



UNIVERSITÀ DEGLI STUDI
DI MILANO
DIPARTIMENTO DI SCIENZE
DELLA TERRA "ARDITO DESIO"

APEGEO

Aperitivi scientifici coi piedi per Terra!

Il pianeta blu: cambiamenti climatici e lezioni dal passato



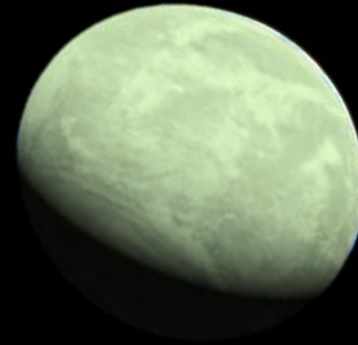
**Cinzia
Bottini**

Ecco il nostro bellissimo pianeta blu...



ma è sempre stato blu?

Archeano (4-2.5 Miliardi di anni fa)



Archeano

Gli oceani erano **anossici** e **ricchi di ferro ferroso** (Fe^{2+}) disciolto.

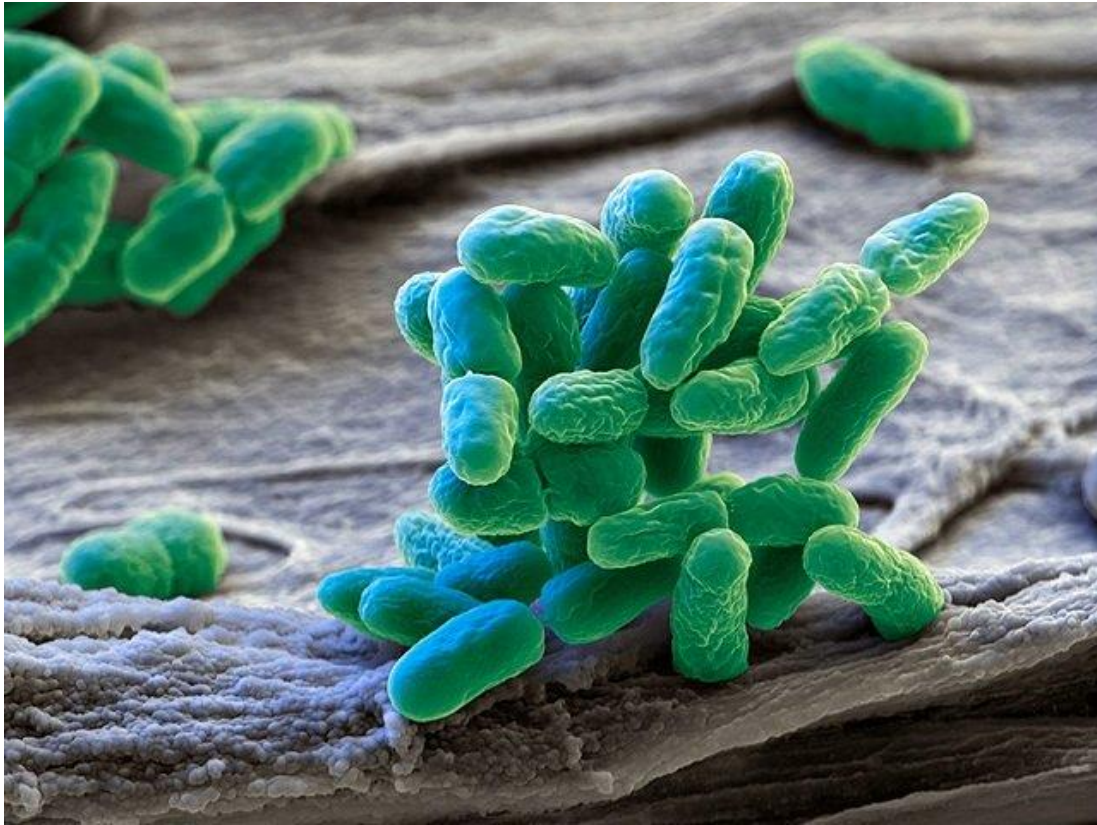
Questo ferro assorbiva selettivamente le lunghezze d'onda blu e rosse della luce, facendo sì che **la luce diffusa sott'acqua** apparisse prevalentemente **verde**.

Di conseguenza, l'oceano avrebbe avuto una tonalità verdastra

Il **Grande Evento di Ossidazione** modificò questo equilibrio, poiché l'ossigeno reagì con il ferro trasformandolo da ferroso a ferrico.

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Chi è stato il responsabile di questa trasformazione?



I cianobatteri !

Organismi che utilizzano l'acqua per produrre ossigeno.

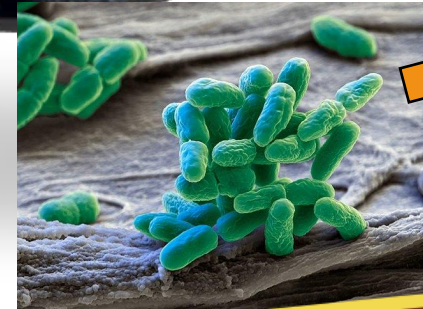
Si ipotizza che, tra circa 2,4 e 2,1 miliardi di anni fa, i livelli di ossigeno rilasciati nell'acqua marina dai cianobatteri siano aumentati e che l'ossigeno sia stato prodotto a una velocità superiore a quella con cui poteva reagire con altri elementi o venire sequestrato dai minerali.

L'ossigeno rilasciato dai cianobatteri si è accumulato progressivamente ossigenando le acque.

Gradualmente, l'ossigeno ha iniziato a diffondersi nell'atmosfera. Col tempo l'ossigeno è diventato una componente principale dell'atmosfera a scapito del metano.

Questo evento è noto come "**Grande Evento di Ossidazione**"

Stromatoliti



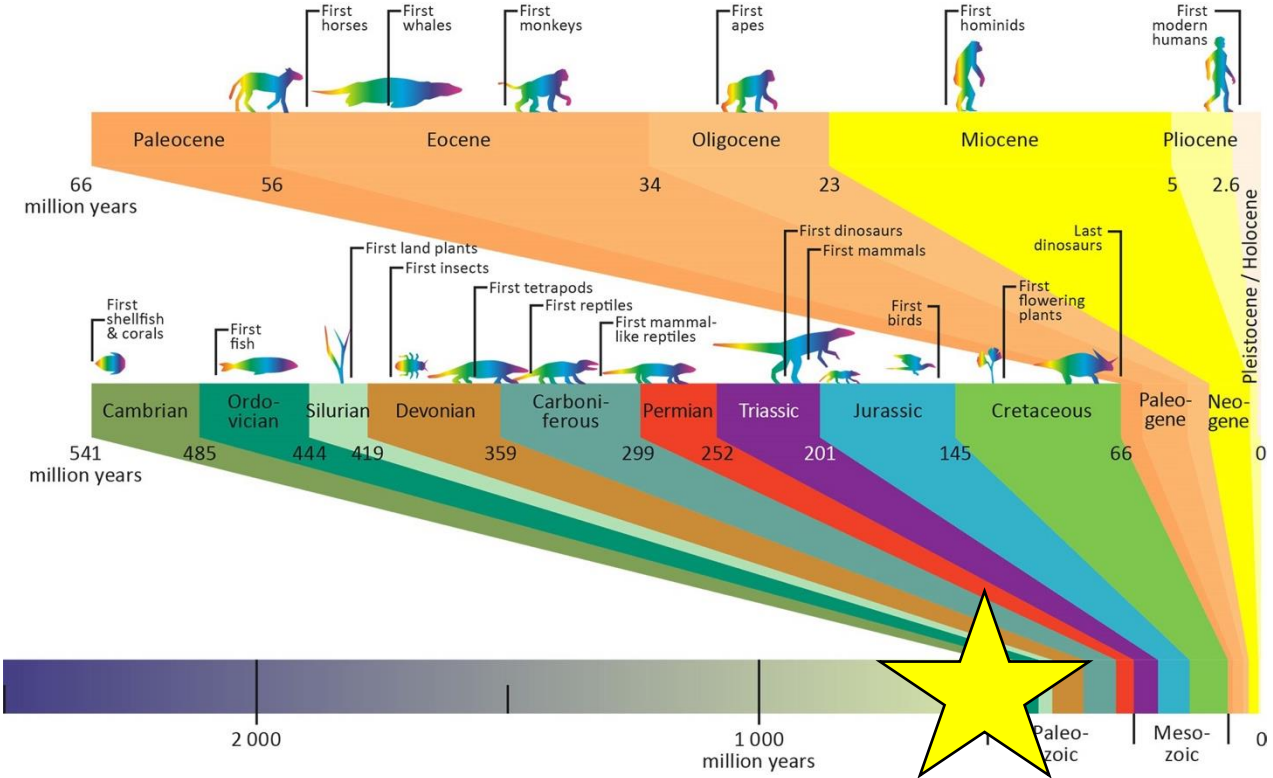
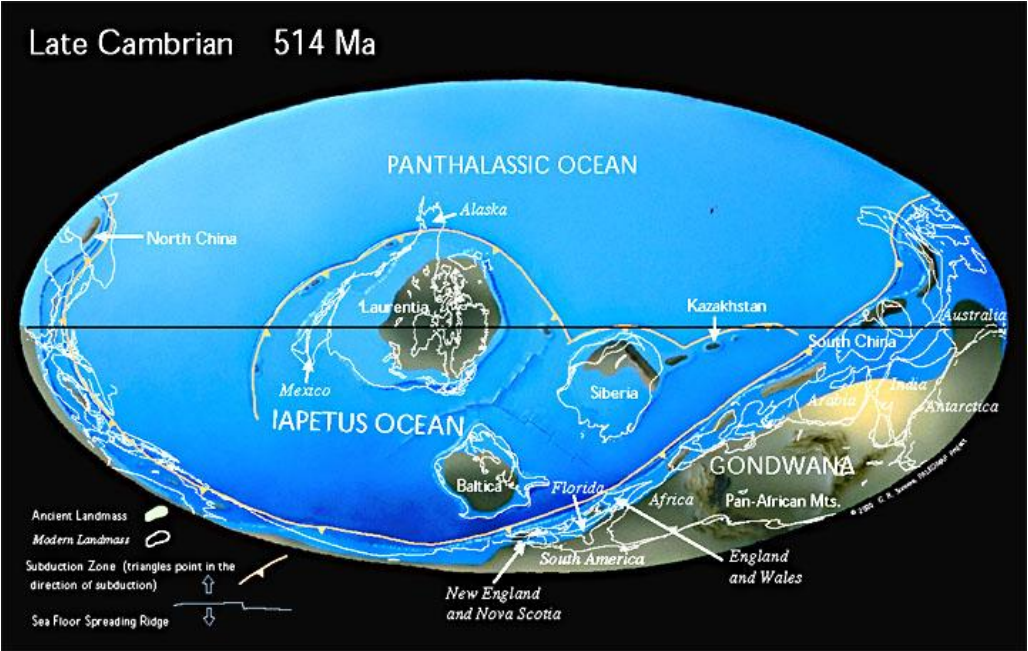
Snow-ball Earth

Raffreddamento globale:

La diminuzione del metano ridusse l'effetto serra, causando un drastico raffreddamento e l'inizio delle glaciazioni circa 2.4-2.1 miliardi di anni fa (Glaciazione Huroniana).



Cambriano (ca. 500 Ma)

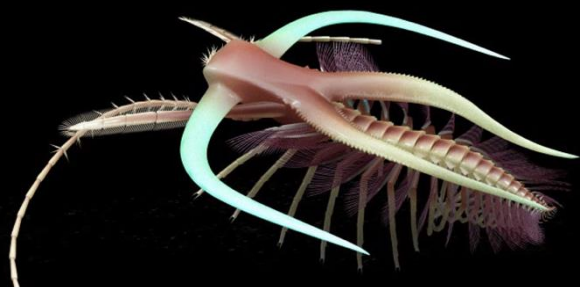
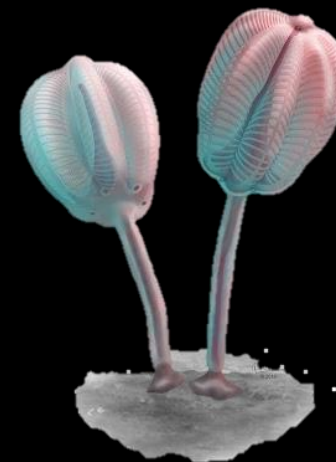
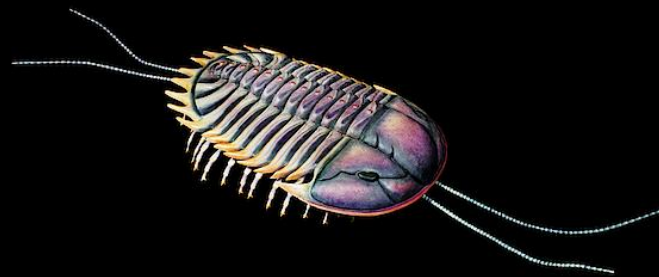


Cambriano (ca. 500 Ma)



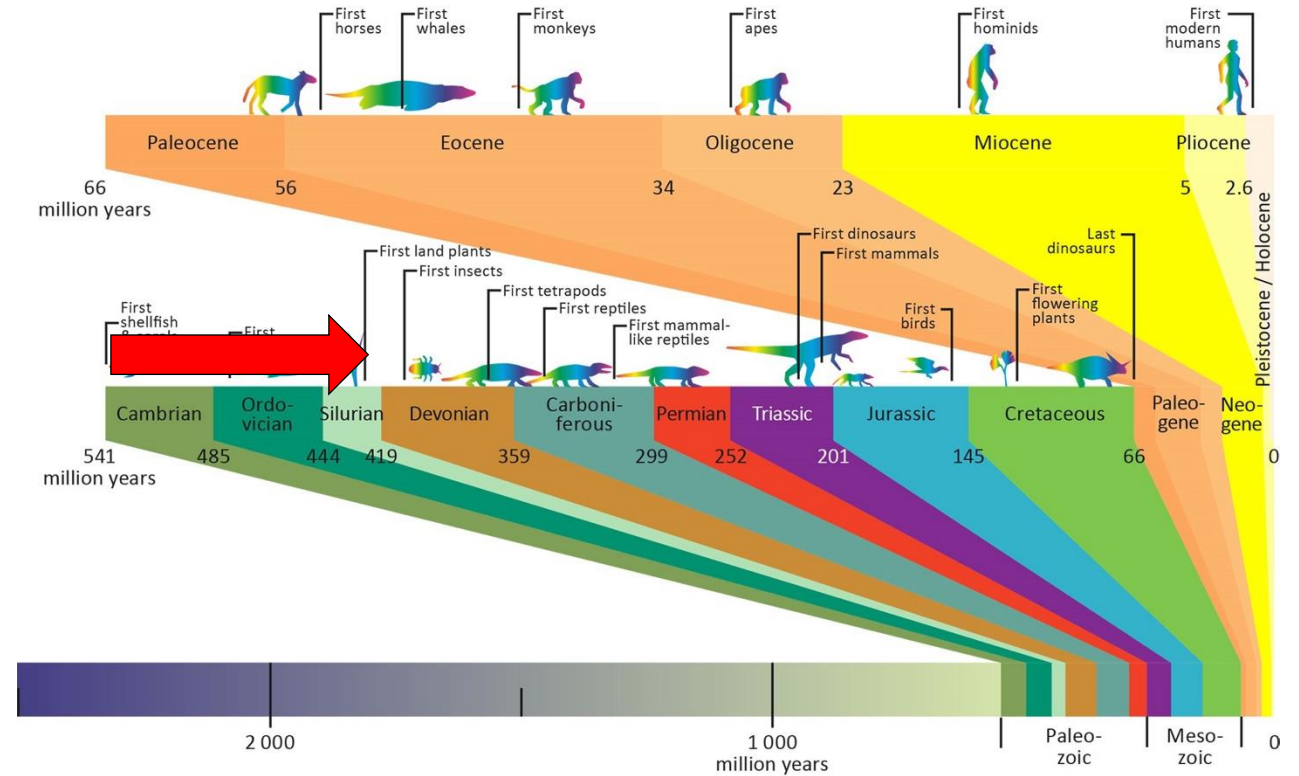
La fauna di Ediacara

Le prime forme di vita complesse



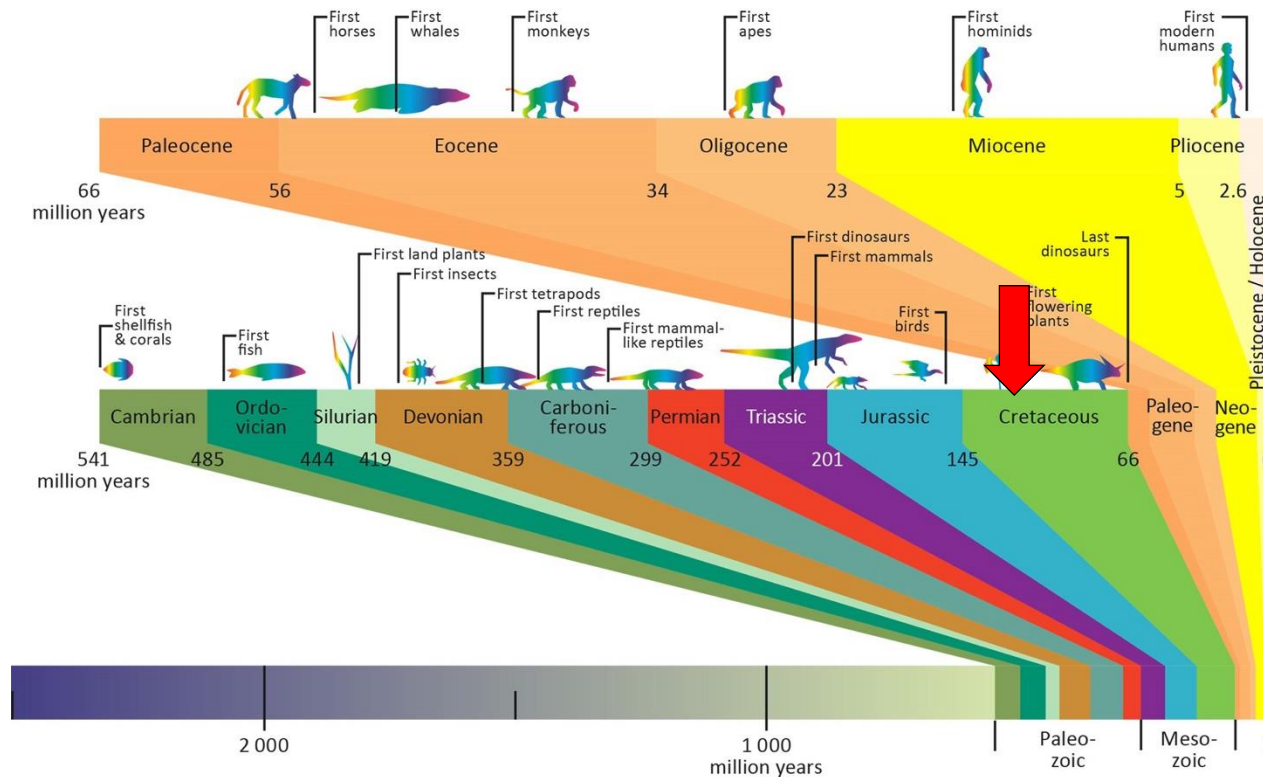
Siluriano (ca. 420 Ma)

Comparsa delle prime piante terrestri



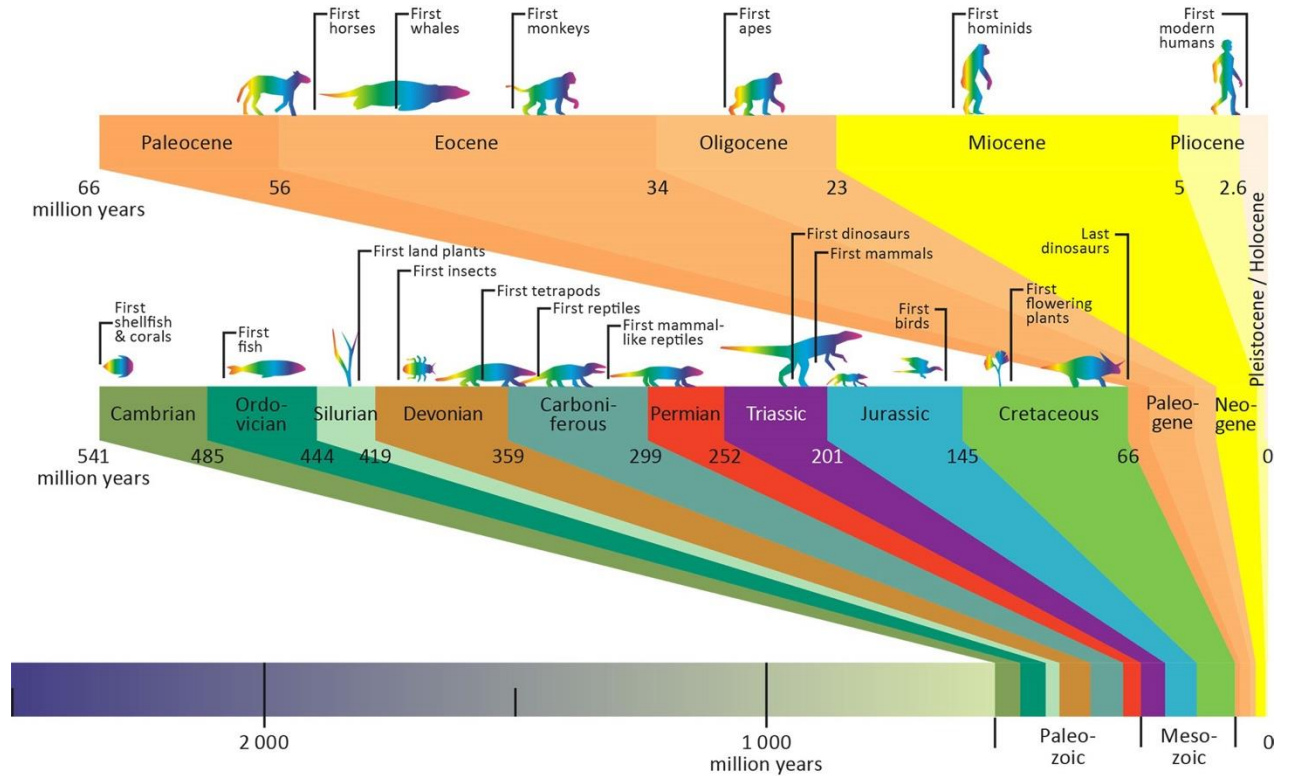
Siluriano (ca. 420 Ma)

Comparsa delle prime piante terrestri



MESOZOICO

Triassico-Giurassico-Cretacico



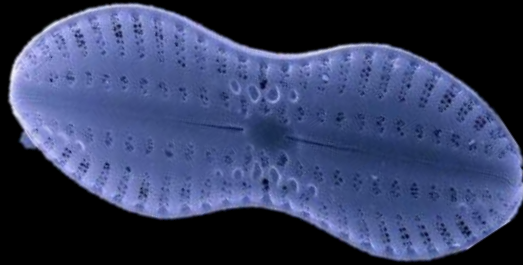


IL FITOPLANKTON

IL FITOPLANCTON



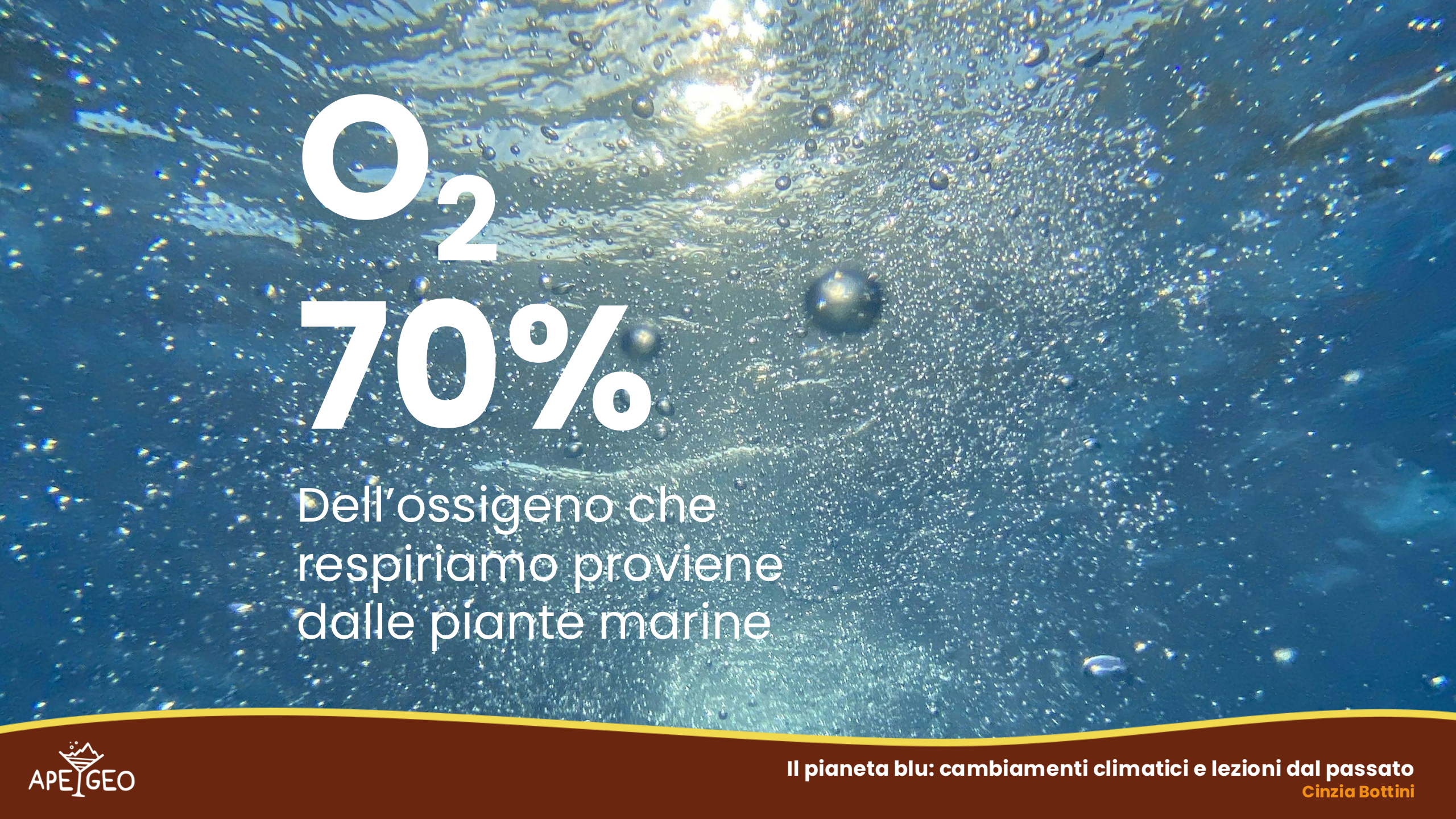
Coccolitoforidi



Diatomee

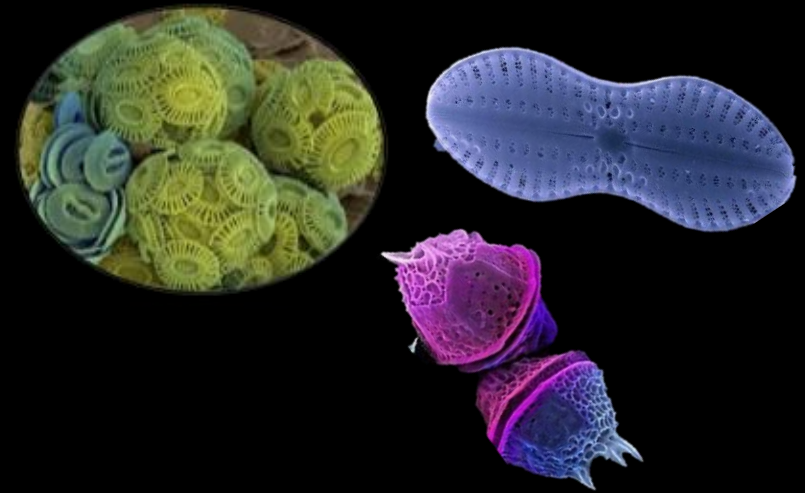
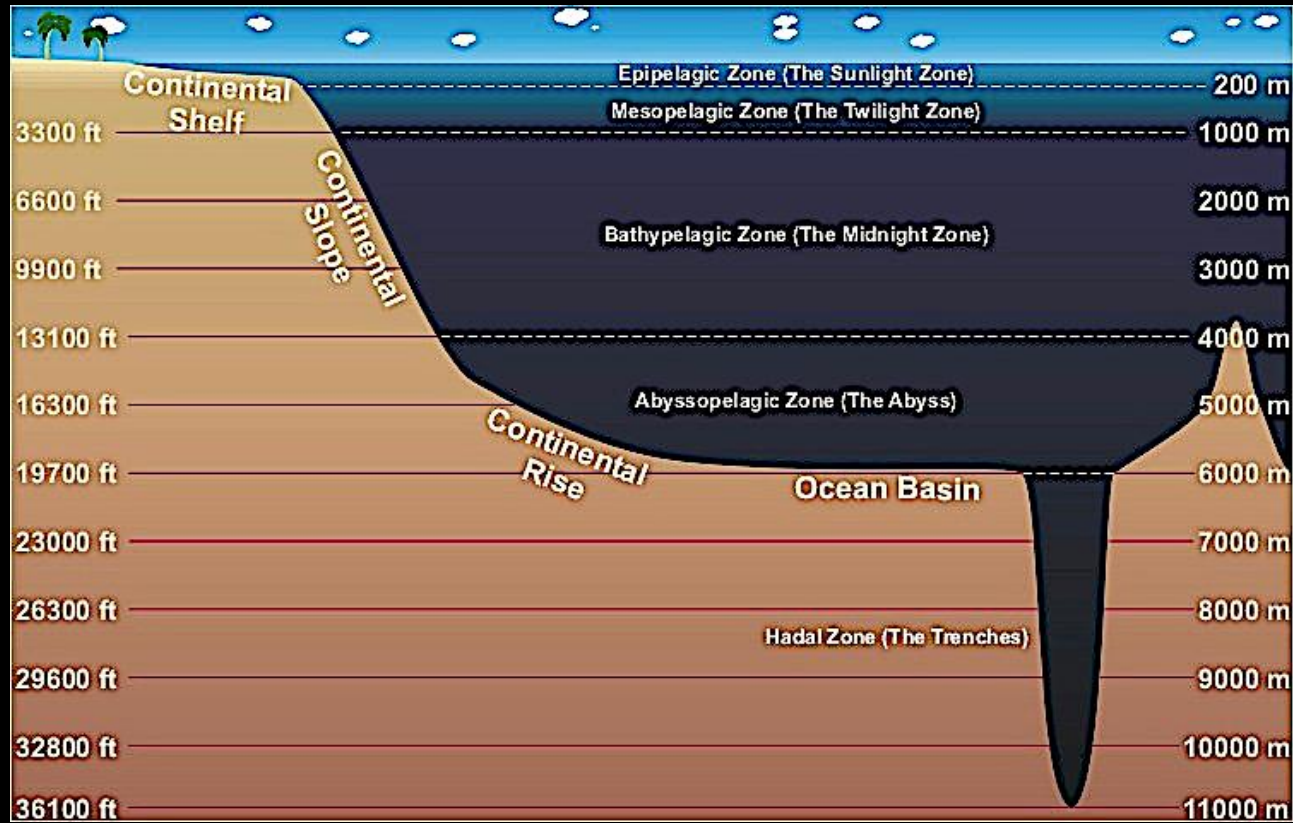


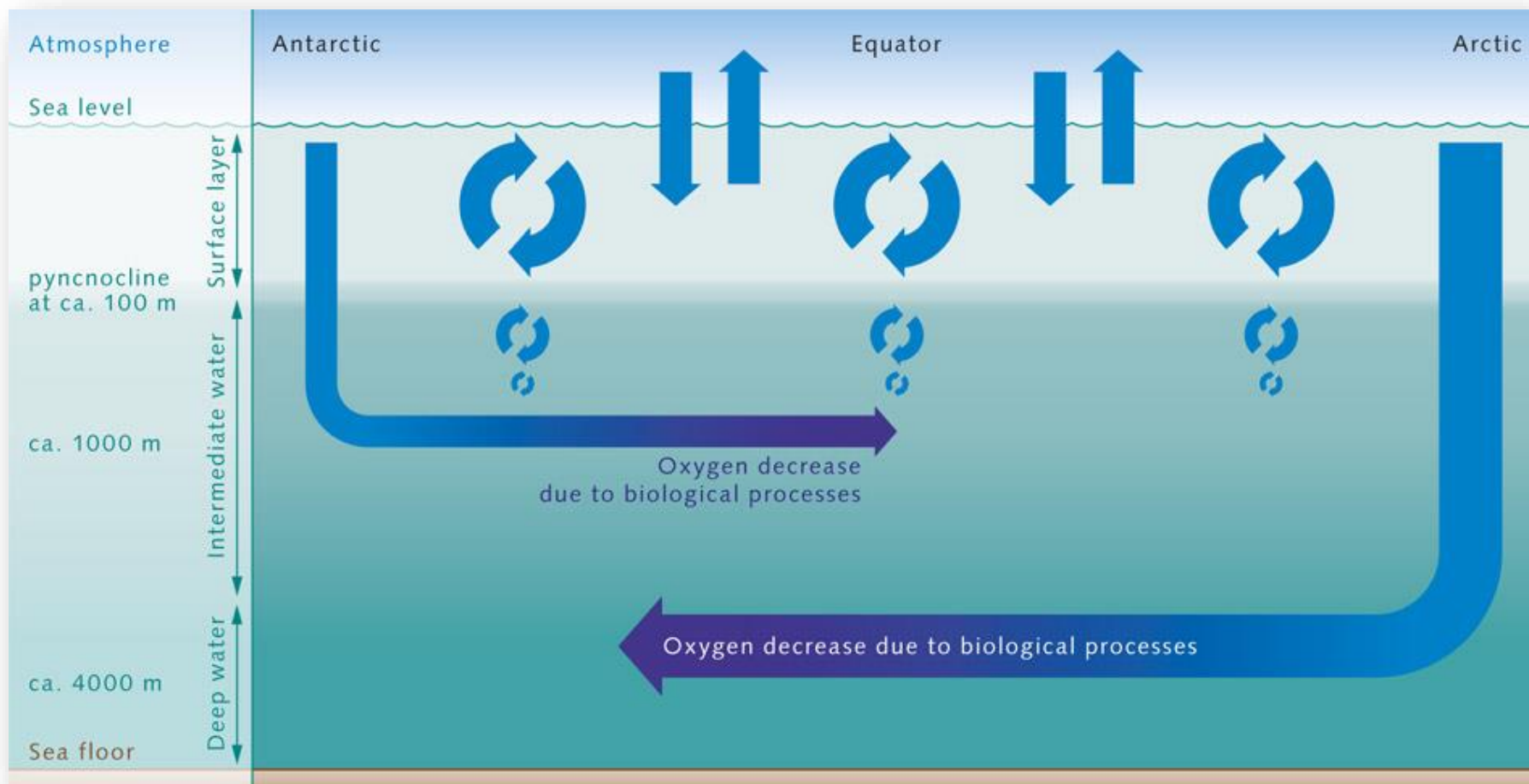
Dinoflagellate



O_2
70%

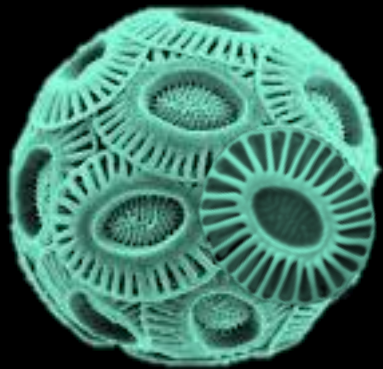
Dell'ossigeno che
respiriamo proviene
dalle piante marine





Coccolitoforidi





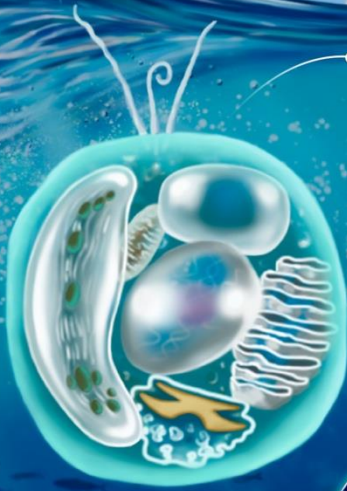
Coccosfera

ca. 5 μm



THE FORESTS OF THE OCEANS

PHOTIC ZONE (first ~ 200 meters deep of the oceans).



Coccolithophores

Are microscopic marine algae that live as far as the sun's rays can reach, in what is known as the **photic zone**

These algae are part of the diverse marine microscopic world, which is still full of mysteries and unknowns.



Calcite plates

During their life cycle, these algae **form various structures** that are composed of the **mineral calcite**.



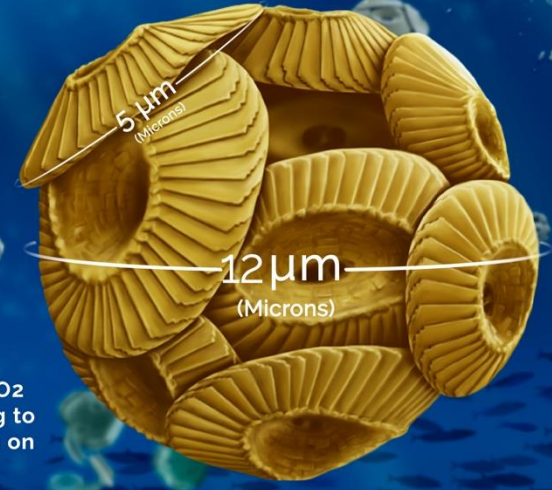
To form their plates, they need to consume CO2 and solar energy.

These processes help with the production of the oxygen we breathe.

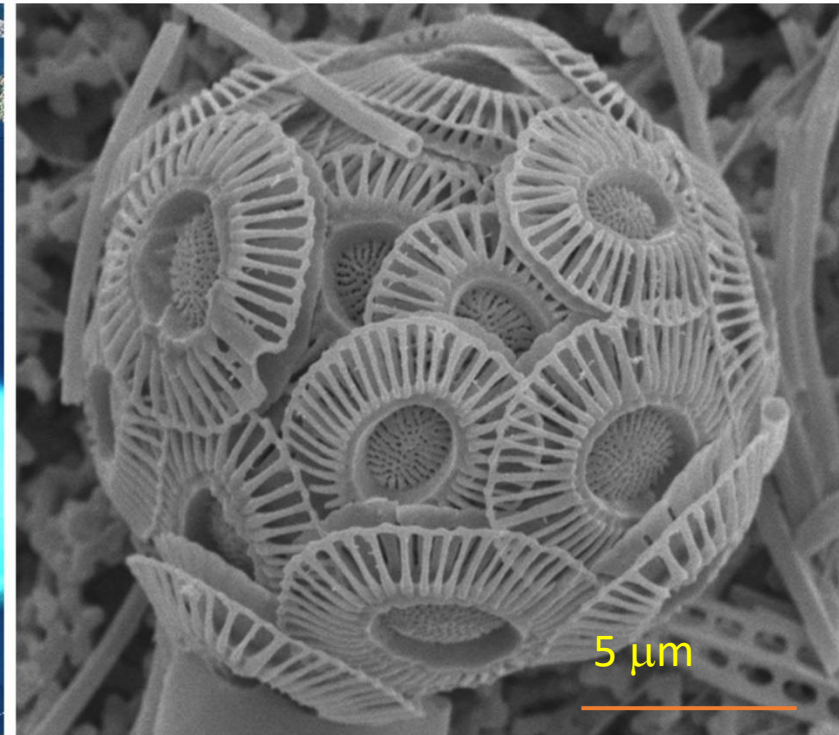


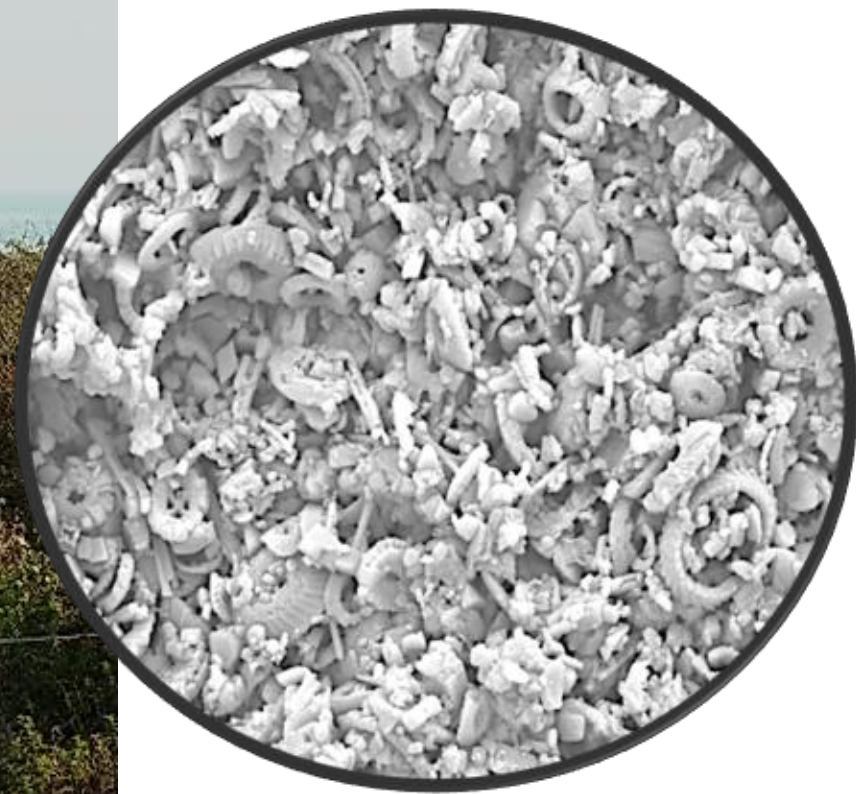
When coccolithophores die, their plates fall and over millions of years **accumulate on the seafloor**.

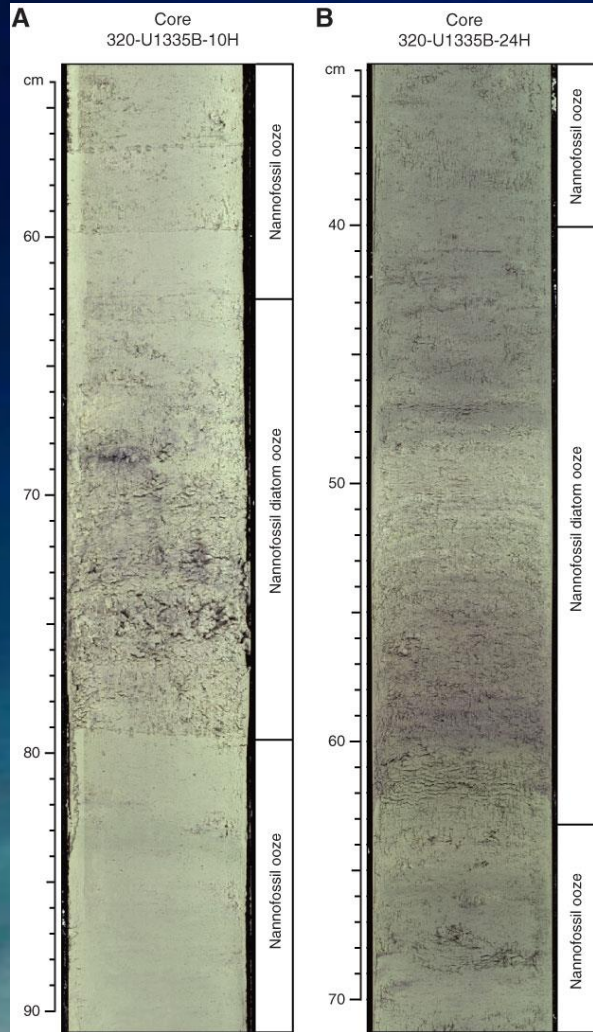
In this way, they **bury CO2** in the deep sea, helping to **reduce global warming on the planet**.



Le **fioriture algali** sono così estese e importanti da essere visibili da satellite

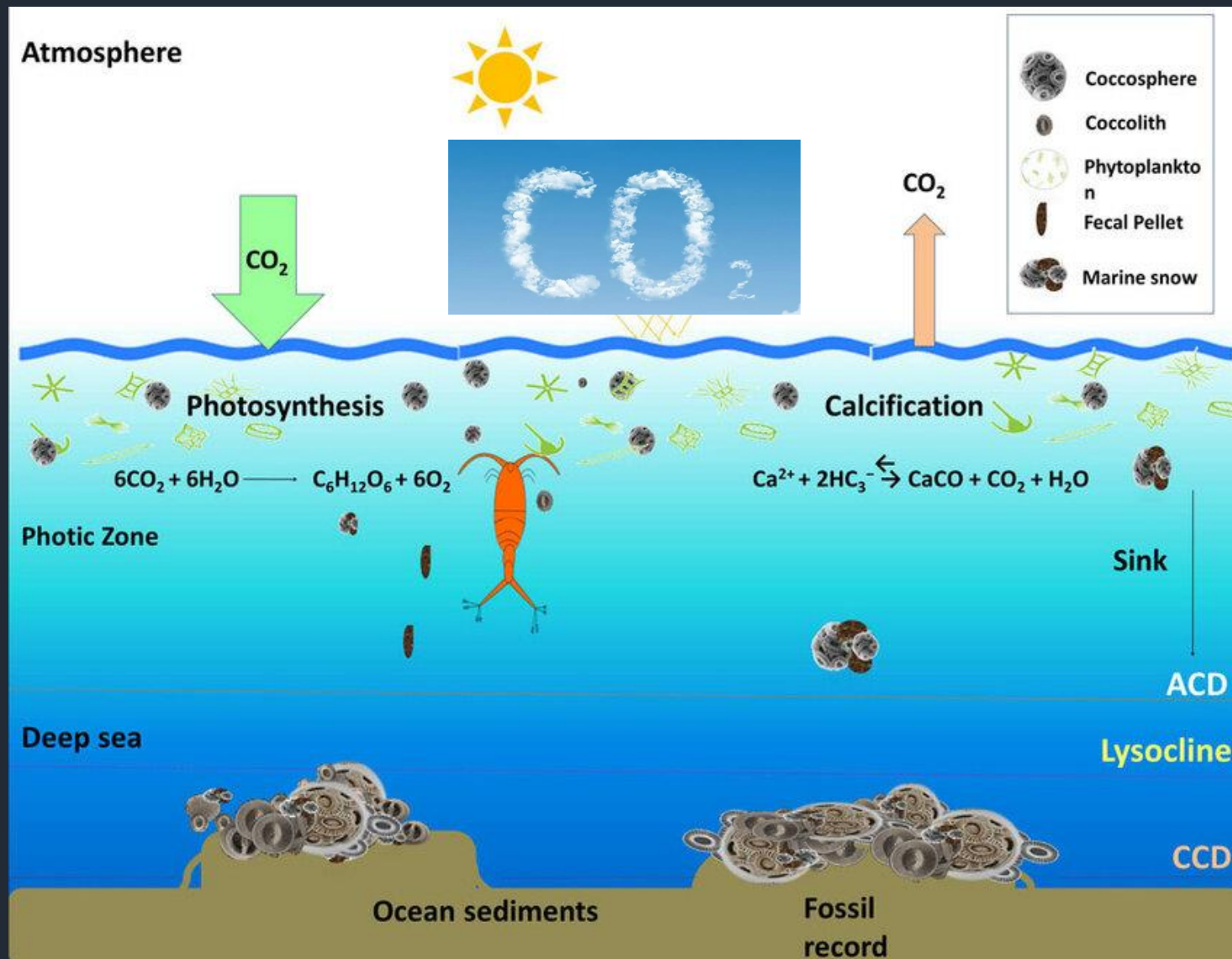




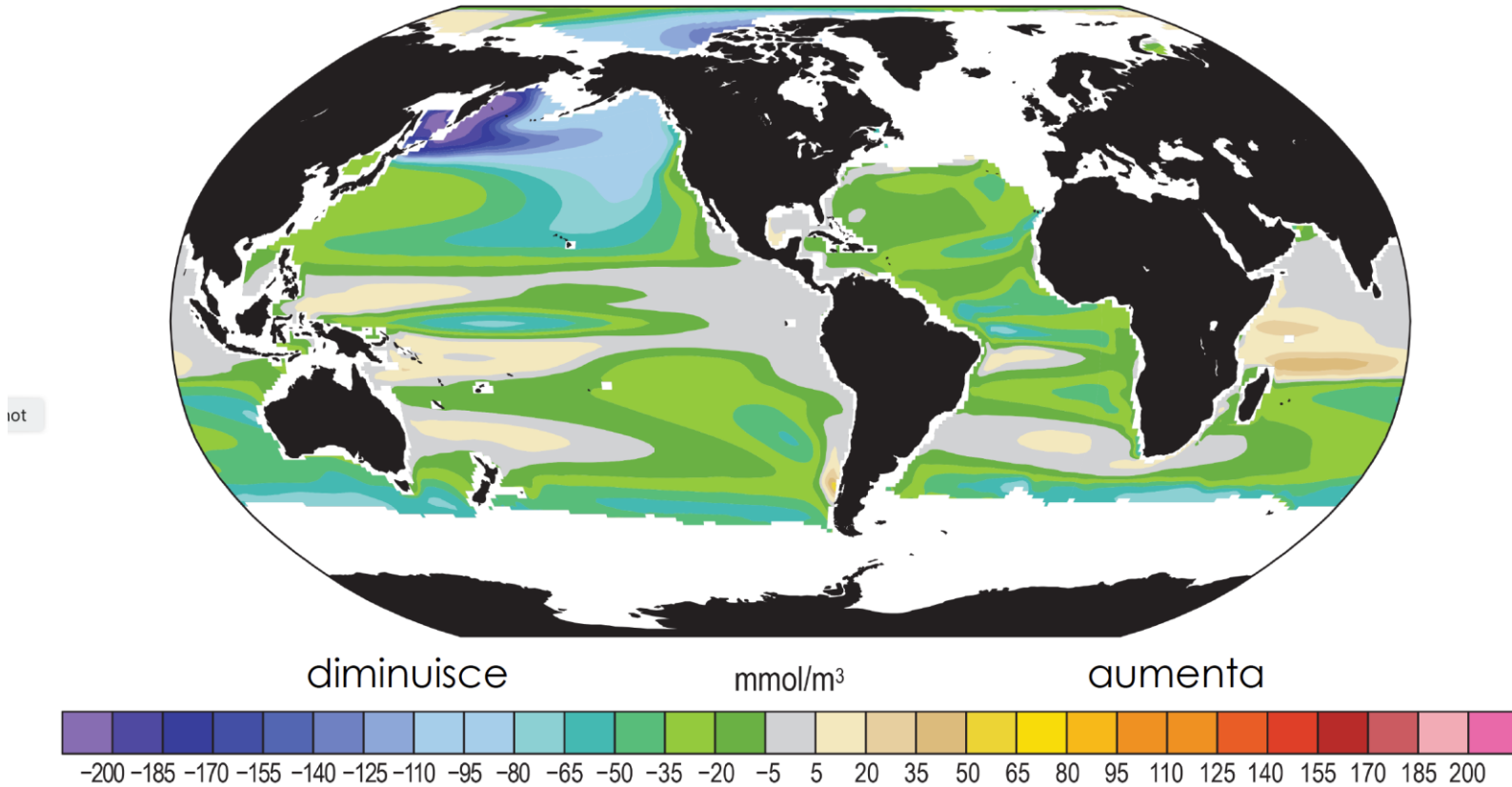


OOZE (fanghi) A NANNOFOSSILI CALCAREI





OSSIGENO NEGLI OCEANI: VARIAZIONI PREVISTE PER IL 2100





OCEANI FRIZZANTI?

An underwater scene featuring a vibrant coral reef with various species of coral in shades of red, orange, and purple. The water is clear and blue. Numerous white, translucent bubbles of different sizes are scattered throughout the scene, particularly in the foreground and around the text. The overall atmosphere is serene yet highlights the environmental theme.

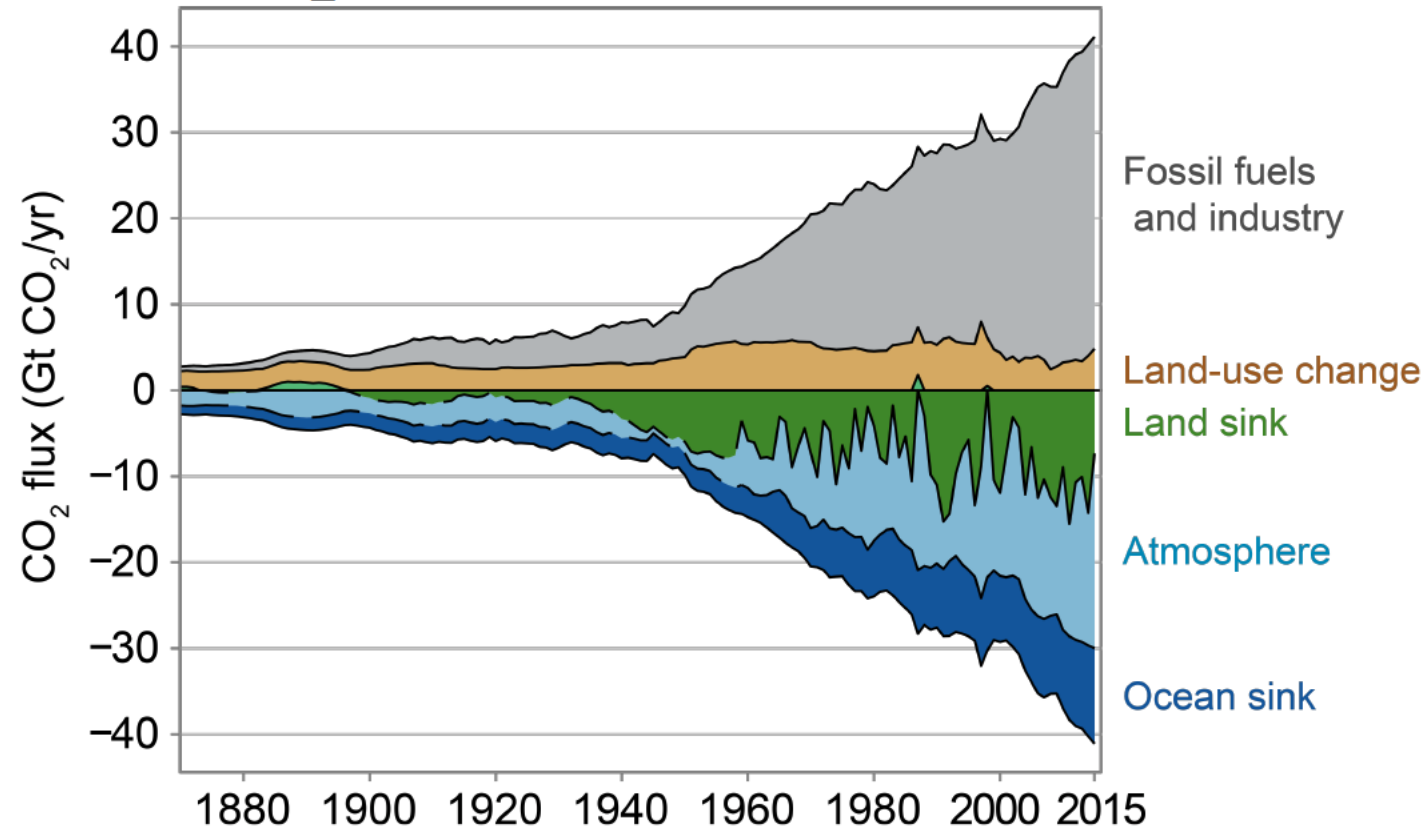
CO₂

30%

OCEANI FRIZZANTI?

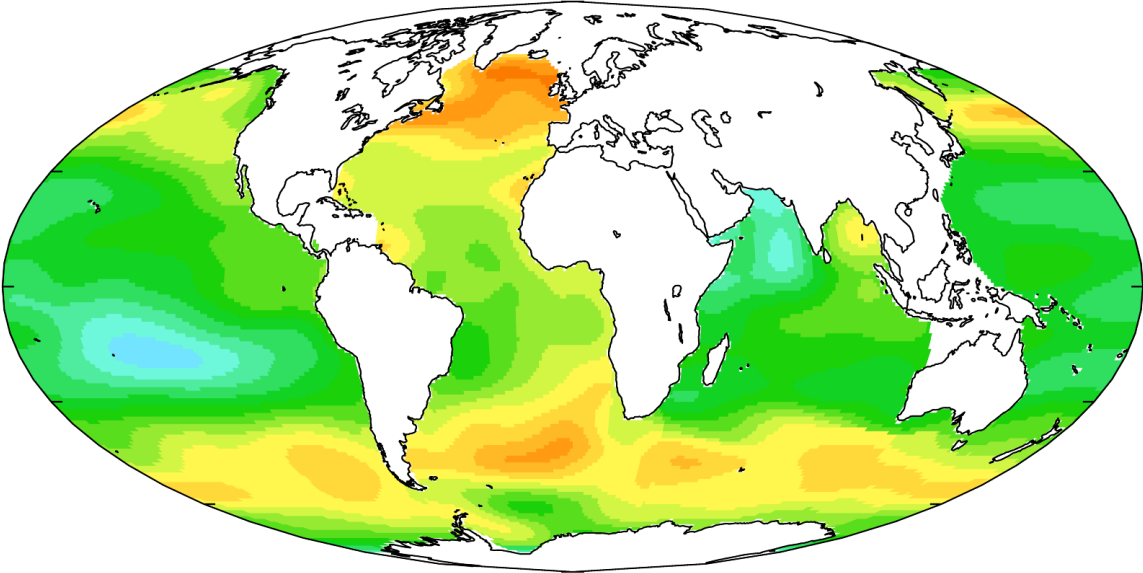
Delle emissioni di CO₂
sono assorbite dagli
oceani

CO₂ sources and sinks

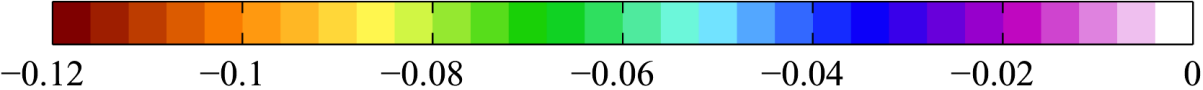




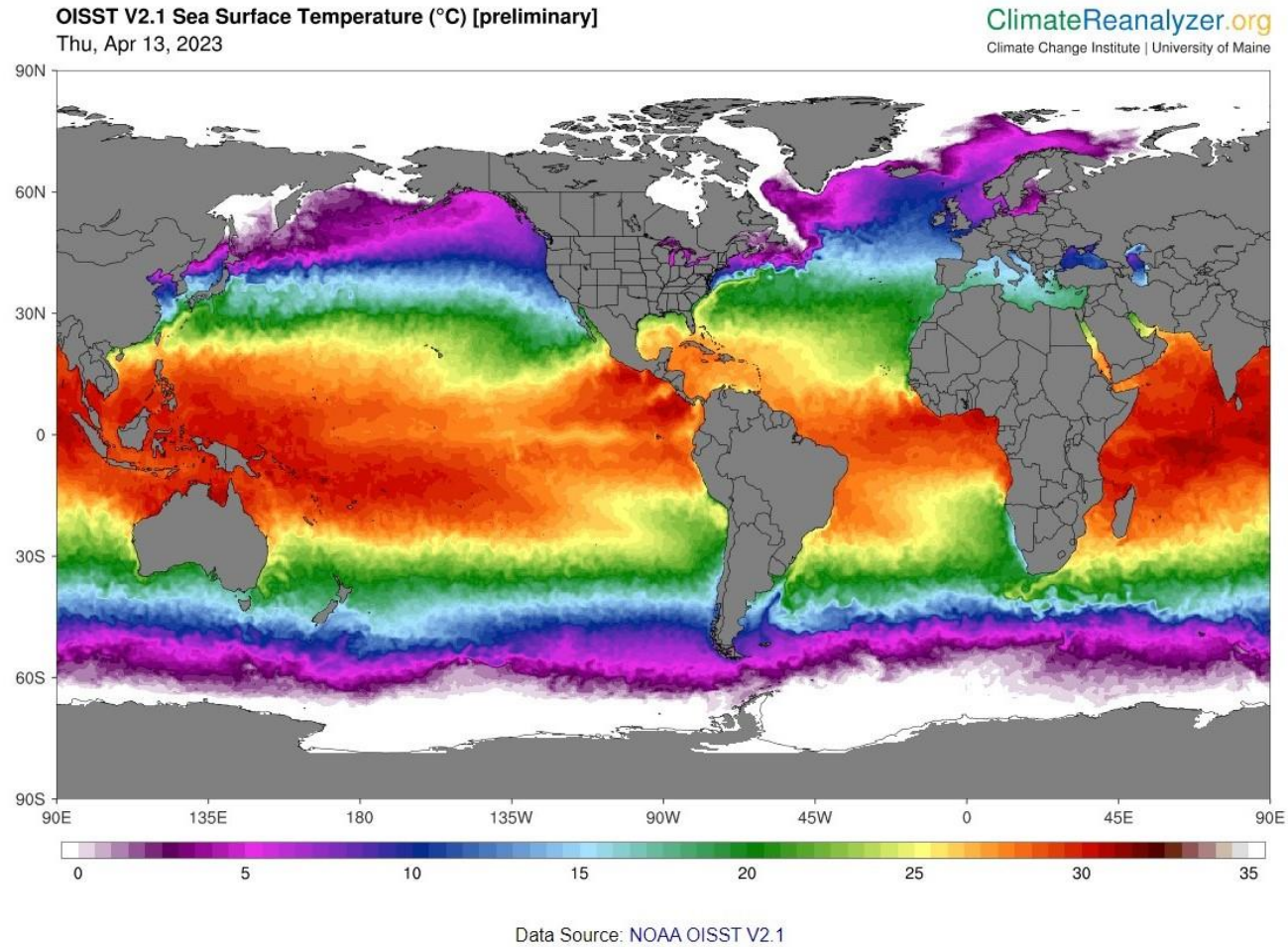
ACIDITA' /ALCALINITA'



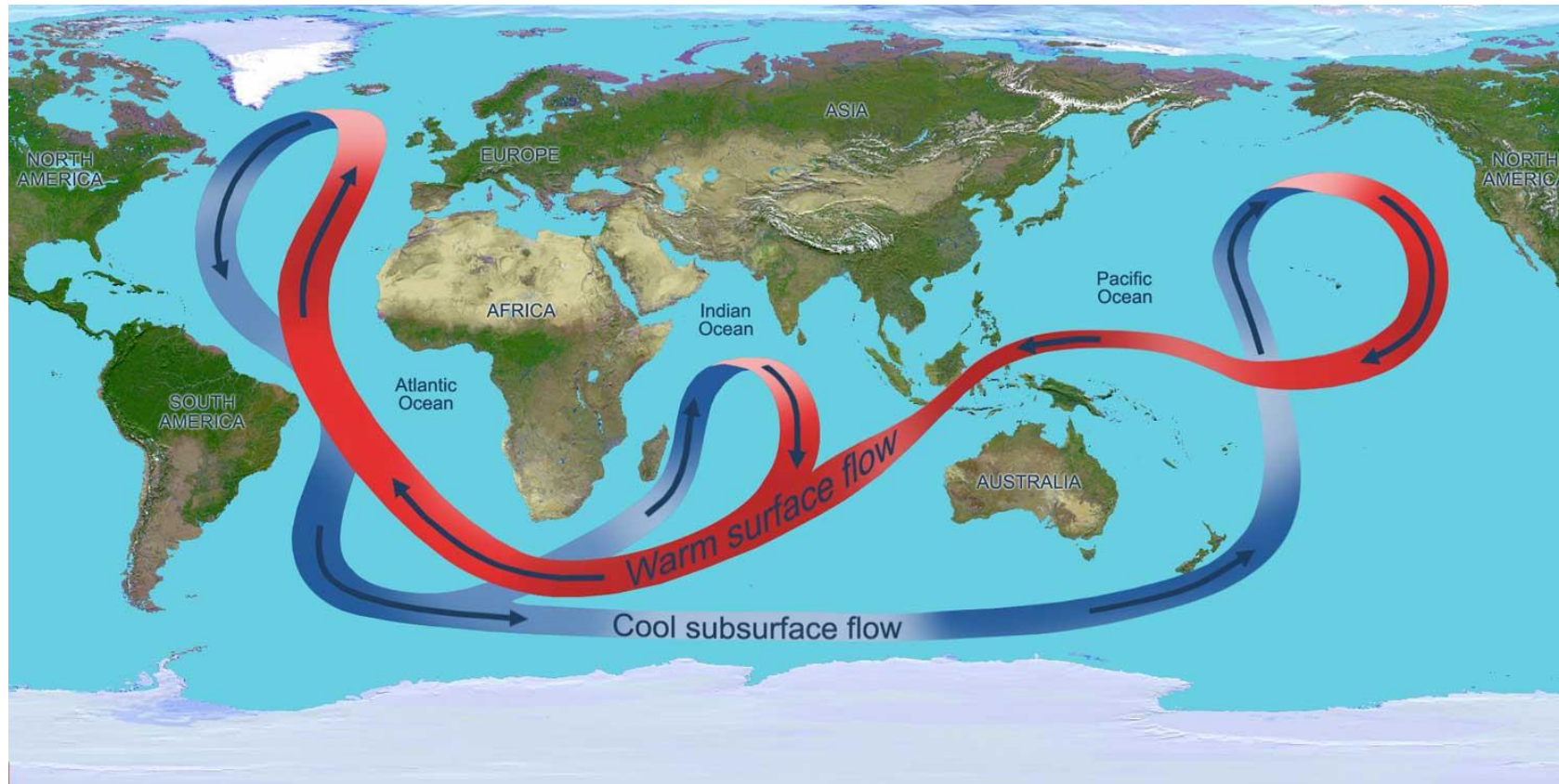
Δ sea-surface pH [-]



Temperatura



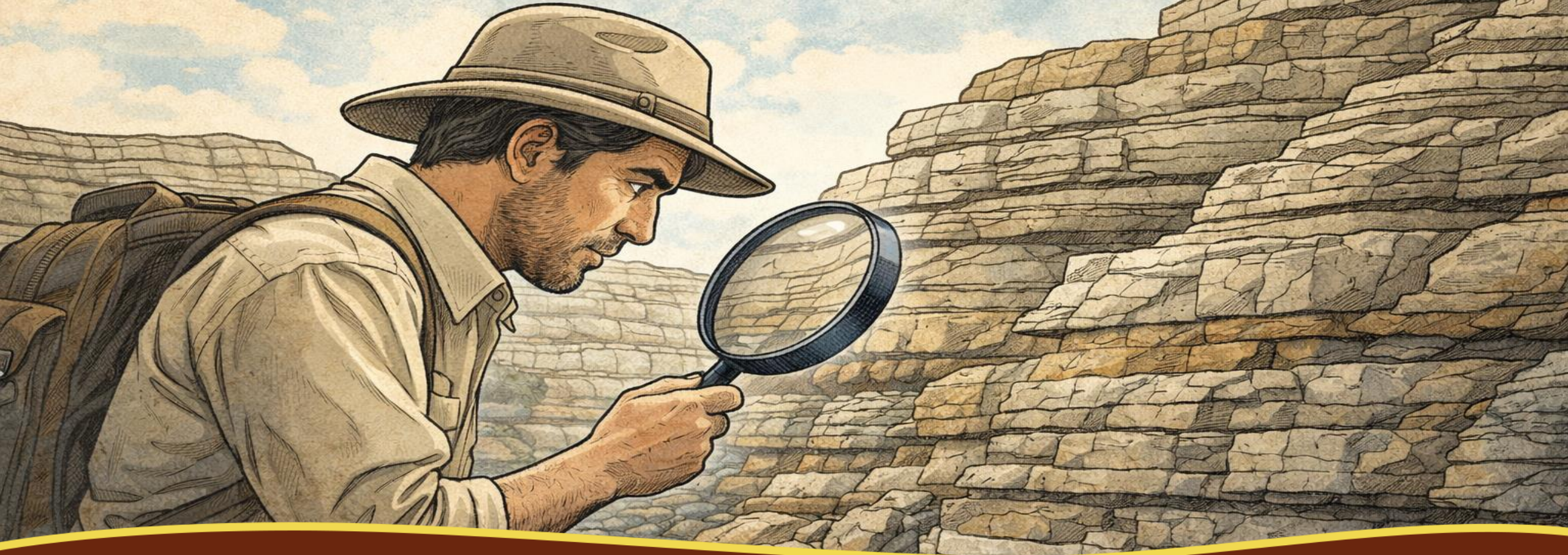
La circolazione oceanica



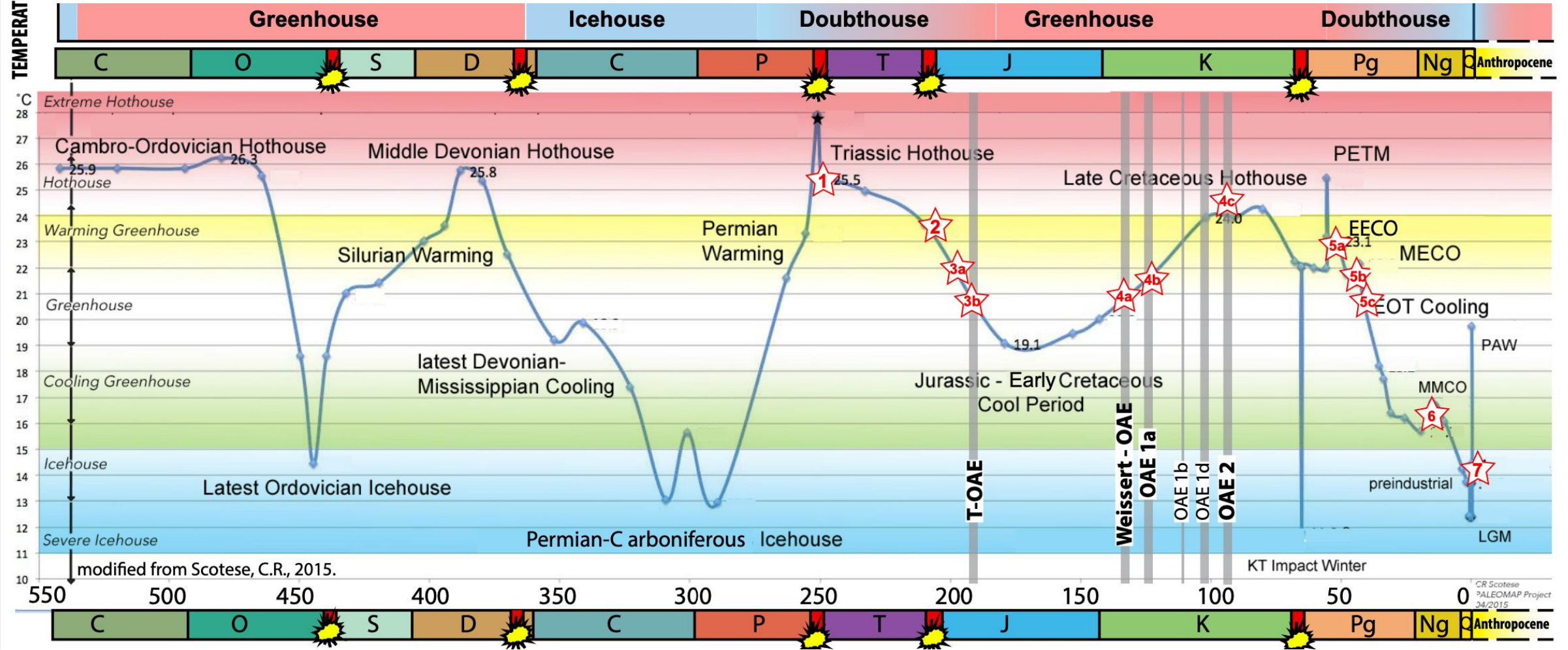
3 Parametri Importanti

- ✓ Ossigeno
- ✓ CO₂ - pH
- ✓ Temperatura

Cosa possiamo comprendere studiando il record geologico?



TEMPERATURE



LE GRANDI PROVINCE MAGMATICHE

Vulcanesimo sottomarino



Vulcanesimo subaereo

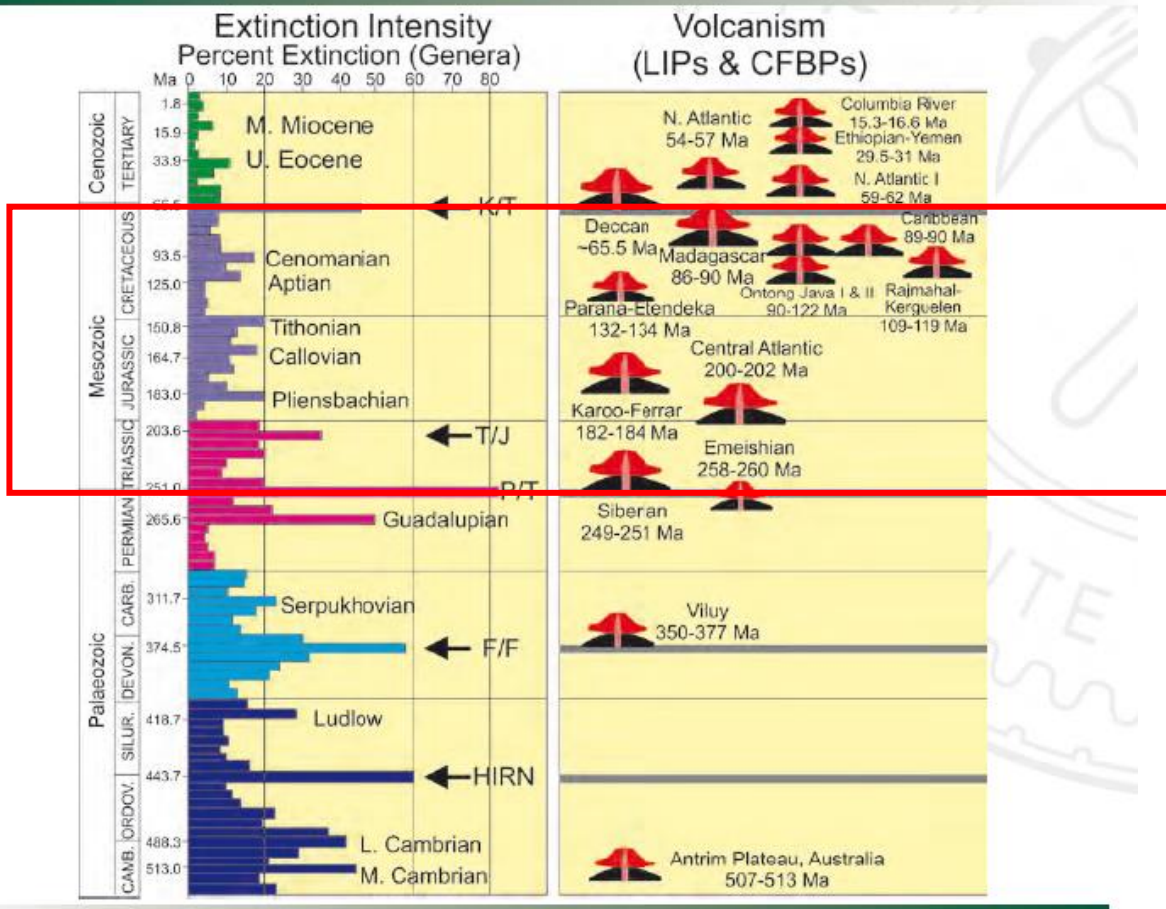
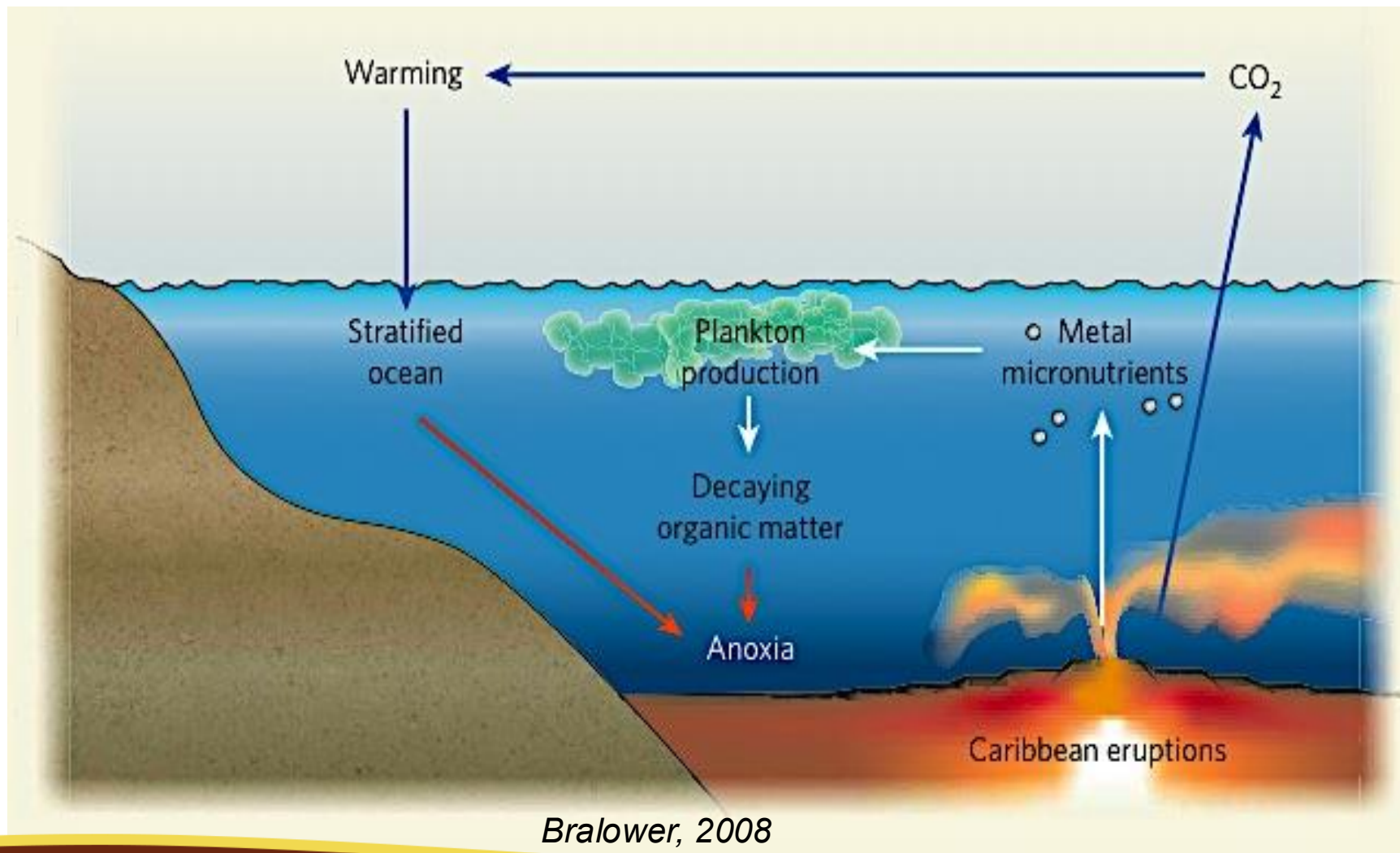


Figura 3 - Estinzioni di massa e grandi province magmatiche (LIPs) durante il Fanerozoico. Modificata da Keller (2005); HIRN (Himantiano); F/F (Frasniano/Famenniano); P/T (Permiano /Triassico); T/J (Triassico/Giurassico); K/T (Cretacico/Terziario).

Effetti delle eruzioni vulcaniche sul sistema oceano-atmosfera

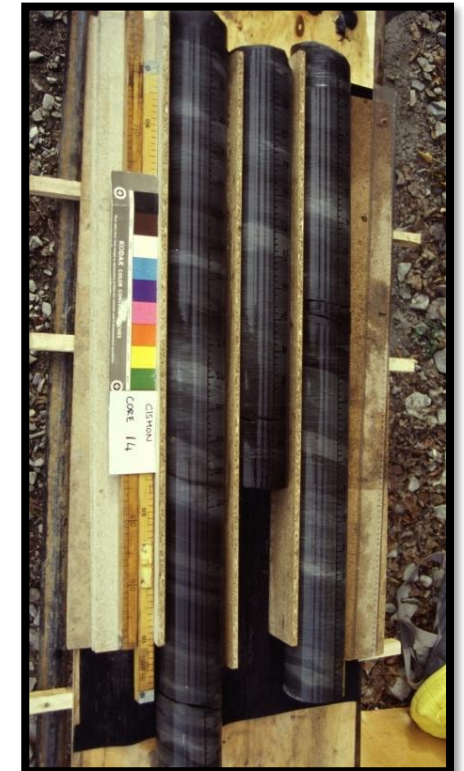
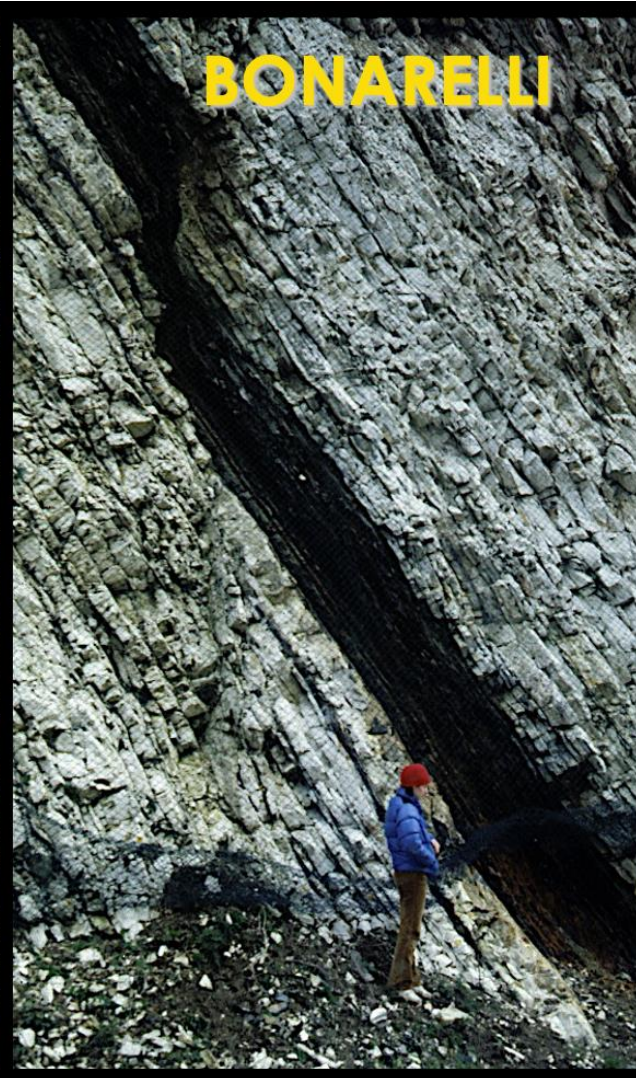
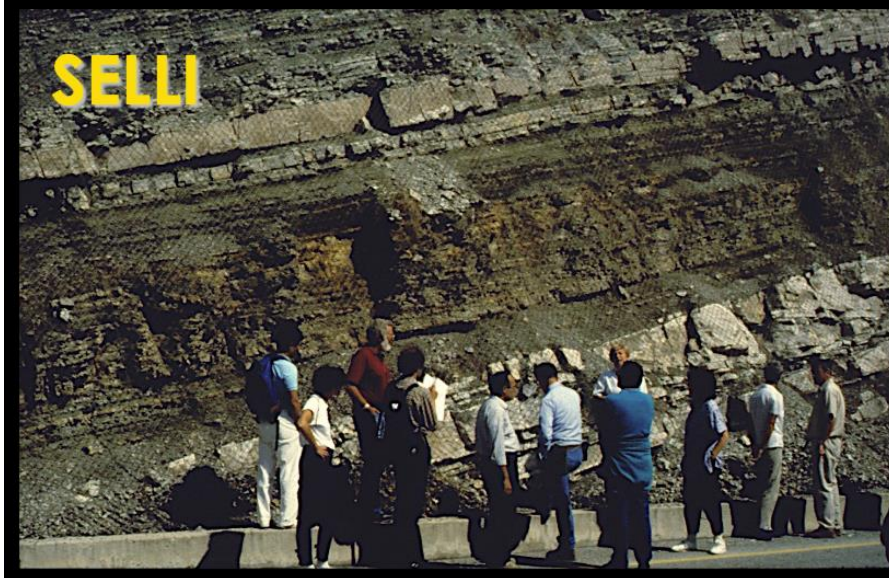
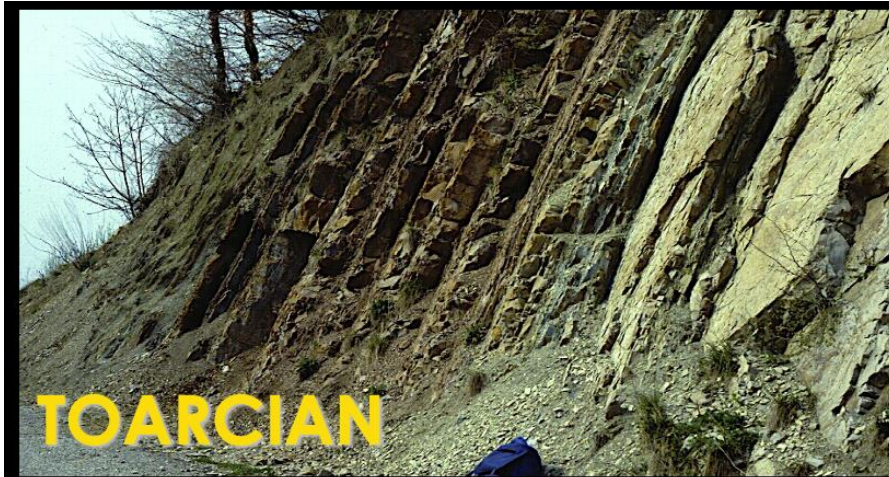


Bralower, 2008





EVENTI ANOSSICI OCEANICI



Courtesy of Erba E.

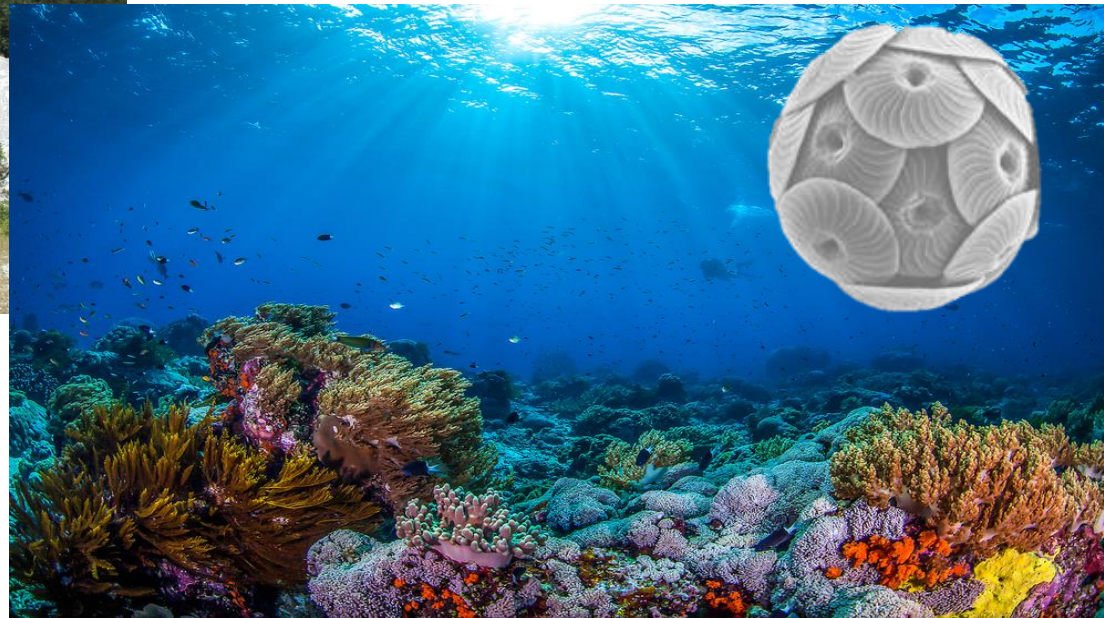
ESPLORAZIONI E PERFORAZIONI OCEANICHE



PASSATO



PRESENTE





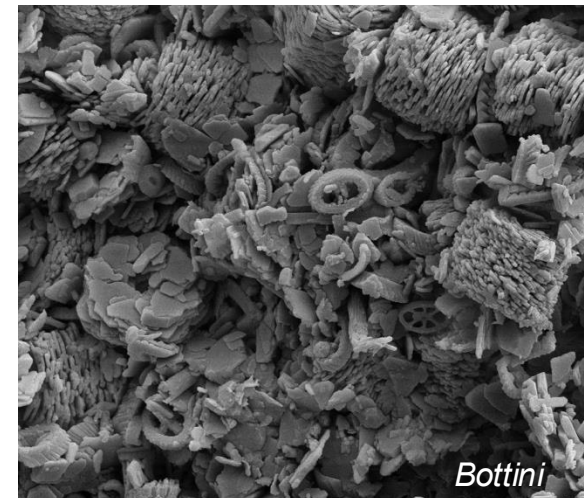
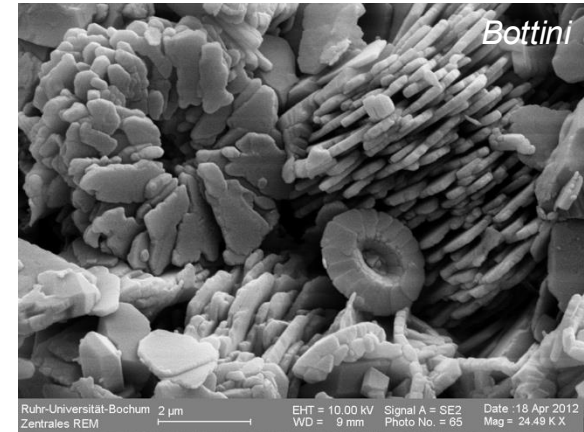
Courtesy of Erba E.

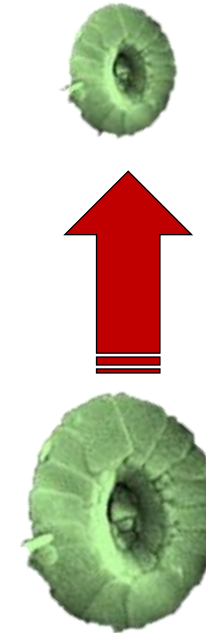


Courtesy of Erba E.



CISMON CORE

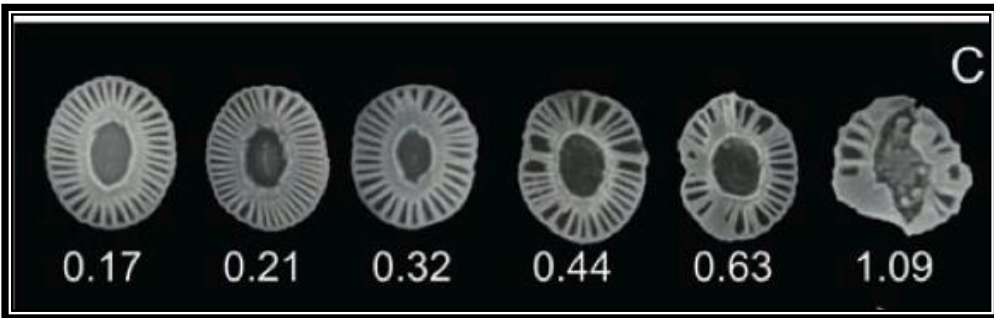




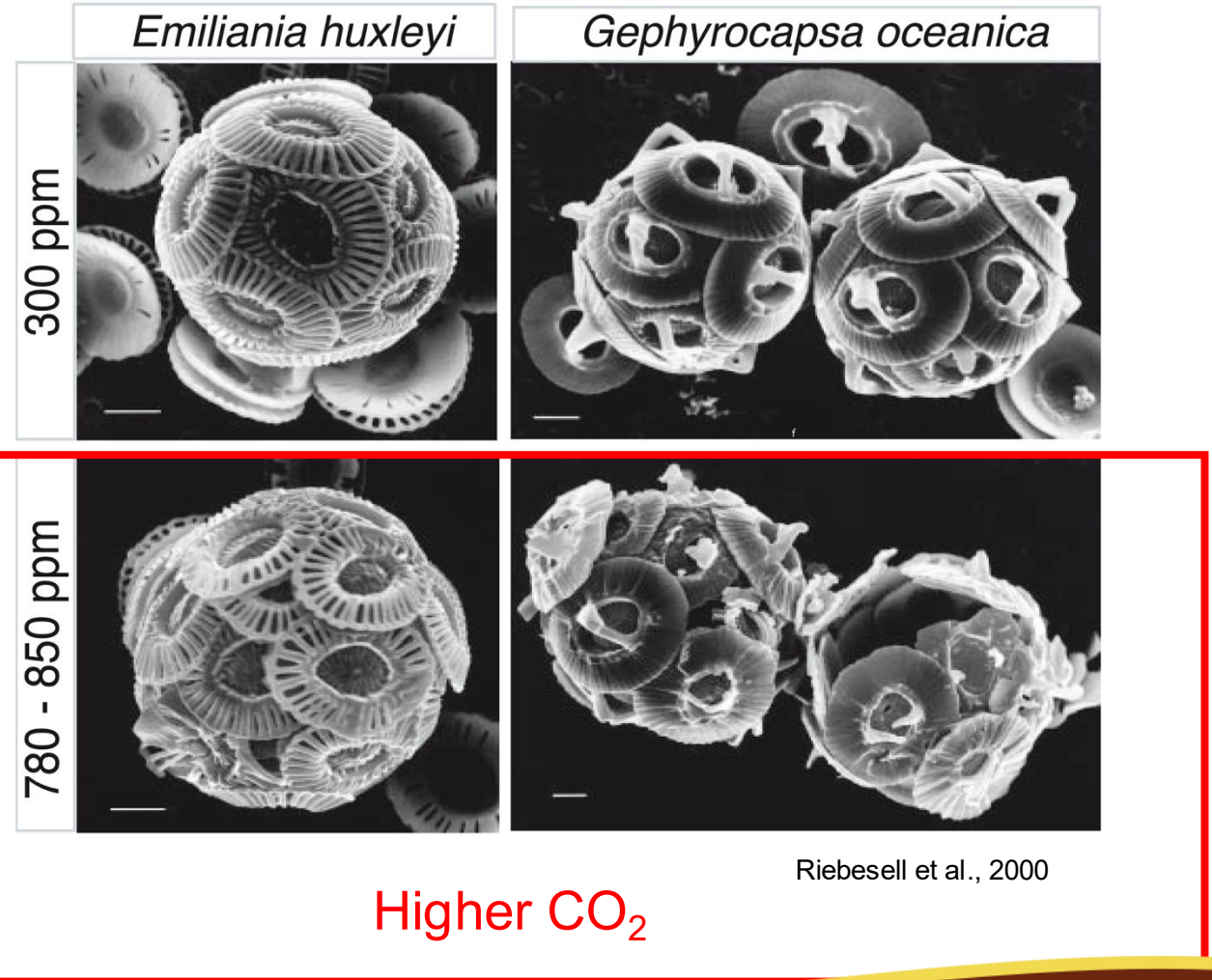


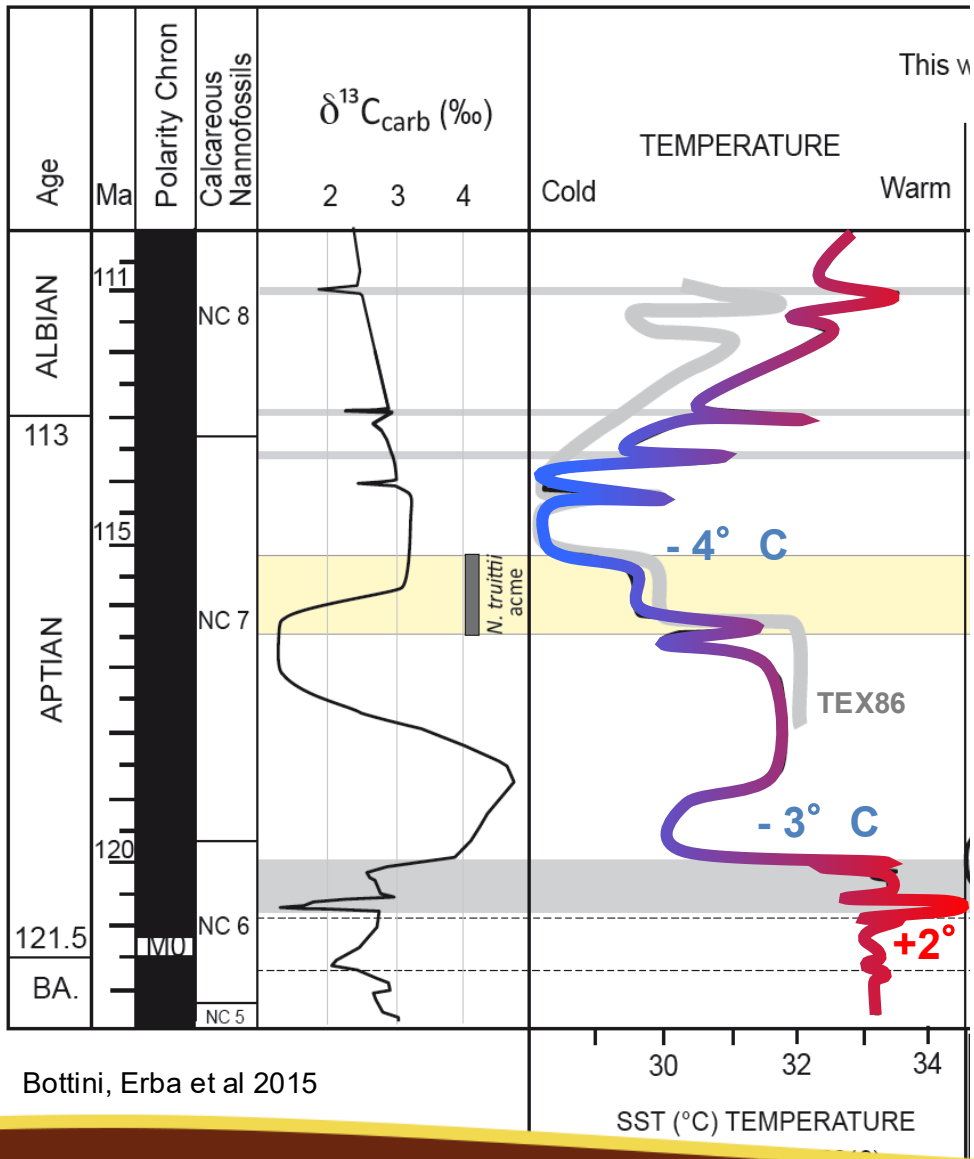
EFFETTO DELLA CO₂ SULLA CALCIFICAZIONE

Diverse specie producono coccoliti malformati e/o di dimensioni ridotte in condizioni di eccesso di CO₂

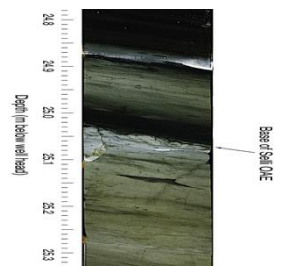


[Bach et al. (2012)]





Bottini, Erba et al 2015



La glaciazione Würm è stata l'ultima glaciazione avvenuta nel Pleistocene tra 110000 e 11700 anni fa



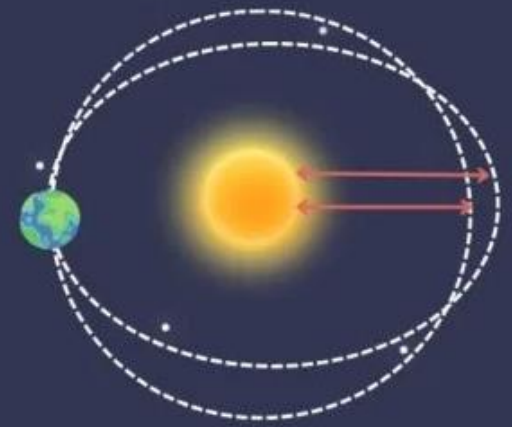
Milankovitch Cycles.



Obliquity
every 41,000 years



Precession
every 19,000-24,000 years

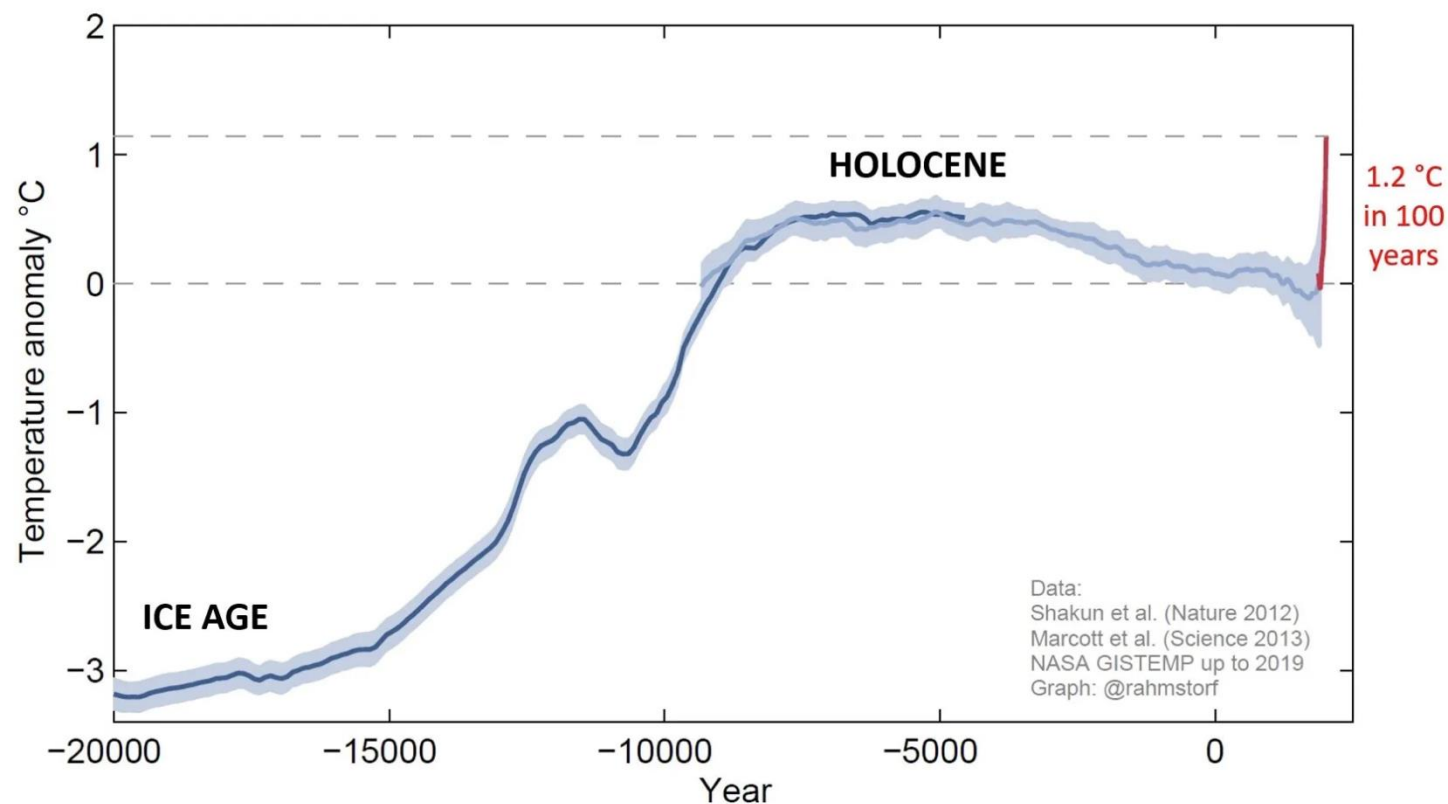


Eccentricity
every 100,000 years

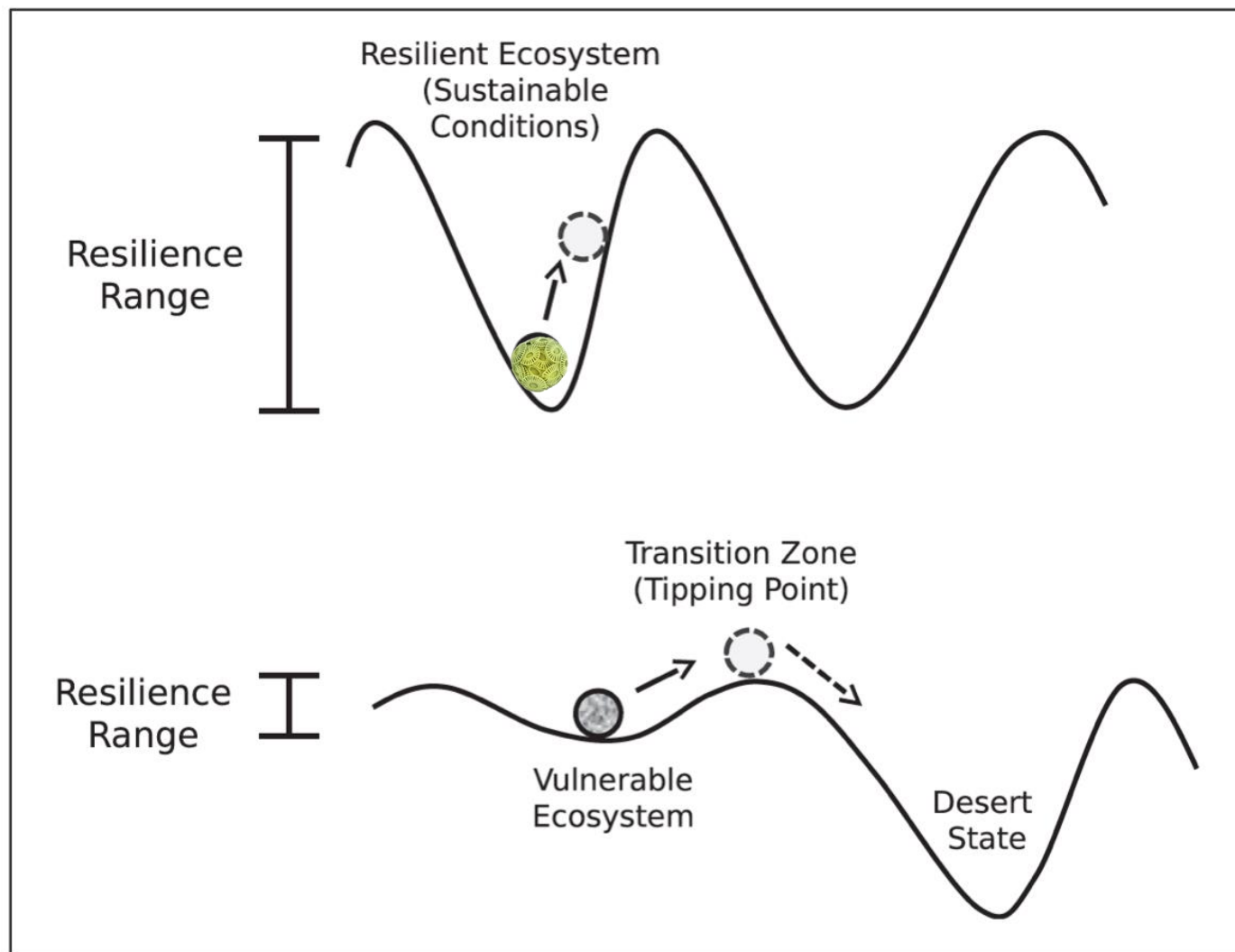
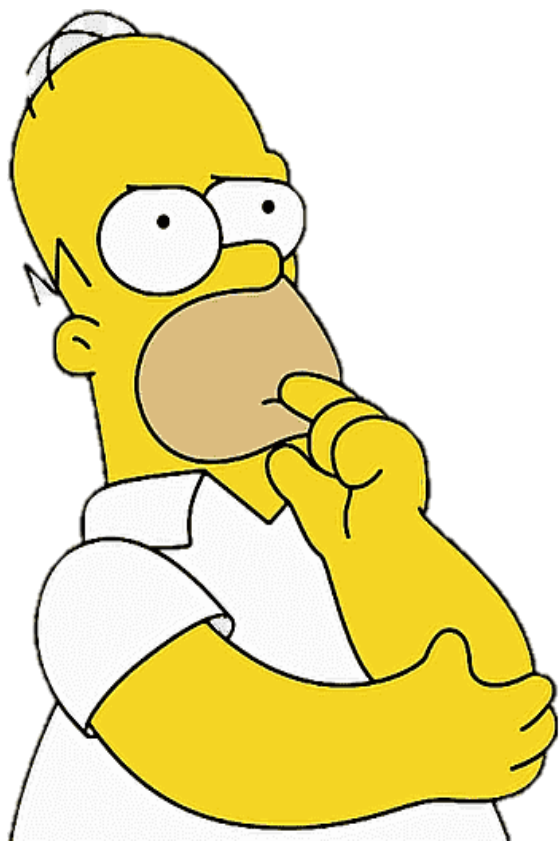


TEMPERATURA

Tra il **1981 e il 2010** la temperatura media annuale in Italia è cresciuta di **oltre 1,1 gradi**.









**GRAZIE
PER
L'ATTENZIONE**