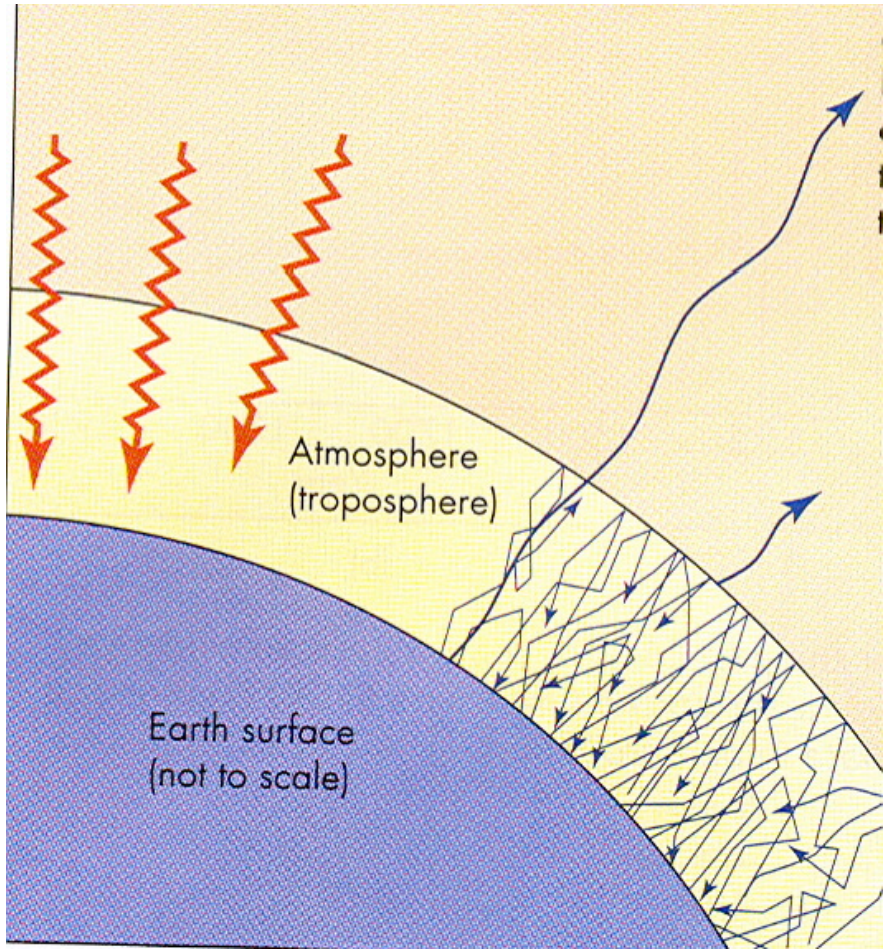
Atmospheric composition and global climate

The greenhouse effect

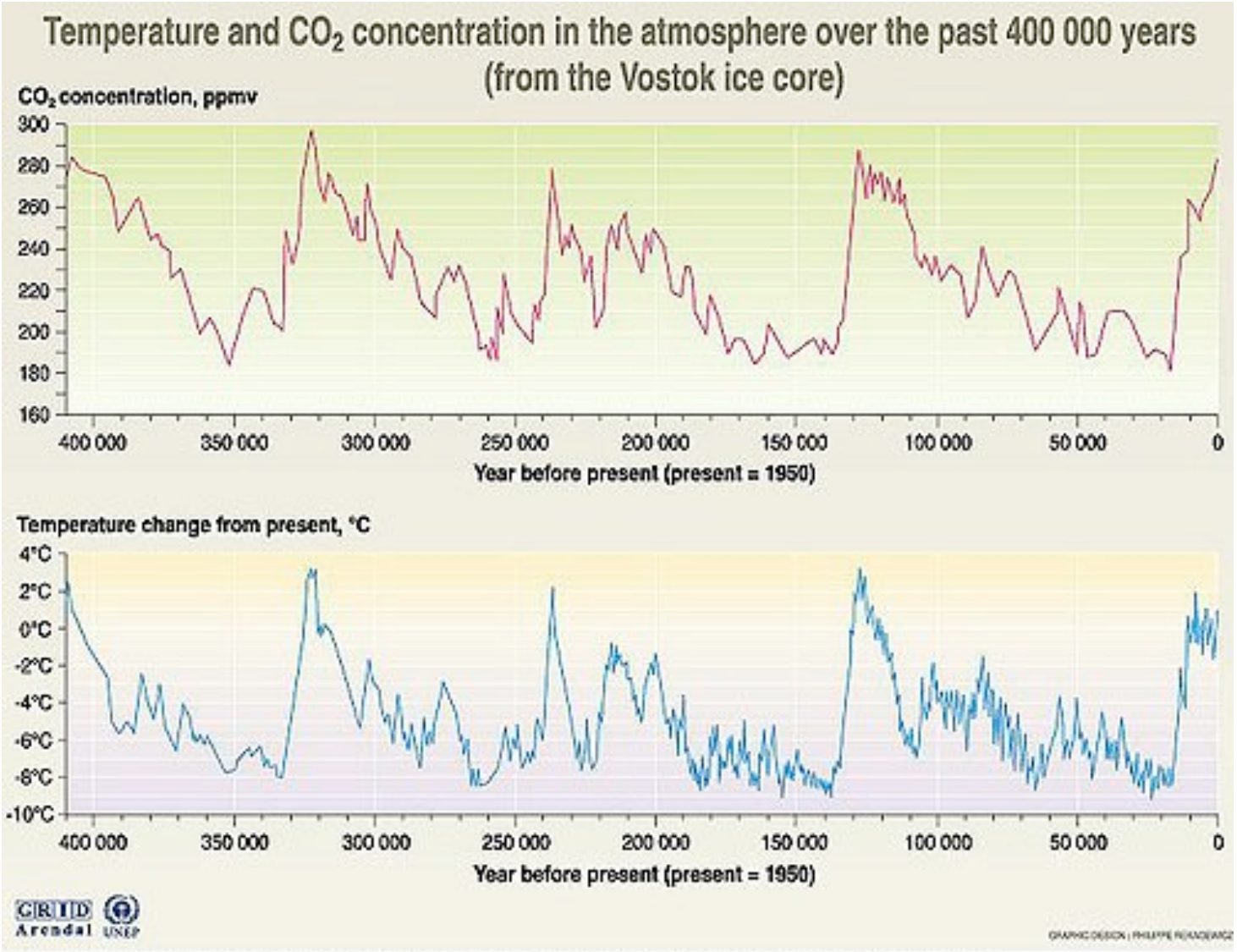
What is a greenhouse gas? Why is CO_2 a greenhouse gas?



The glass of a greenhouse acts to trap heat by changing the wavelength of light entering and leaving.

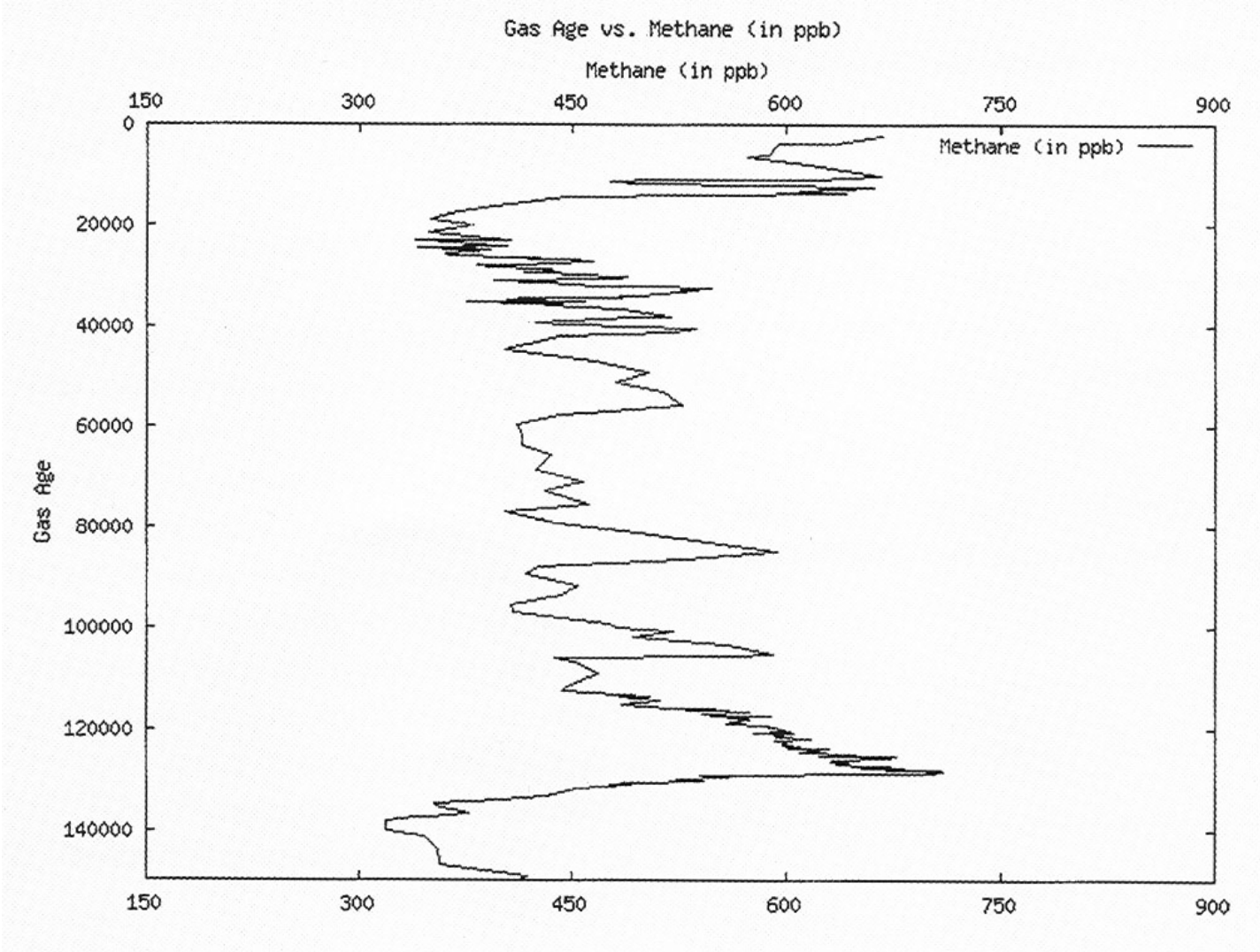
Incoming short wavelength radiation from the sun(=red arrows); some energy is absorbed, some is reflected back into space as long wavelength radiation (blue arrows) and much is trapped by the atmosphere. Thus, heat builds up.

We believe that there is a correlation of atmospheric CO_2 levels and global temp



Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

There is a very strong correlation, but does this show "cause & effect"?



CO_2 is not the only "greenhouse gas" to fluctuate in the atmosphere over time: methane (CH_4) levels over the past 140K

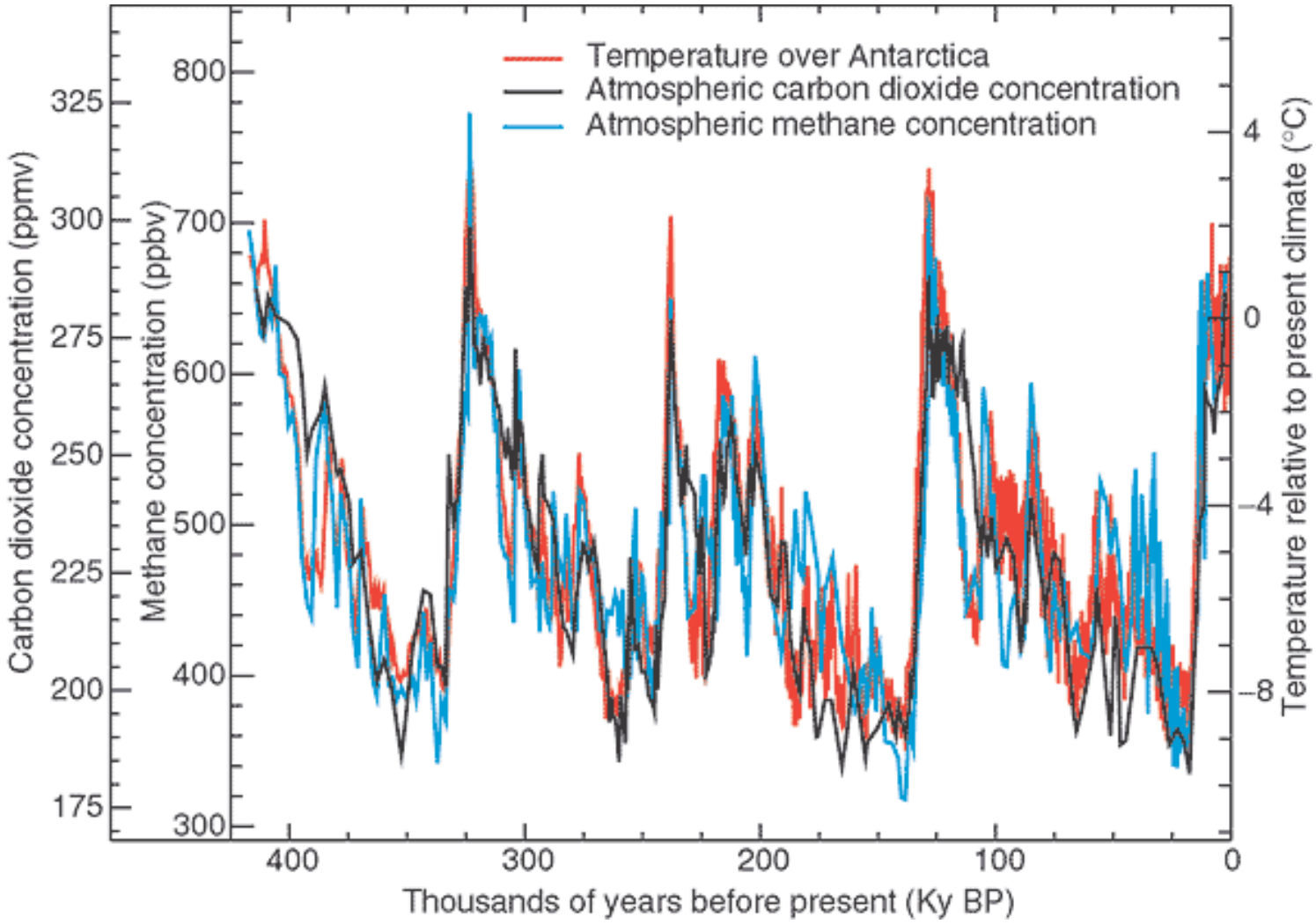
What is methane? aka “swamp gas,” CH_4, but it also exists in a solid form called methane hydrate (or methane clathrate)…as its name implies it is CH_4 surrounded and bound to a ring of H_2O molecules. It is solid at low temps and high pressures and is abundant in oxygen poor sediments. When M.H. warms up, It melts, and “bubbles off”…but sometimes this degassing is explosive…the sea floor is pockmarked with craters from methane hydrate degassing

Methane hydrate is making a lot of people excited about its potential use as a burnable energy source but is also making a lot of people worried about its potential to contribute further to global warming (it's another fossil fuel)

Another potential environmental effect: the unplanned, explosive release of methane hydrate when sediment on the sea floor is disturbed…big burp!

Episodic clathrate emissions in the geologic past have been hypothesized to explain stable carbon isotope data that suggests massive enrichment of organically-derived carbon into CO_2 gas

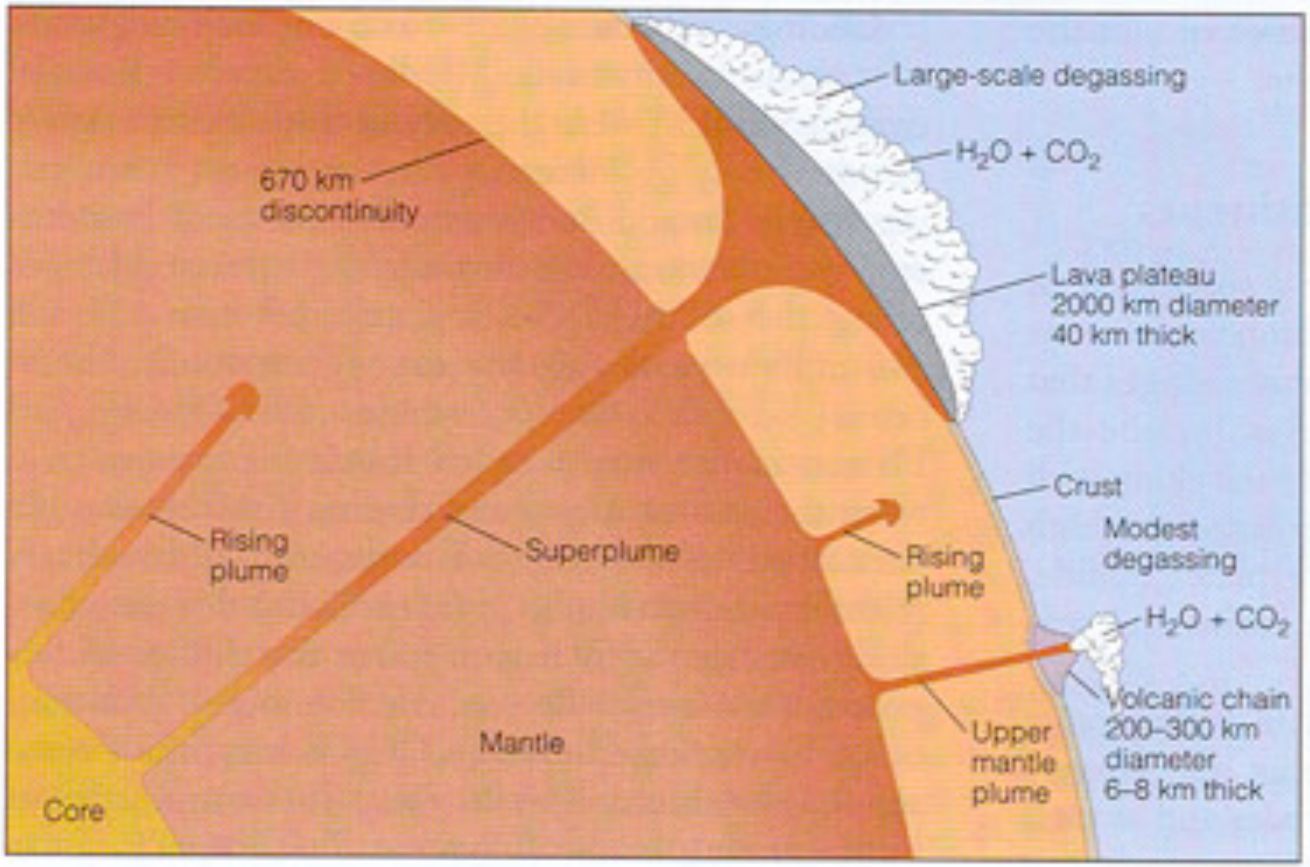
When atmospheric CO_2 and CH_4 combine:



What does this data mean?

- If both CO_2 and CH_4 cycling is related, is the *cause* of this cycling related? (cause and effect)
- If the cycle frequency matches that of the duration of some of the Milankovitch cycles for orbital variation, is this there a cause and effect link to the cycles?
- If these *natural* cycles exist, what is our responsibility?

A “natural” cause of climate variation: large scale degassing of CO_2 into the atmosphere from the mantle

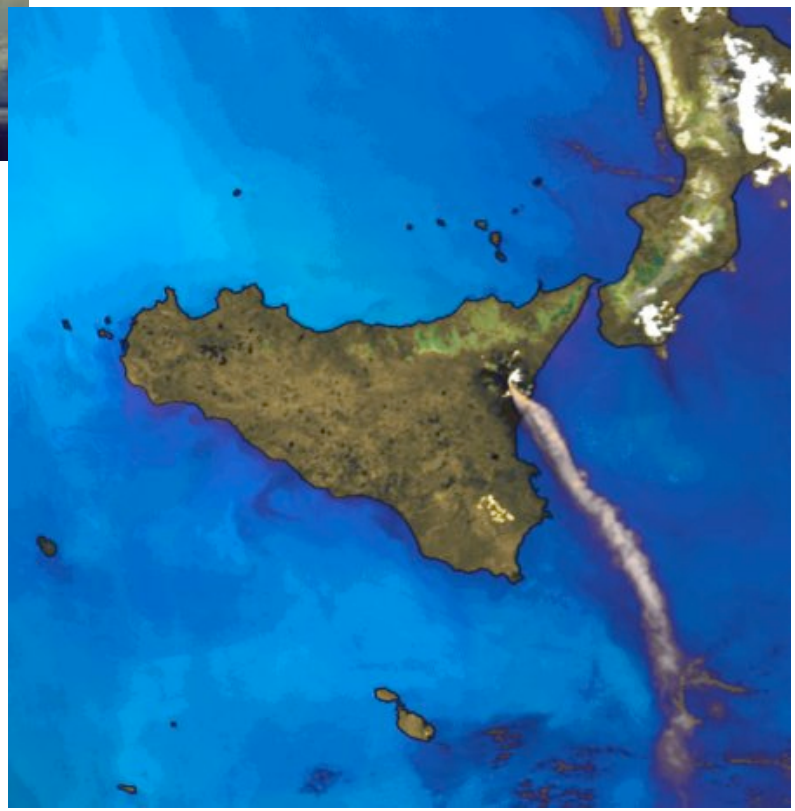


Is this possibly cyclic as well?

“degassing” refers to the release of gas dissolved in magma.

Just as a soda bottle fizzes when you open the top, when you release the pressure on magma, the gasses bubble out.

Because each volcano’s magma composition is different, so will the specific gas composition.



Passage of the Indian plate over a "hot spot"

2 km of basalt flows over 500,000km^2 erupted in the Late Cretaceous, between 65-68Ma; prior to erosion the volume of basalt may have been 3x current outcrop calculations

Artist's rendition of the gasses (steam, CO_2, SO_2, CO, etc) that would be emitted into the atmosphere from such a huge eruption.

Double whammy link to extinctions
By Paul Rincon
BBC News Online science staff

The chances that asteroid impacts and huge bouts of volcanism coincide randomly to cause mass extinctions may be greater than previously imagined.

THE SHIVA CRATER: IMPLICATIONS FOR DECCAN VOLCANISM, INDIA-SEYCHELLES RIFTING, DINOSAUR EXTINCTION, AND PETROLEUM ENTRAPMENT AT THE KT BOUNDARY
GSA 2003 Seattle Annual Meeting (November 2–5, 2003)

To summarize:

- Many processes control climate on Earth, we know some of these operate on a cyclic basis, some are driven by plate tectonics.
- There is evidence that extreme climate changes have occurred in the geologic past
- We still need to discuss ways in which changes in the biosphere can impact climate.
- A goal of this class was to apply our knowledge of how the Earth systems are inter-related to discuss how changes in one system (atmosphere, lithosphere, biosphere, hydrosphere) might impact the others. Be sure you can discuss this (with examples)