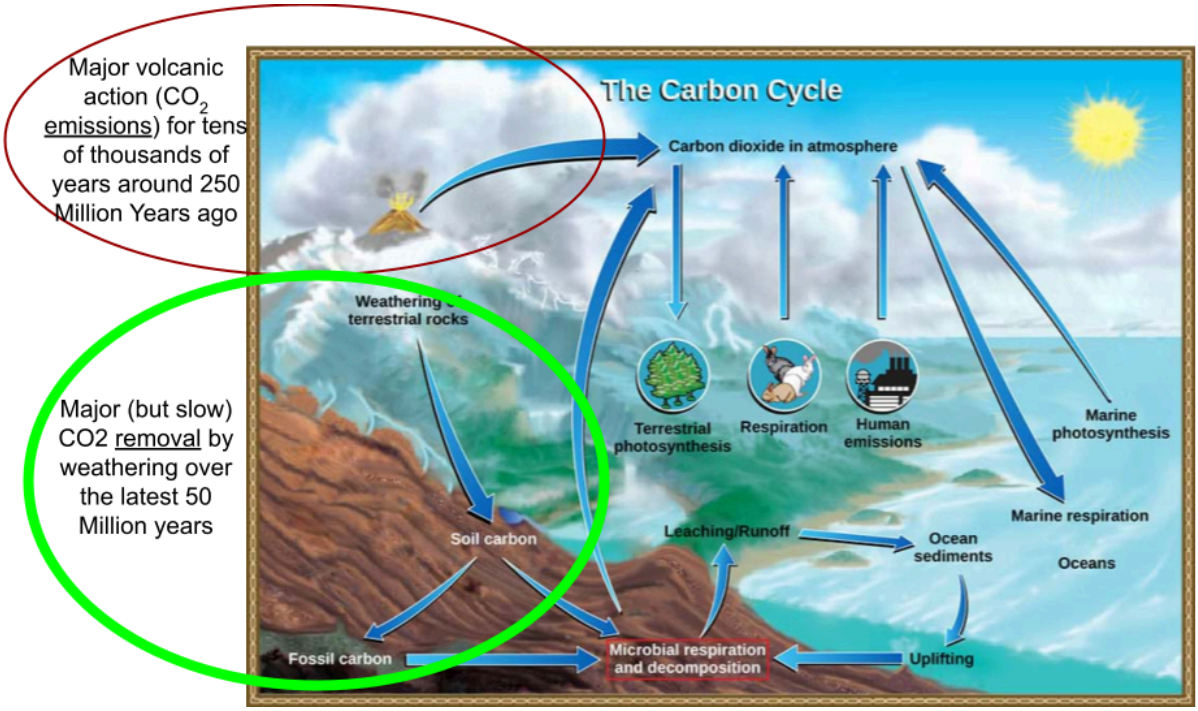
https://www.coolantarctica.com/Antarctica%20fact%20file/antarctica%20environment/whats-it-like-in-Antarctica.php

Some possible Punchlines just from these discussions include:

What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

1. As the **Indian subcontinent collided with Asia**, starting around 50 million years ago, the huge uplifting of bare rock had two effects: 1) the warm, very moist air circulating from the Indian Ocean was now driven upward into cold air. This dramatically increased the monsoon rainfall. 2) Rain and the atmospheric CO_2 (which had been keeping the planet pretty hot for hundreds of millions of years through the dinosaur ages) - reacted with the bare rock, taking a large amount of CO_2 out of the atmosphere. This process is called Weathering. **And the removal of the CO_2 resulted in cooling the planet**.

   At a later date, we will see that this is one part of a planetary **CARBON CYCLE**, in this case a very slow, but major part. Also later, we will address other, much more rapid, parts of the carbon cycle. As part of that we will address just what a **GREENHOUSE GAS** (like carbon dioxide - CO_2) is, why it is different from the other components of the atmosphere, how the planet is affected by such gases, and how they are removed.



https://www.teachengineering.org/lessons/view/cub_carbon_lesson01

The movement of carbon from the atmosphere to the lithosphere (rocks) begins with rain. Atmospheric **carbon dioxide combines with water to form a weak acid**—carbonic acid—that falls to the surface in rain. **The acid dissolves rocks—a process called**

What do we know about
Past (Paleo) Global Conditions and Causes ?
Paleo: Part 3 - The Latest 50 Million Years - the Big Cooldown

chemical weathering—and releases calcium, magnesium, potassium, or sodium ions. Rivers carry the ions to the ocean.

This form of weathering is continuing today, as shown here, but is a very slow process.

2. The long cooling trend resulted in **enormous ice sheets** developing in the Antarctic and, later, over large portions of the Northern hemisphere continents (during the ice ages in the last million+ years we've touched on).

3. Conveniently for this discussion, the positionings of the continental masses were generally similar to today's, with the major exception of the Indian subcontinent action, above. BUT, one critical change occurred around 3+ million years ago: **the Isthmus of Panama closed**. It is postulated that this made a major change to the motion of warm, tropical waters - allowing the ocean currents to carry heat differently (the Gulf Stream is part of this new system), and the poles to cool even more.

4. The **difference** between there being **no ice sheets** and **what we now have stored in today's Greenland and Antarctic ice sheets** looks to be **around 3-4 ^{0}C**. BUT, perhaps the lower CO_2 levels given to us by the Himalayas, as well as the closed Isthmus of Panama, could provide some insulation against a simple reversal of conditions with increased CO_2 and that amount of heating… This will be something we should keep our attention on as we learn more.