Extreme icehouse: snowball earth !?

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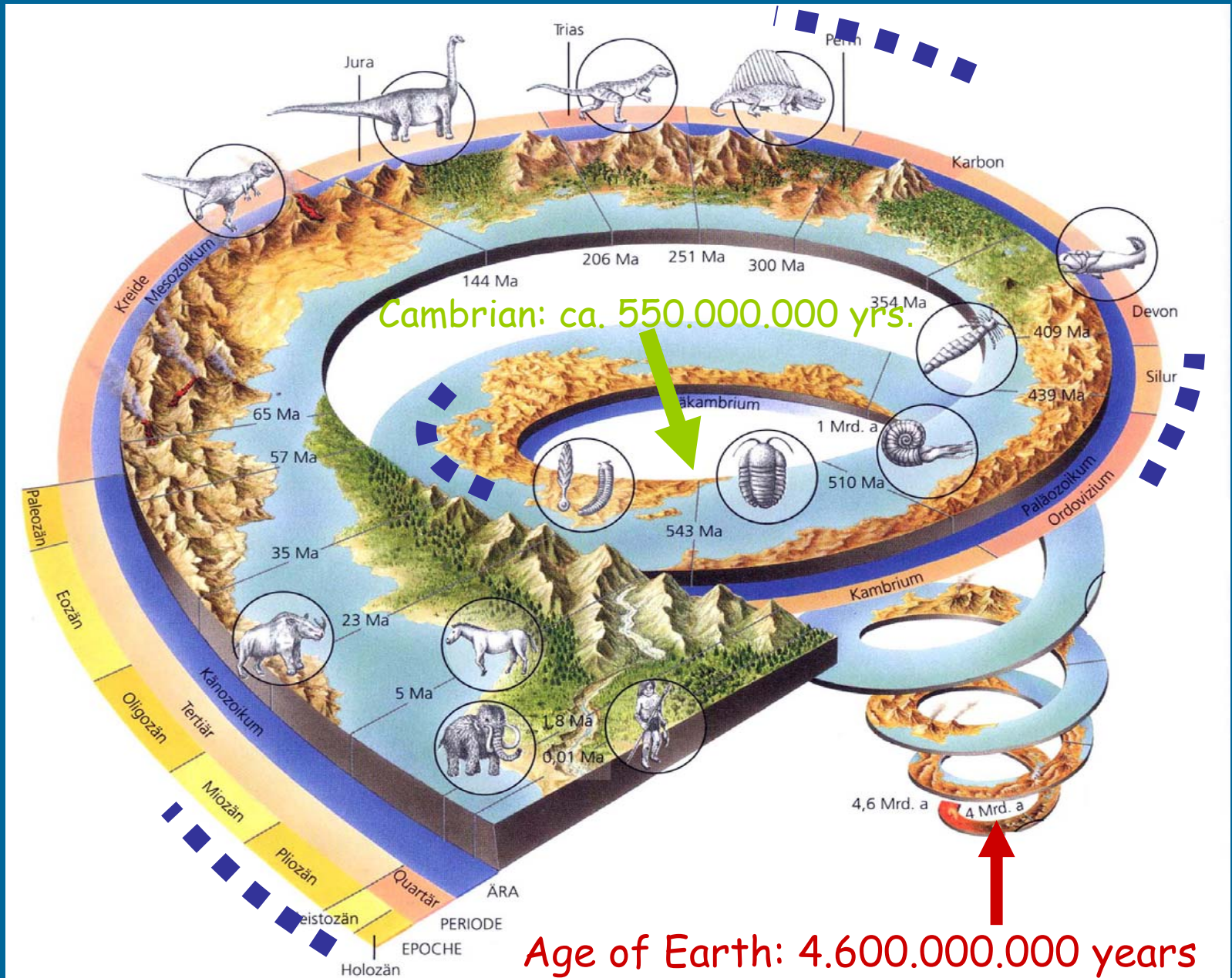
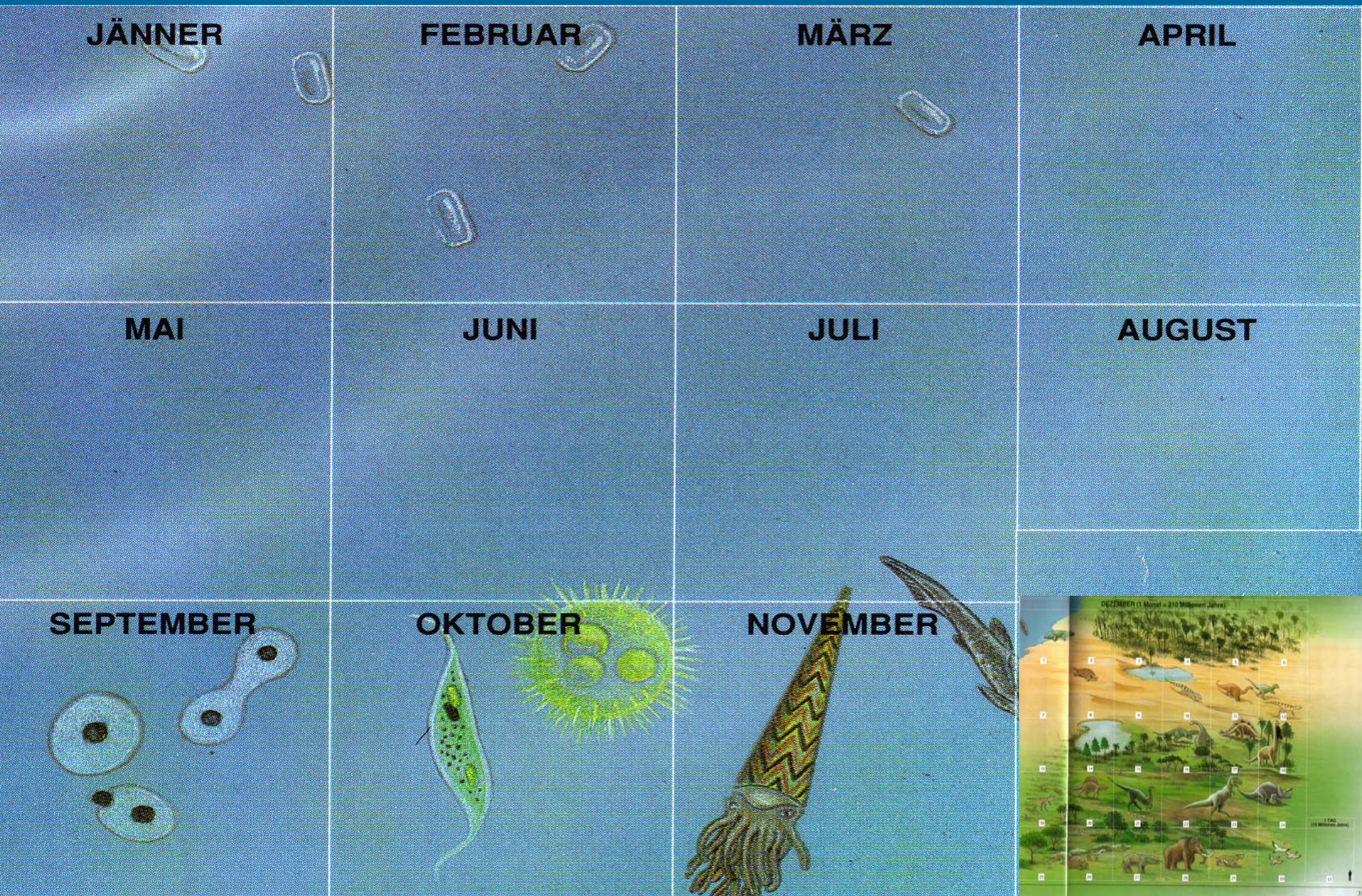
‚snowball earth' ?

in the
Neoproterozoic

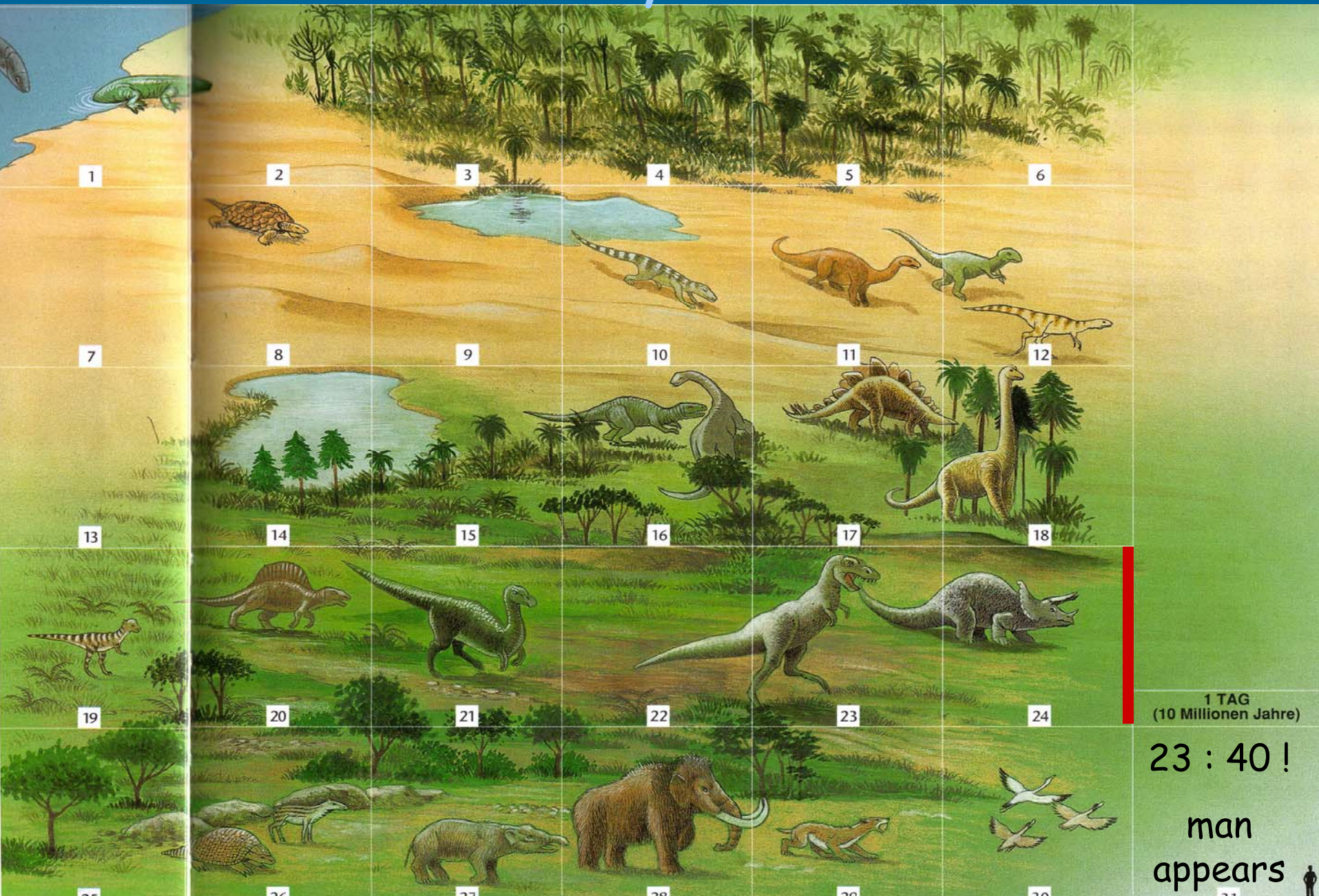
The Geological Timescale



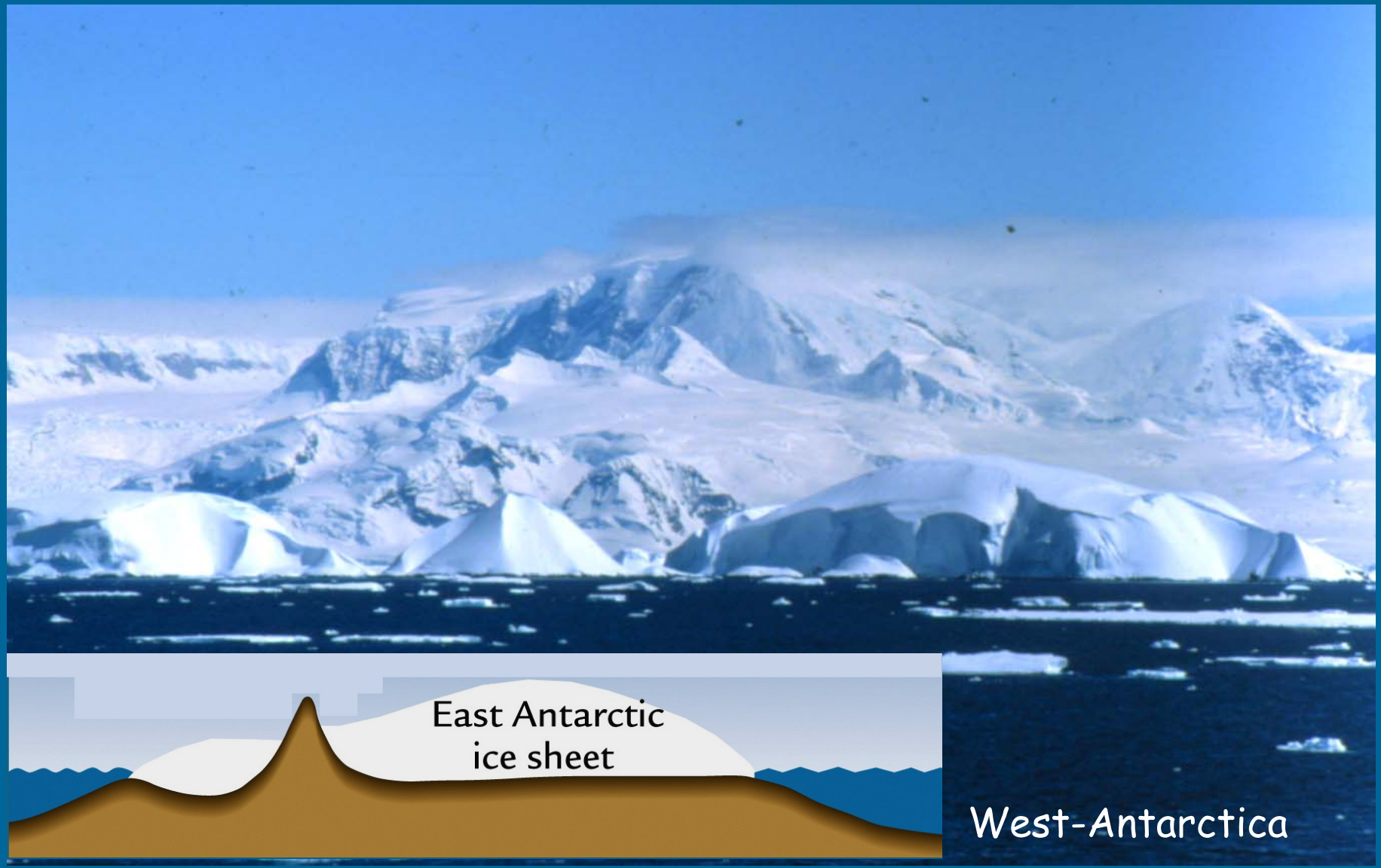
suppose: the earth is 1 year old !



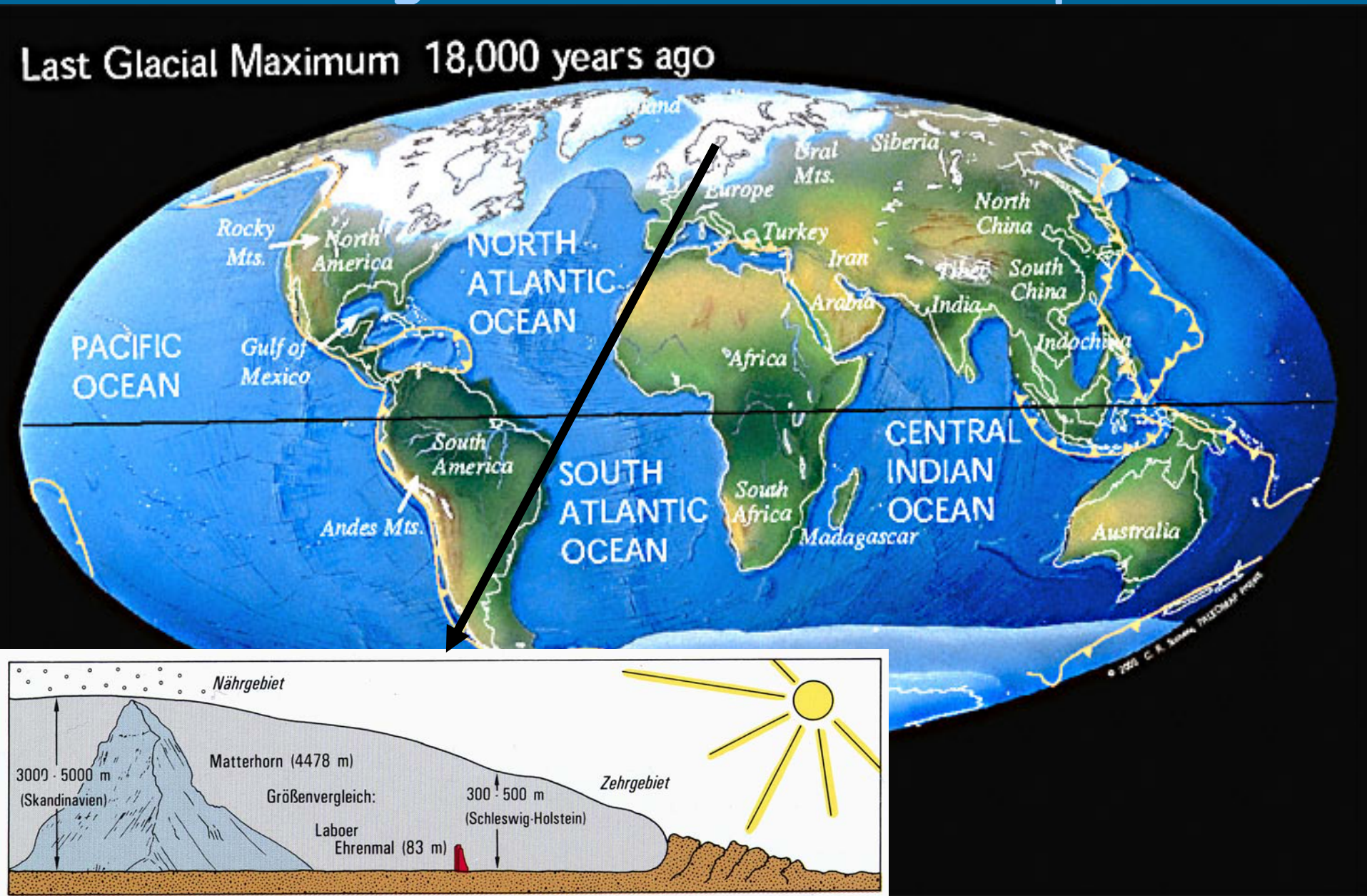
the last 31 days in december



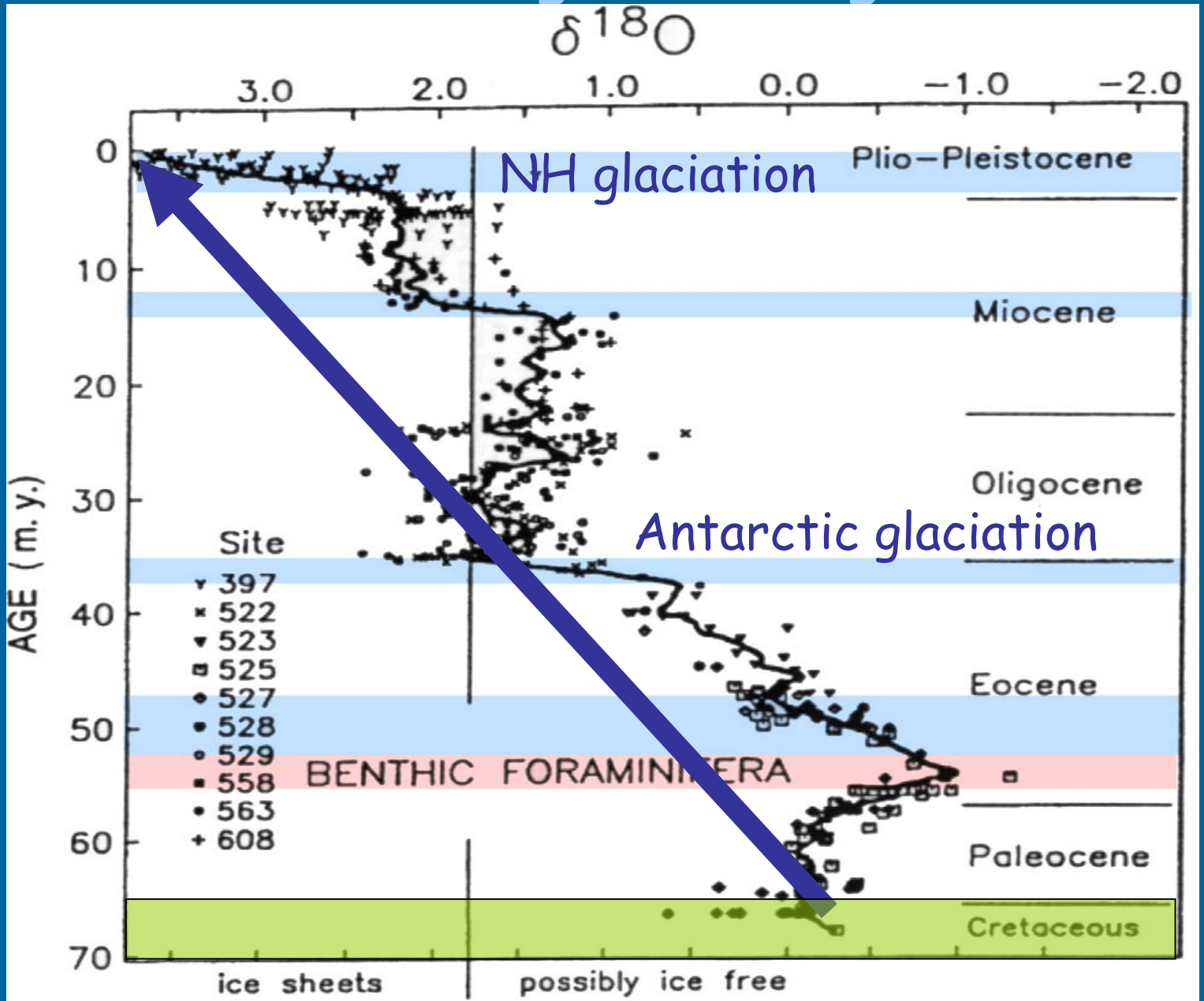
The earth today: large ice sheets in both hemispheres



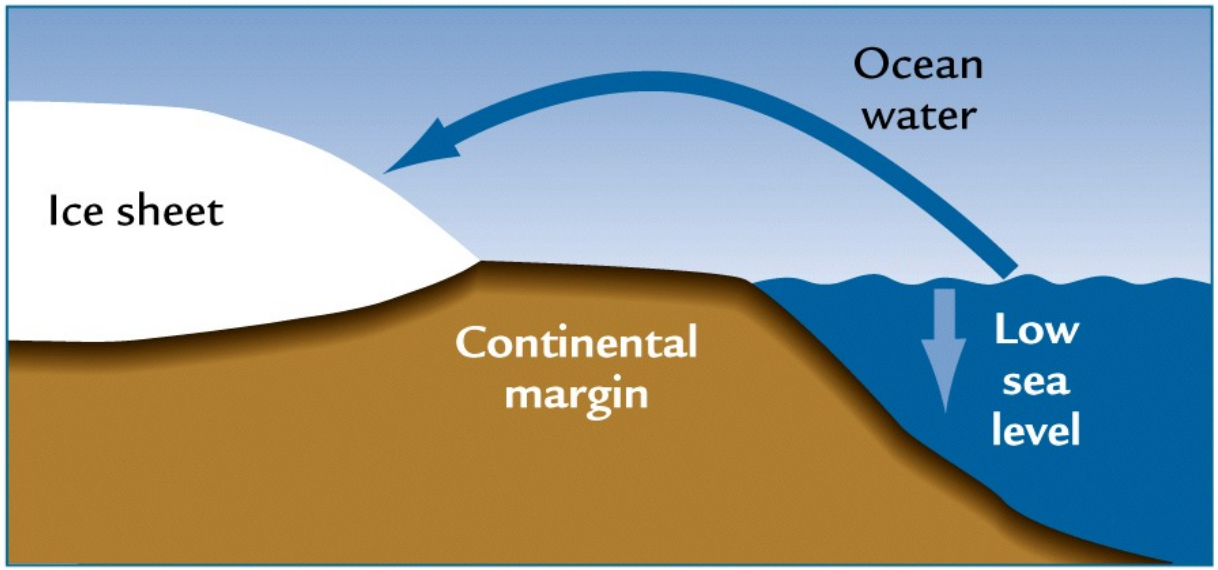
ice coverage at 18.000 before present



Antarctic cooling and NH glaciation



glaciations and sea level



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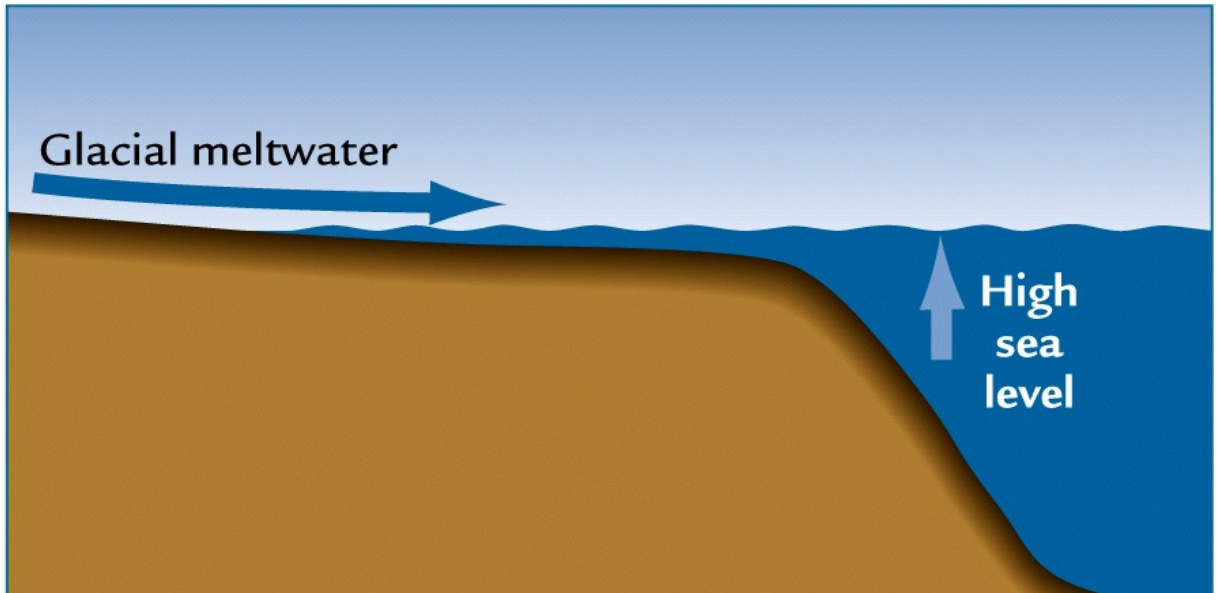
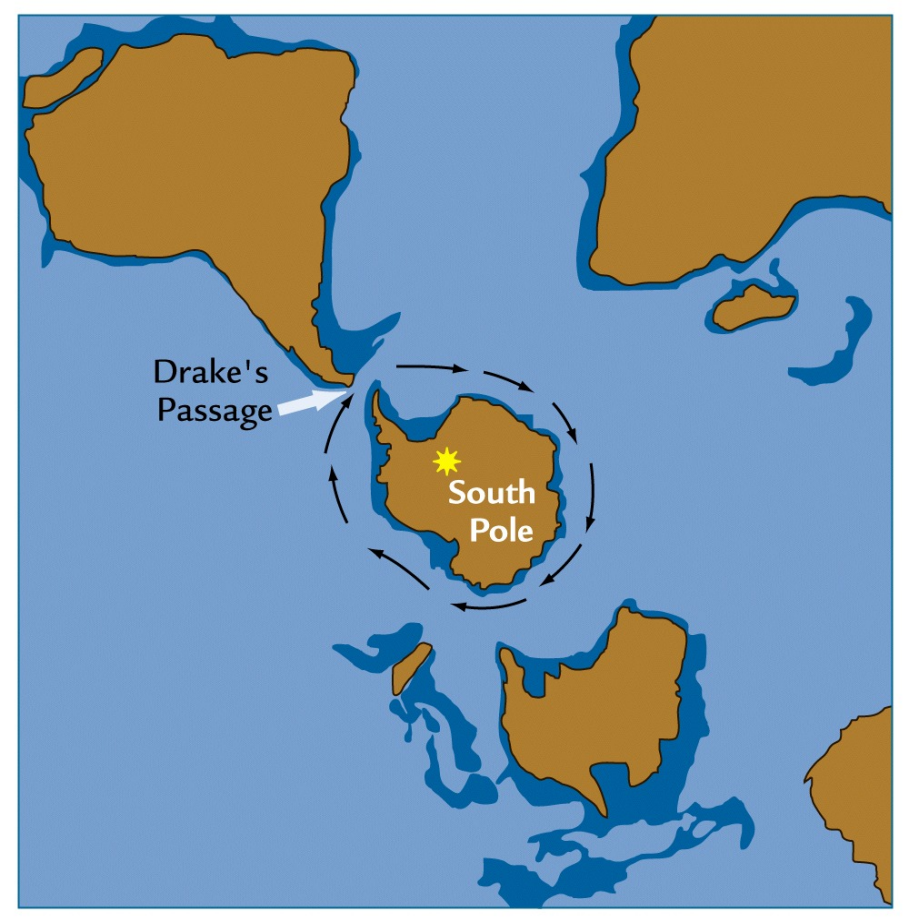


100 to 300 m sea level change

why glaciations ?



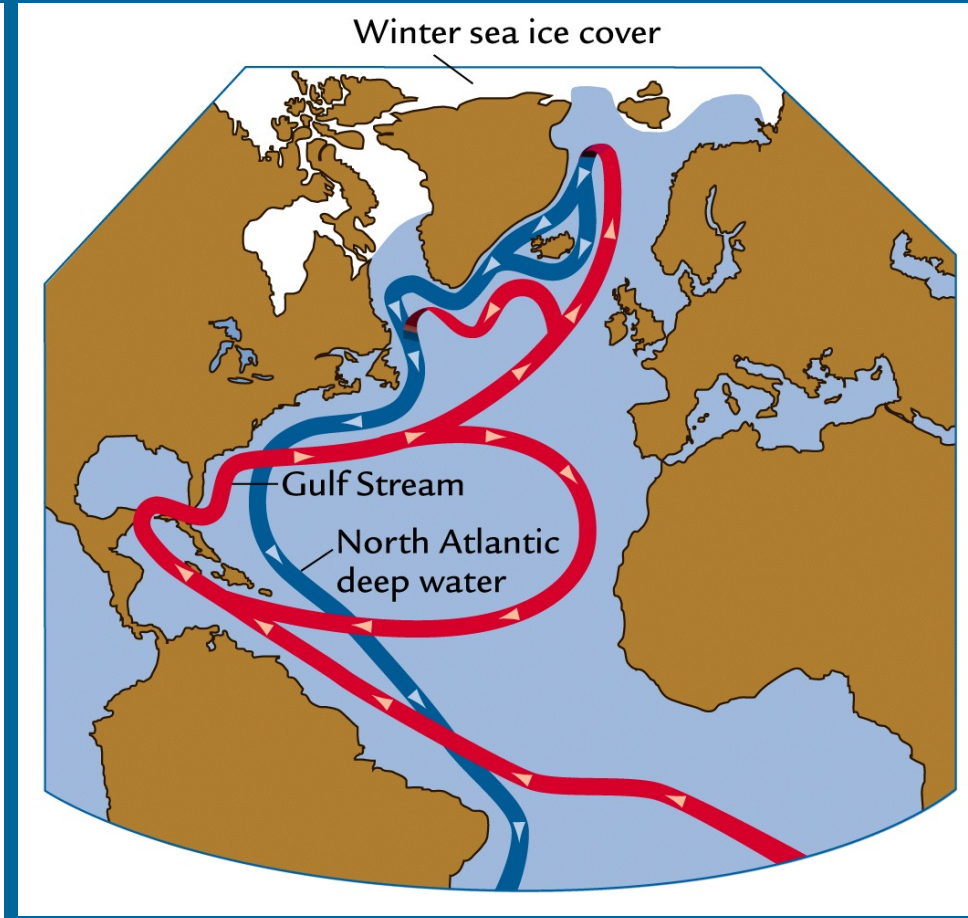
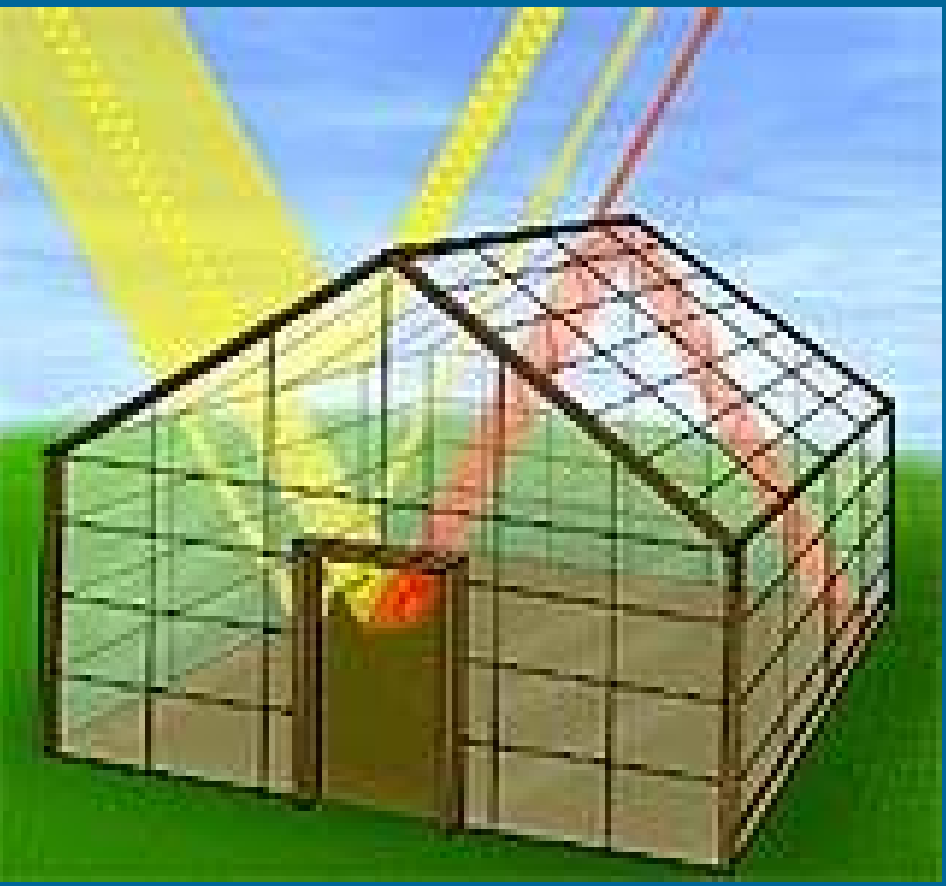
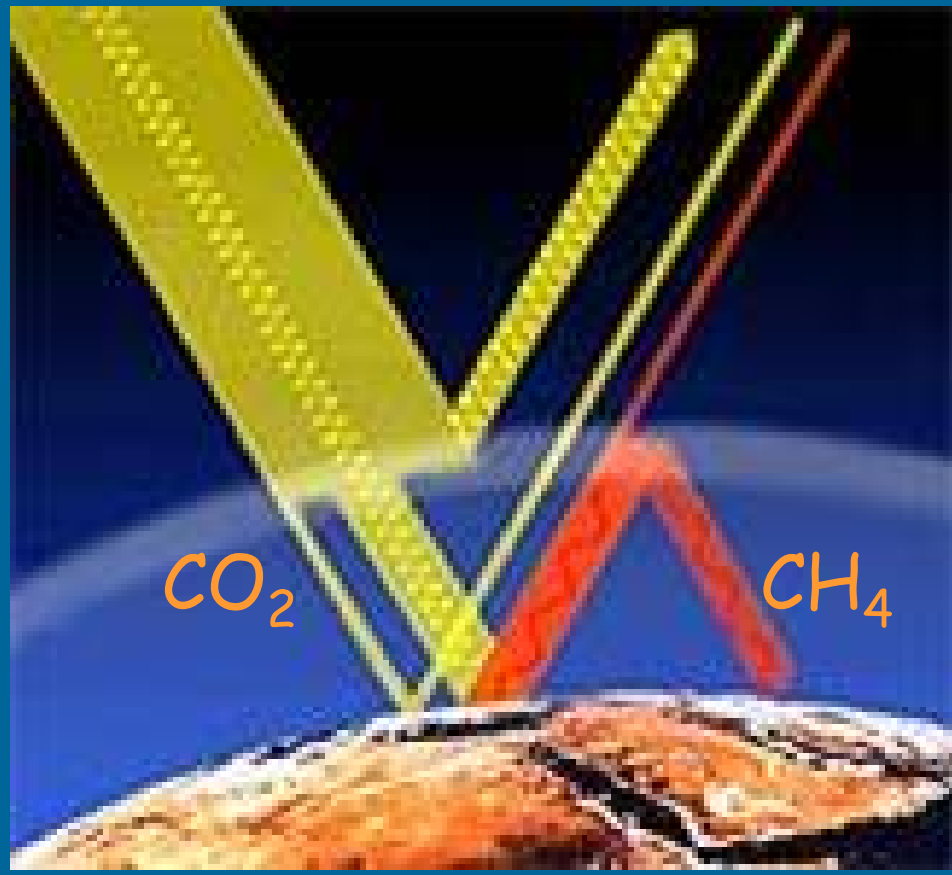


plate tectonics
(land close to poles)

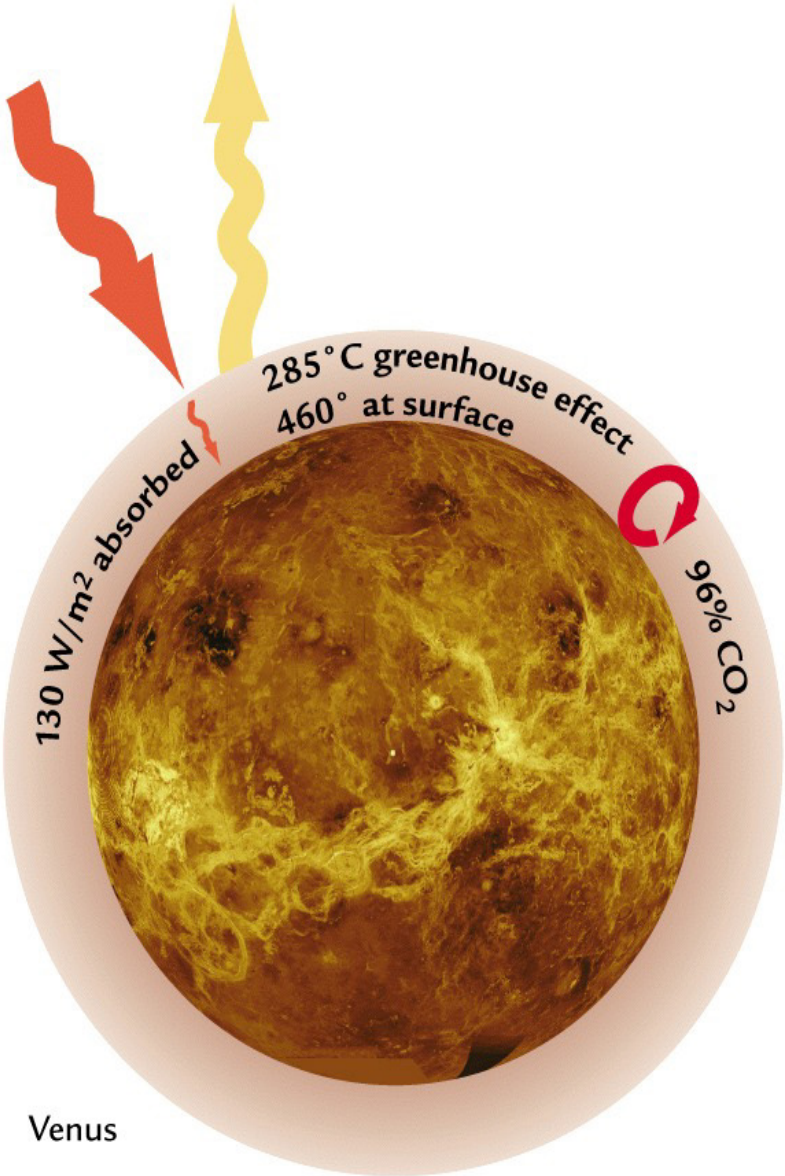
ocean currents
(moisture)

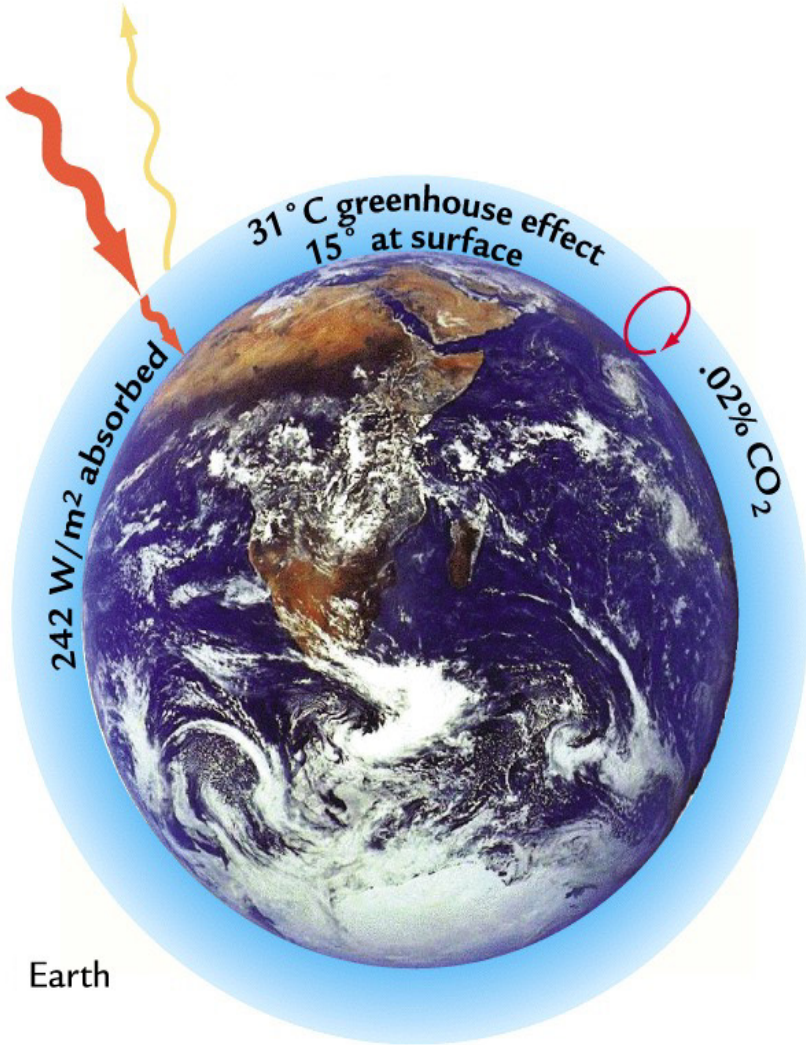
Global climate and greenhouse effect: the global carbon cycle !





Venus: 96% CO_2 Earth: 0.03% CO_2



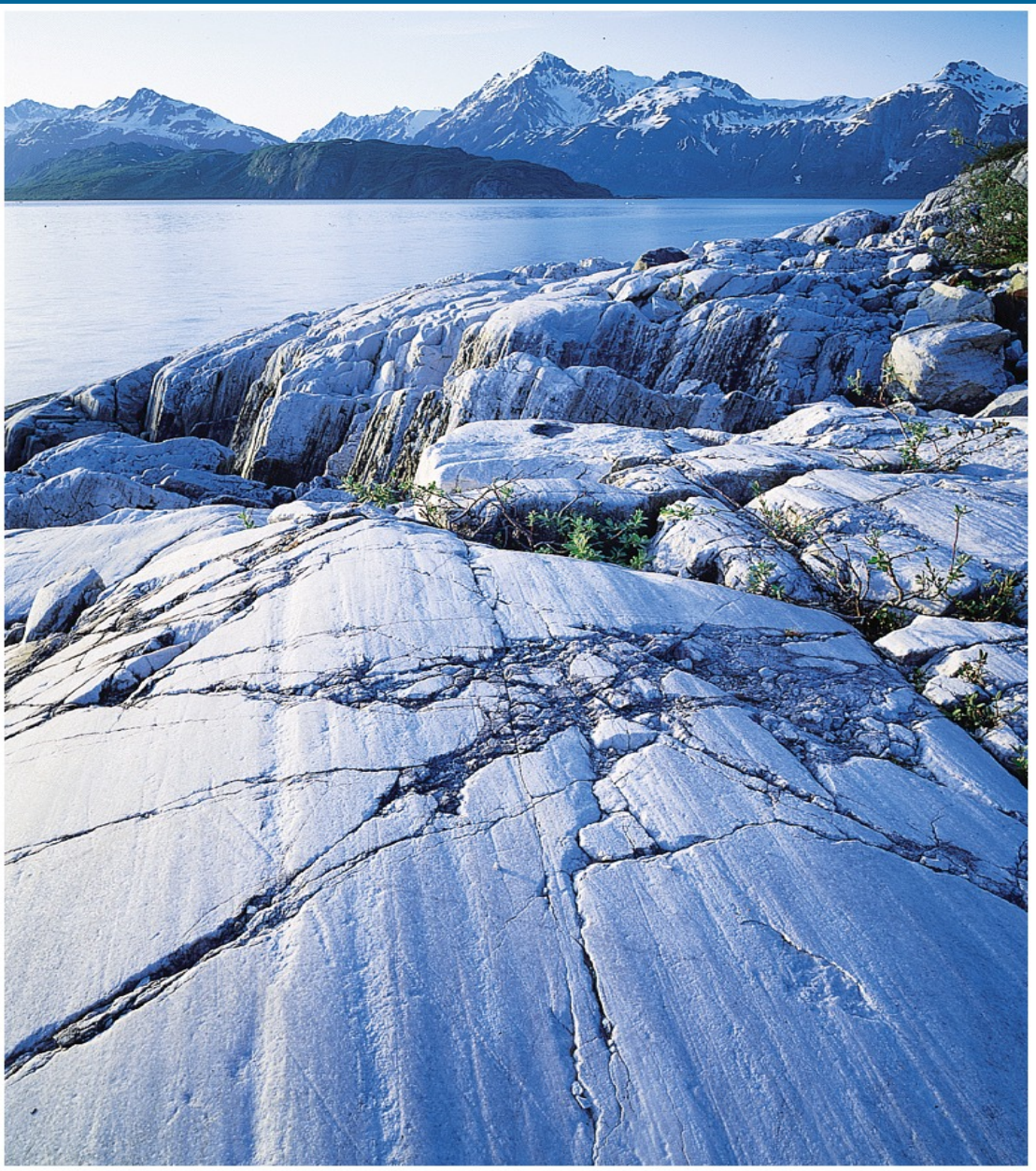


how to recognize glaciations ?
1. moraines = tills

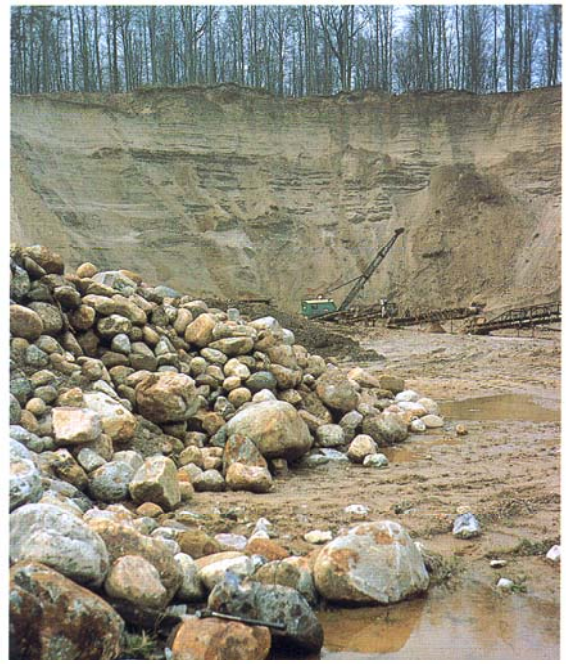
Spitzbergen today

Weichsel glaciation at 18.000 BP

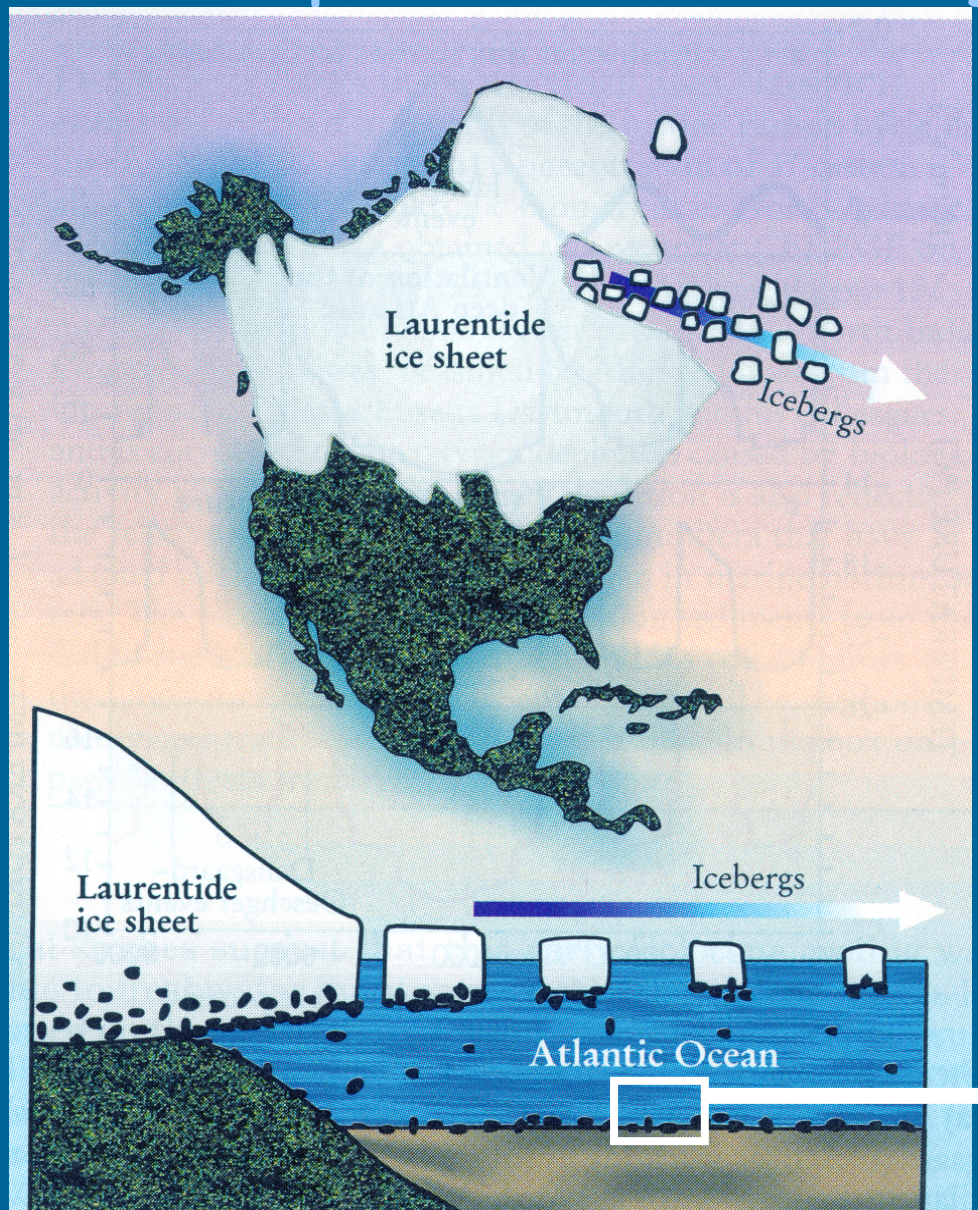
2. glacial scratches and striated pavements

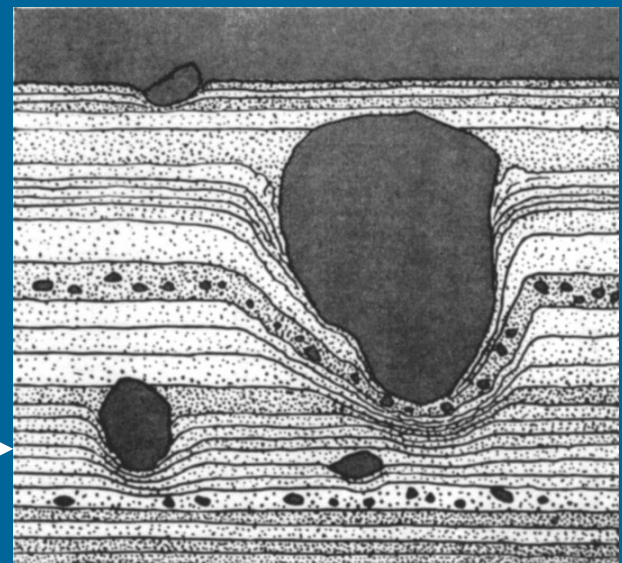


3. large blocks of rock

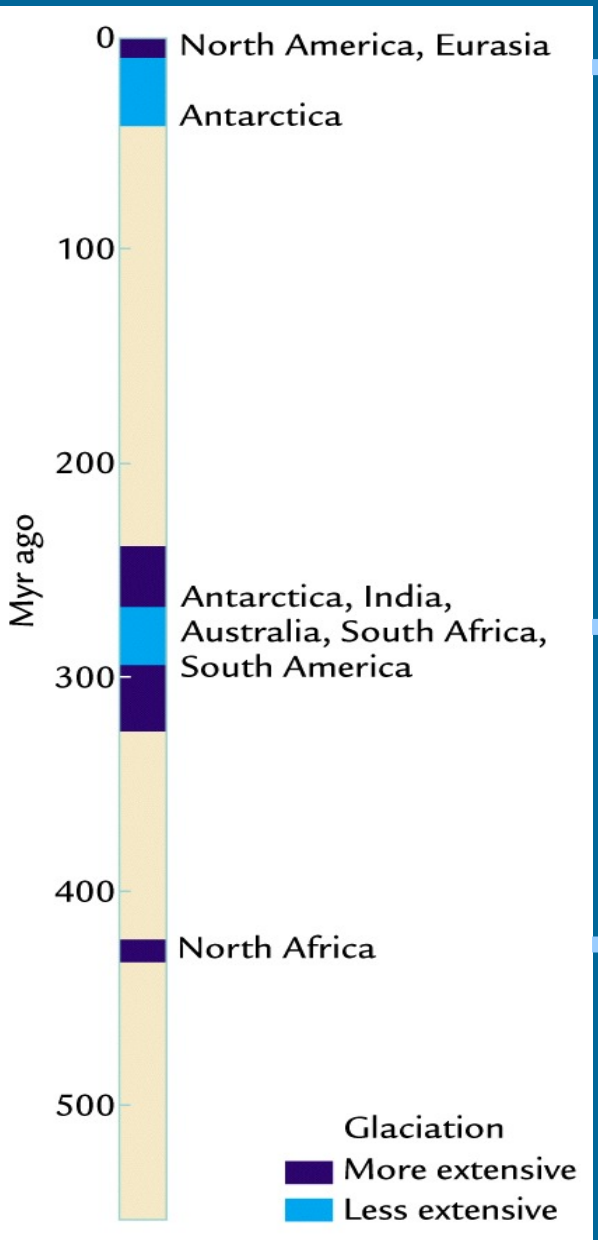


4. ocean sediments: ‚dropstones' in fine-grained sediments





3 global glaciations since 550 Mio yrs ?

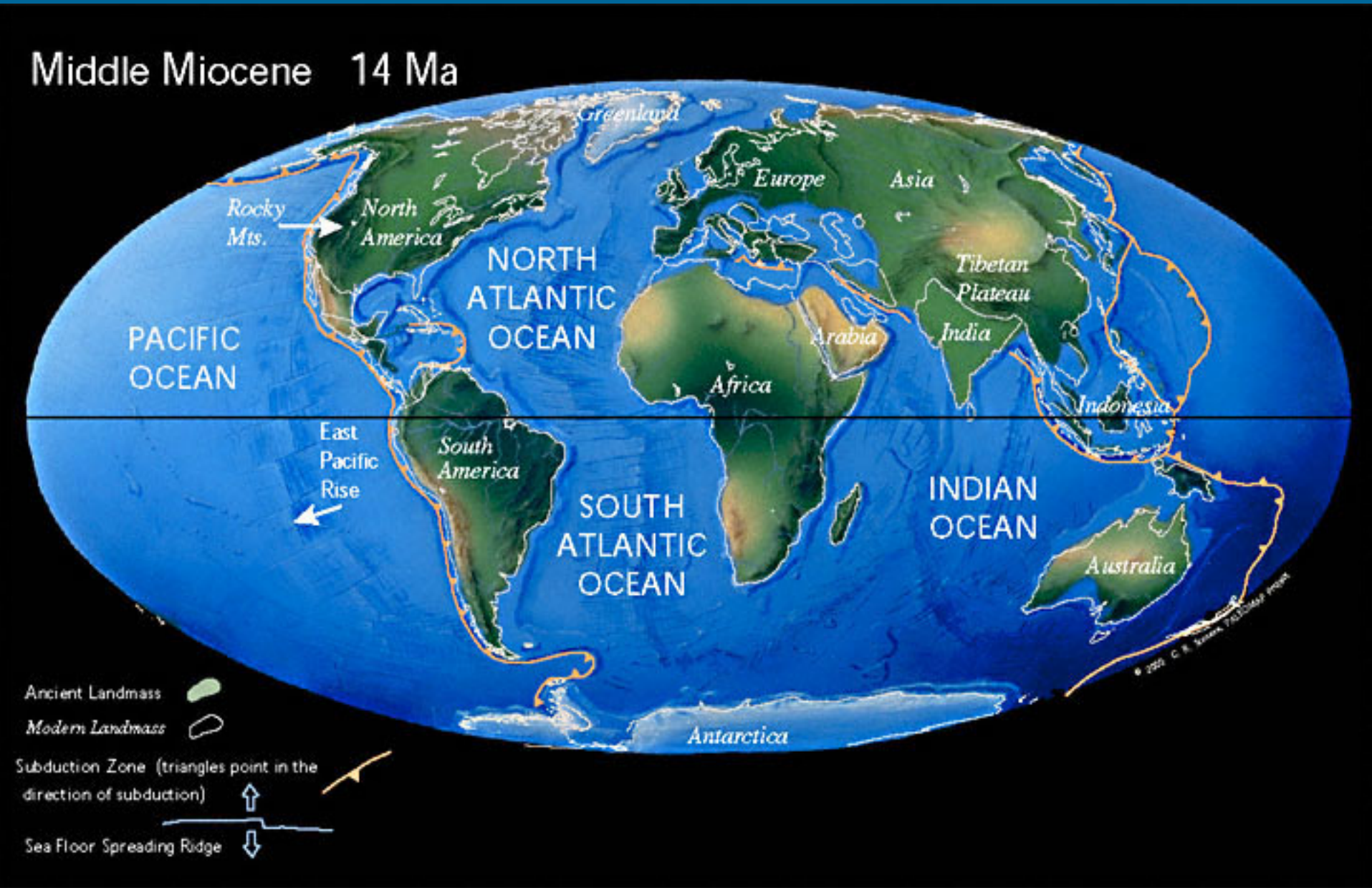


35 Mio yrs BP to recent

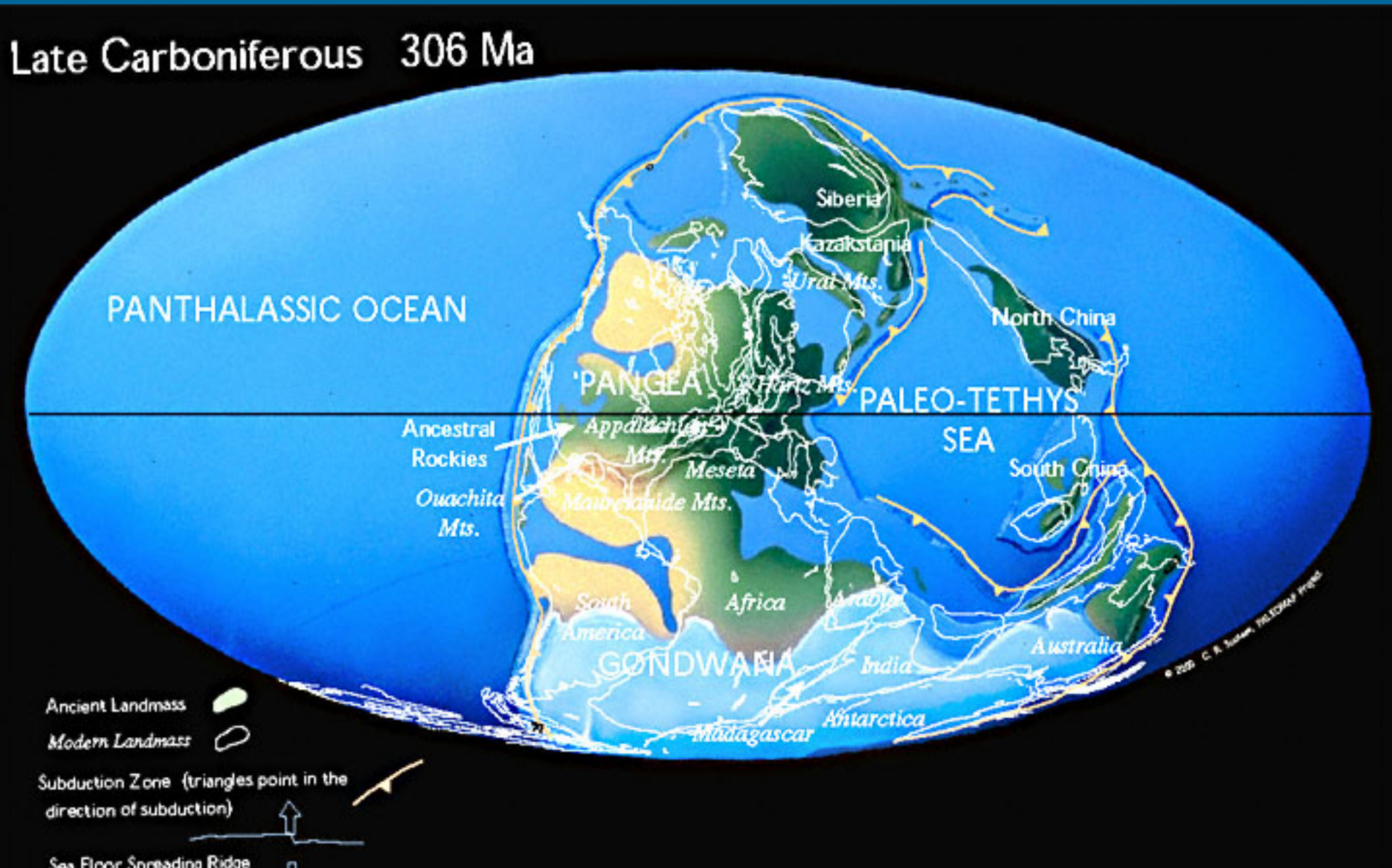
300-250 Mio yrs BP

ca. 450 Mio yrs BP

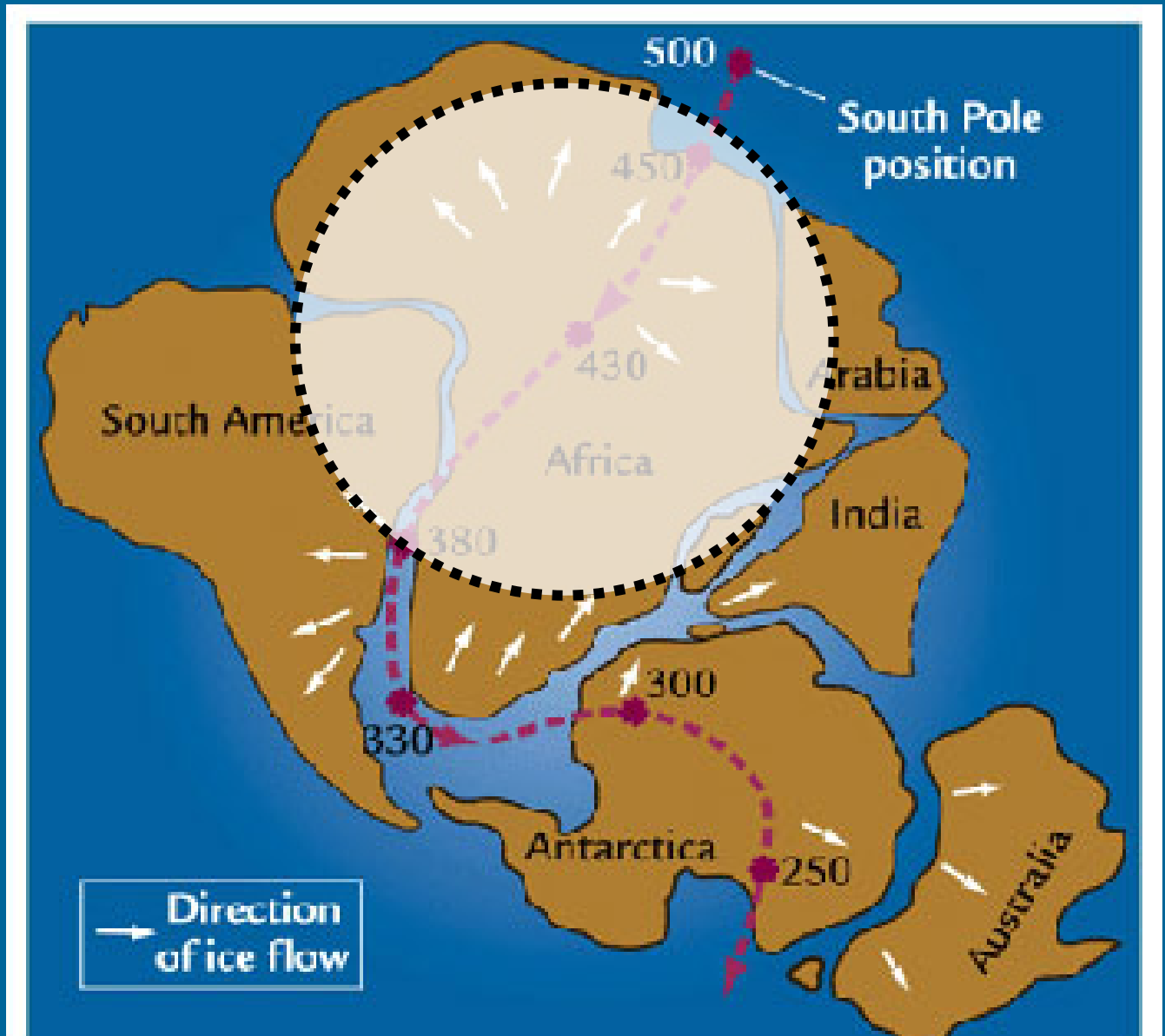
1. icehouse since ca. 35 Mio years



2. icehouse in Permo-Carboniferous (ca. 300 Mio yrs)



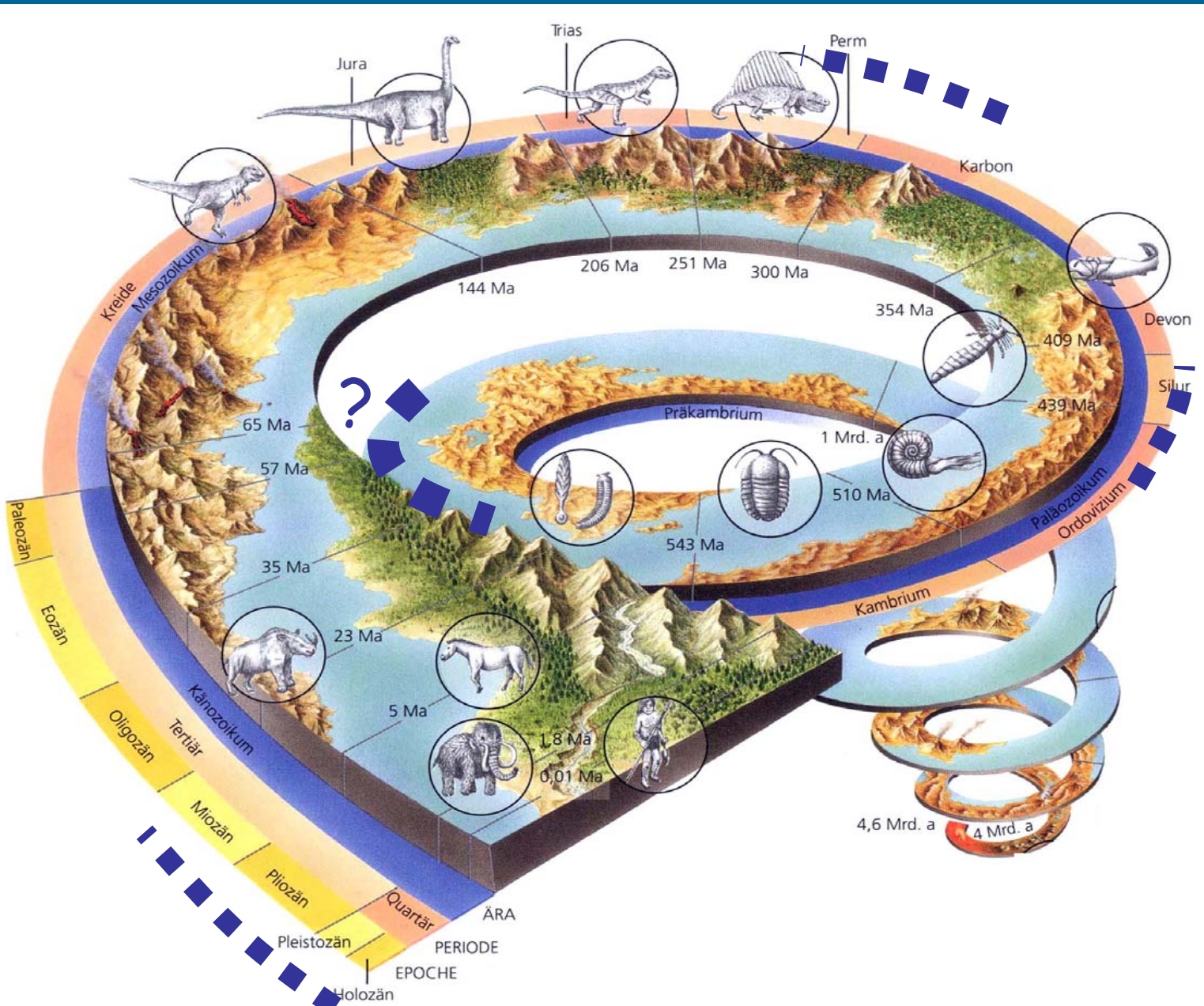
3. icehouse in Upper Ordovician (450 Mio BP)



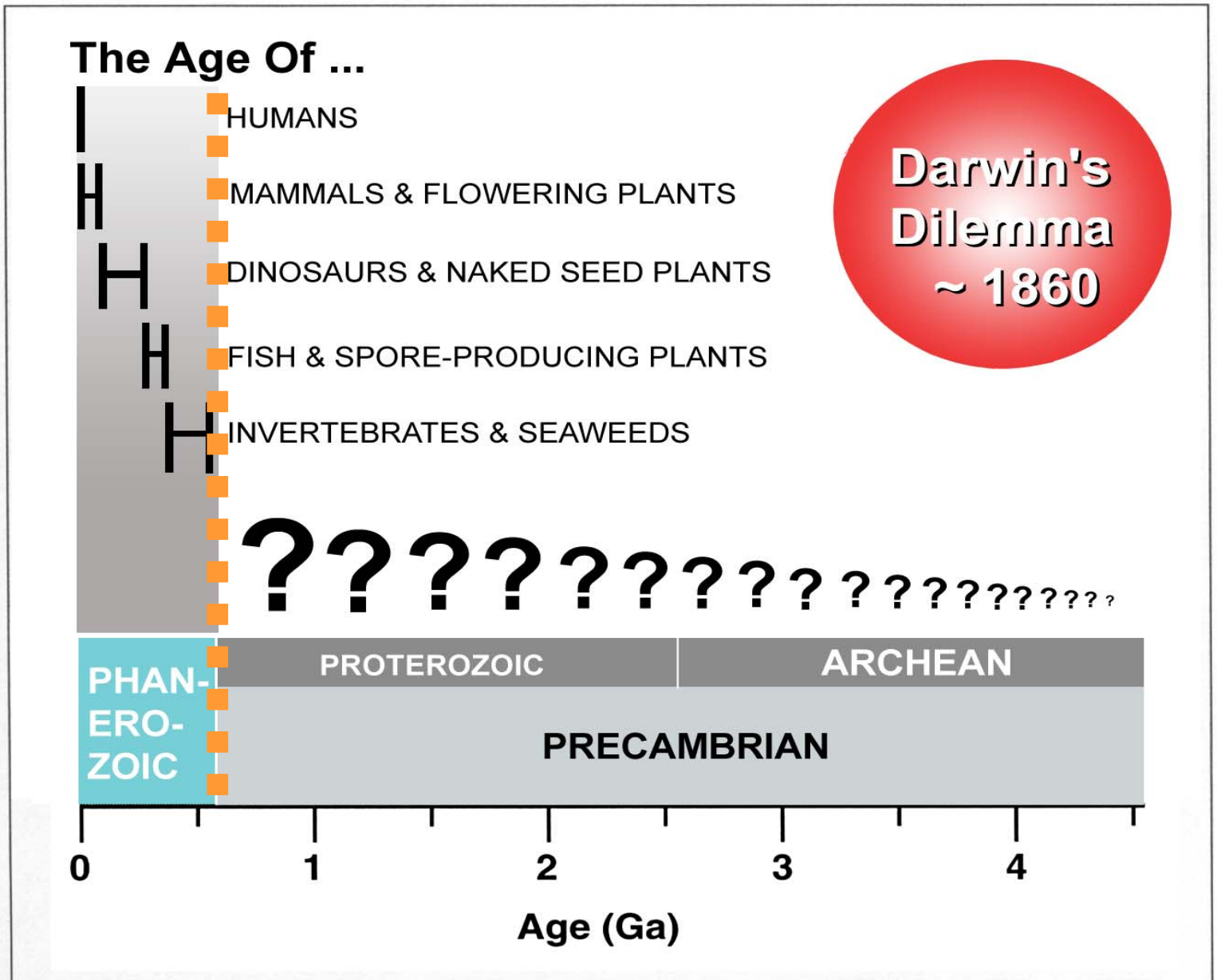
Animation

- SCOTESE: plate tectonics

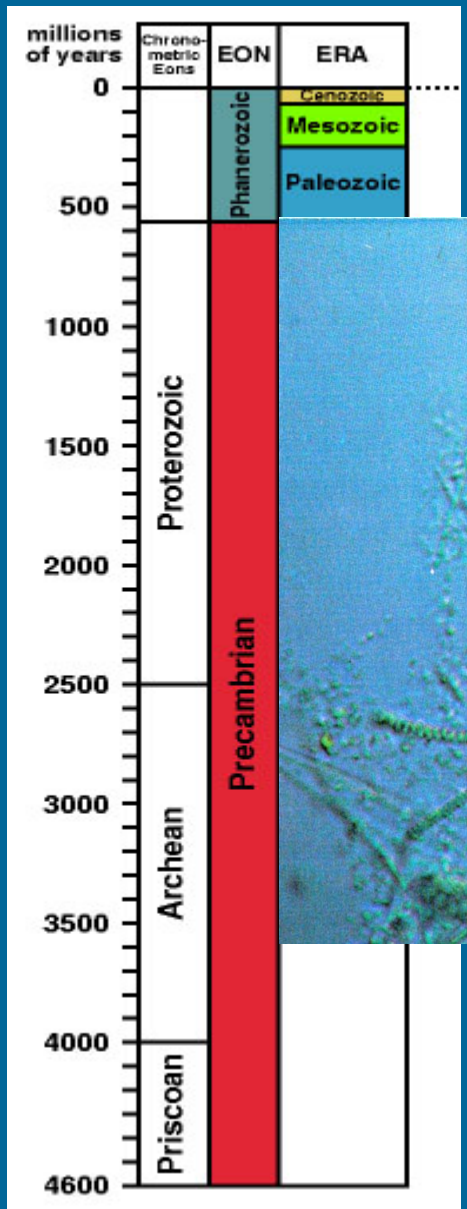
Precambrian glaciations on earth ?

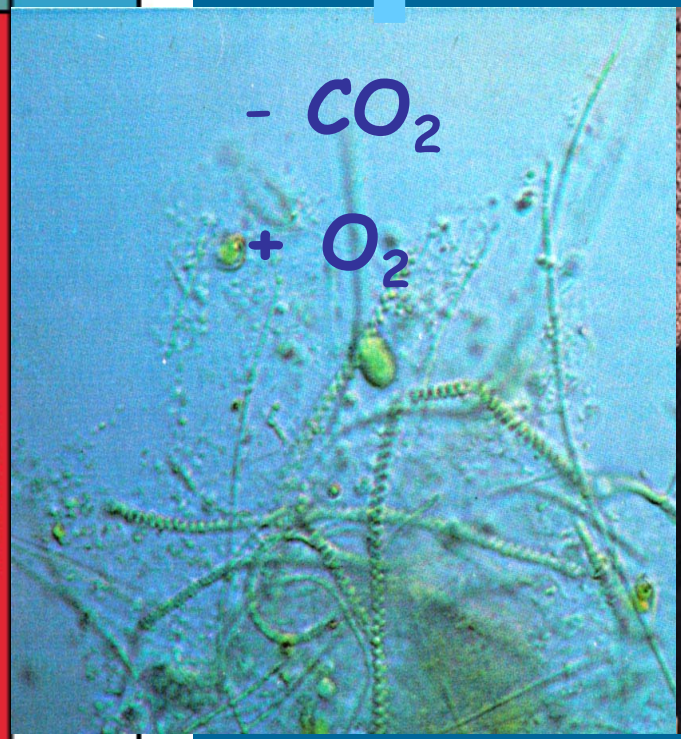


what was different in the Precambrian?



the Precambrian: endless time of primitive life

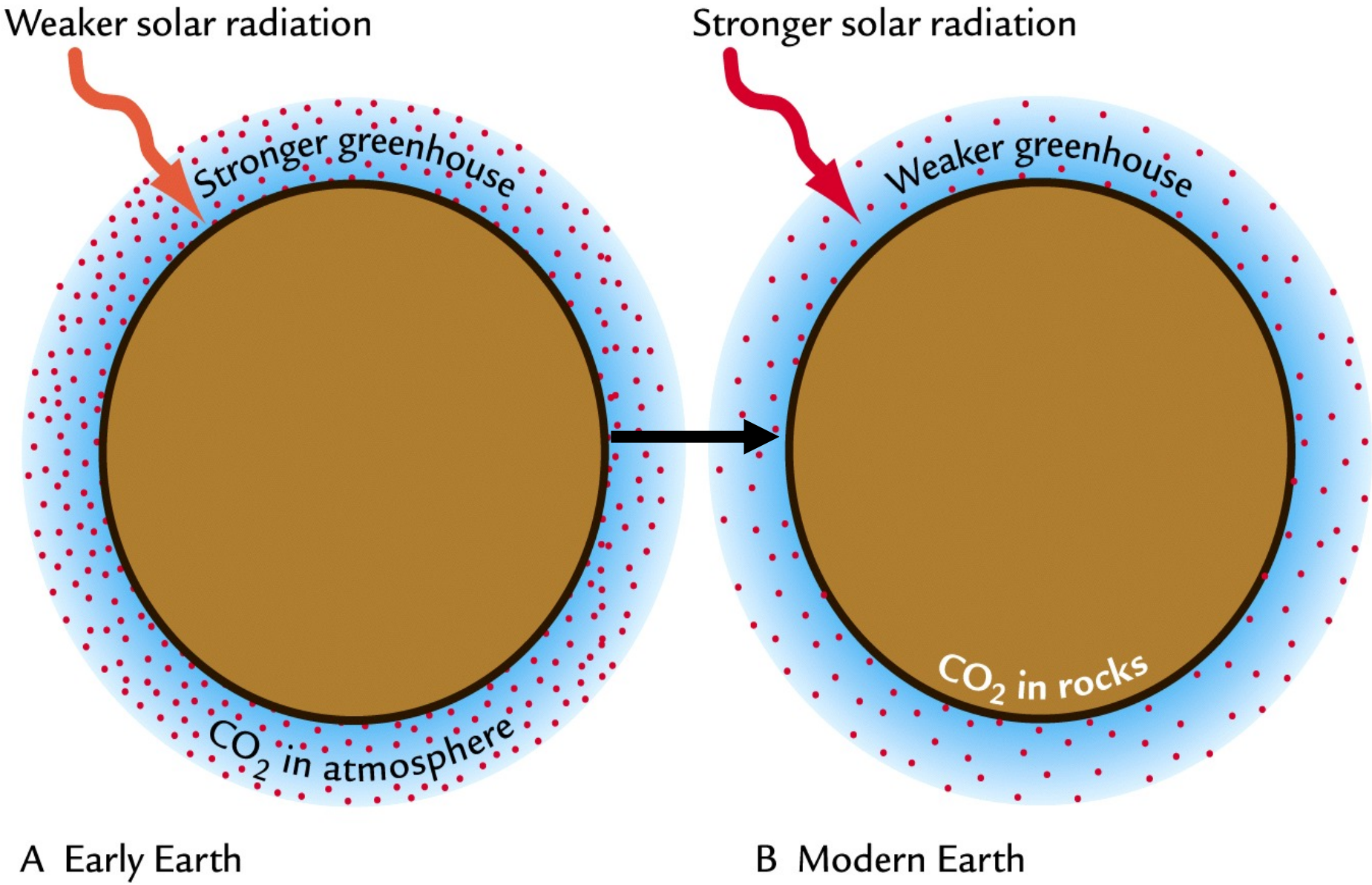




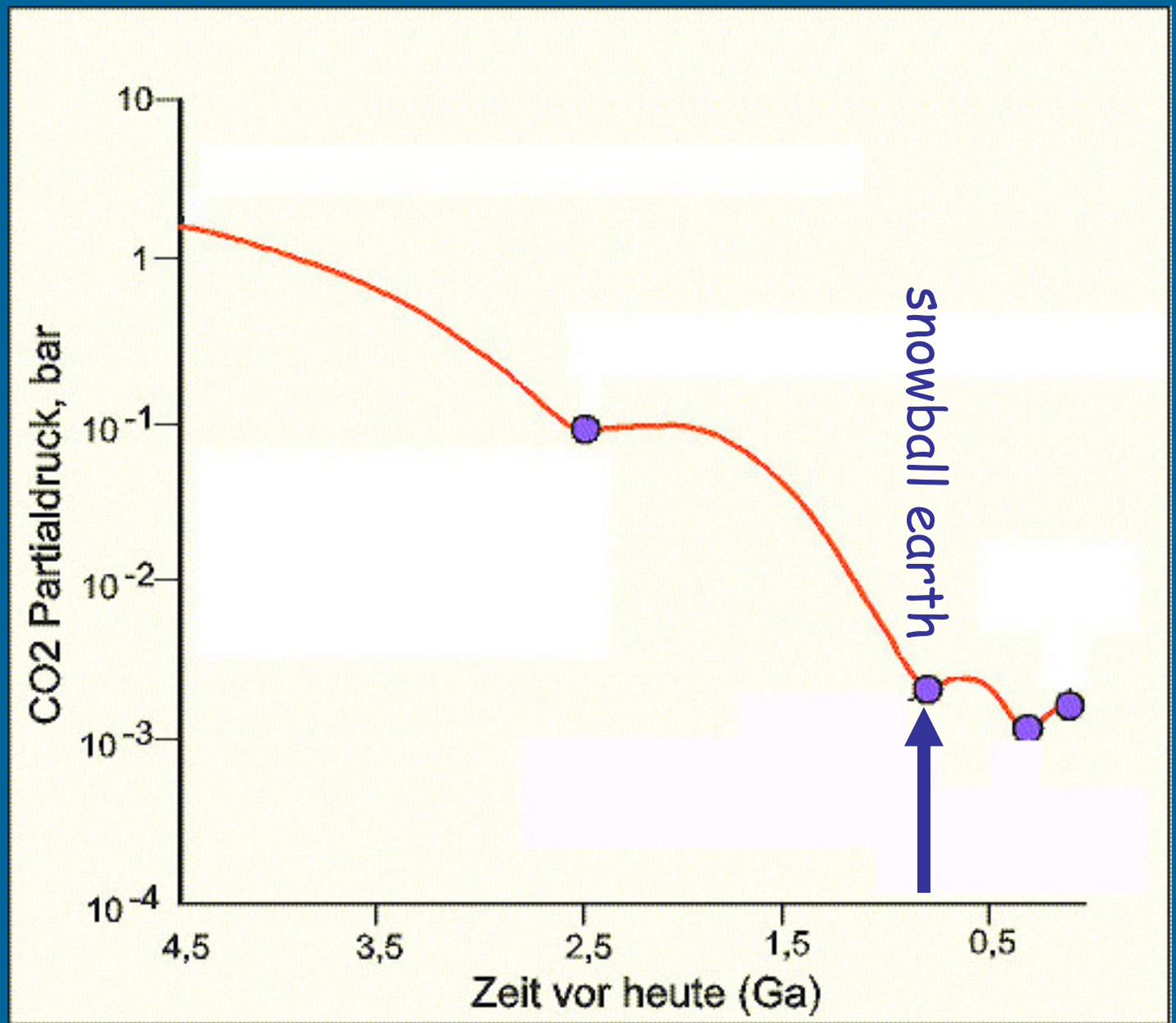
algal carbonates = stromatolites

$CaCO_3$

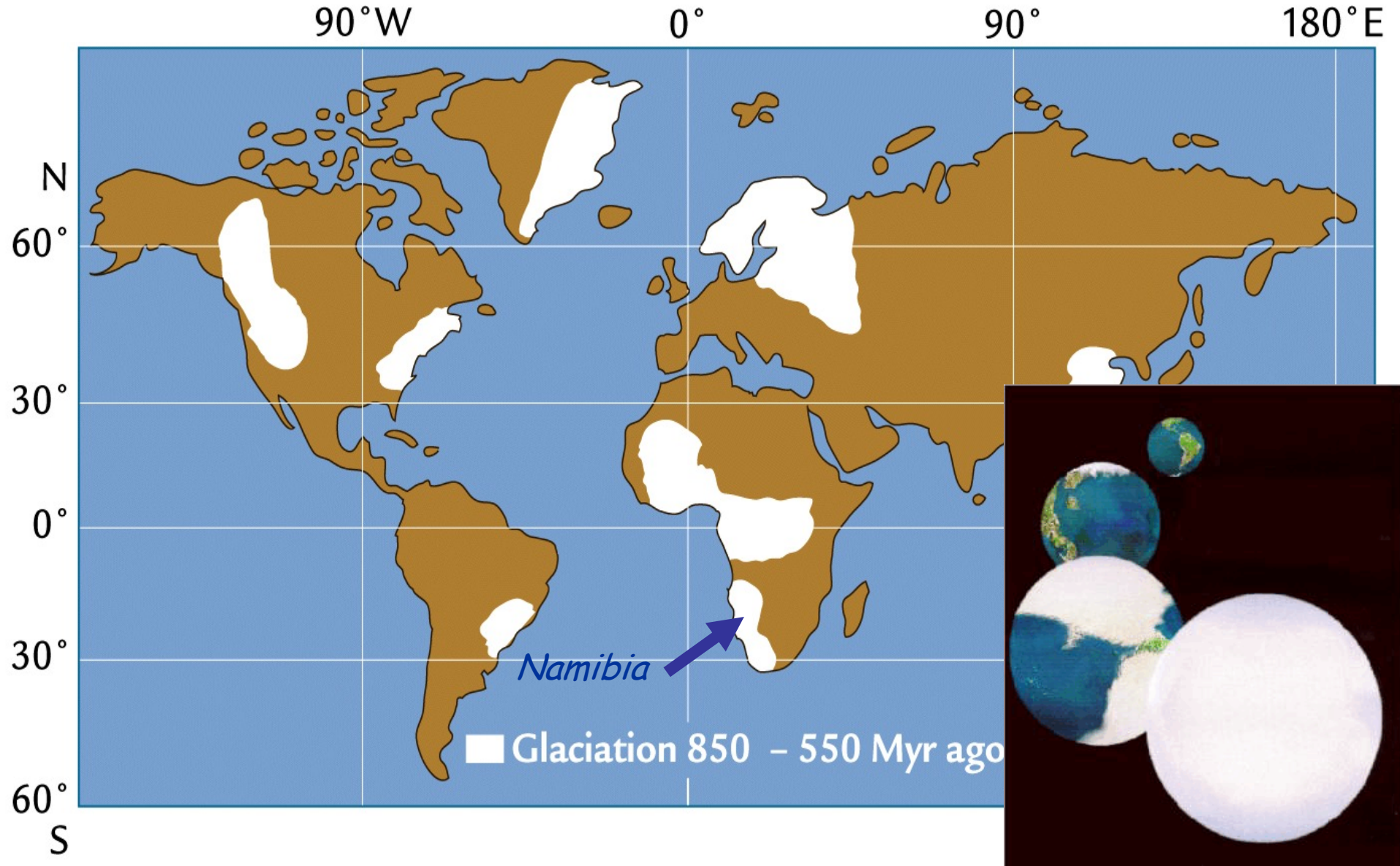
earth's atmosphere: distant past and modern



general decrease in CO_2 in the Precambrian

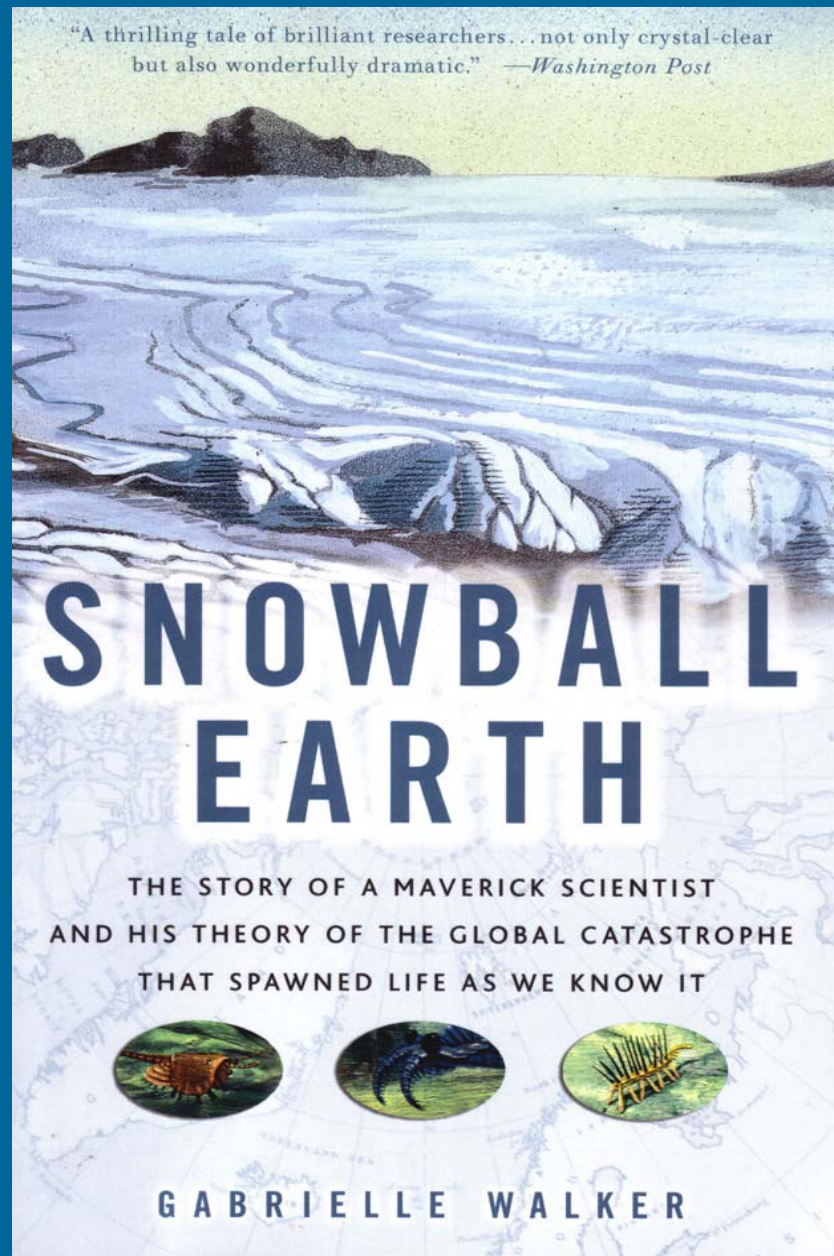


paradox: glacial sediments in the Neoproterozoic on all continents !?

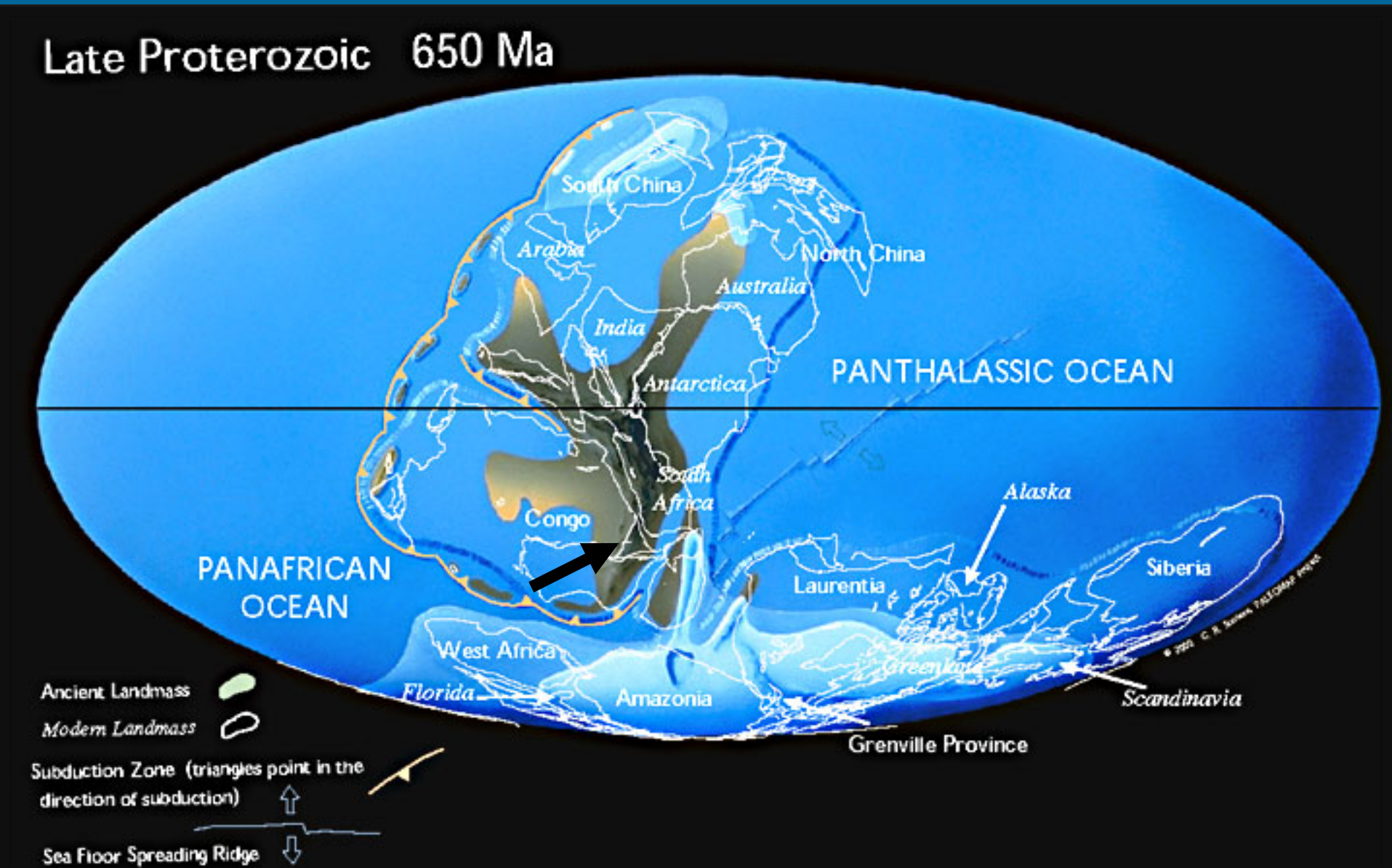


history of snowball earth

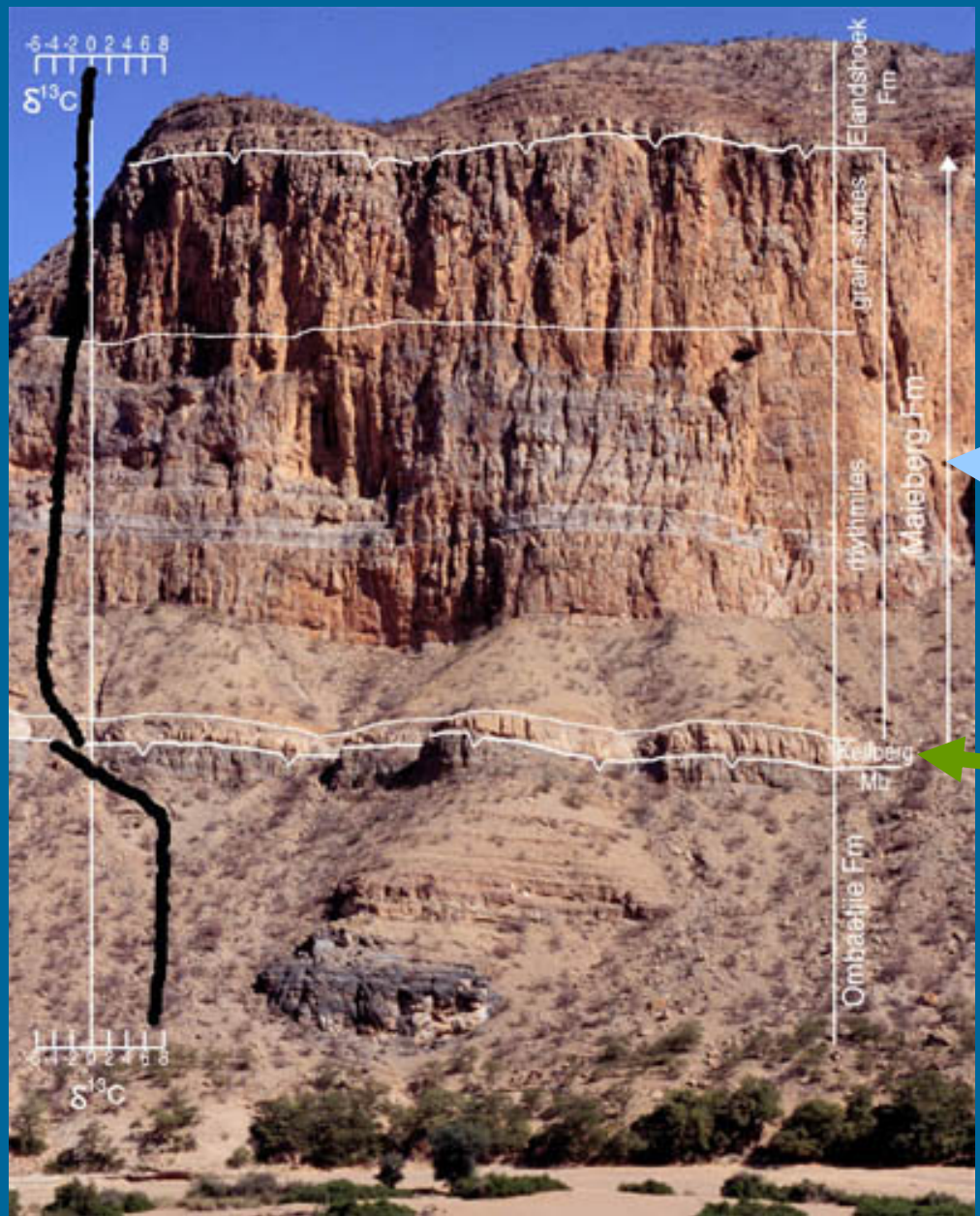
- 1964: B. Harland:
  ‚The great Infra-Cambrian ice age'
- 1992: J. Kirschvink
  ‚snowball earth'
- 1998: P. Hoffmann and D. Schrag
  evidence for ‚snowball earth'

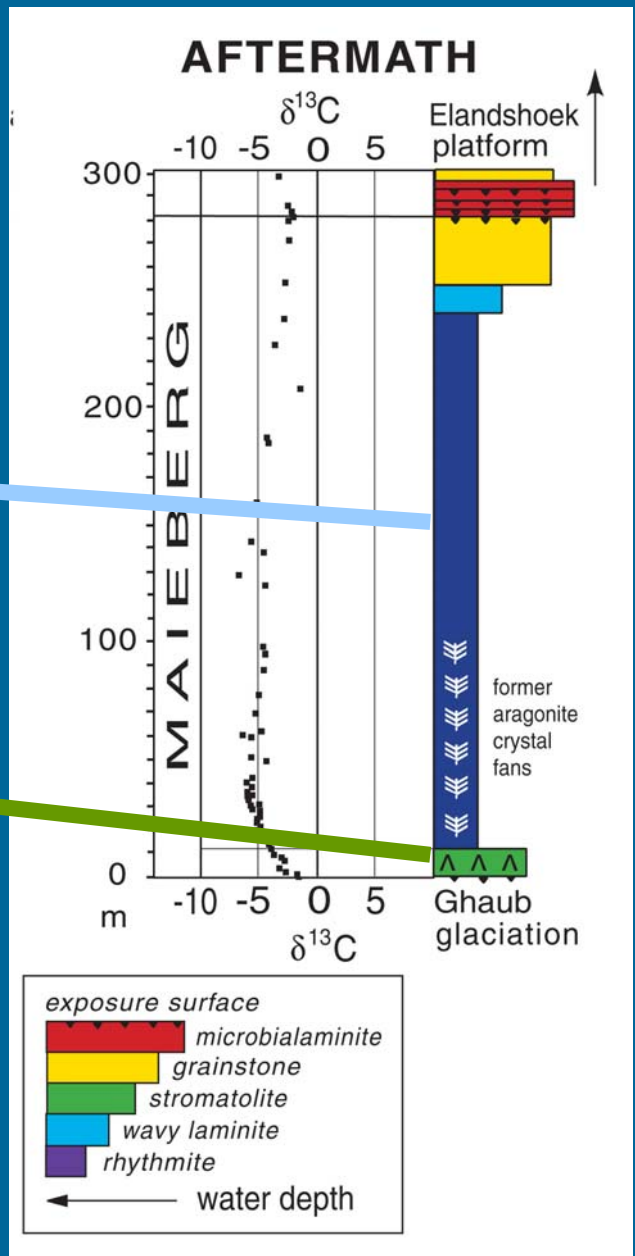


the continents during times of ‚snowball earth'



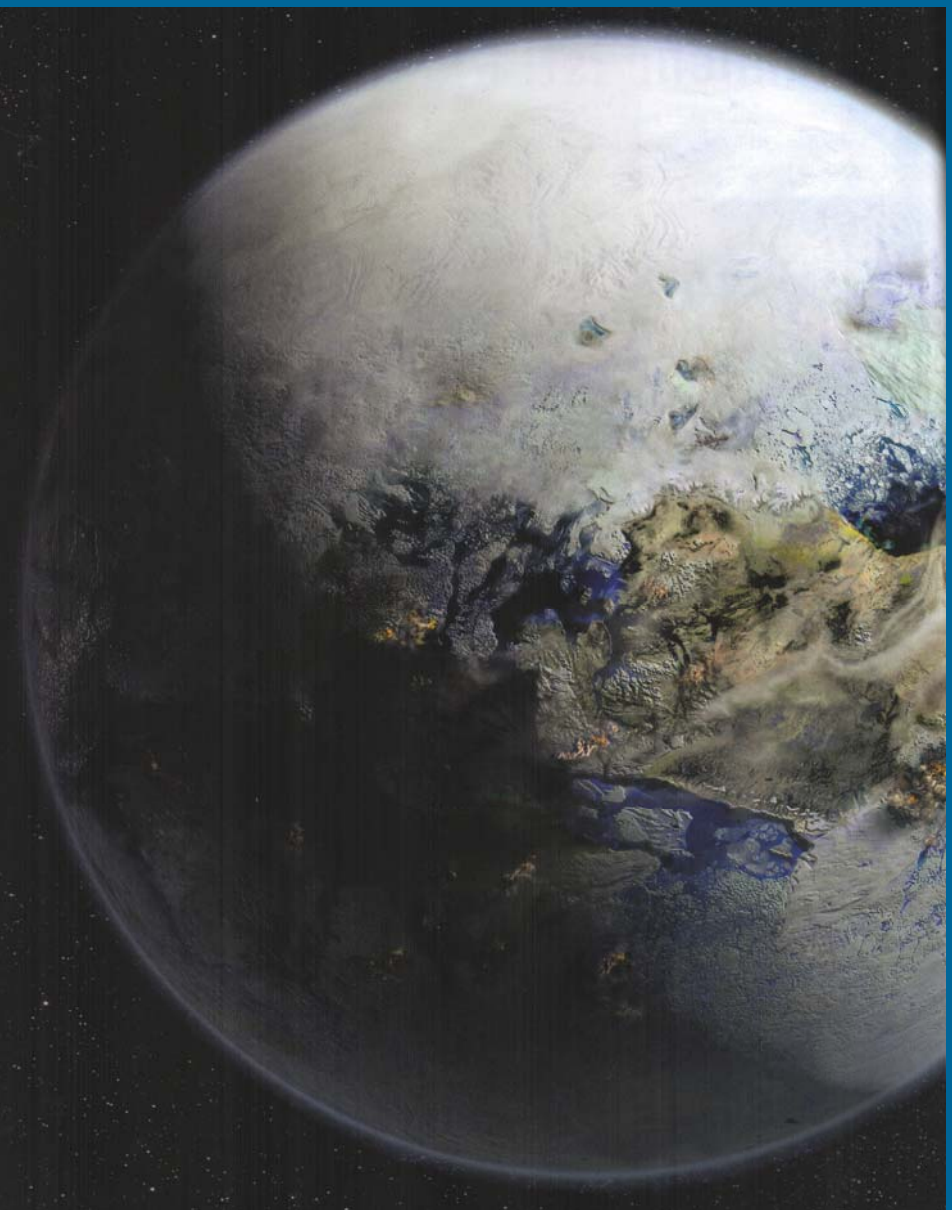
key study regions : Namibia

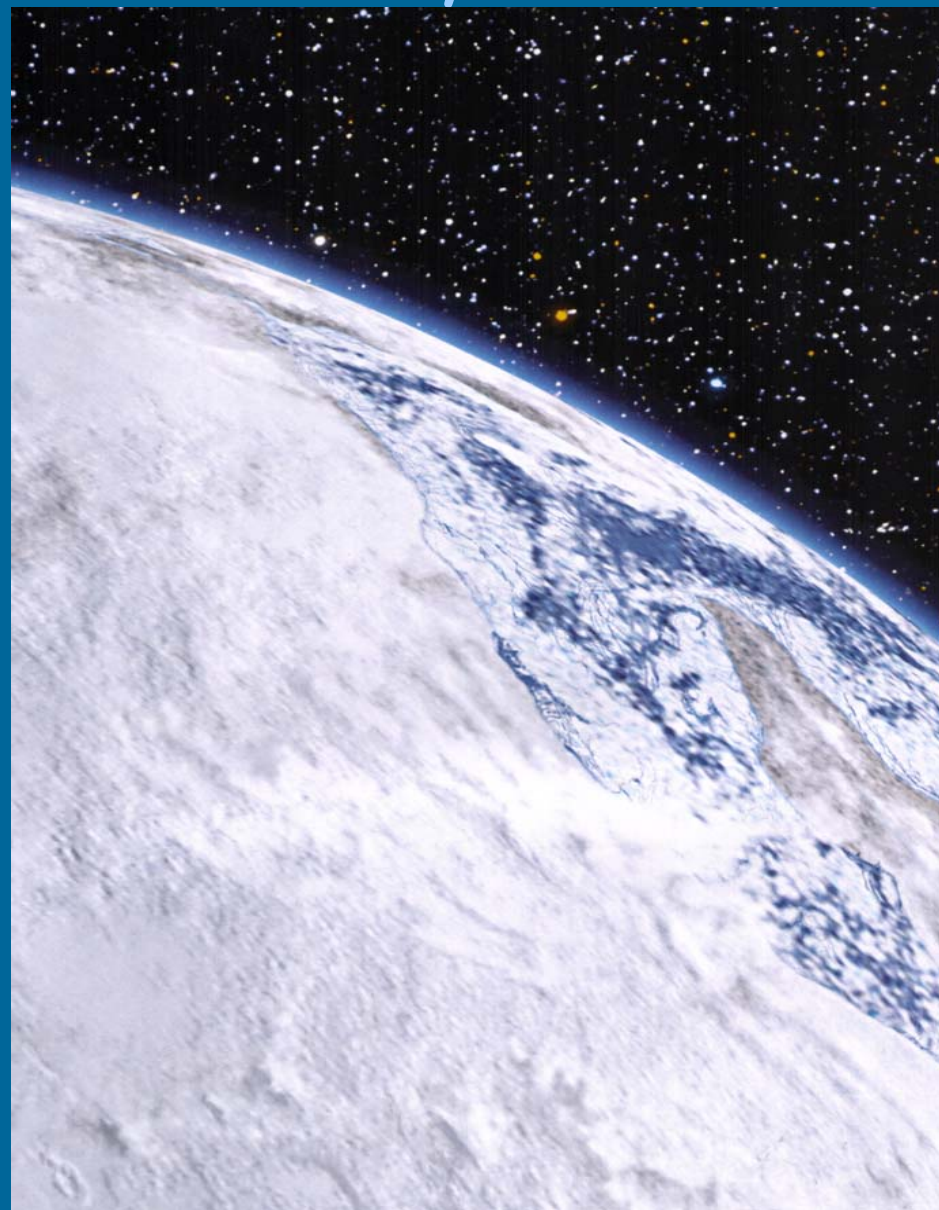




evidence for glaciation (Namibia): large blocks in fine-grained matrix

was the earth completely covered by ice ?
‚Snowball Earth' - theory



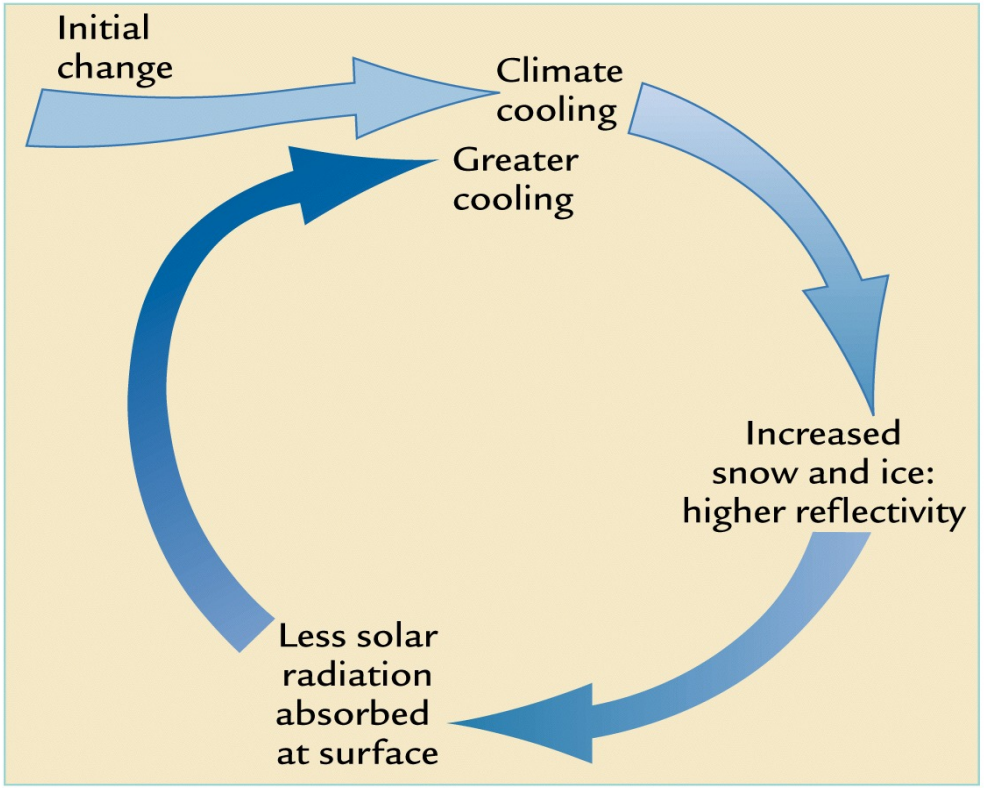


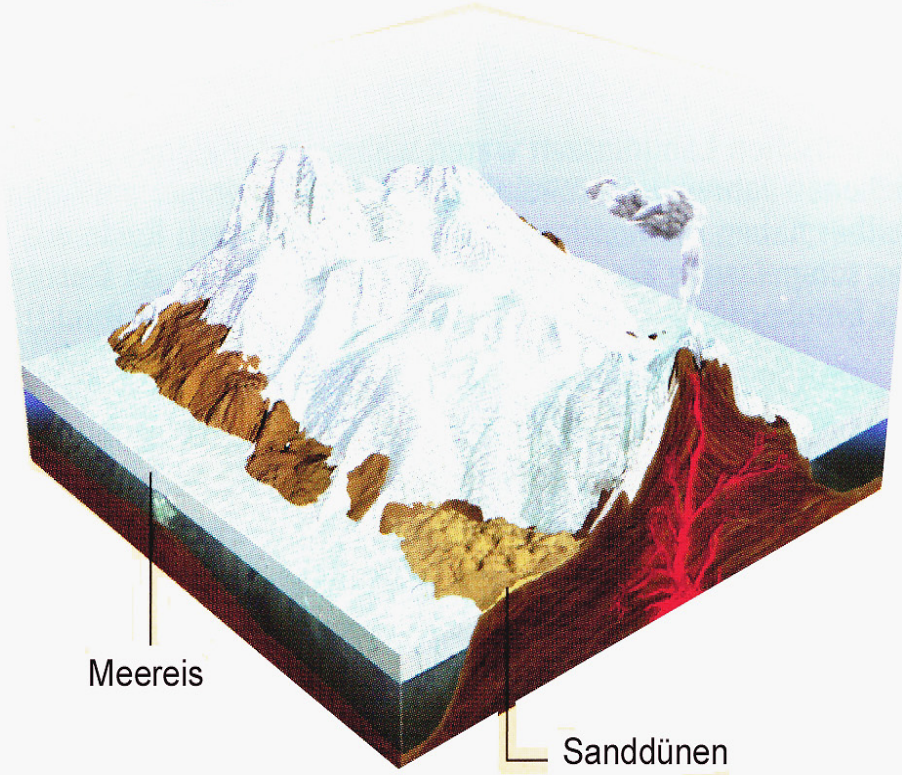
another paradox:
warm climates (‚cap' carbonate) -> glaciation

runaway icehouse = ‚snowball earth'

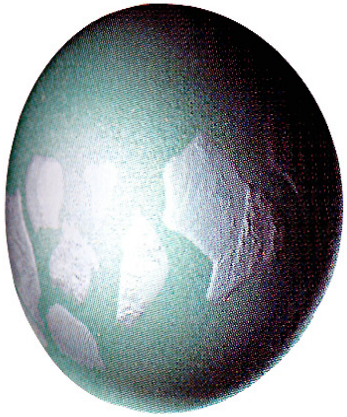
1. Phase
Auf dem Weg zur
Schneeball-Erde

2. Phase
Höhepunkt der
Schneeball-Episode





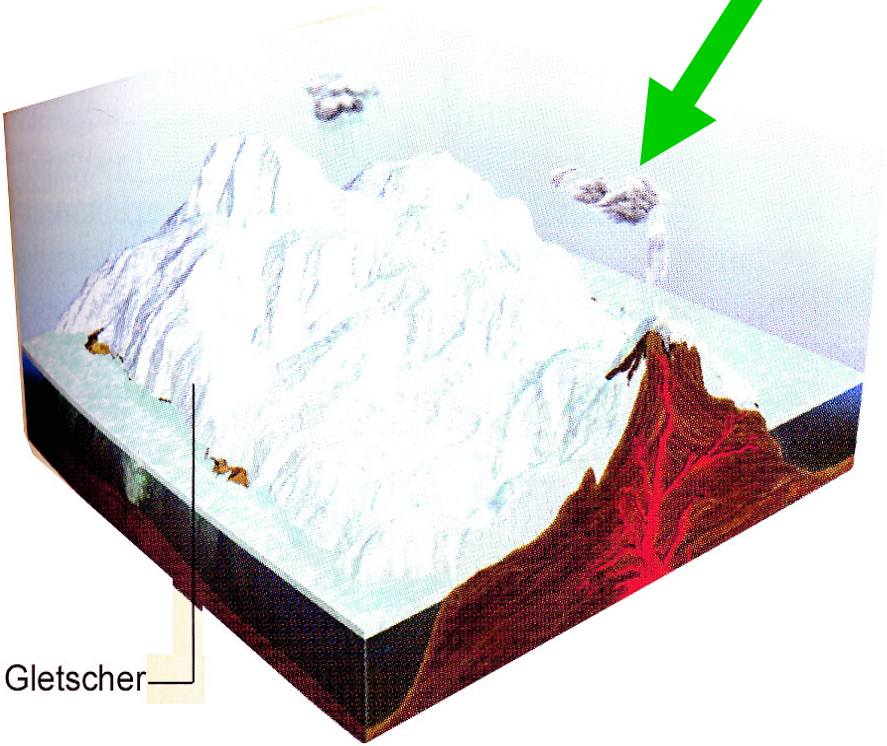
how to escape from ‚snowball' ?

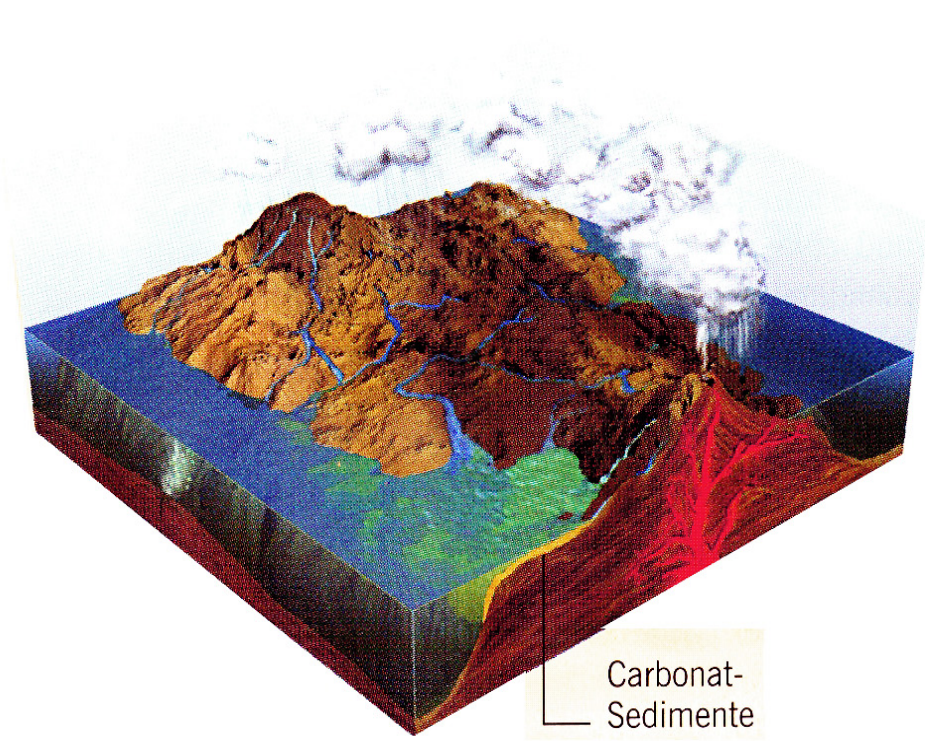


3. Phase
Die Schneeball-Erde
taut auf

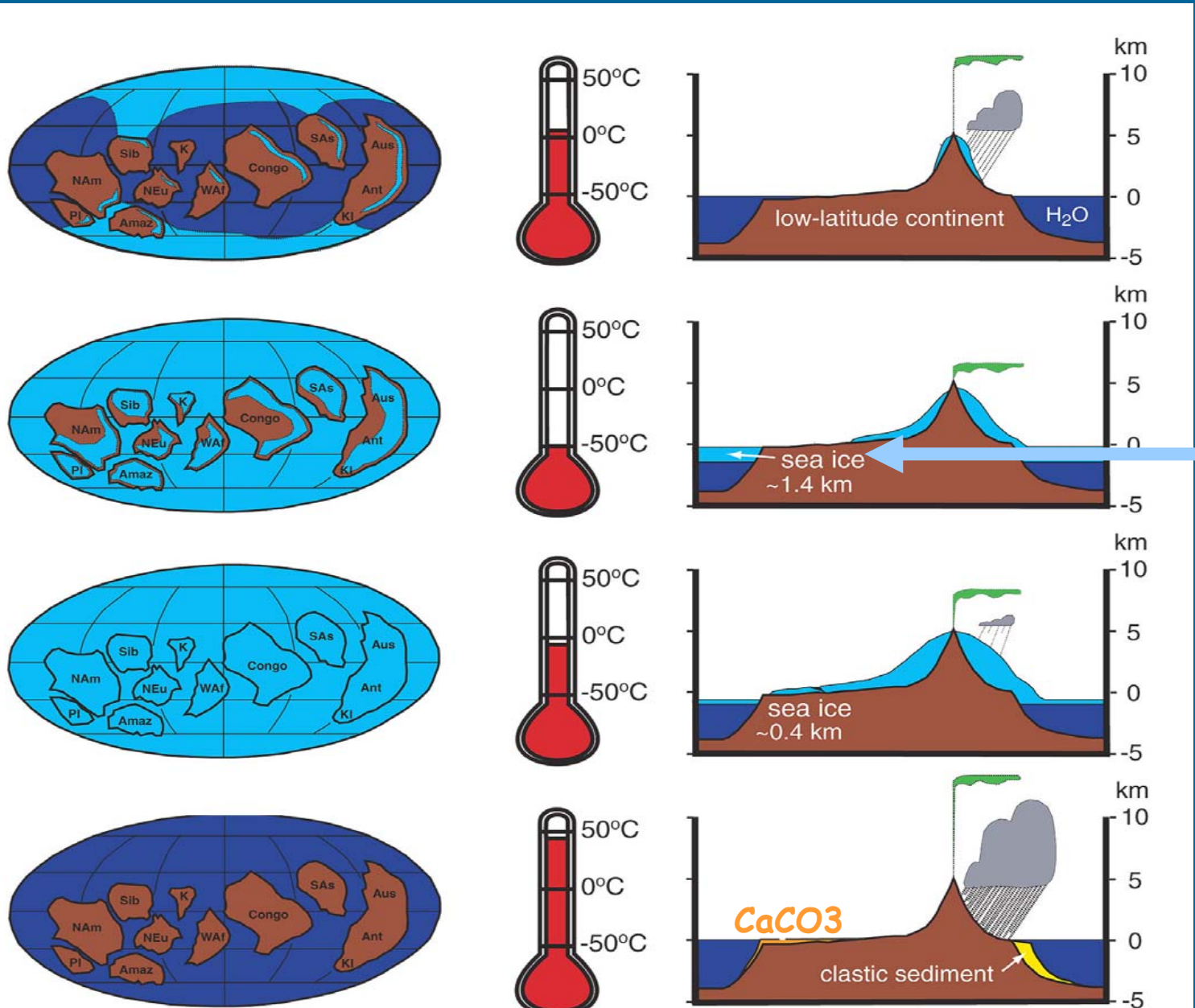
4. Phase
Das globale Treibhaus

CO_2





from -50°C icehouse to 50°C hothouse/sauna ?

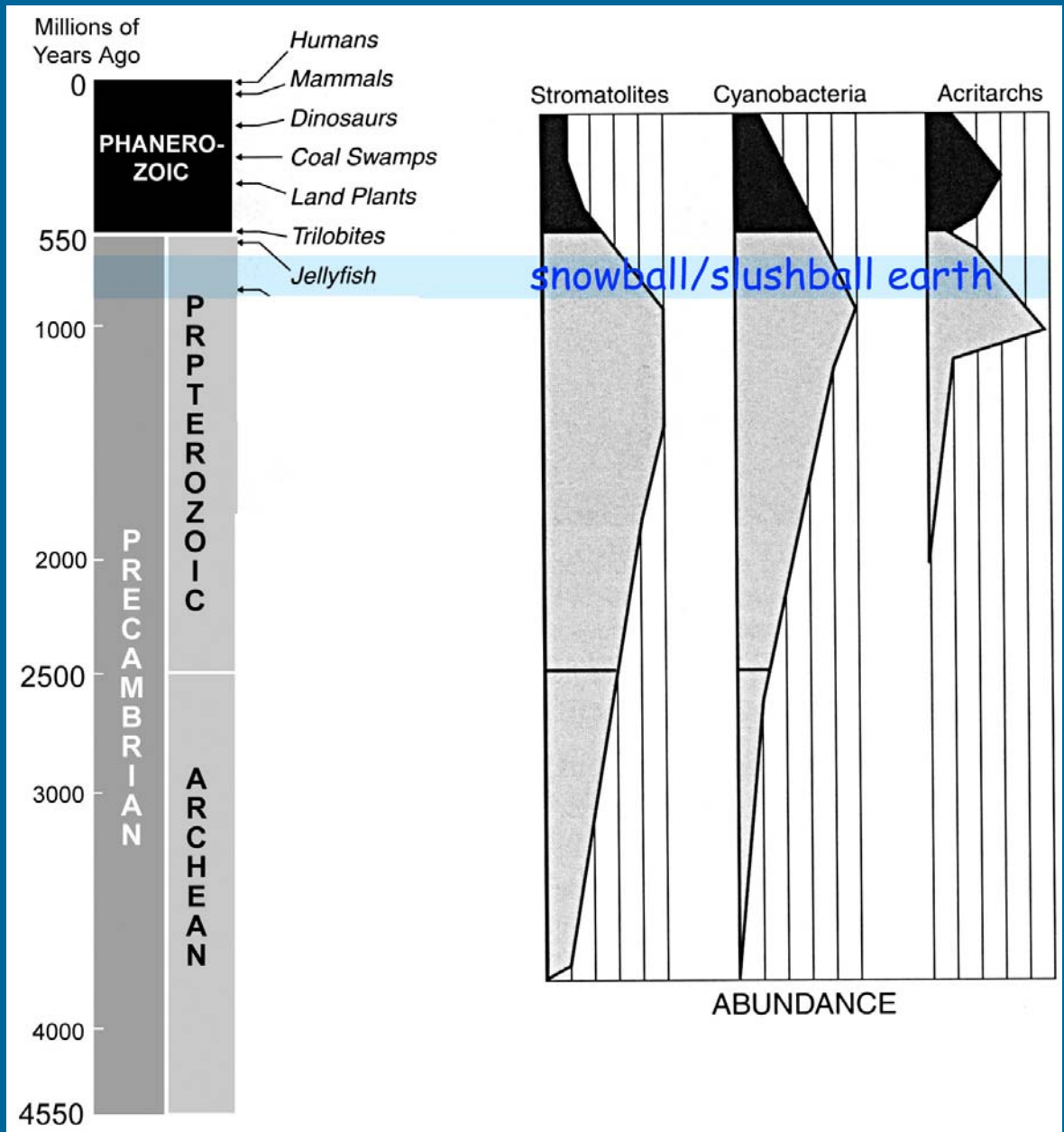


~ 1 km of sea ice !?

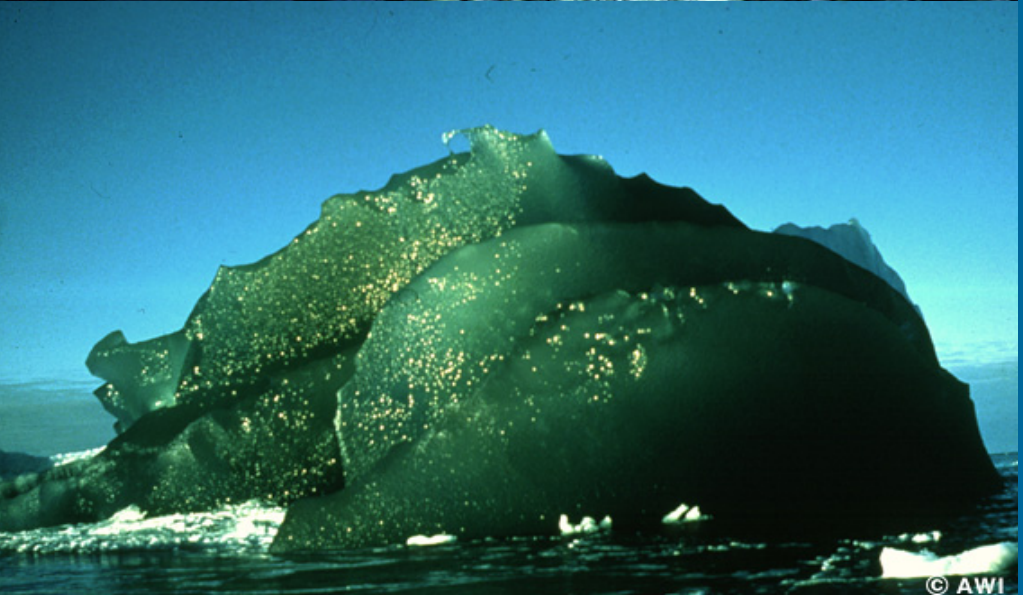
- but photosynthetic organisms have survived !

‚slushball ecean !?

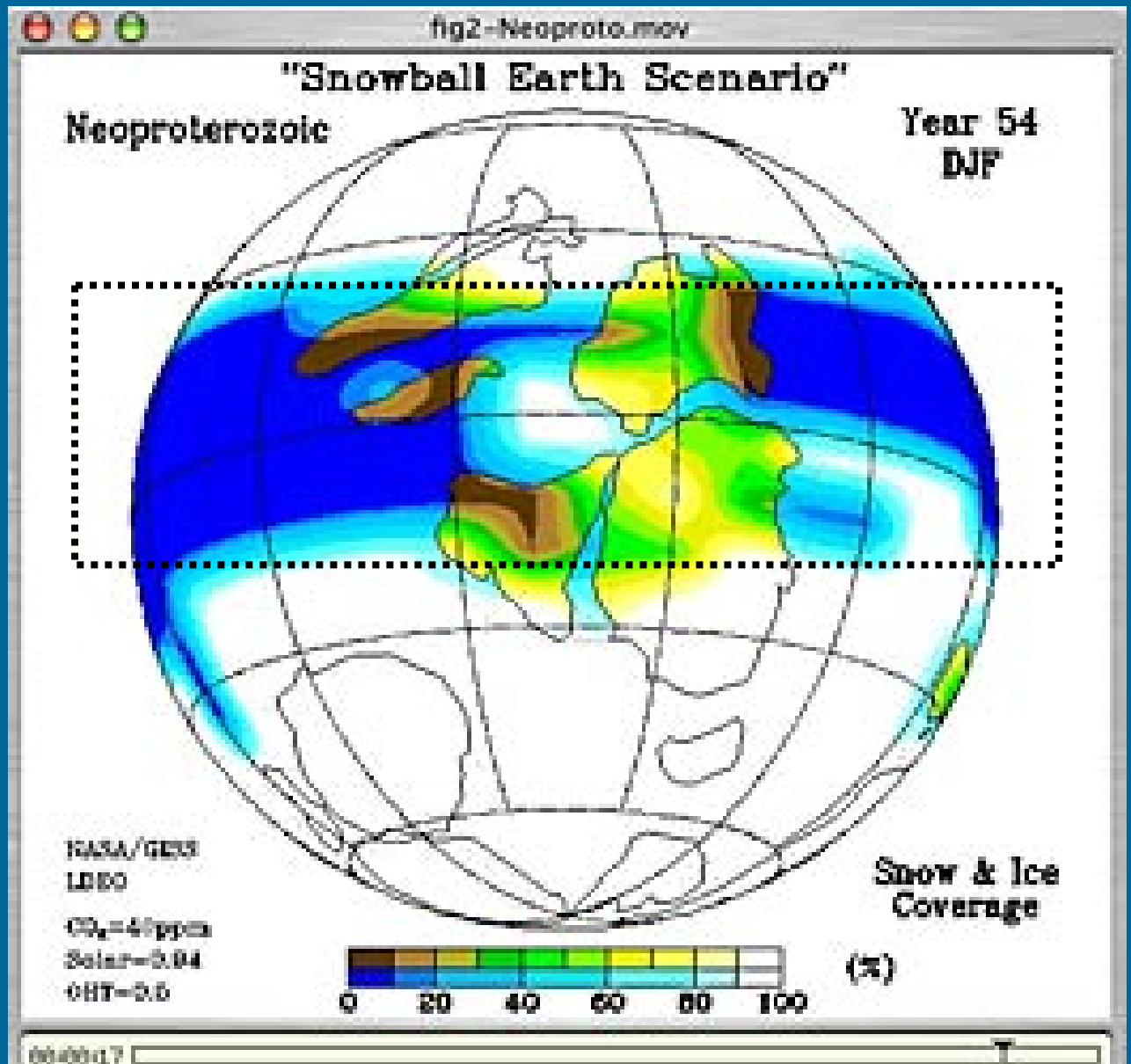
reduction in abundance during ‚snow-slushball'



life under and between sea ice !

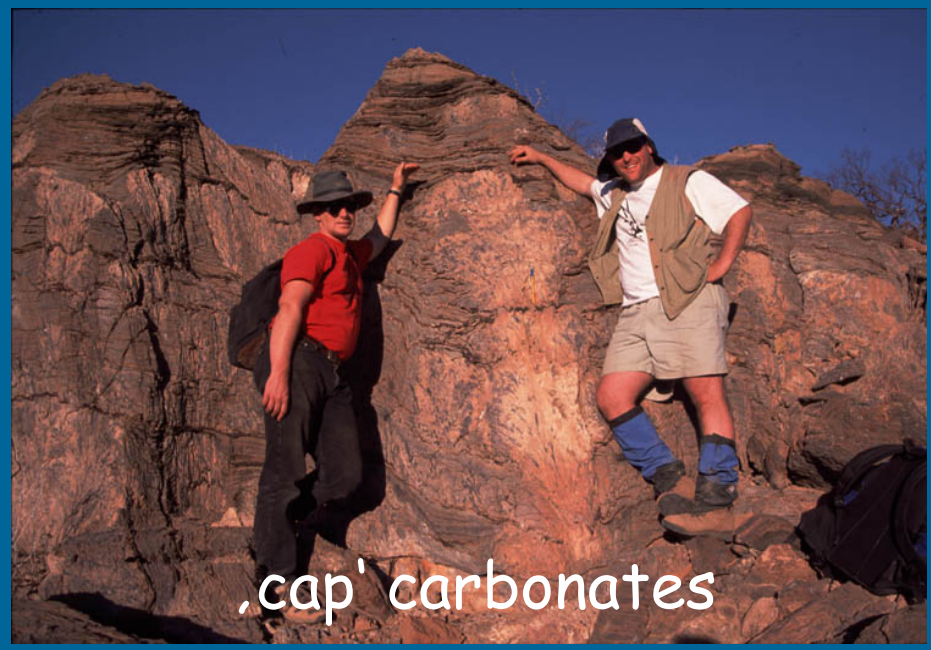


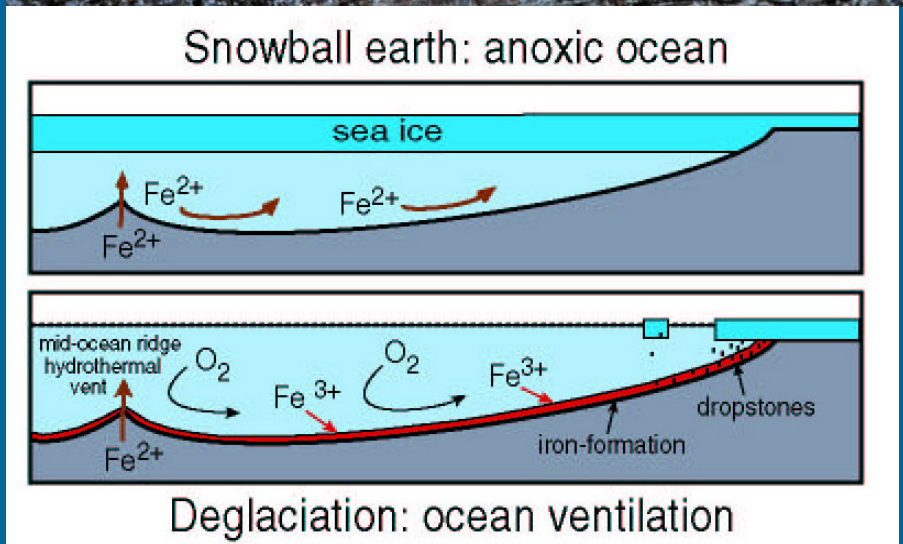
animation: ‚snowball/slusball earth'



Hoffmann and Schrag: the geological record requires complete ice coverage ('snowball')

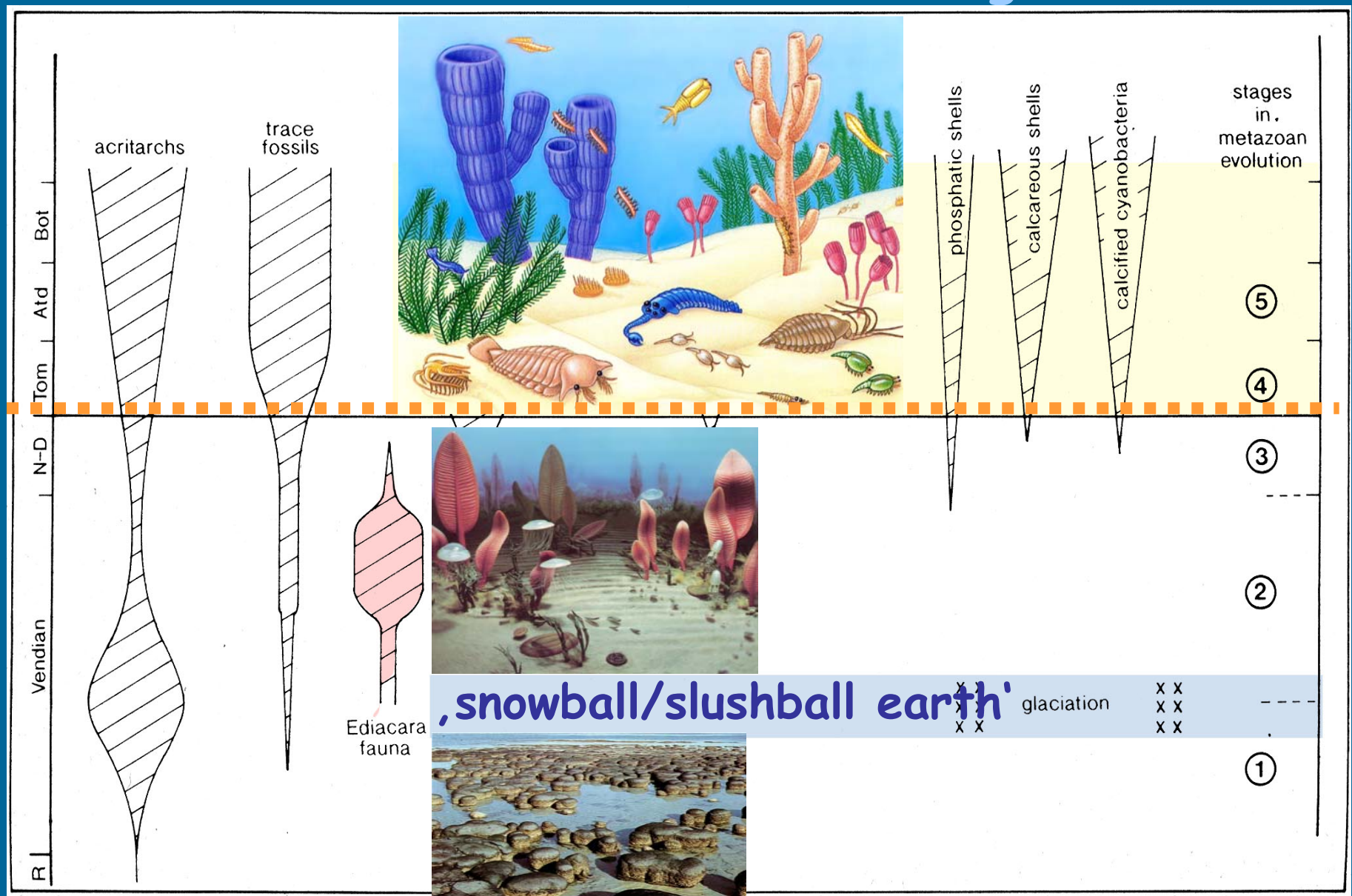

red iron-rich cherts (BIF's)


'cap' carbonates

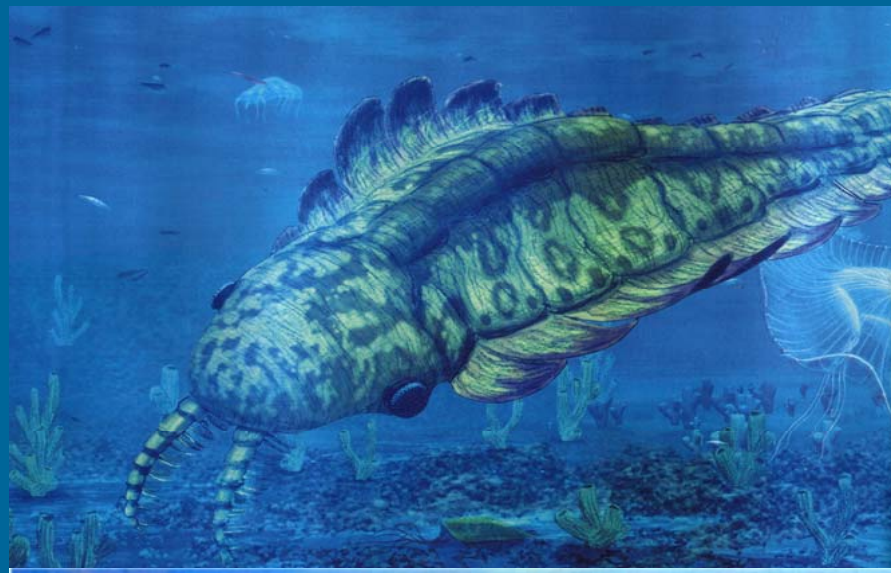


an ongoing discussion

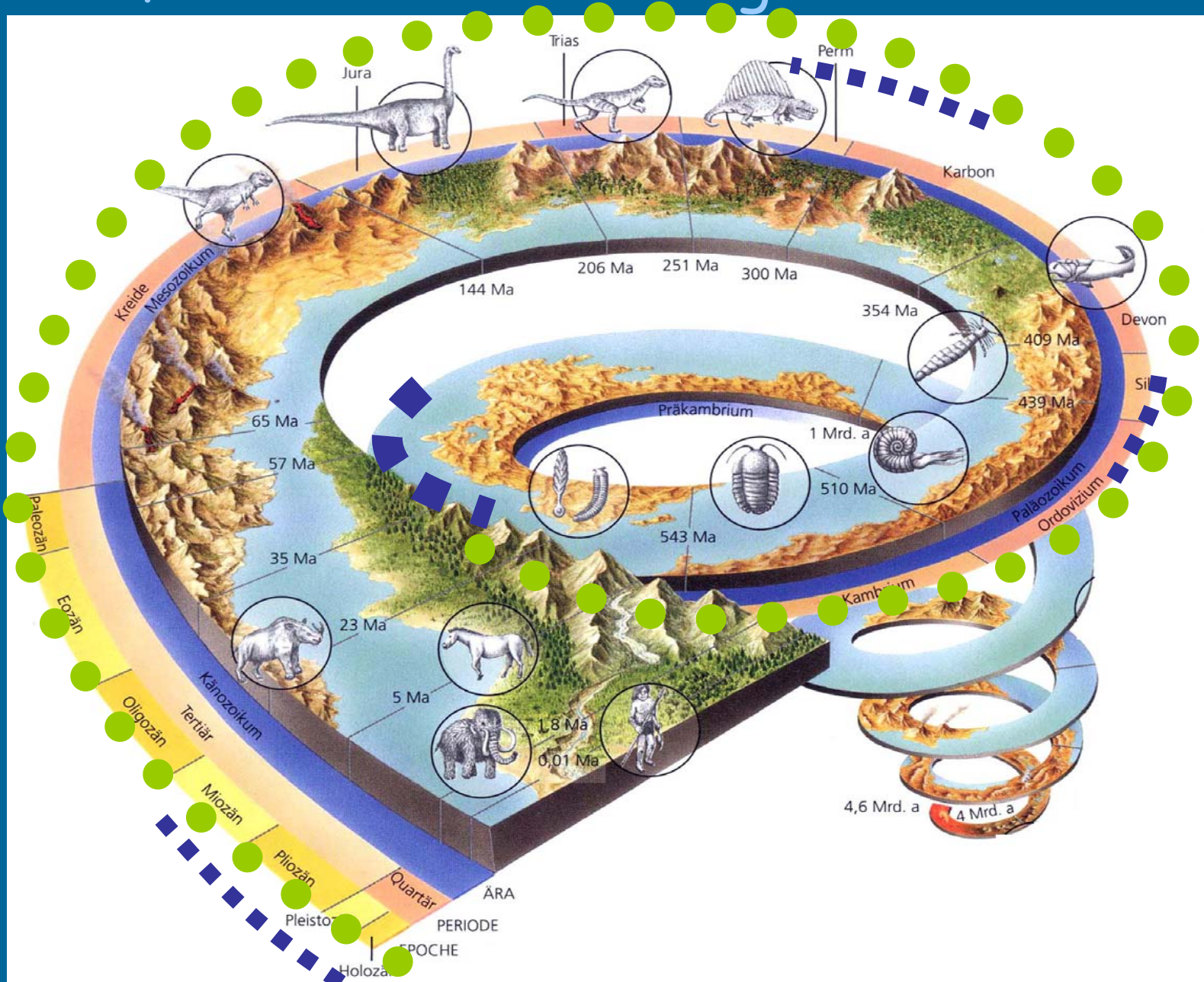
‚snowball-slushball earth'
and the first multicellular organisms



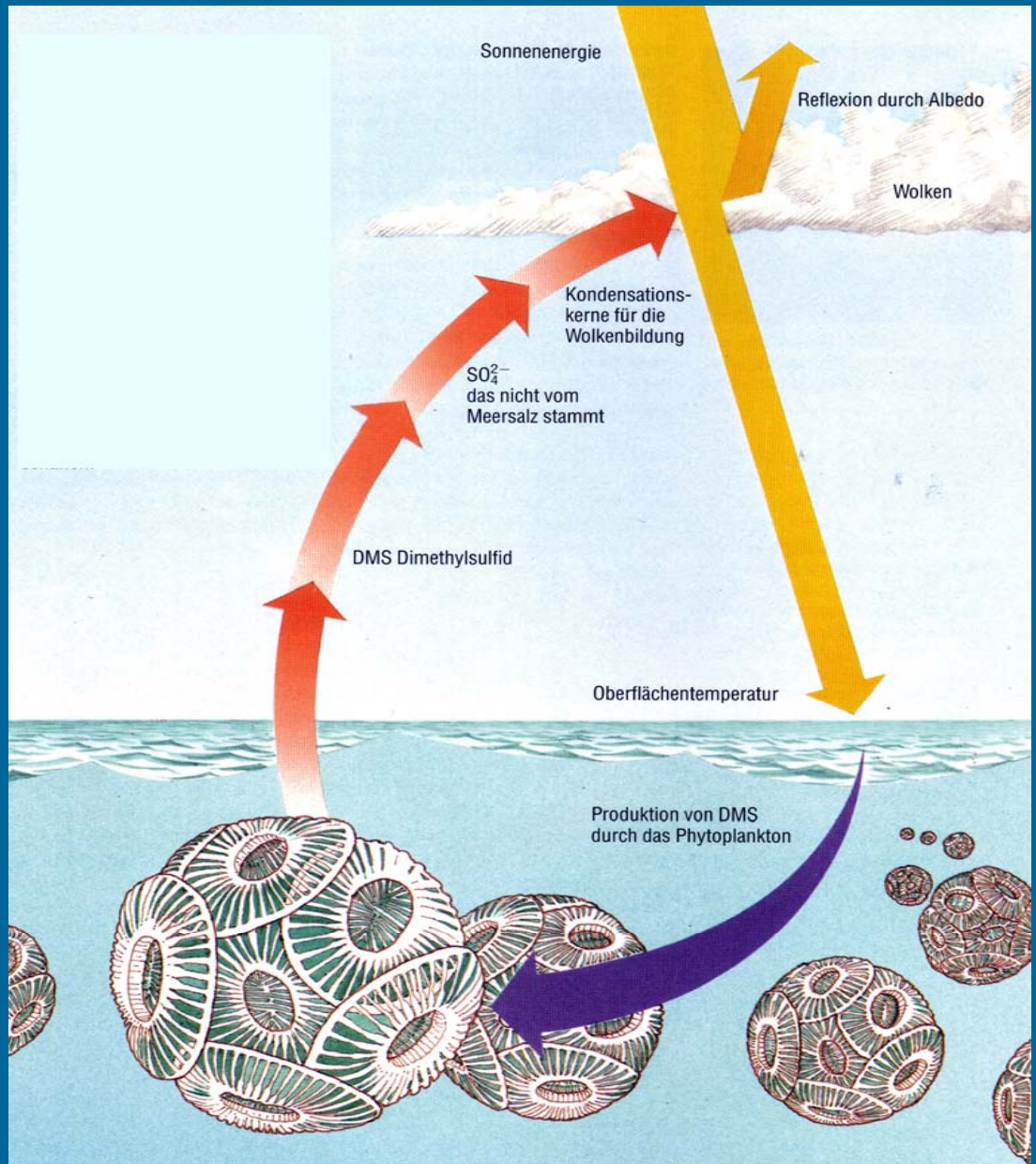
the ‚cambrian explosion' of organisms: the first shells !



‚snowball' and later glaciations !



the organisms on earth may regulate climate



summary

- since 540 million years: ice coverage at the poles
- before 540 million years: ice in the tropics ‚snowball earth/slushball ocean'
- since then no ‚snowball/slushball earth'
- since 600/540 million years:
  →rapid evolution of metazoan life !
- life on earth may have prevented more extreme icehouse scenarios ?

selected references

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