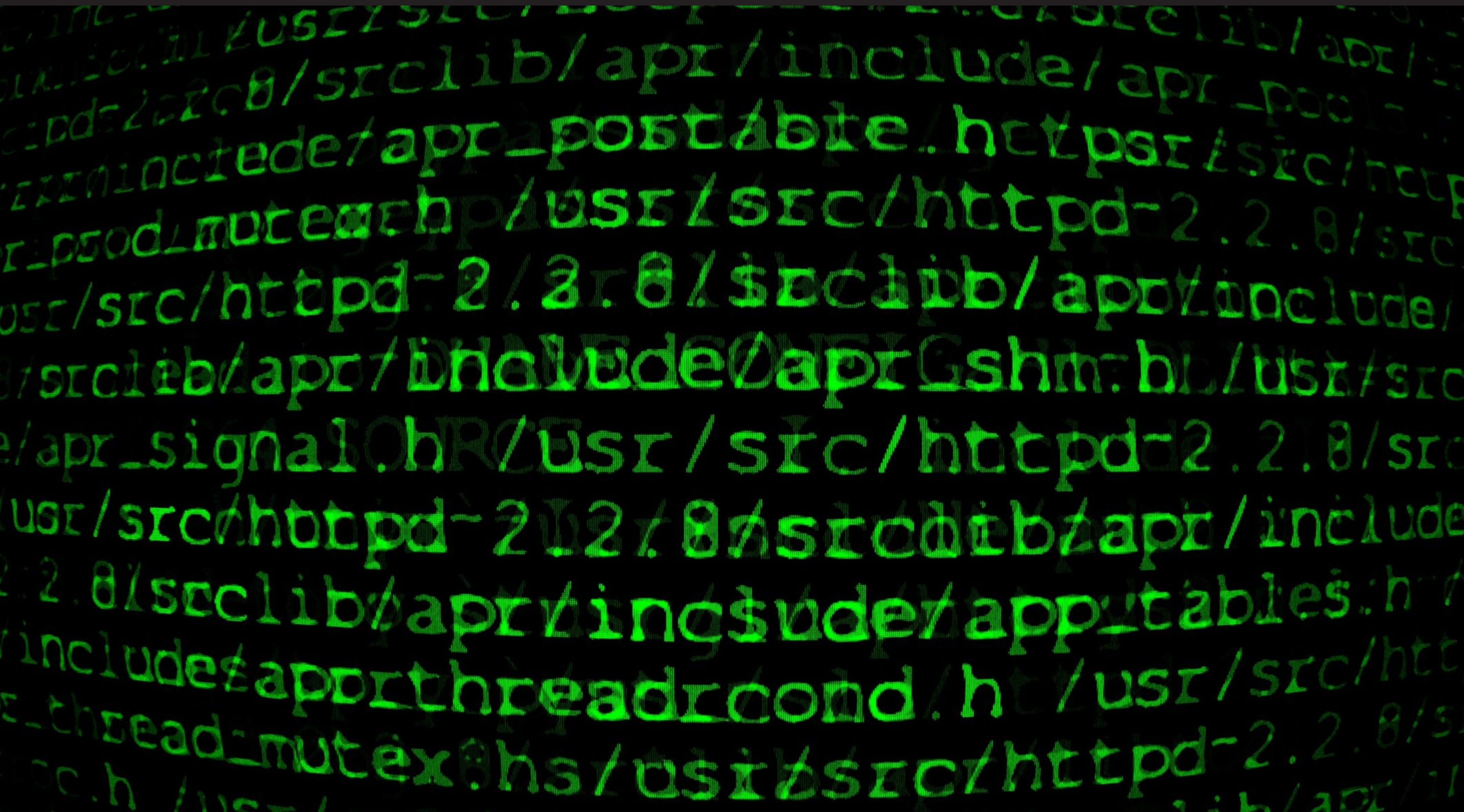
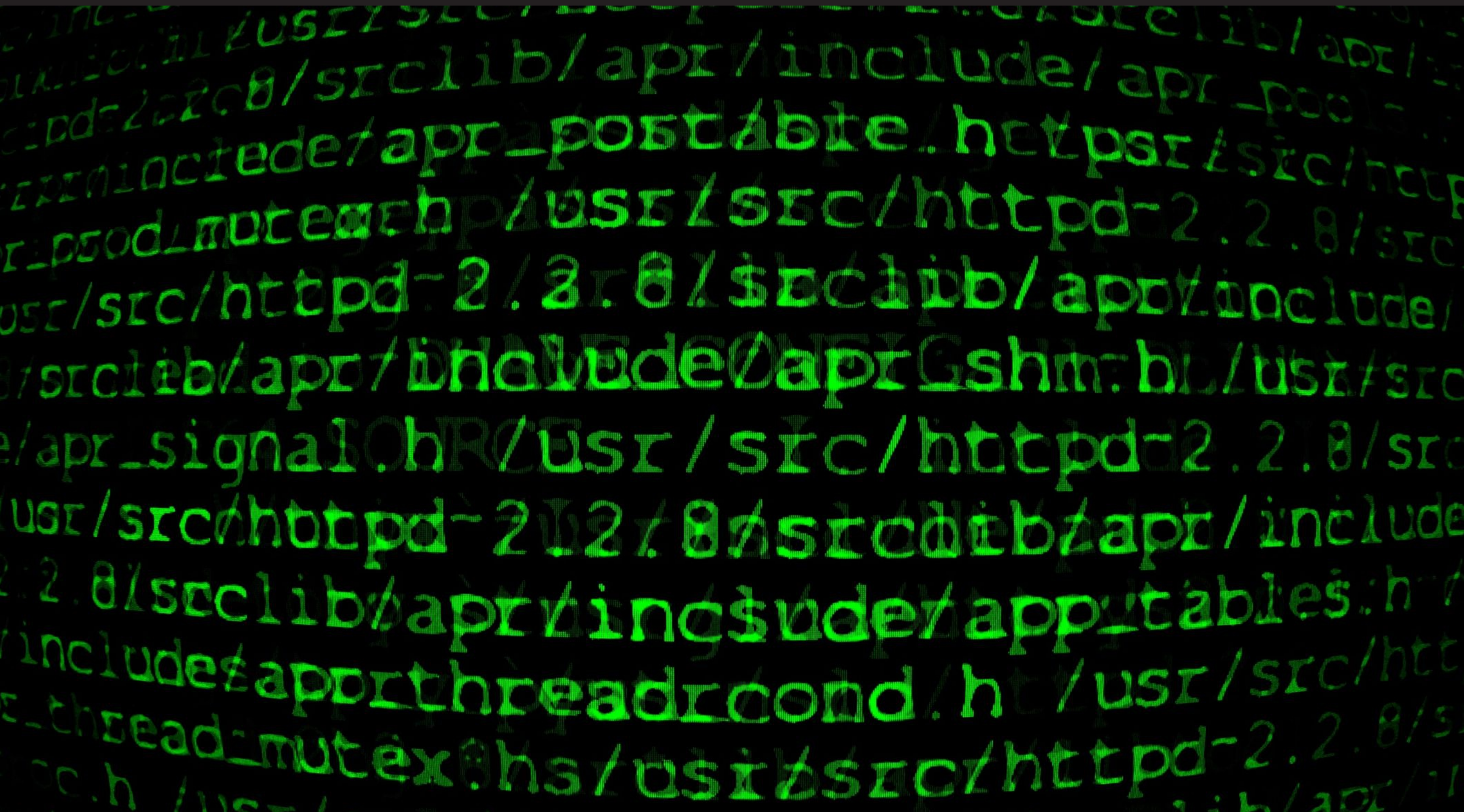
ECODINGT HES OURCESO FC ARBONA TT HEP ETMD

Ndyr lidgwella



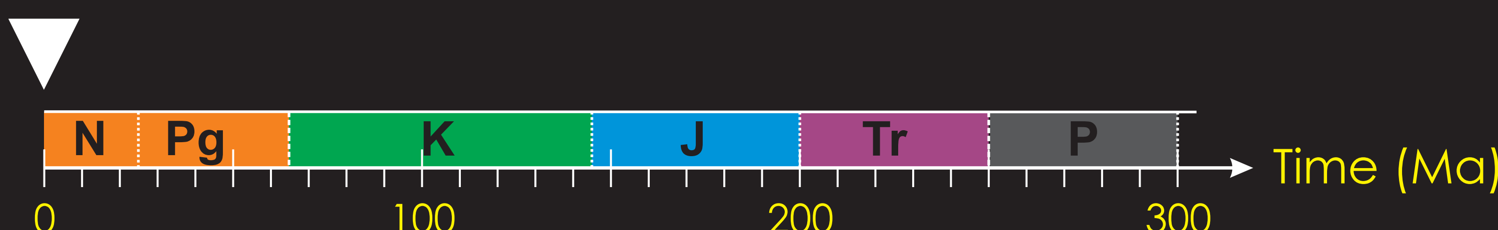
DECODING THE SOURCES OF CARBON AT THE PETM

Andy Ridgwell



Background – ‘analogues’ for future global change?

Biotic/ecosystem response?



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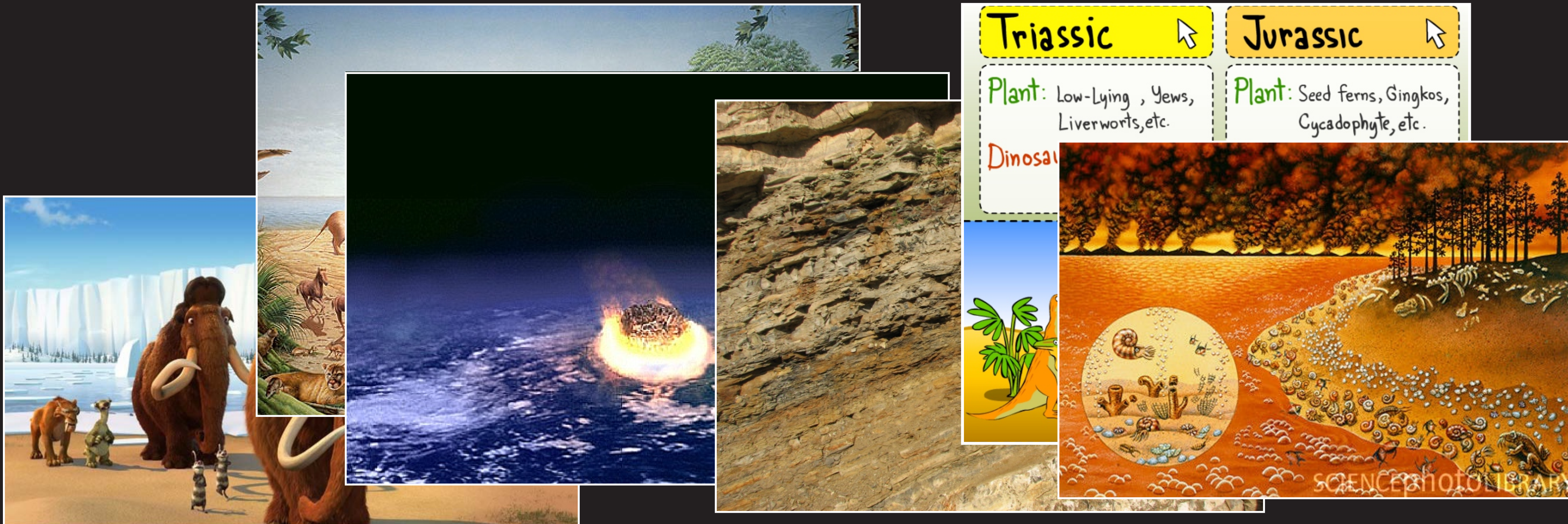
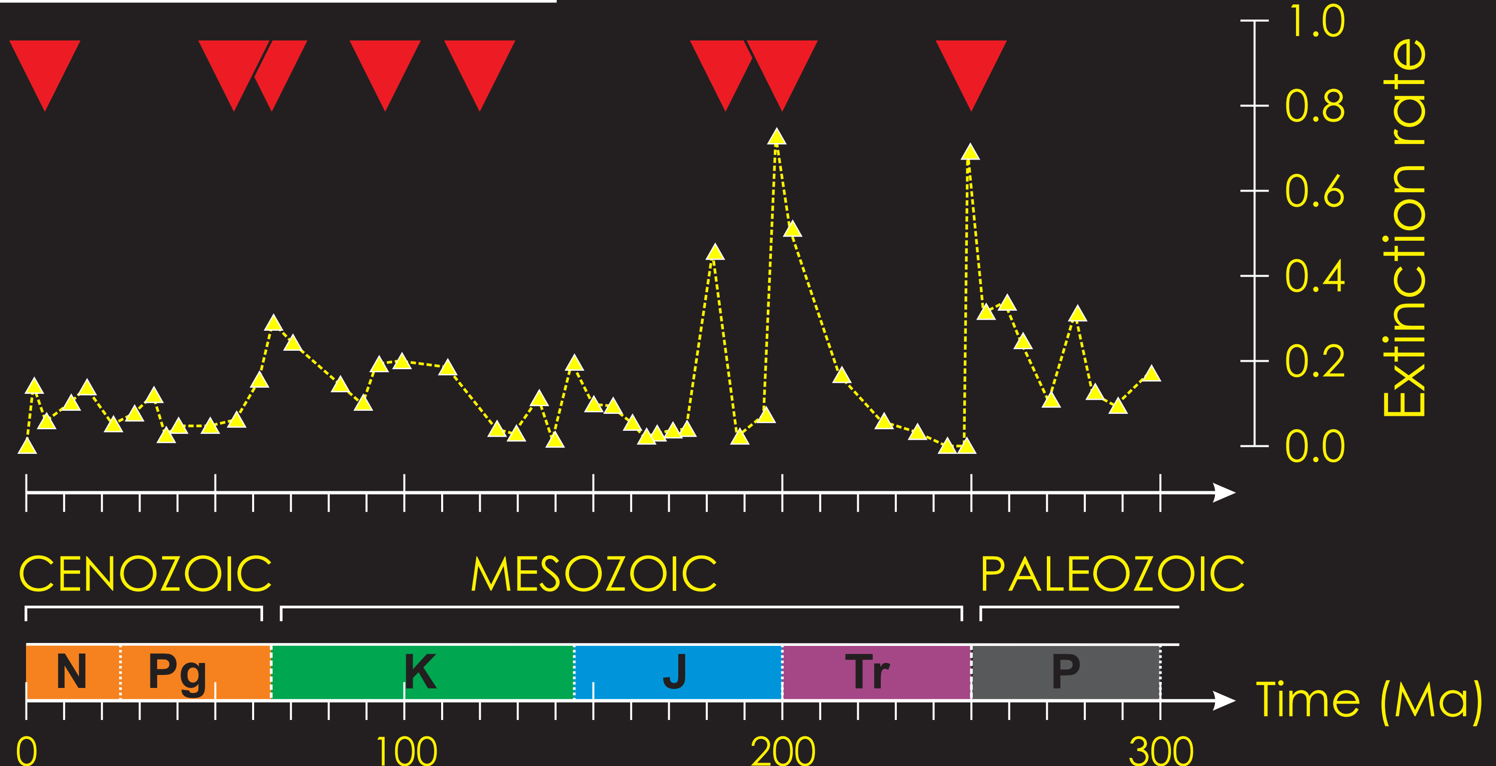




Hönisch et al. [2012]

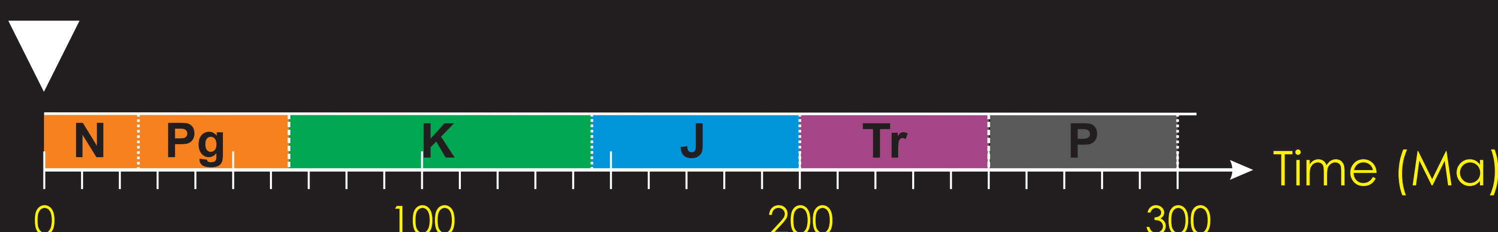
Background – 'analogues' for future global change?

Massive CO_2 release

Increasing atmospheric pCO_2

Warming

Biotic/ecosystem response?



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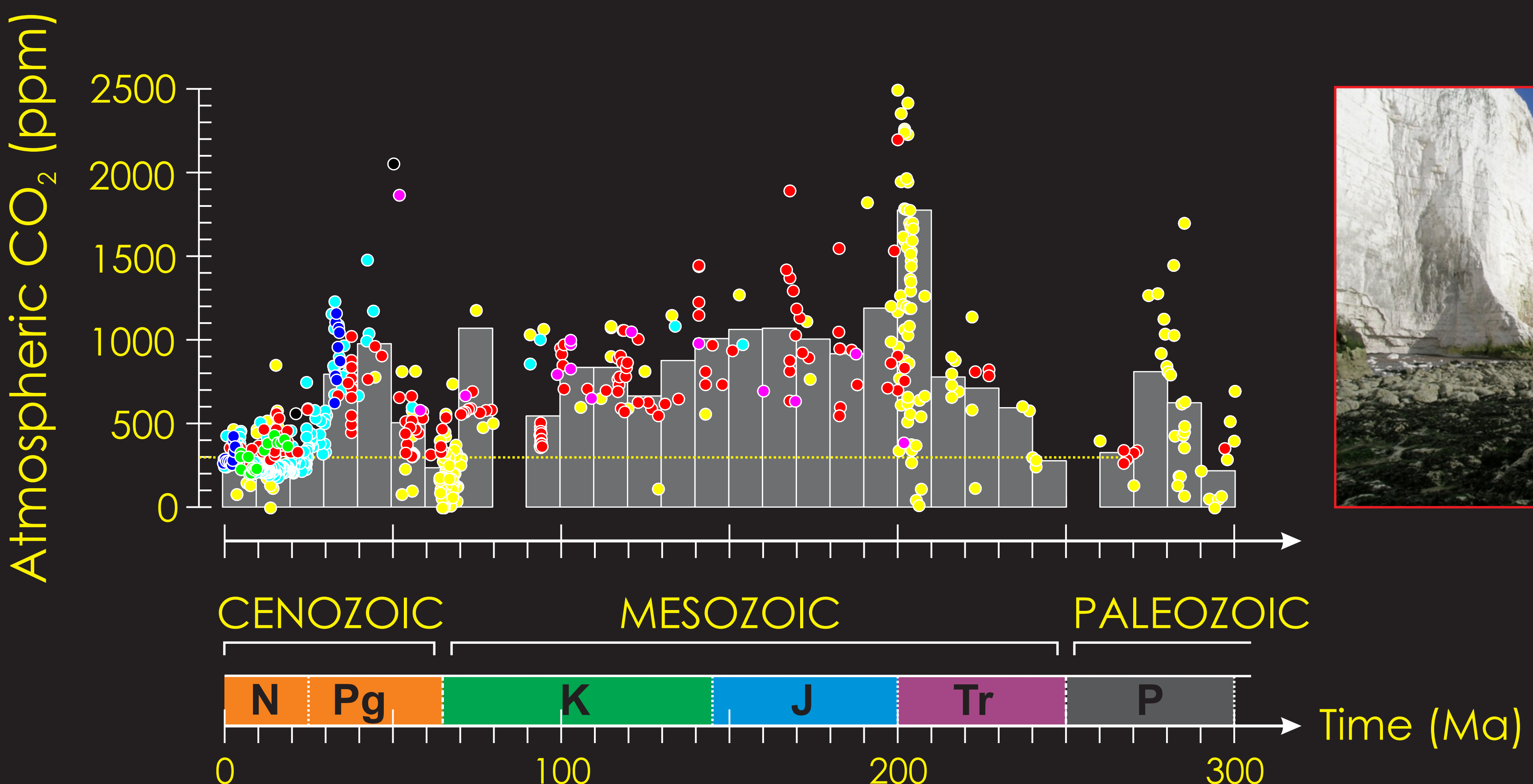
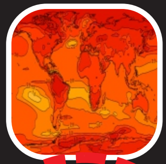


Hönisch et al. [2012]

Background – ‘analogues’ for future global change?

 Massive CO_2 release

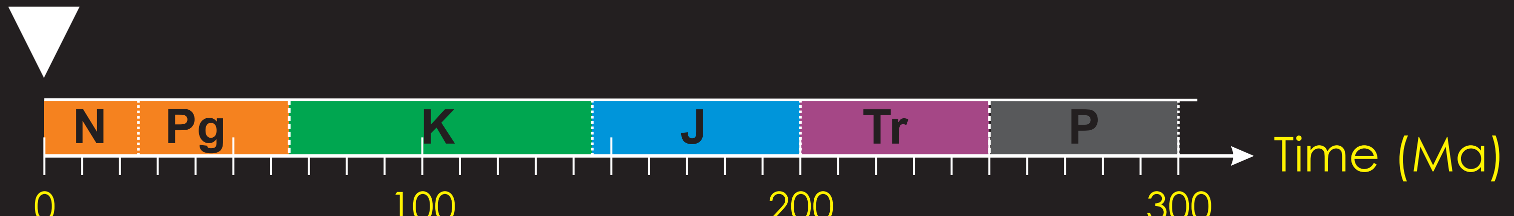
 Increasing atmospheric pCO_2

 Warming

 pH decline

 Carbonate saturation decline

 Biotic/ecosystem response?



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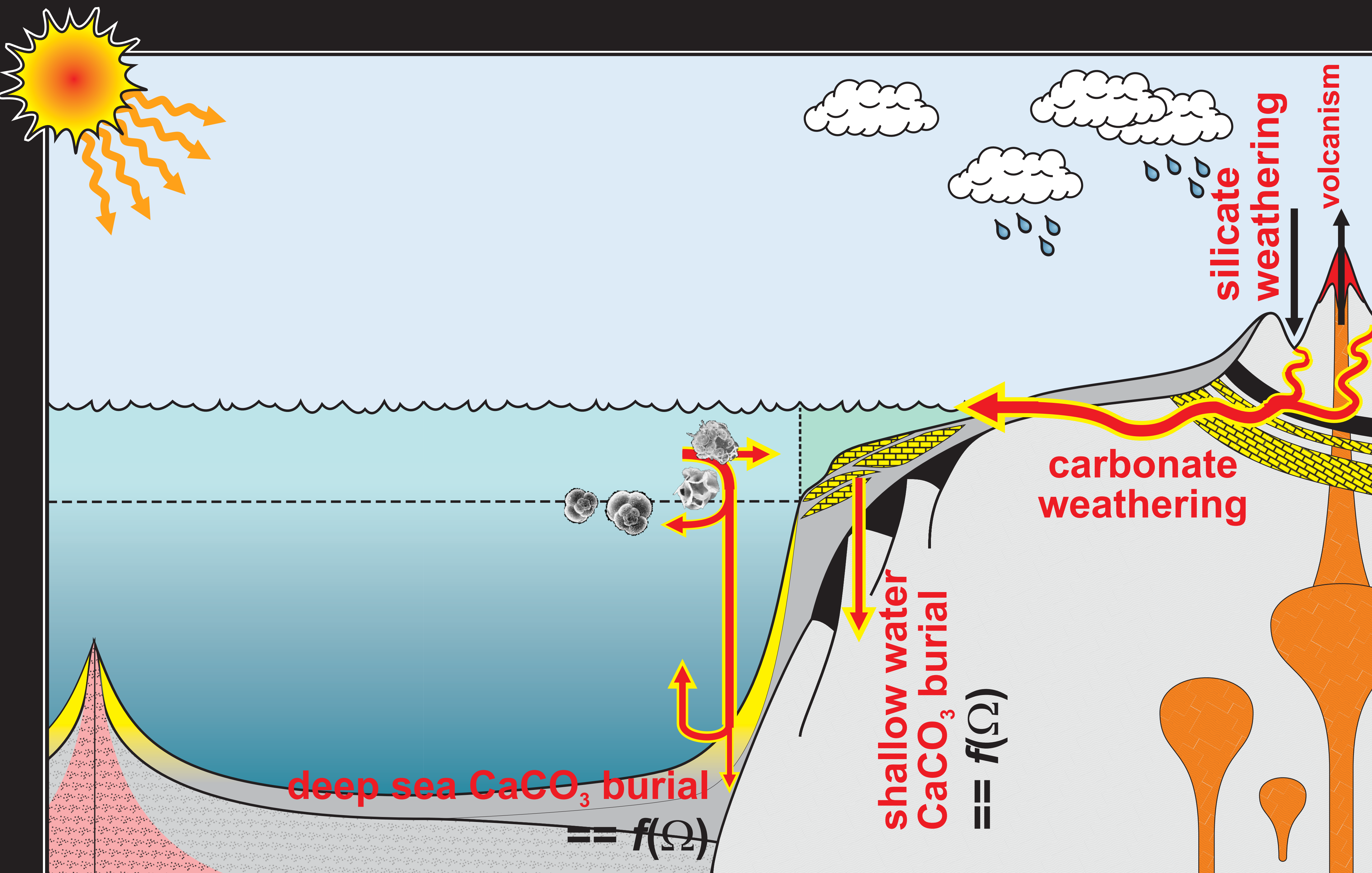

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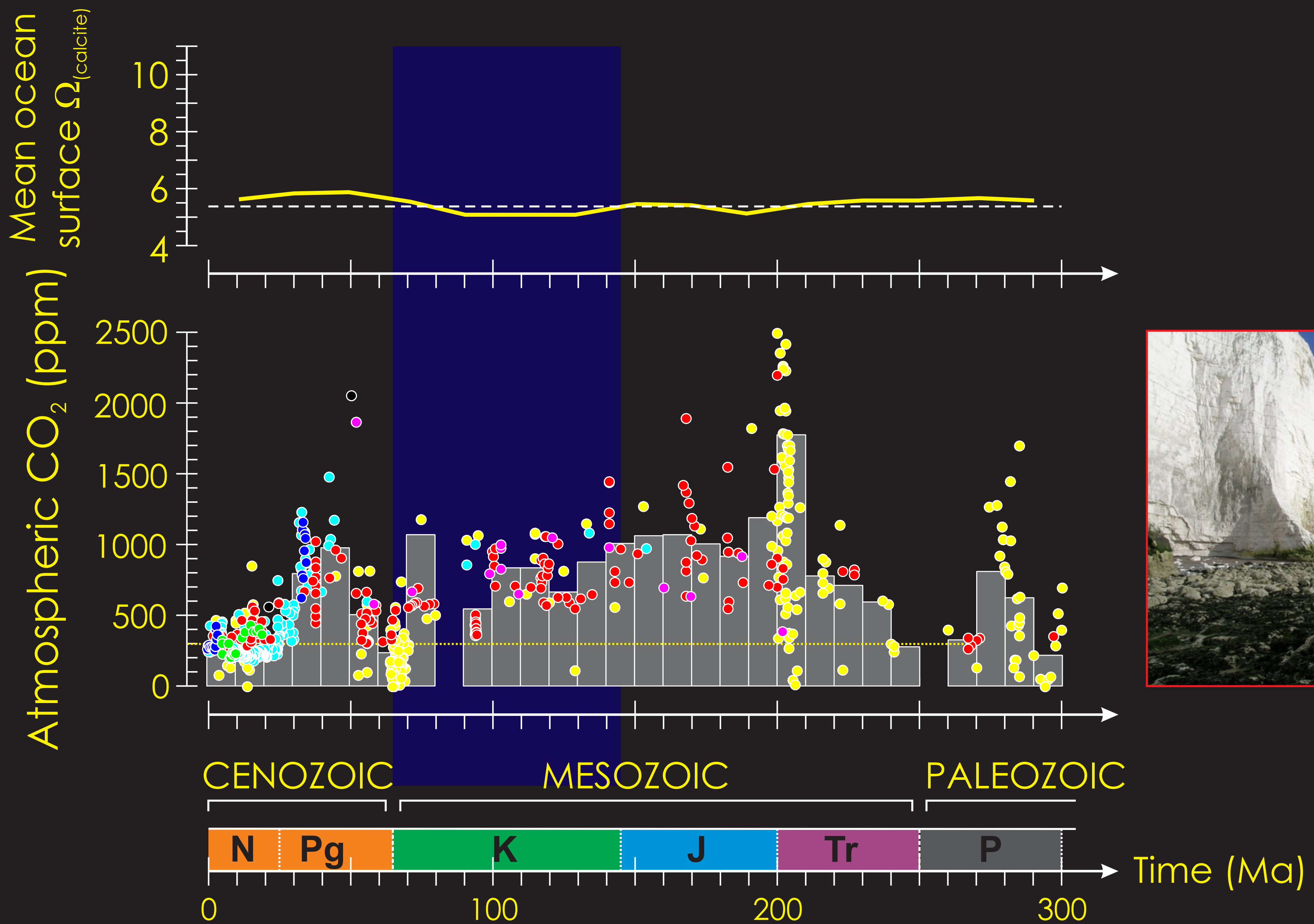
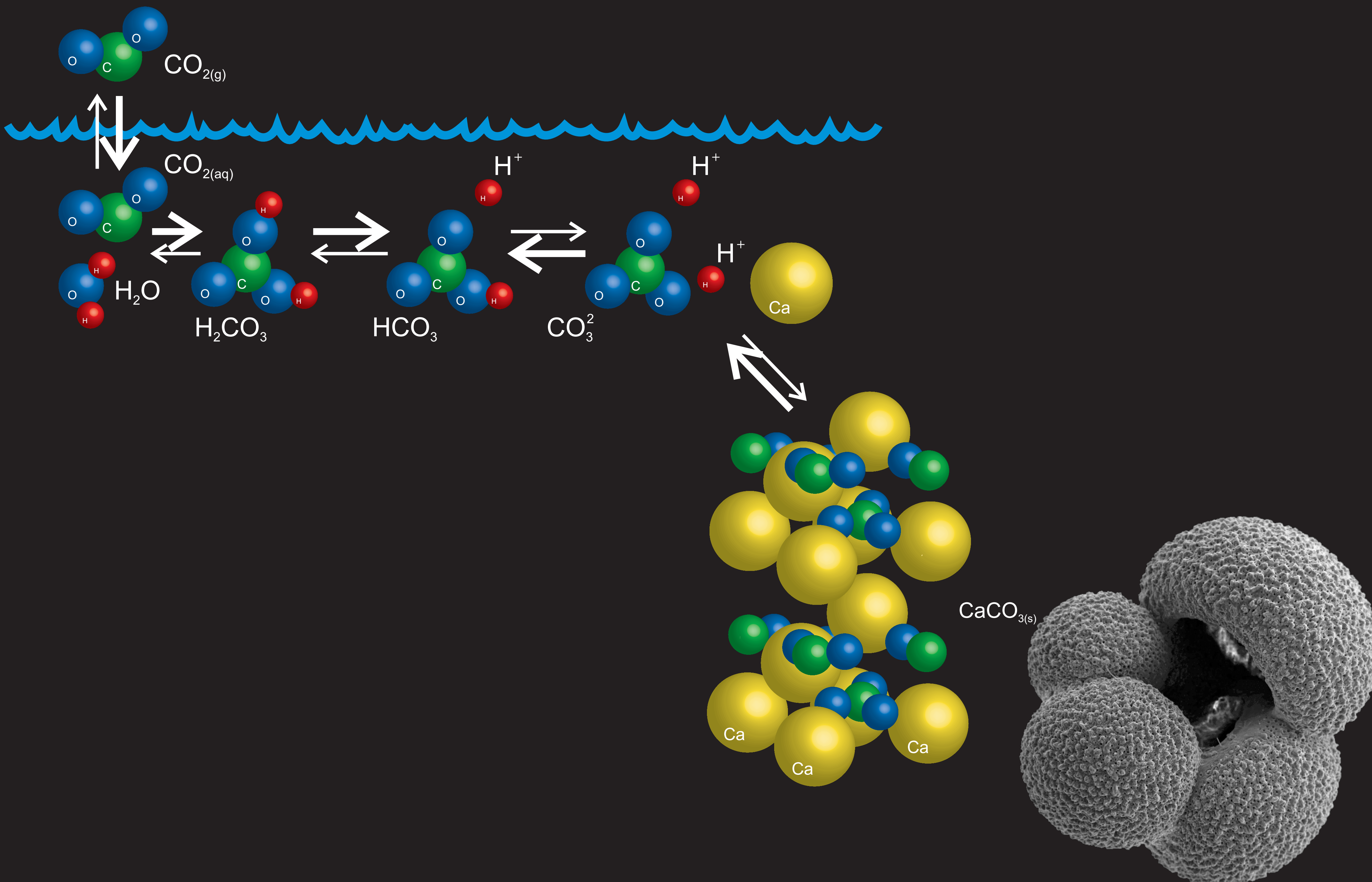
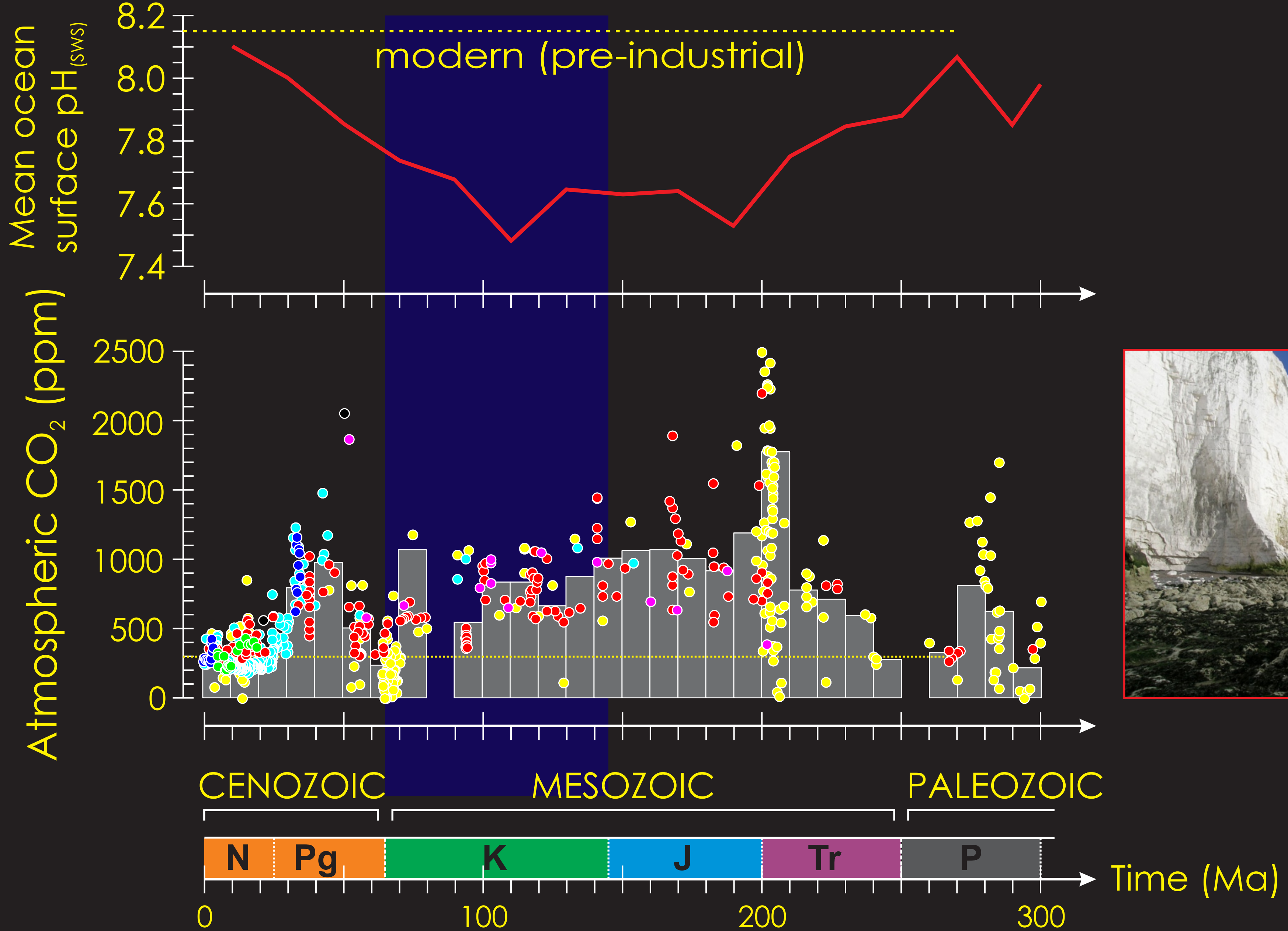


Ridgwell [2005]

Background – ‘analogues’ for future global change?



Background – 'analogues' for future global change?



Ridgwell [2005]

Background – 'analogues' for future global change?

pH

saturation

'slow'
(quasi steady-state)

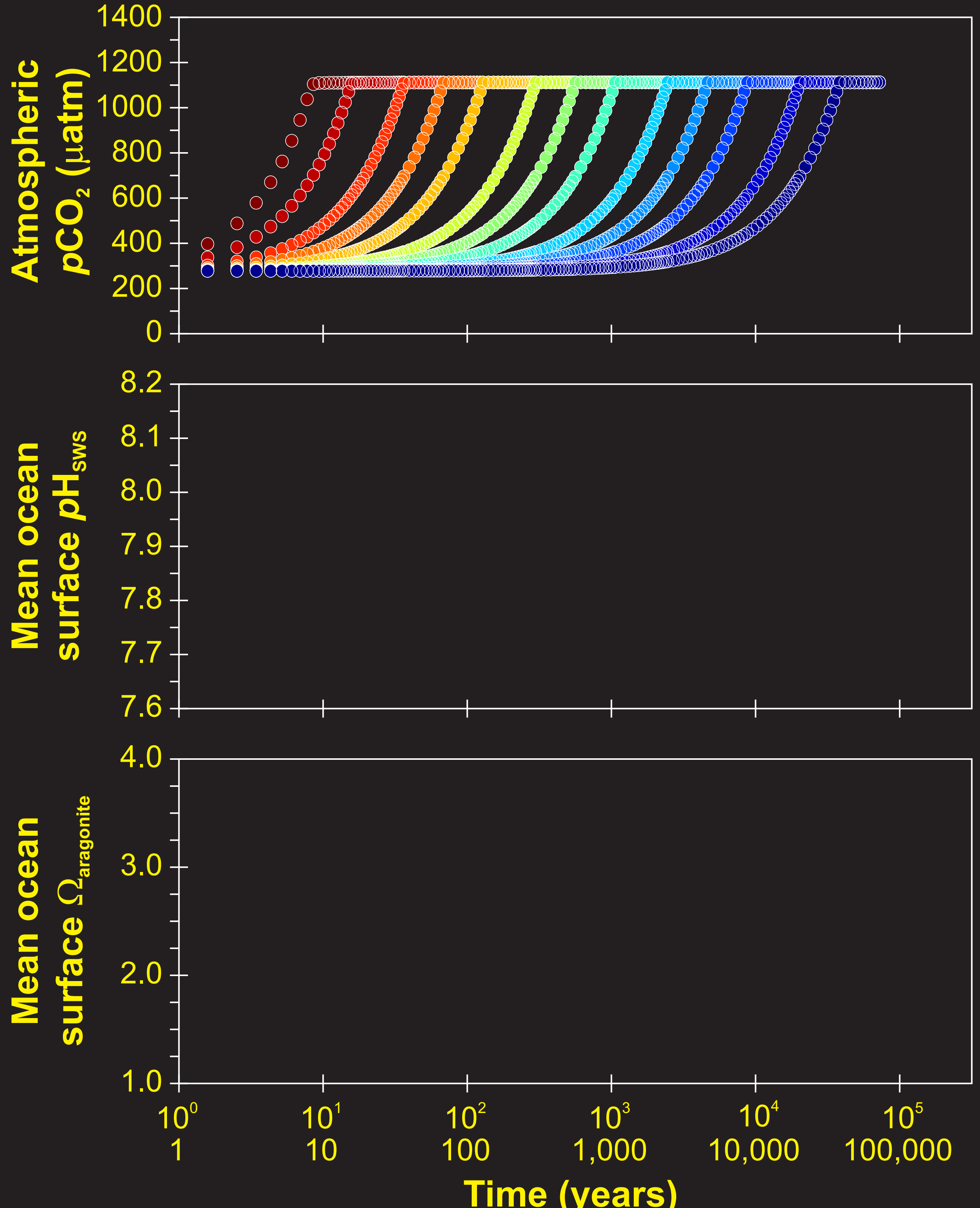
pH

saturation

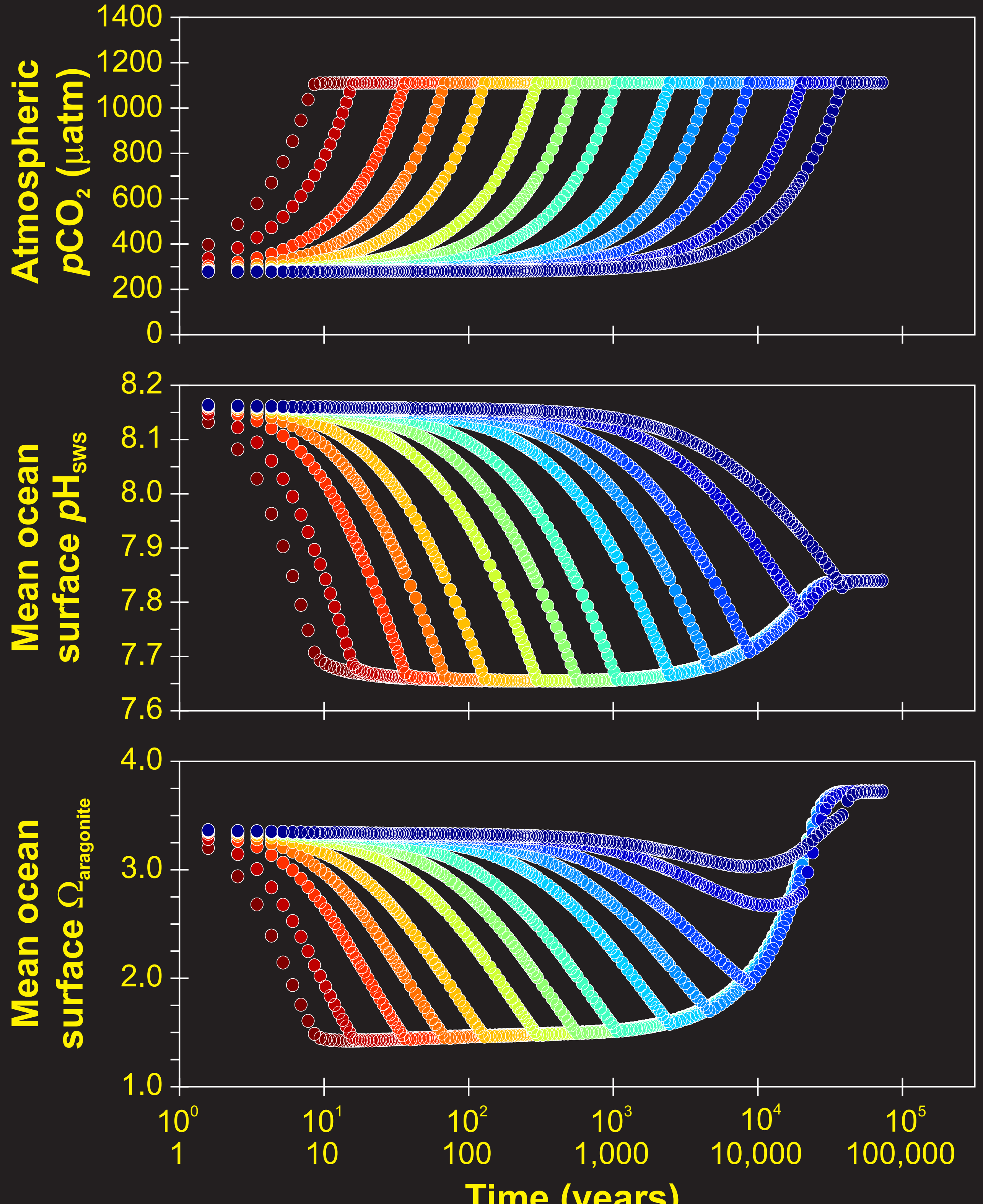
'fast'
(geologically abrupt)

Rate of change (magnitude of CO_2 emissions)

Hönisch et al. [2012]



Hönisch et al. [2012]



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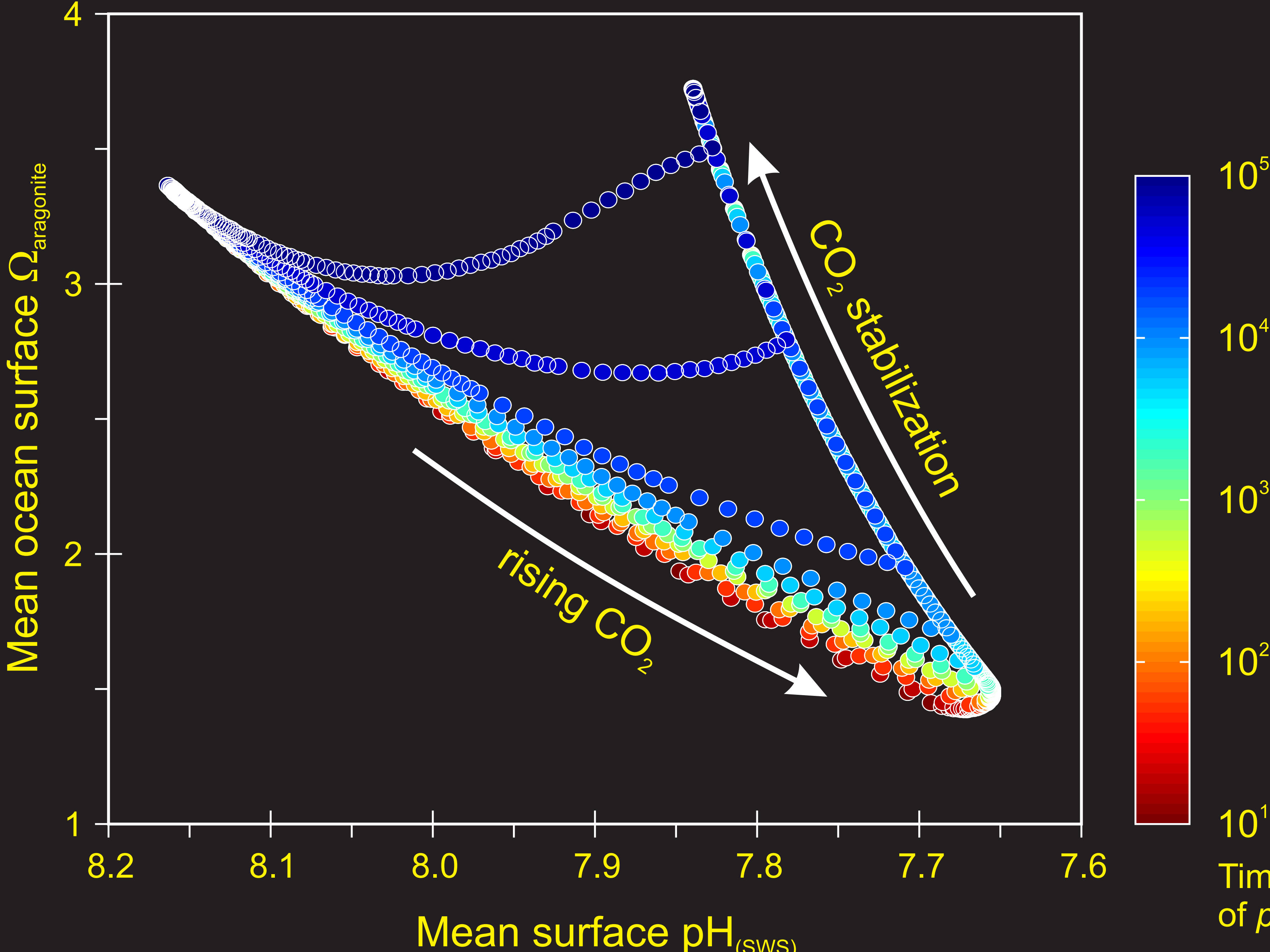

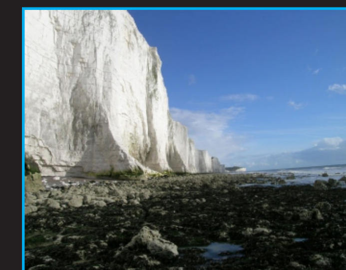

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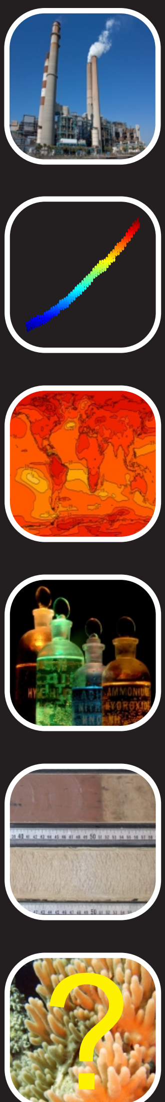
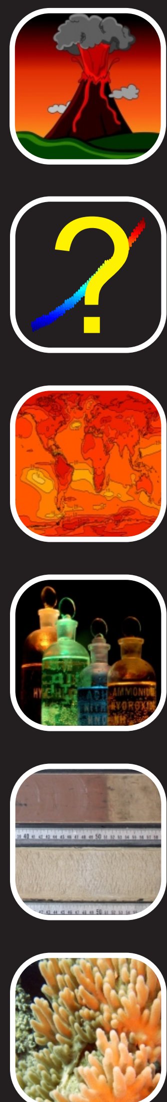
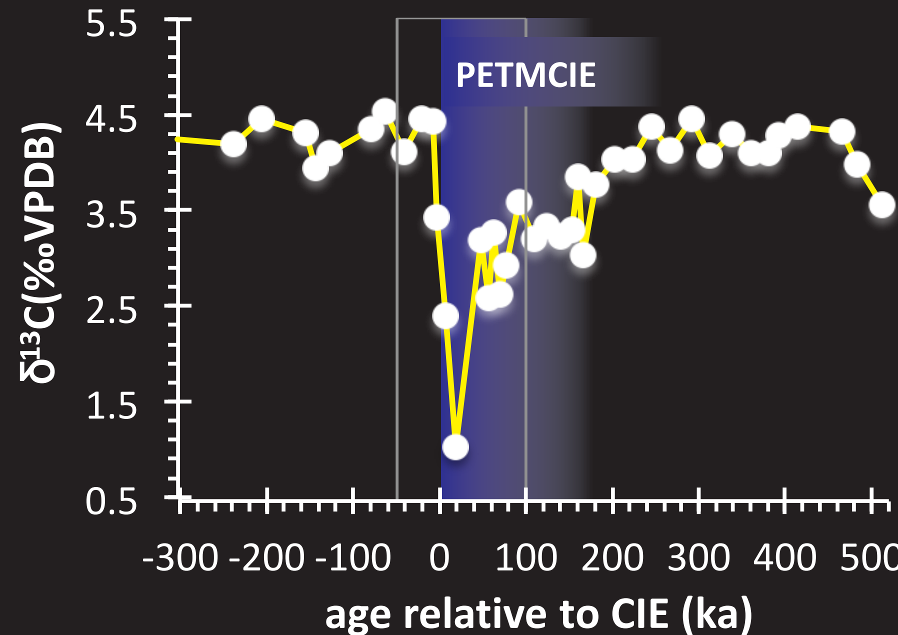
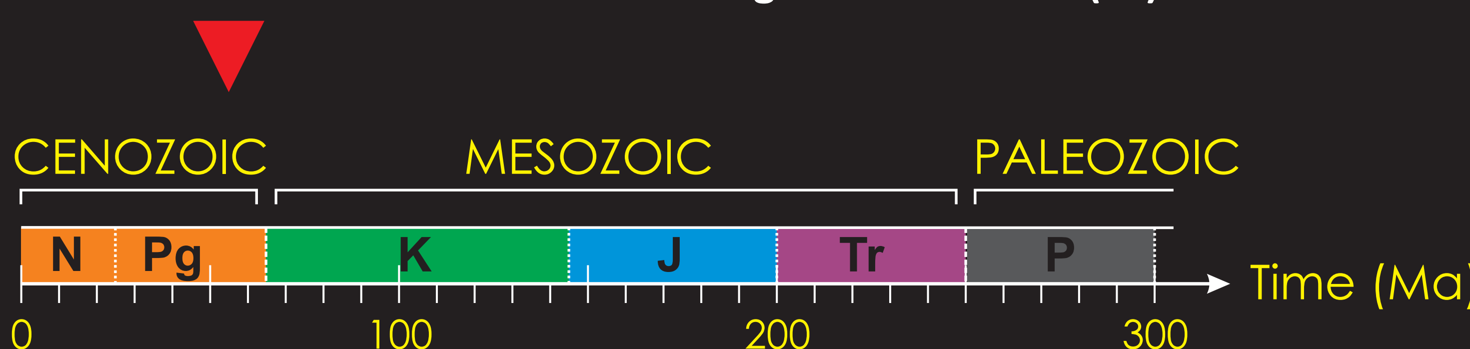
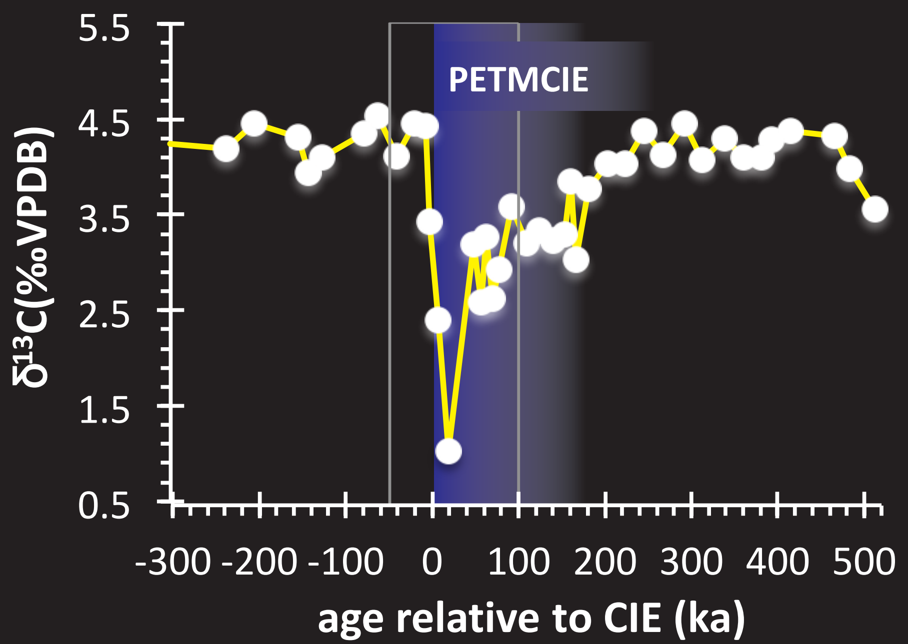


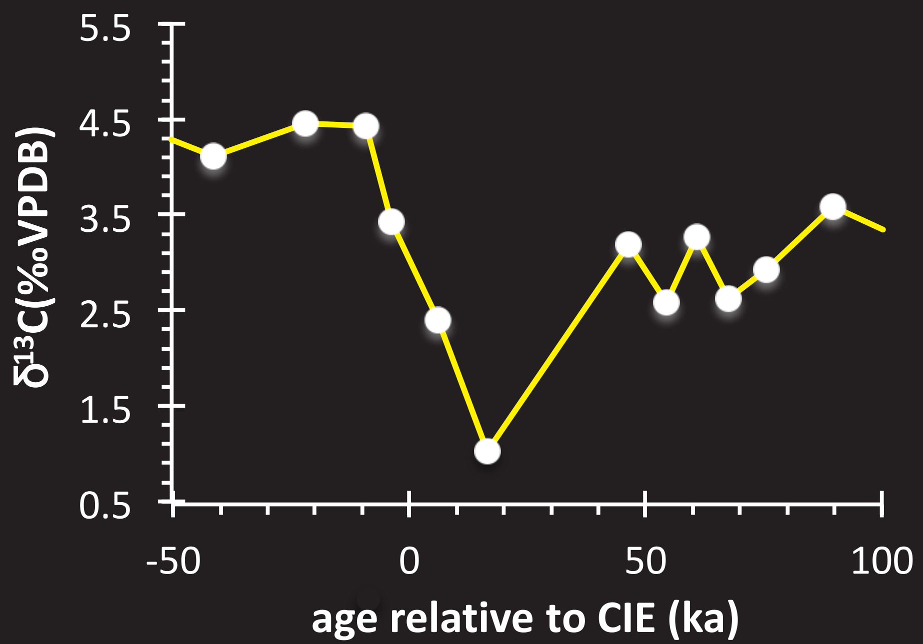






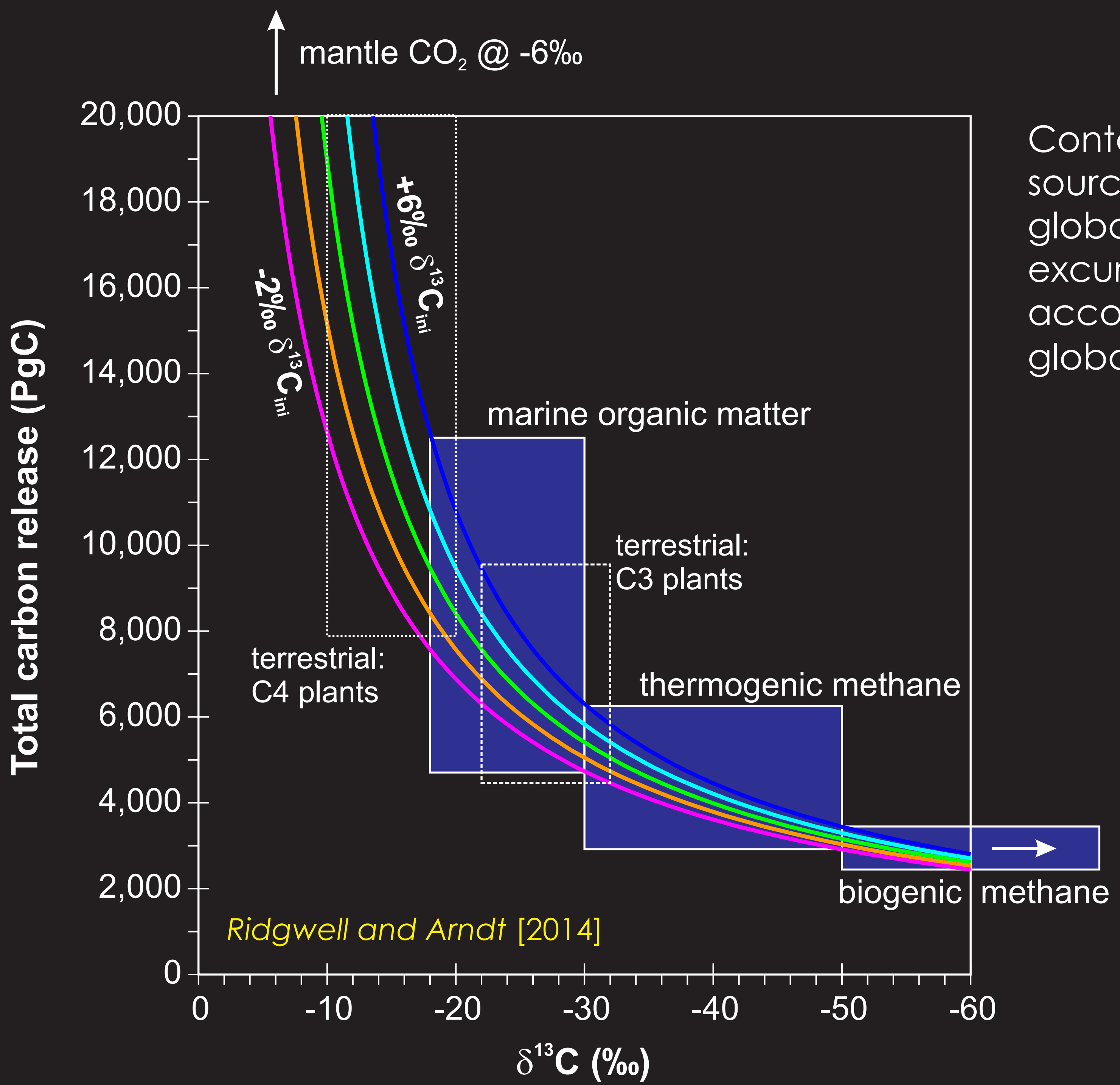
Methods – interpreting carbon isotopic excursions





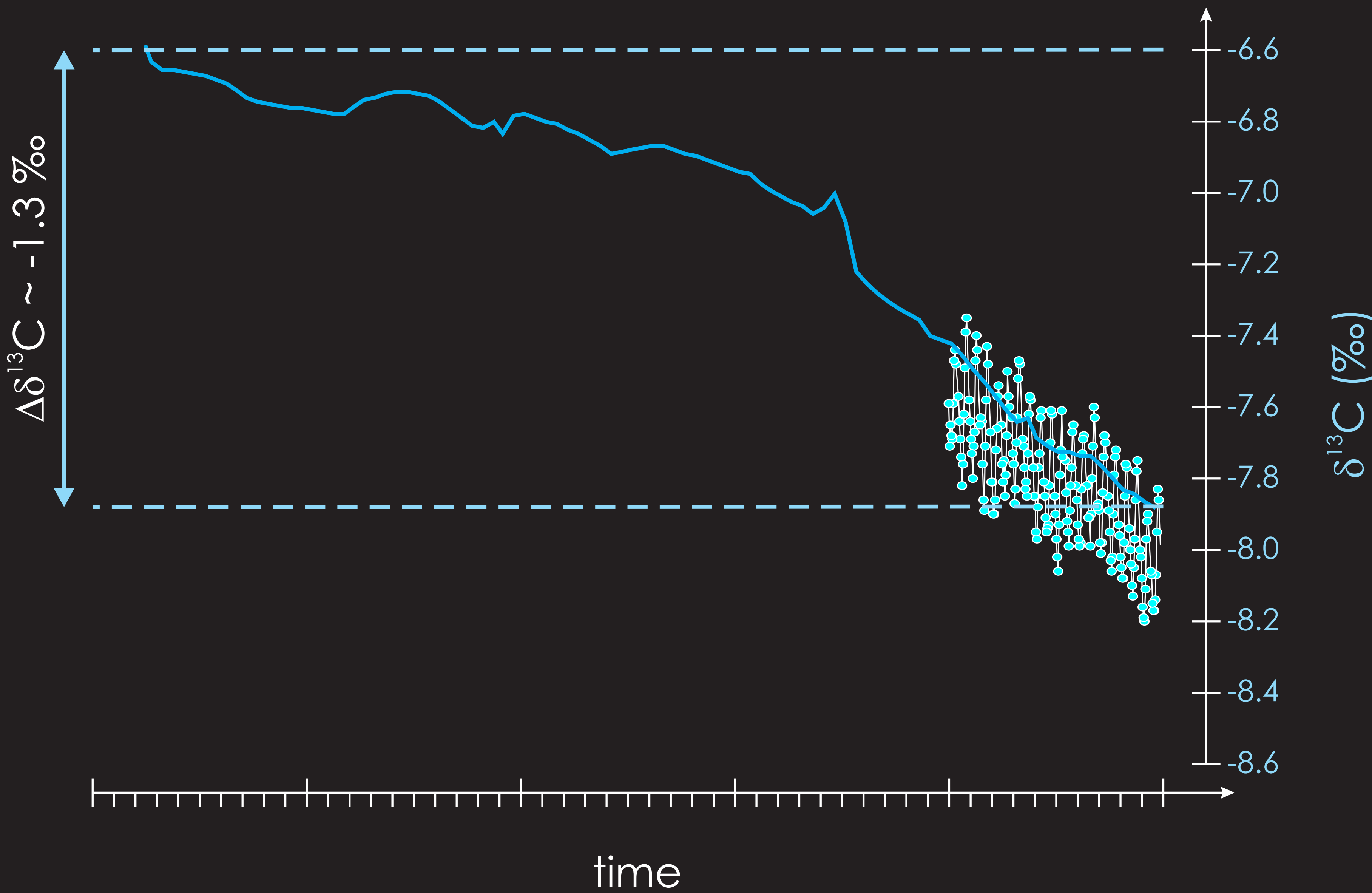
Site 401 (North East Atlantic)

Methods – interpreting carbon isotopic excursions



Contours of carbon release vs. source isotopic signature for a global -4‰ carbon isotopic excursion. Contours differ according to the initial mean global $\delta^{13}C$.

Methods – interpreting carbon isotopic excursions



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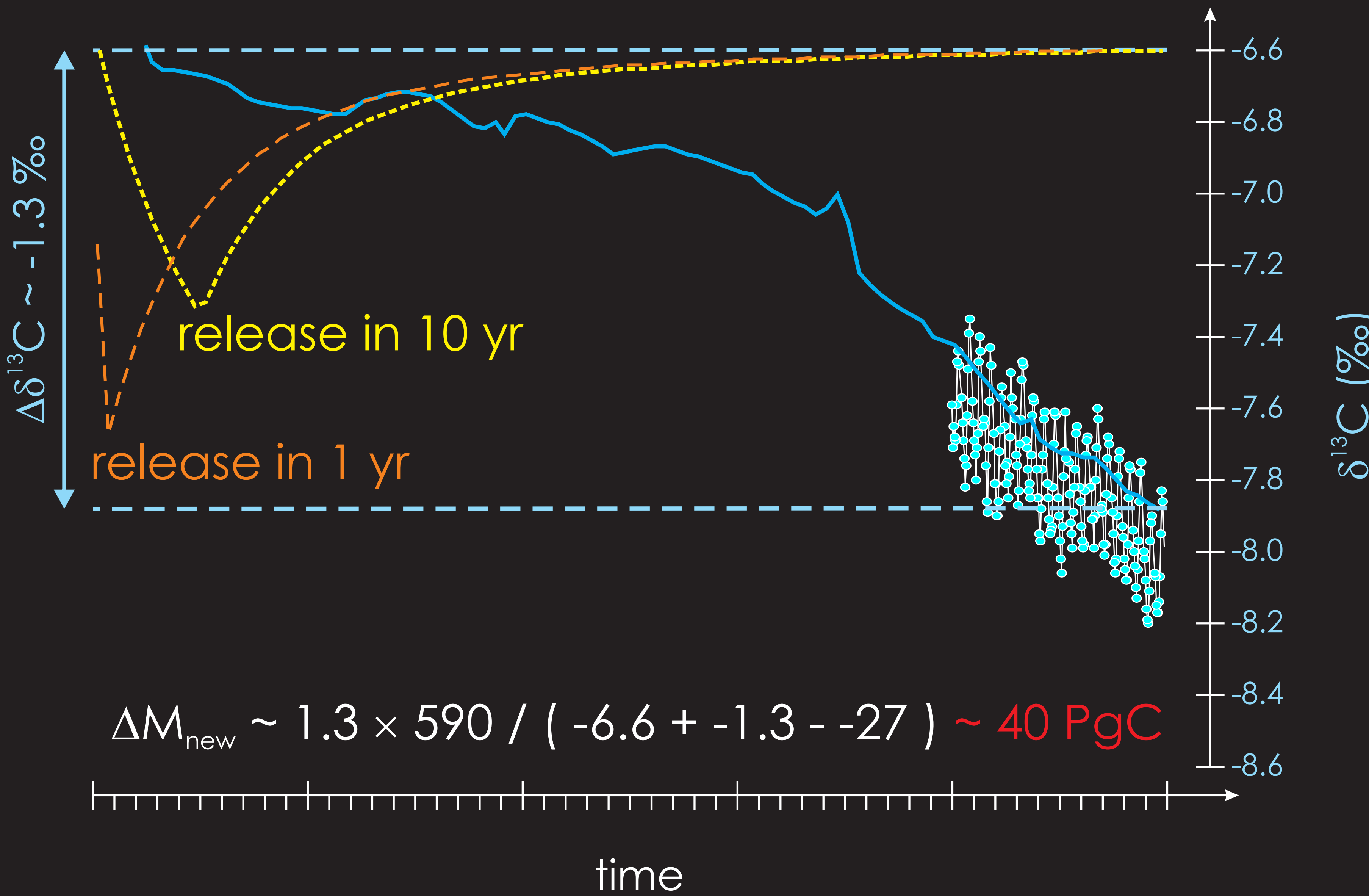

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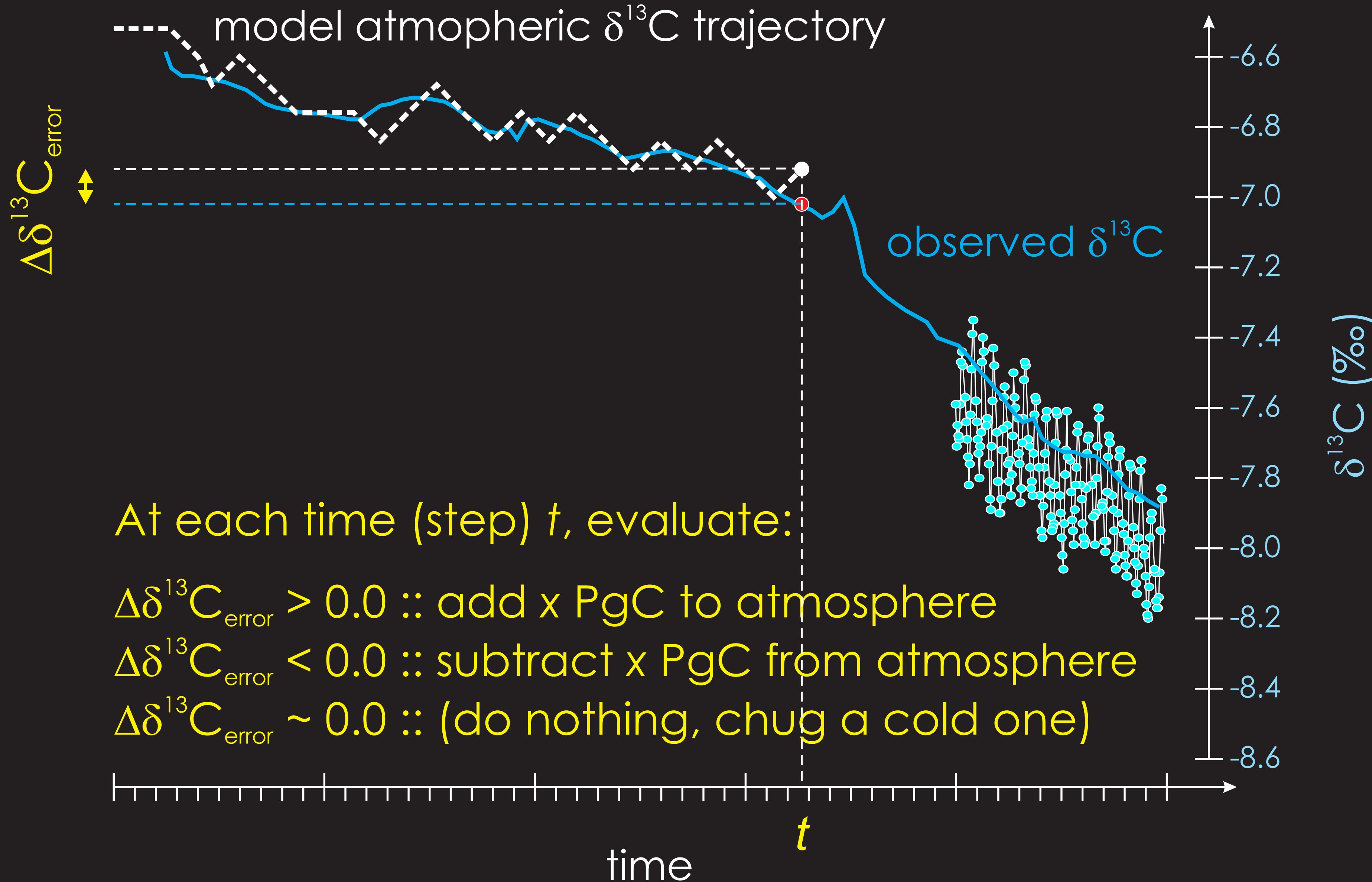


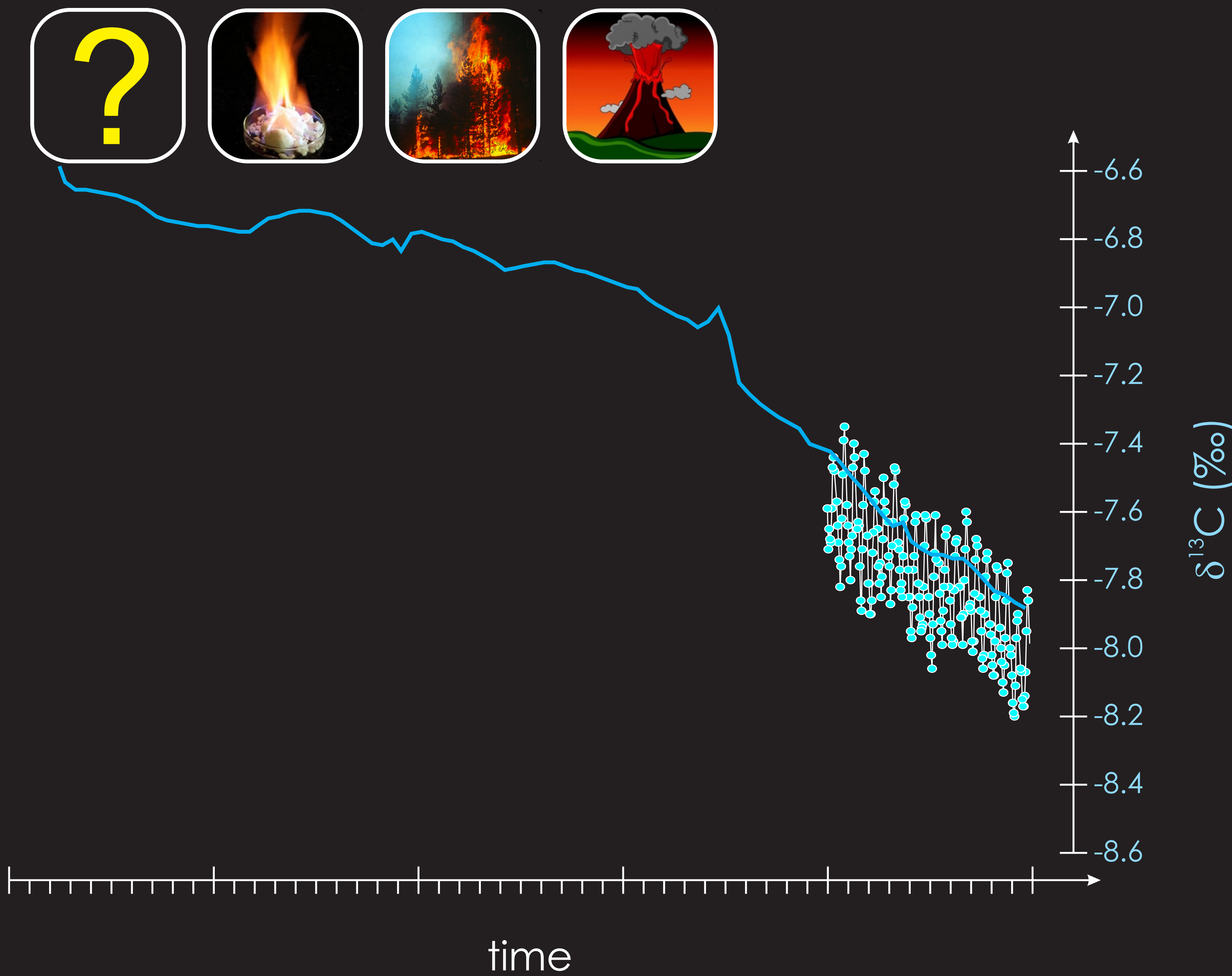
At each time (step) *t*, evaluate:

$\Delta\delta^{13}C_{error} > 0.0$ :: add x PgC to atmosphere

$\Delta\delta^{13}C_{error} < 0.0$ :: subtract x PgC from atmosphere

$\Delta\delta^{13}C_{error} \sim 0.0$ :: (do nothing, chug a cold one)

Methods – interpreting carbon isotopic excursions



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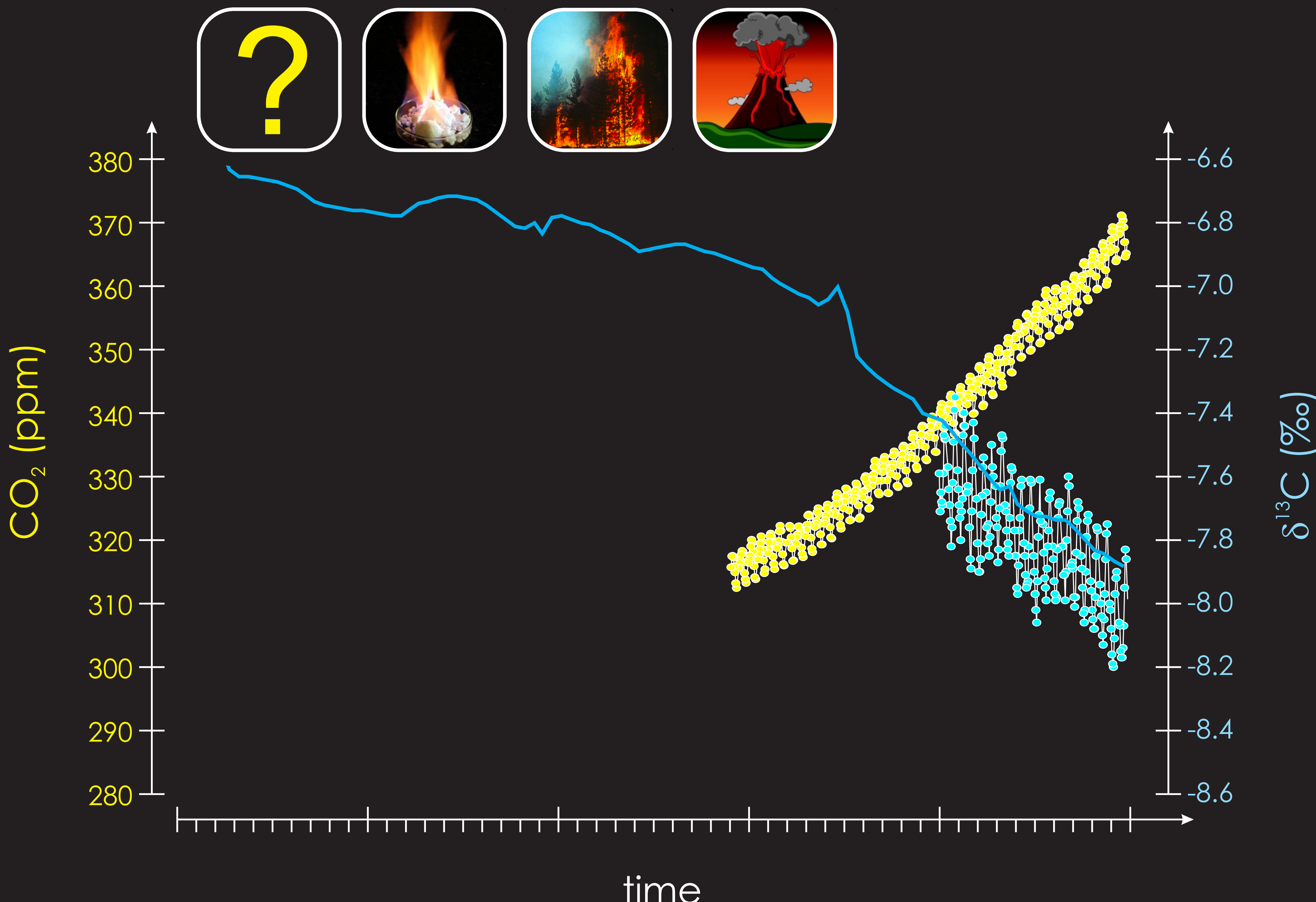

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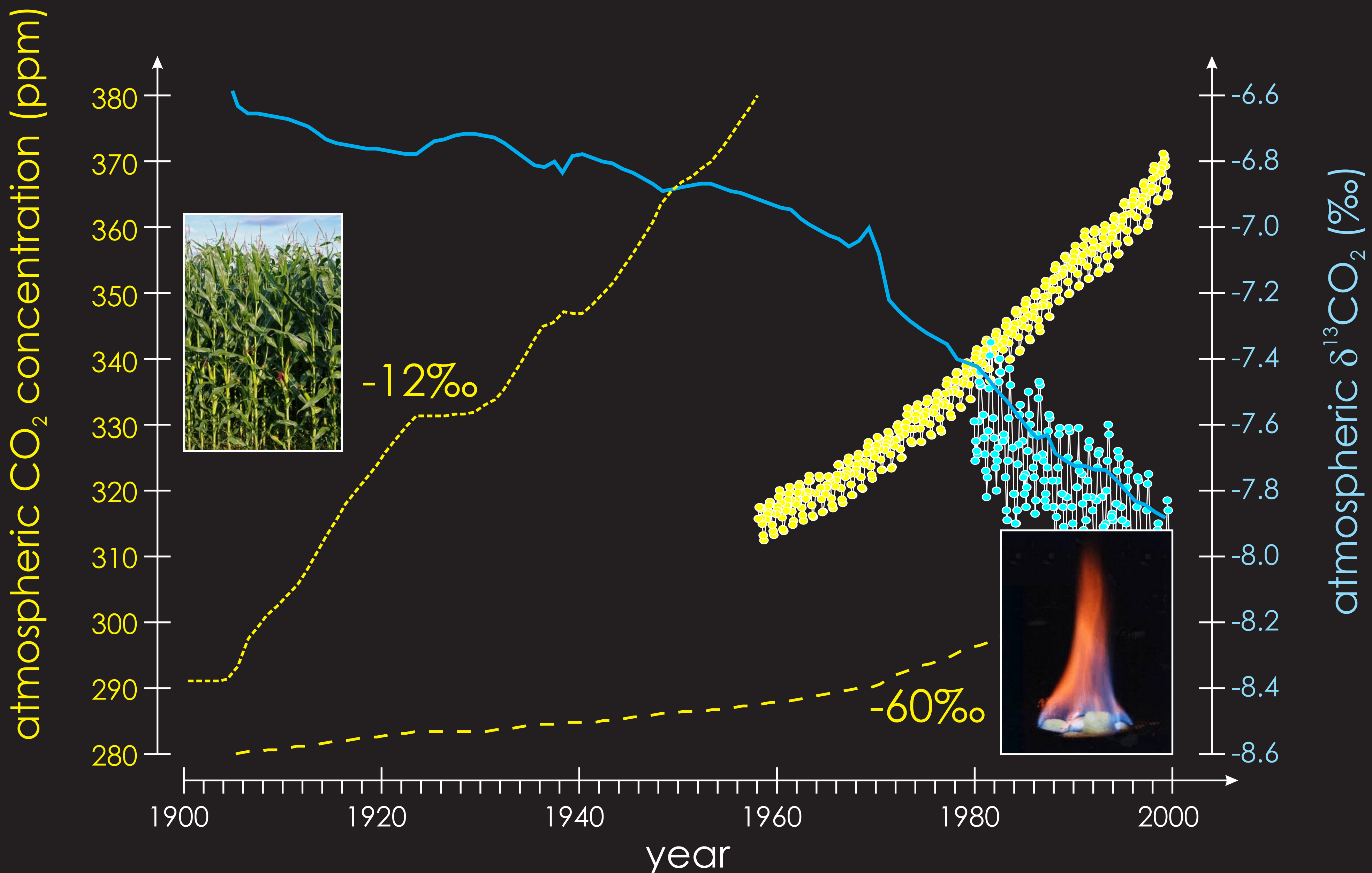

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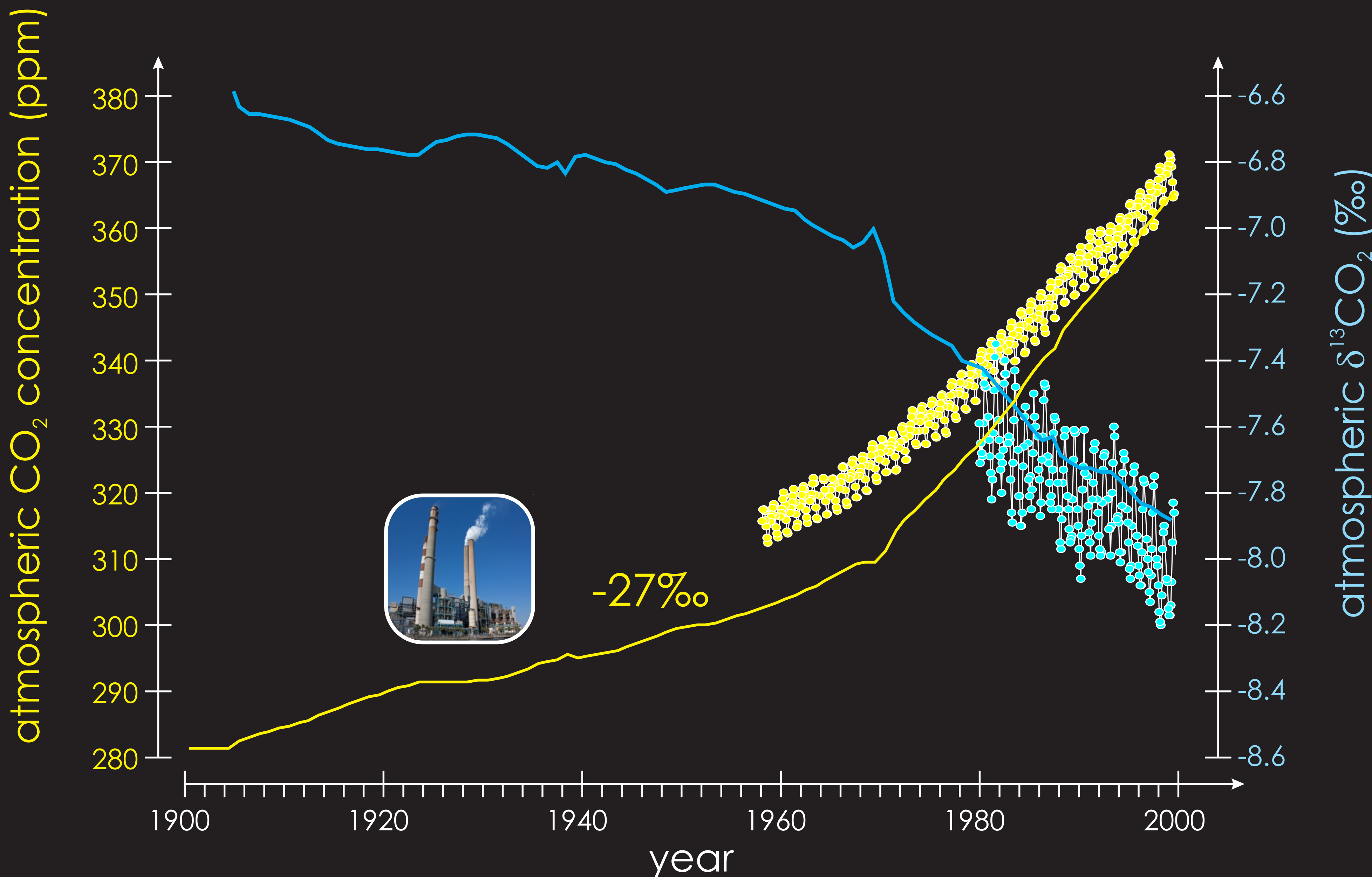

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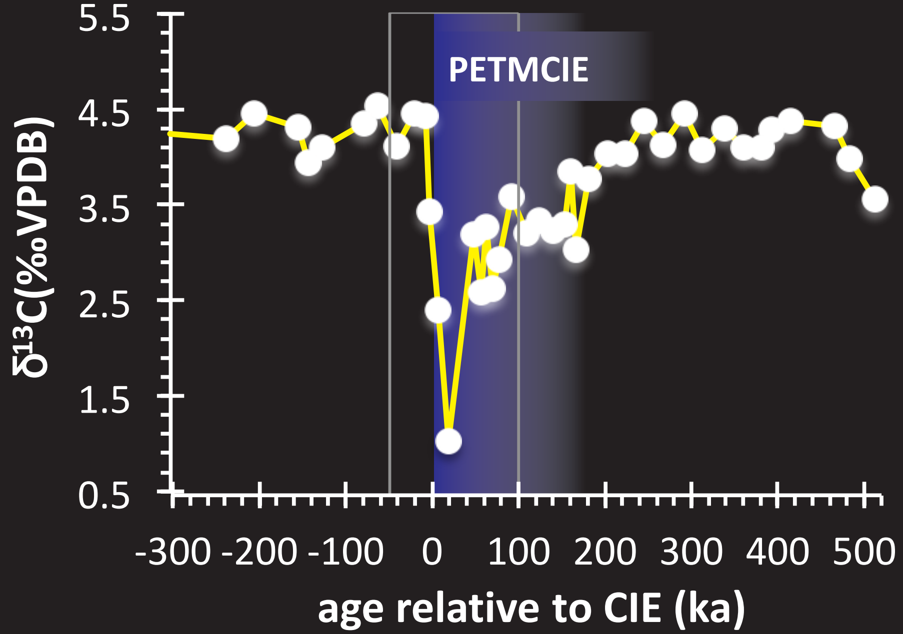

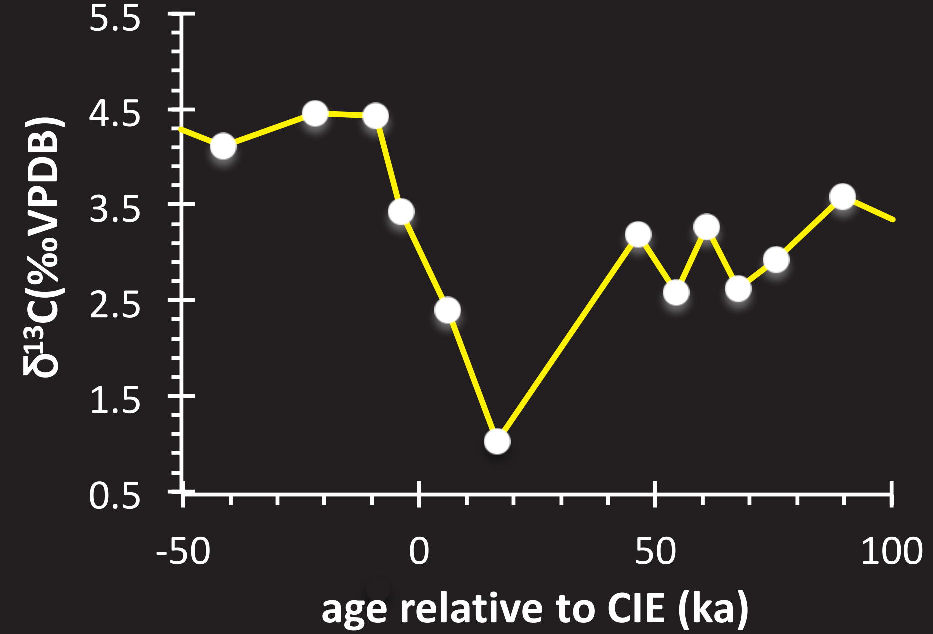

Site 401 (North East Atlantic)

Methods – interpreting carbon isotopic excursions

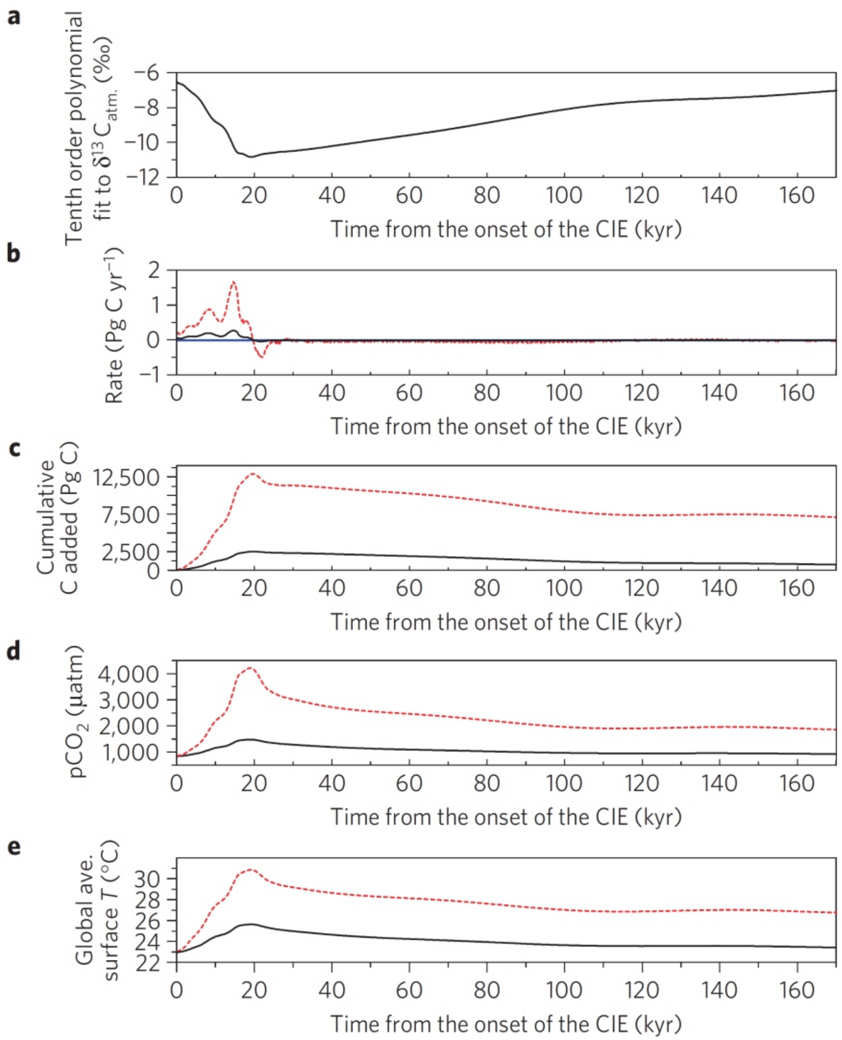

Figure 4 | Model results of the PETM carbon release rate and cumulative amount of carbon added versus time from the onset of the CIE (535 mbs) (age model is from ref. 2). a, $\delta^{13}C_{atm}$ that we used to force GENIE. **b**, Model results of the PETM carbon release rate. **c**, Model results of the cumulative amount of carbon added. **d**, Model results of the PETM atmospheric pCO_2. **e**, Model results of the PETM global average temperature (°C). The two best-fit simulations are shown in **b–e**:(1) CH_4 simulation (black solid line); (2) C_{org} simulation (red dotted line). Both simulations are with bioturbation on.

nature geoscience

ARTICLES

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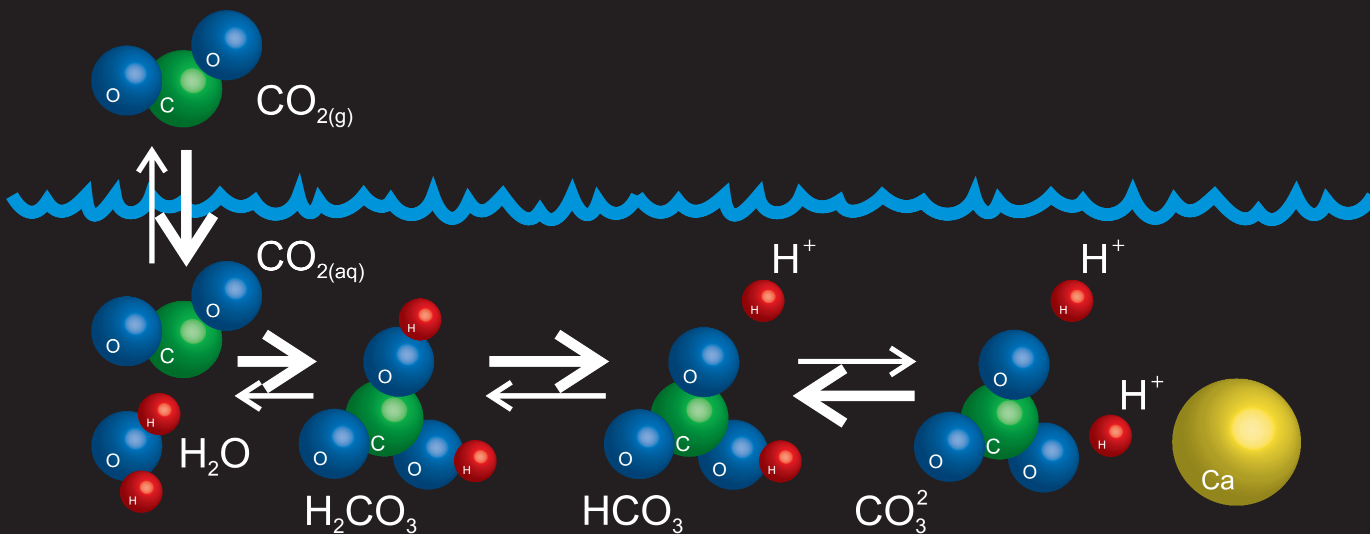
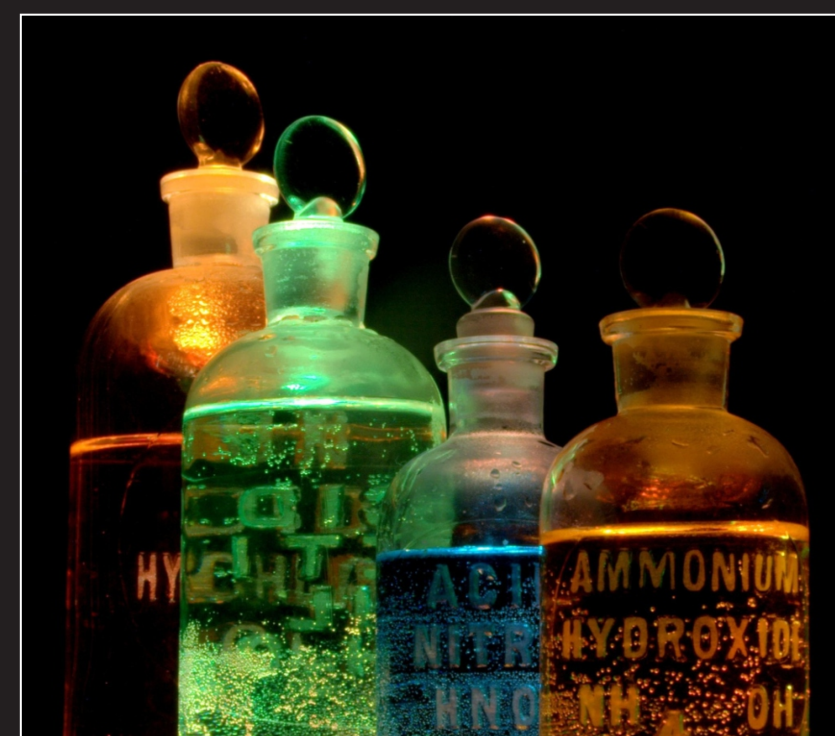
Slow release of fossil carbon during the Palaeocene–Eocene Thermal Maximum

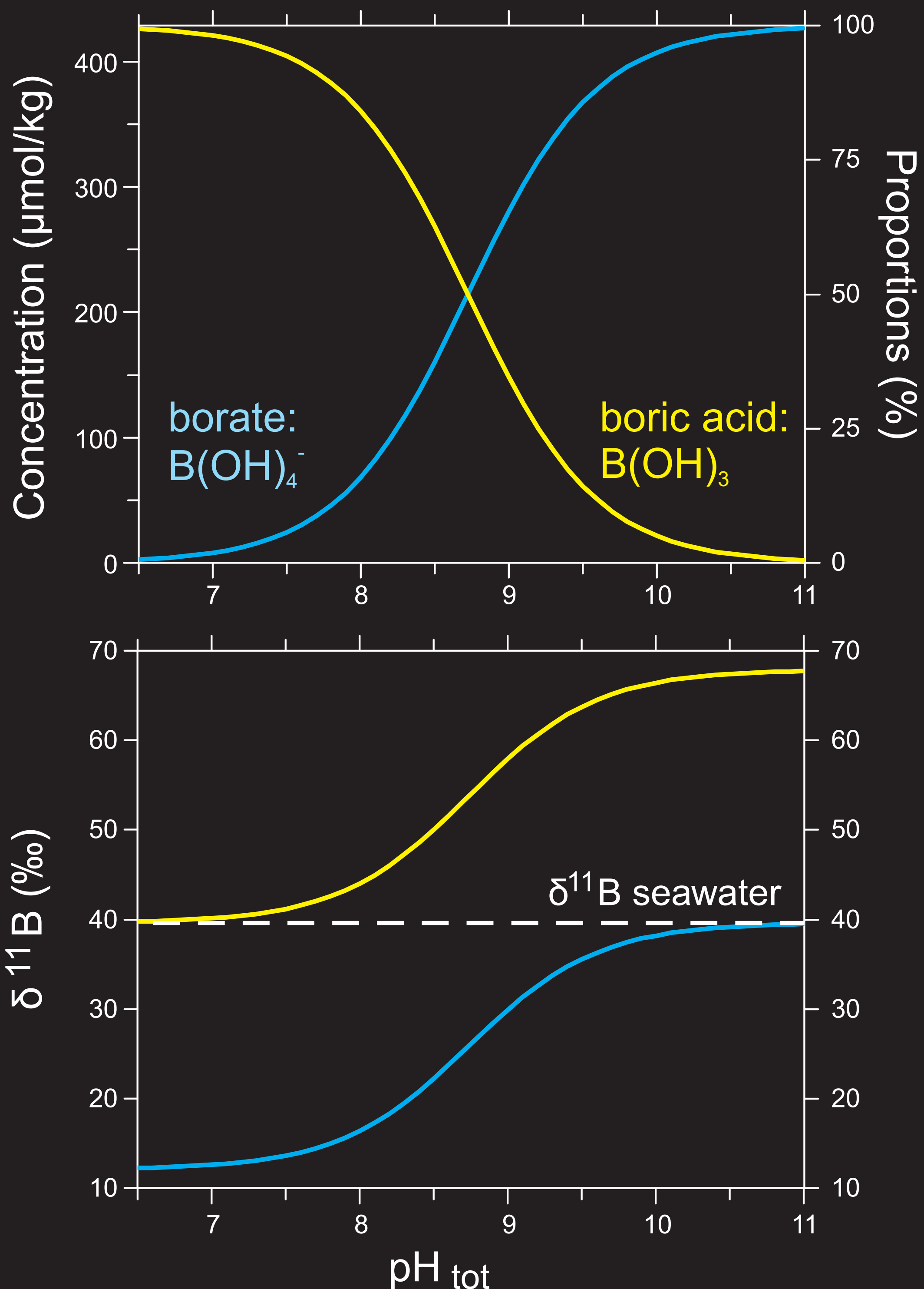
Ying Cui[1]*, Lee R. Kump[1], Andy J. Ridgwell[2], Adam J. Charles[3], Christopher K. Junium[1†], Aaron F. Diefendorf[1†], Katherine H. Freeman[1], Nathan M. Urban[1†] and Ian C. Harding[3]

Boron, isotopes, and paleo pH





Boron, isotopes, and paleo pH



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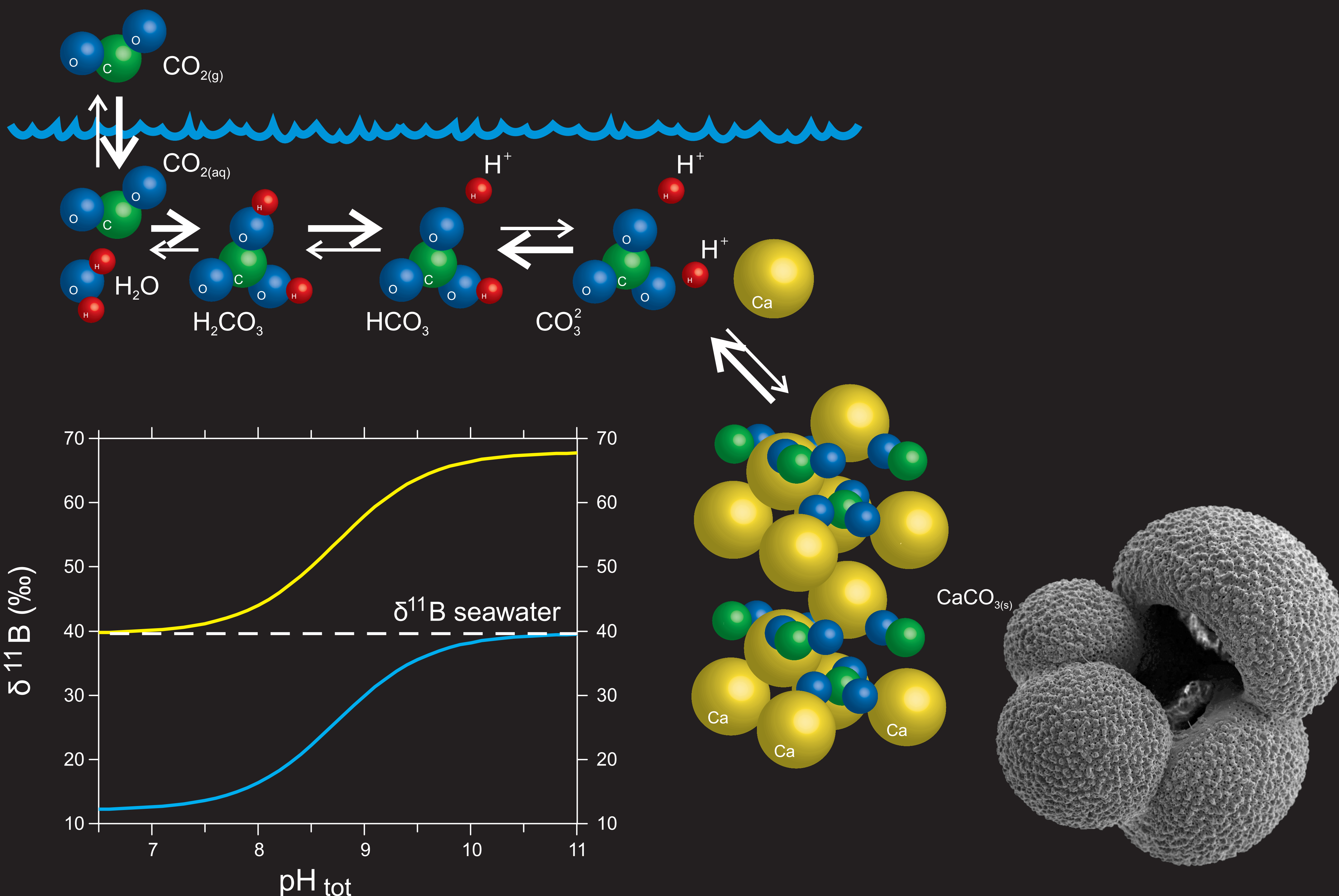
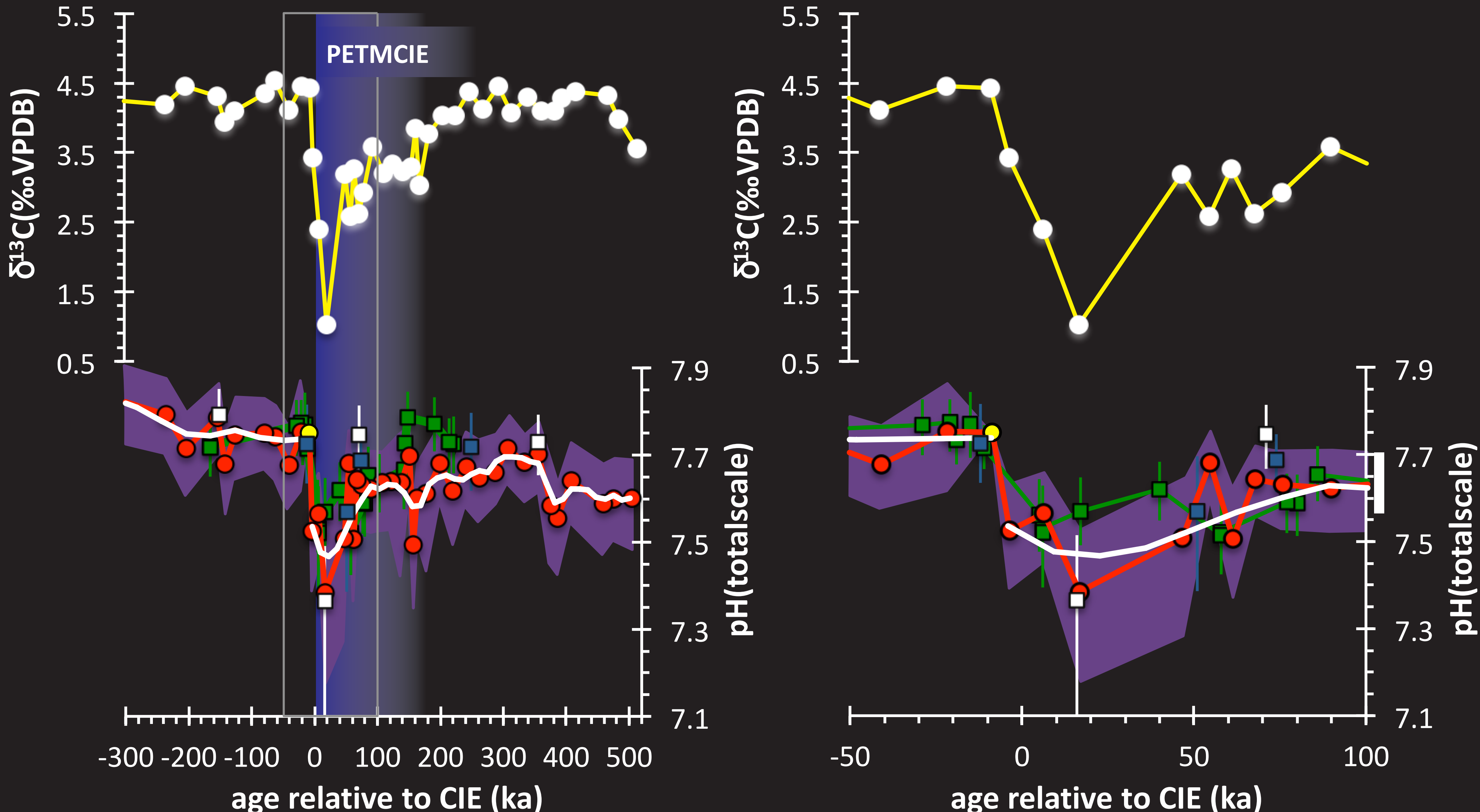


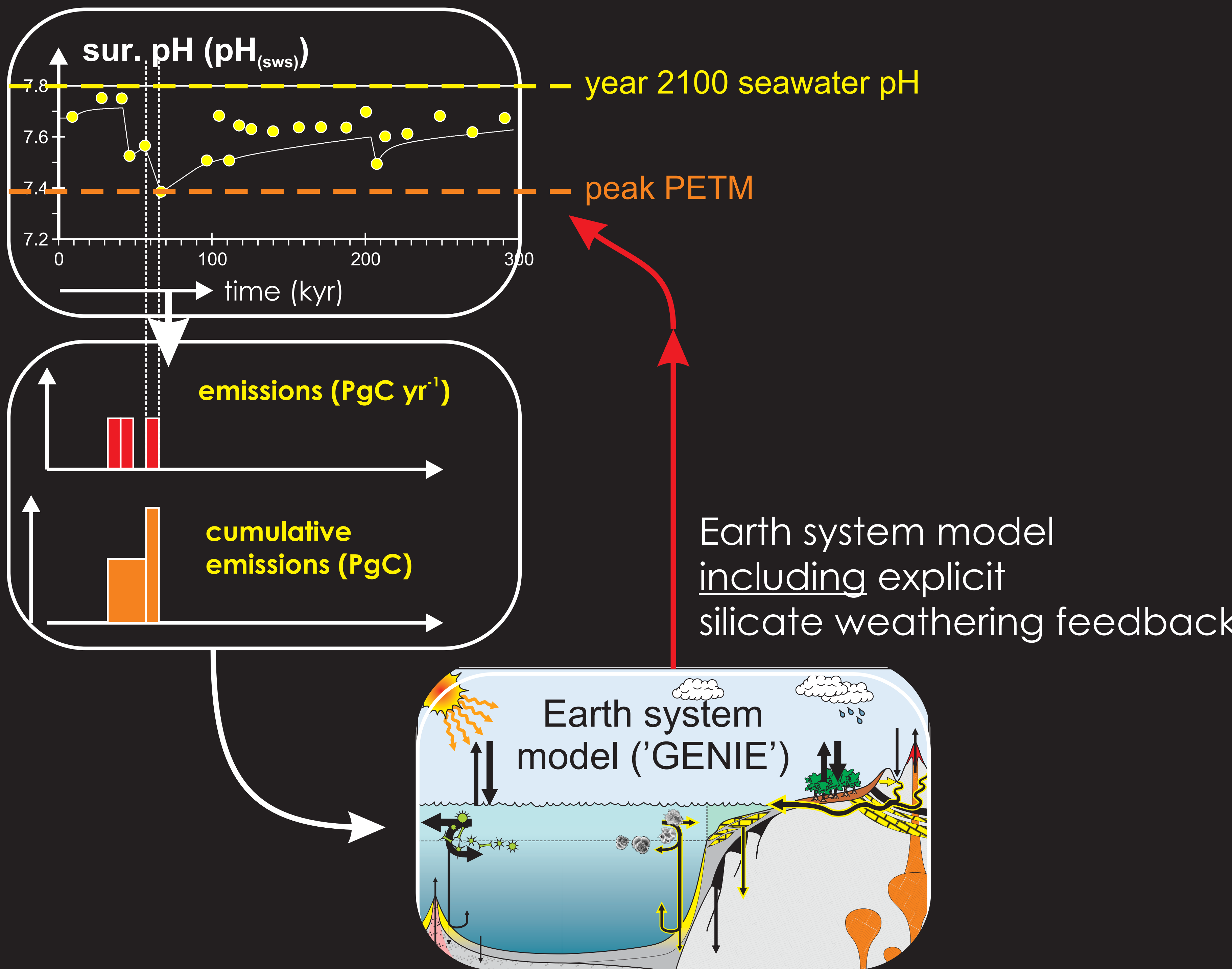
Boron, isotopes, and paleo pH



Site 401 (NE Atlantic) [unpublished]

Site 865 (Eq. Pacific) Site 1263 (ES Atlantic) Site 1209 (N Pacific) [*Penman et al.*, 2014]

Assimilating surface ocean pH change (only)



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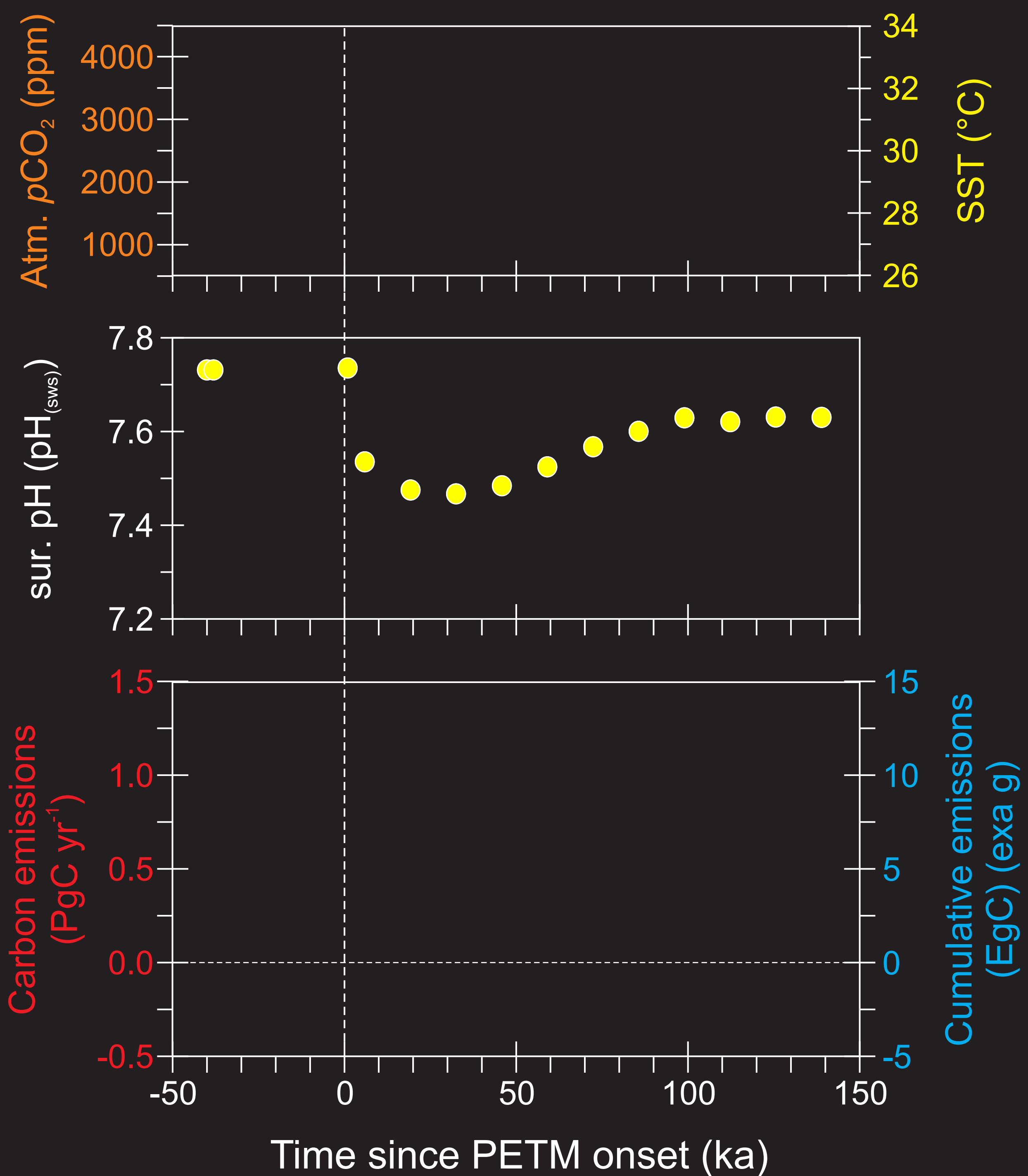

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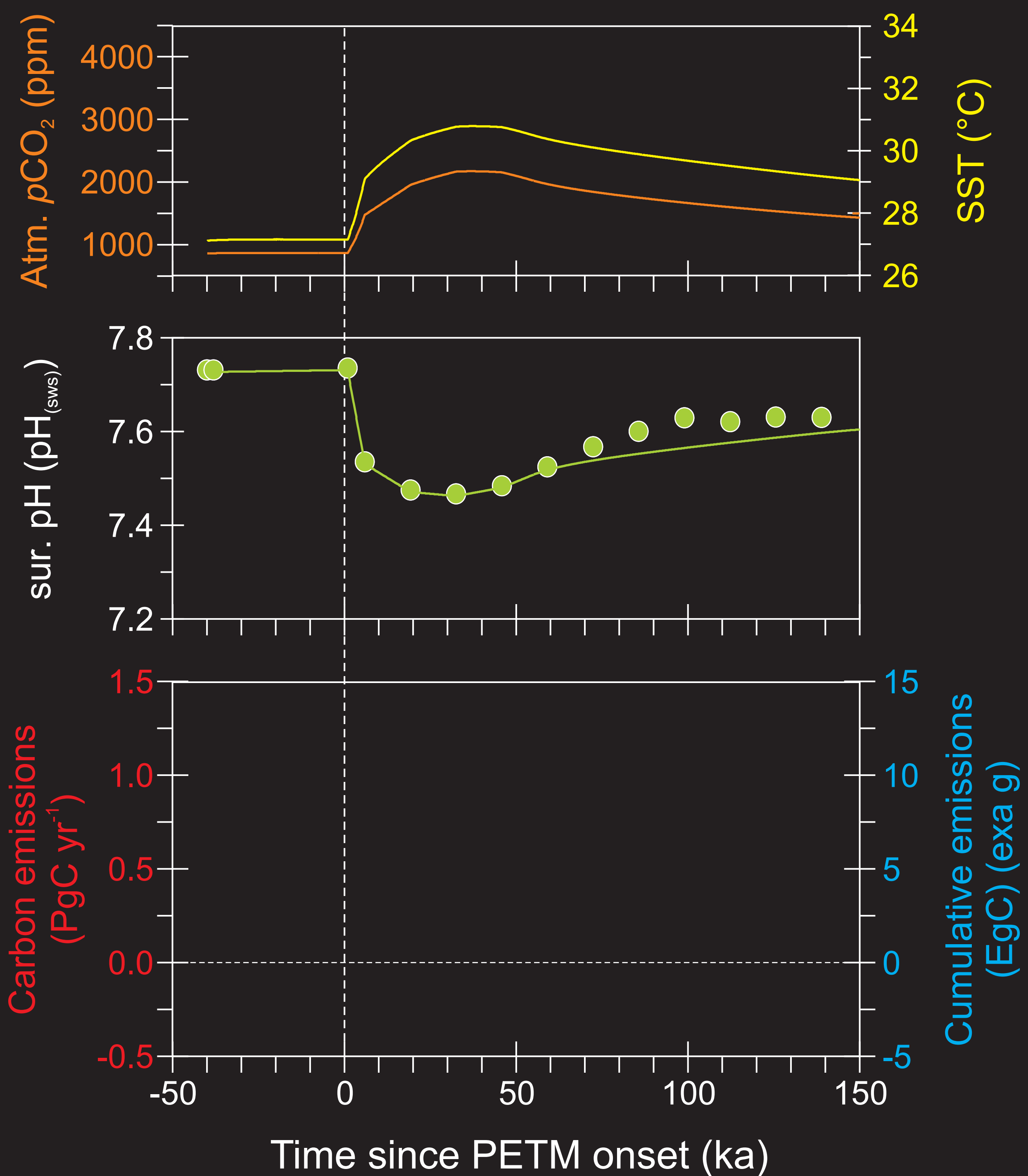

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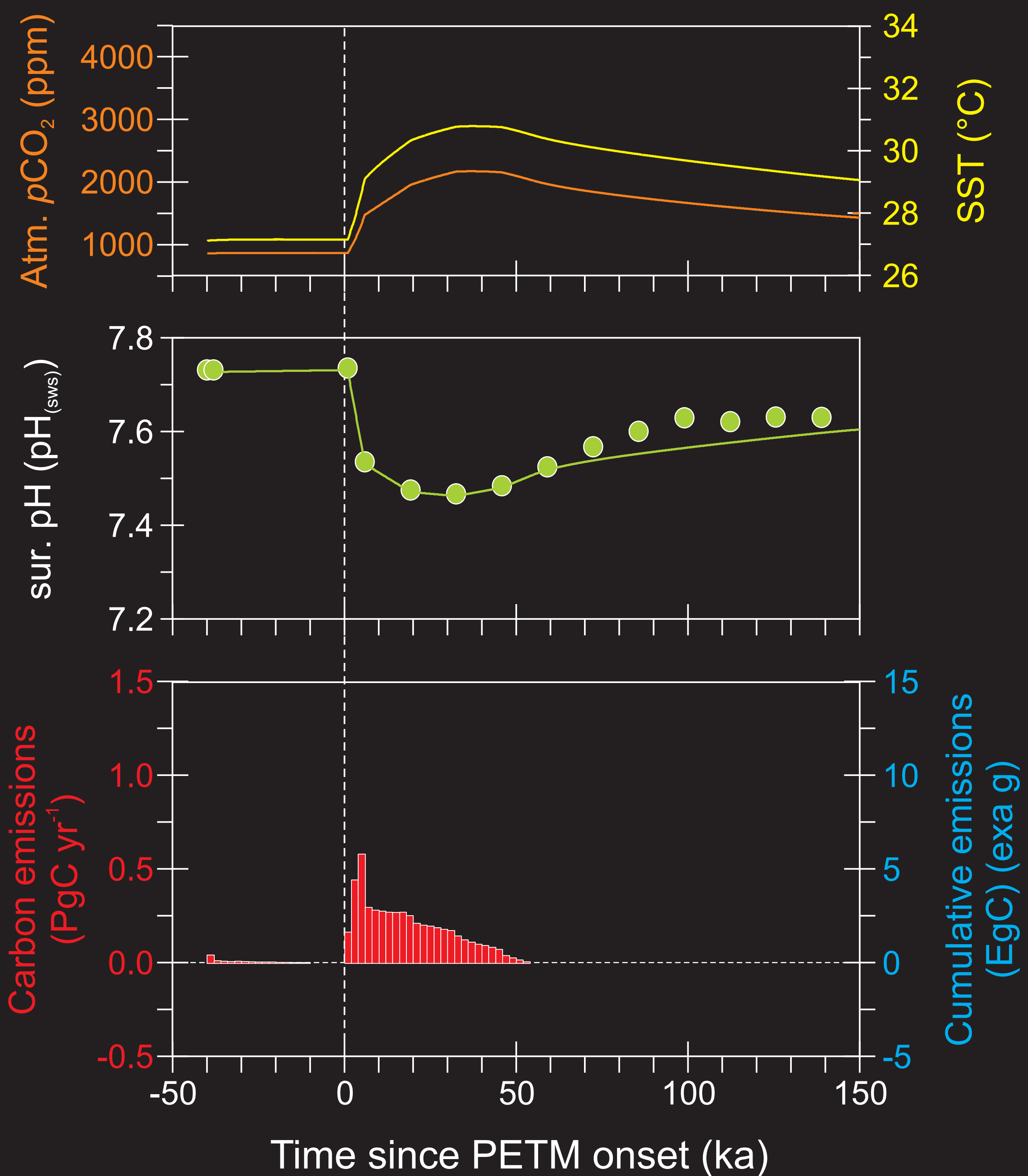

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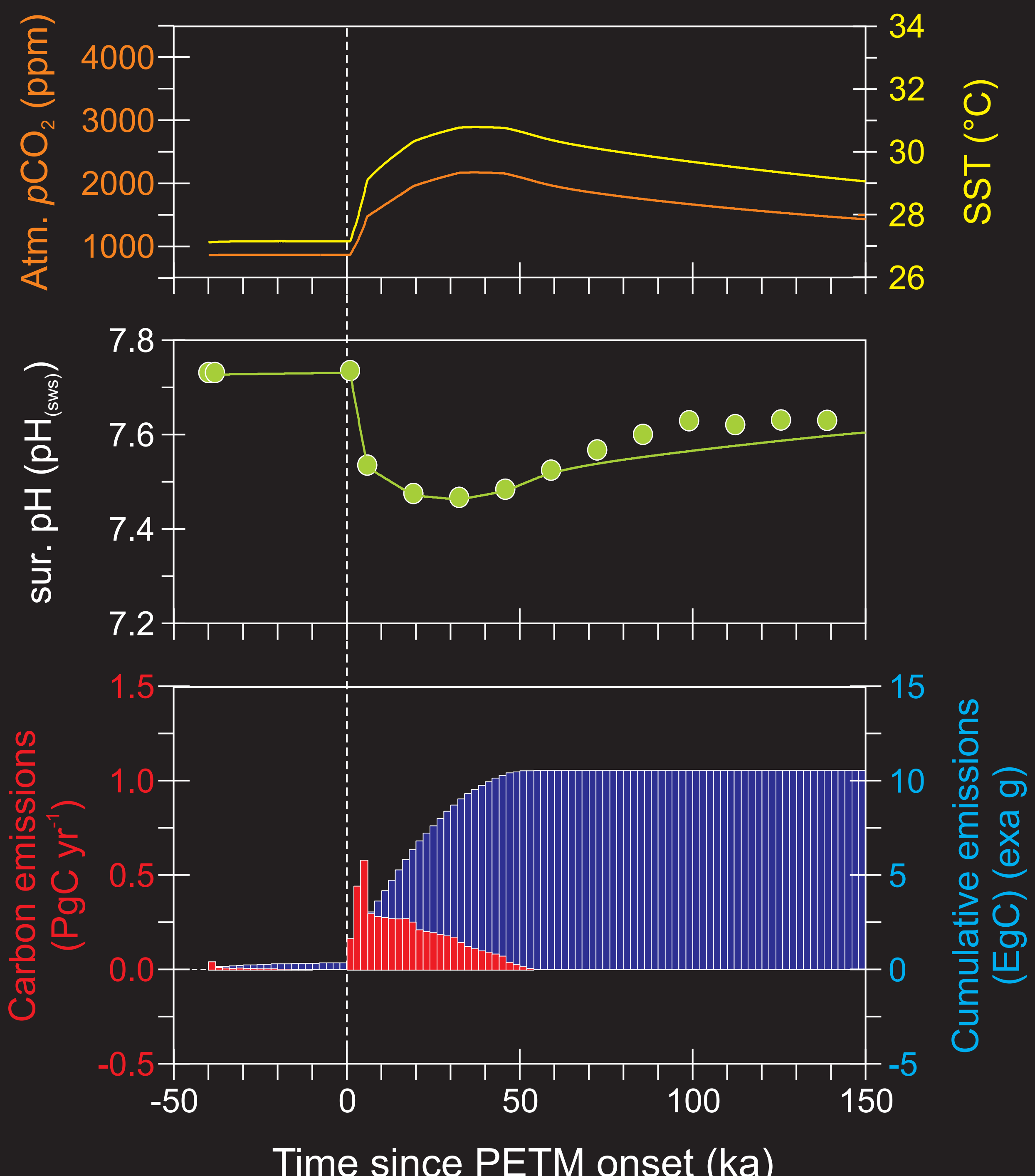

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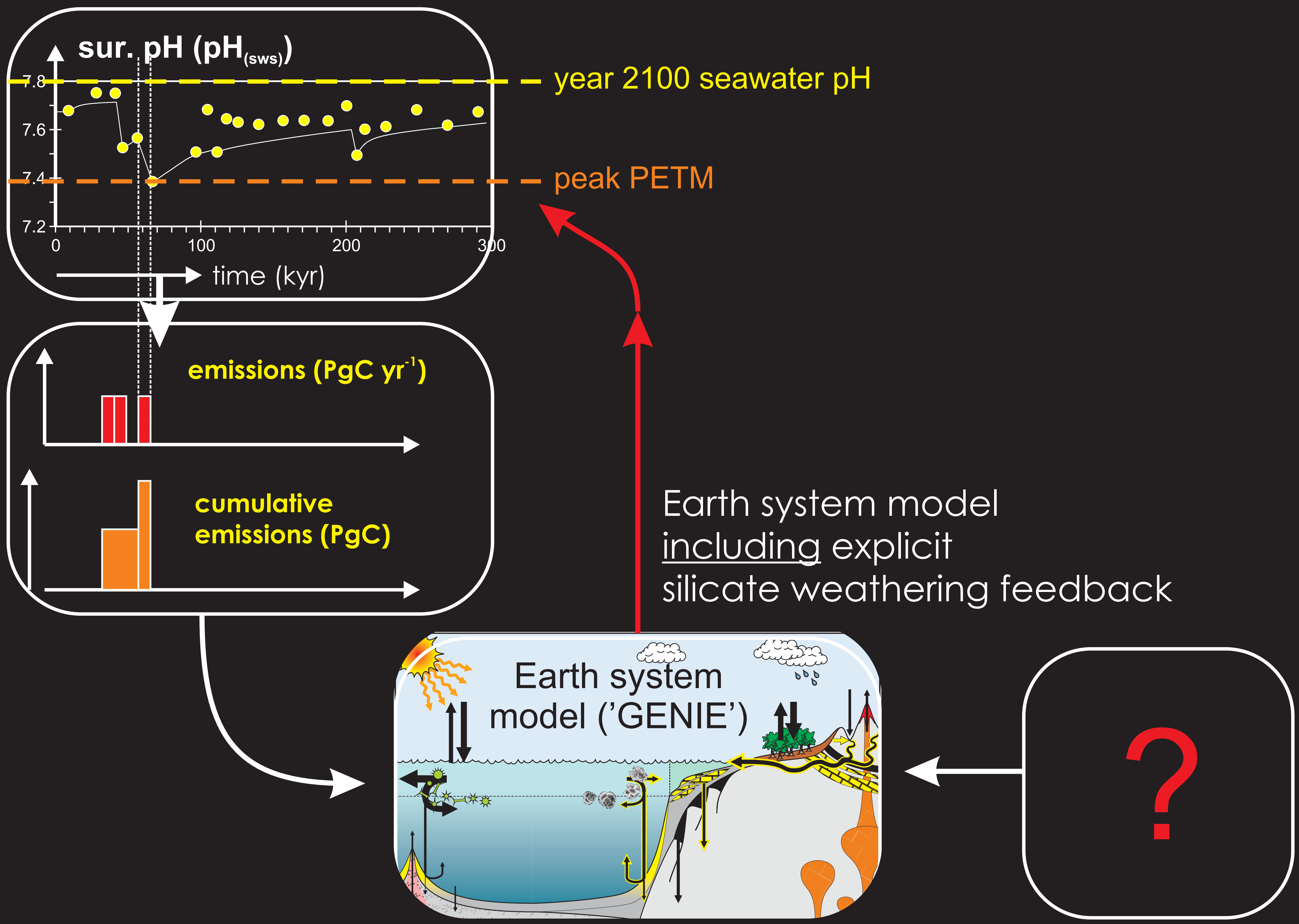
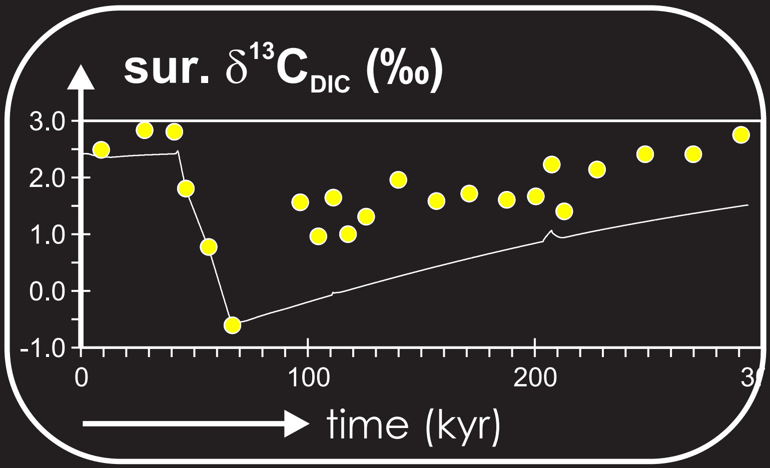


Assimilating surface ocean pH and $\delta^{13}C$



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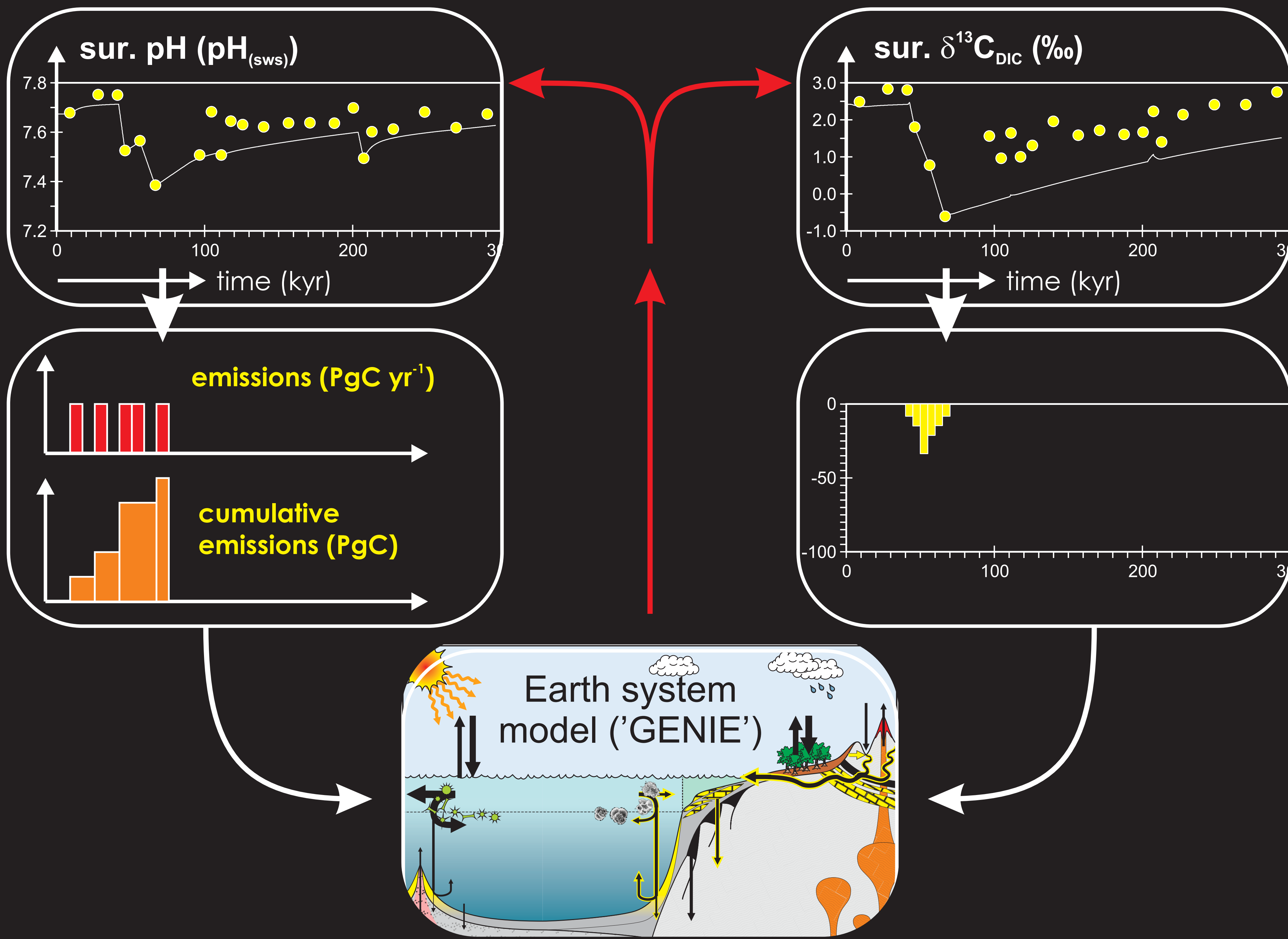

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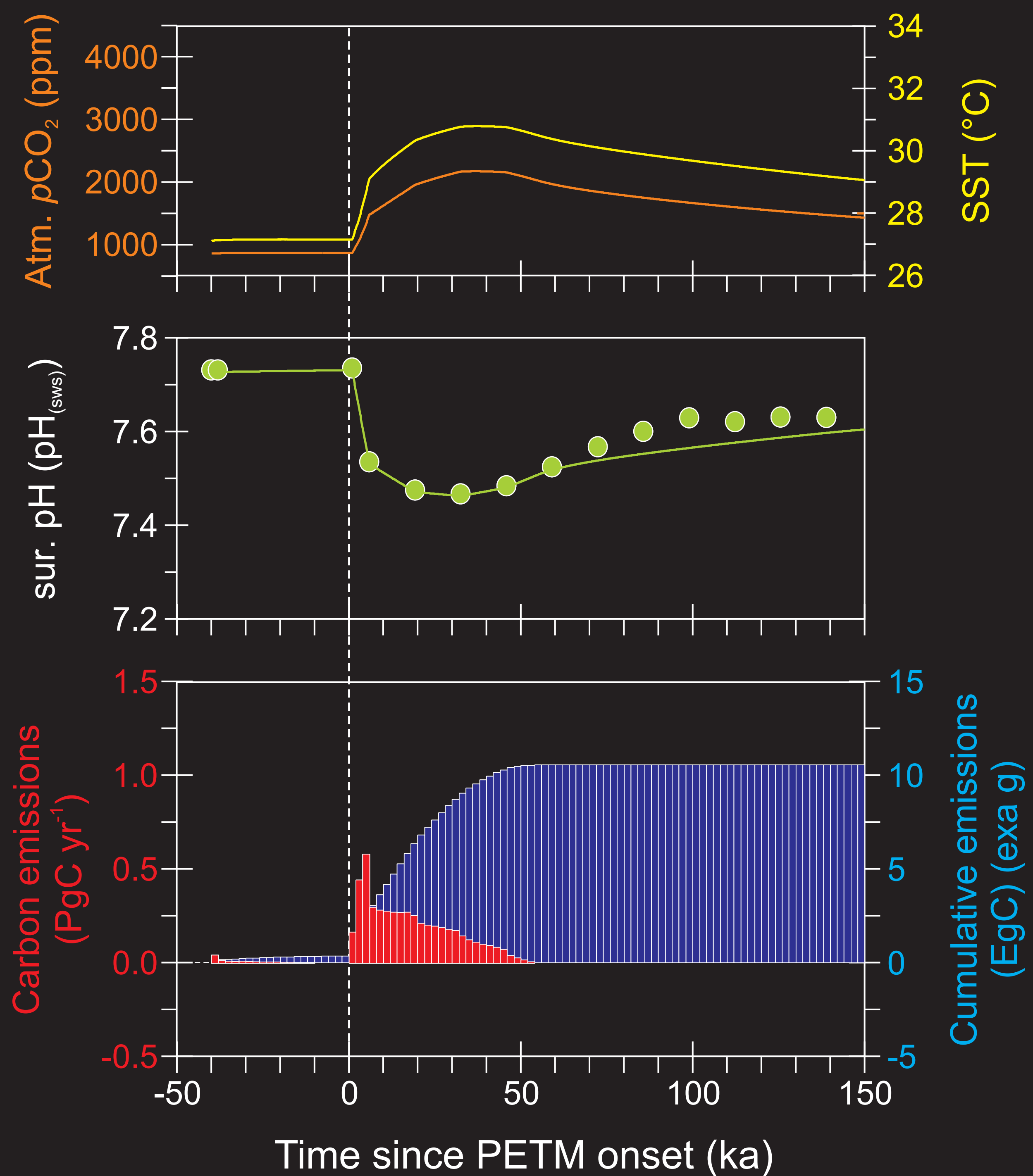
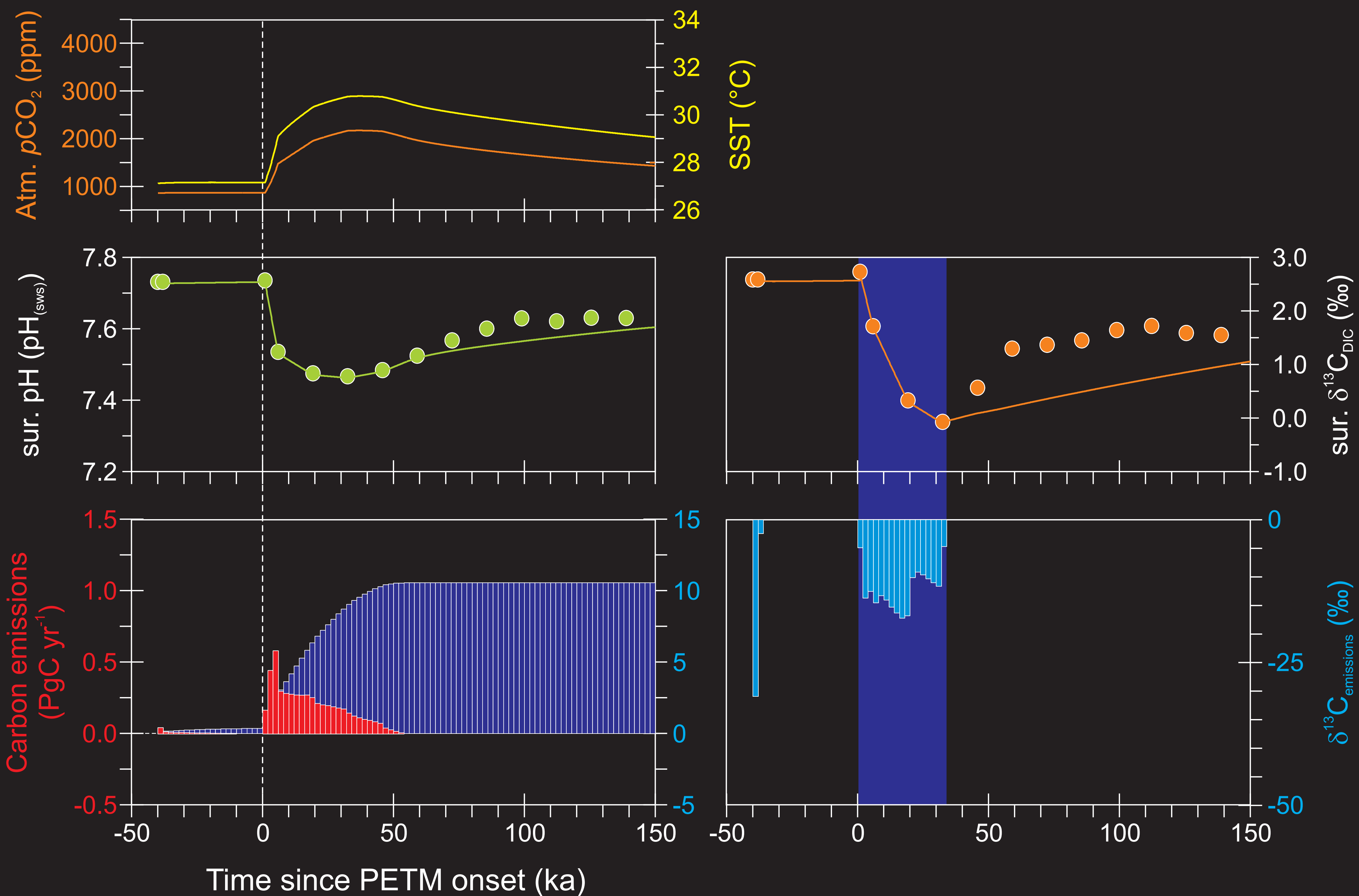


Assimilating surface ocean pH <u>and</u> $\delta^{13}C$



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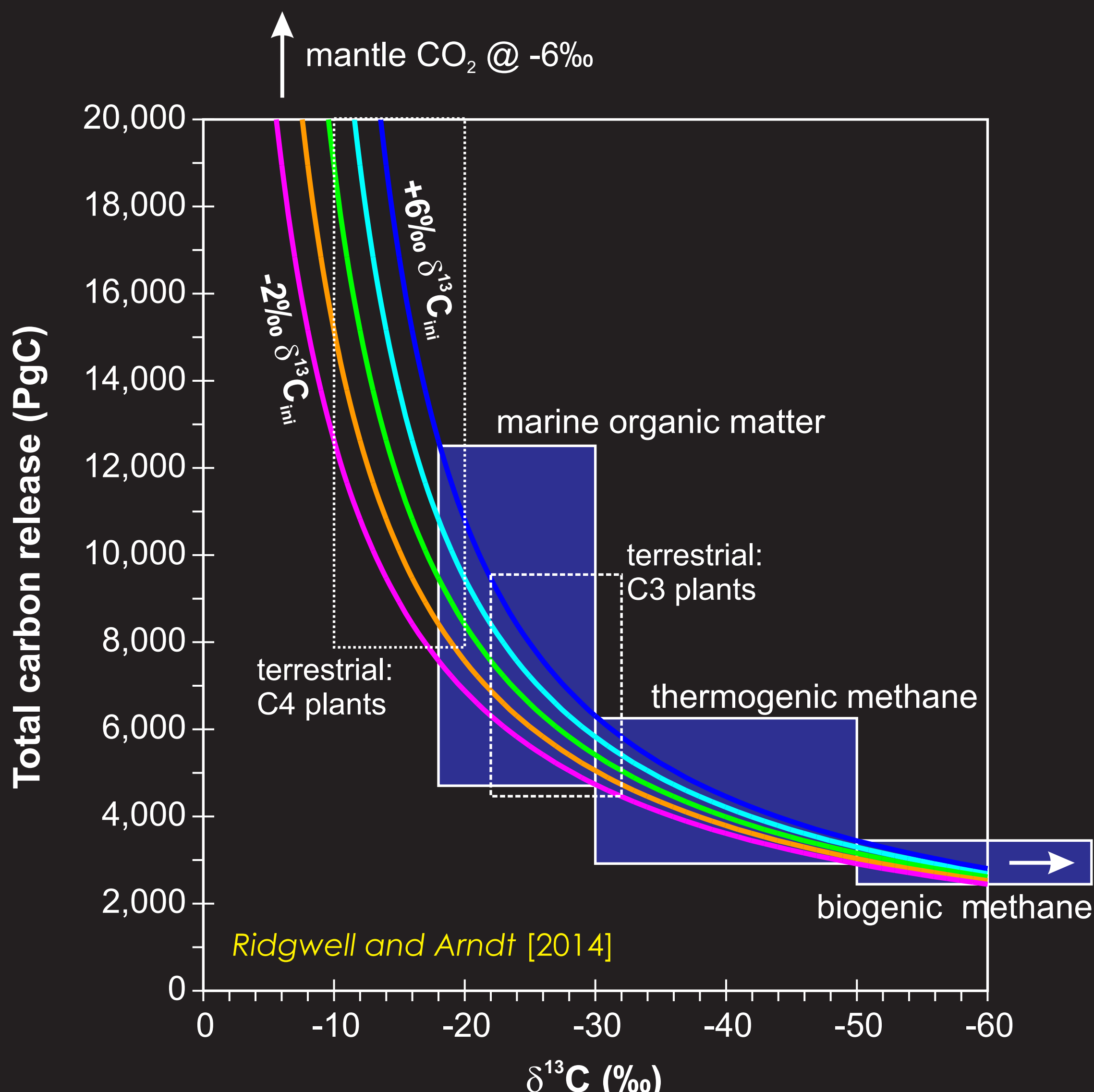

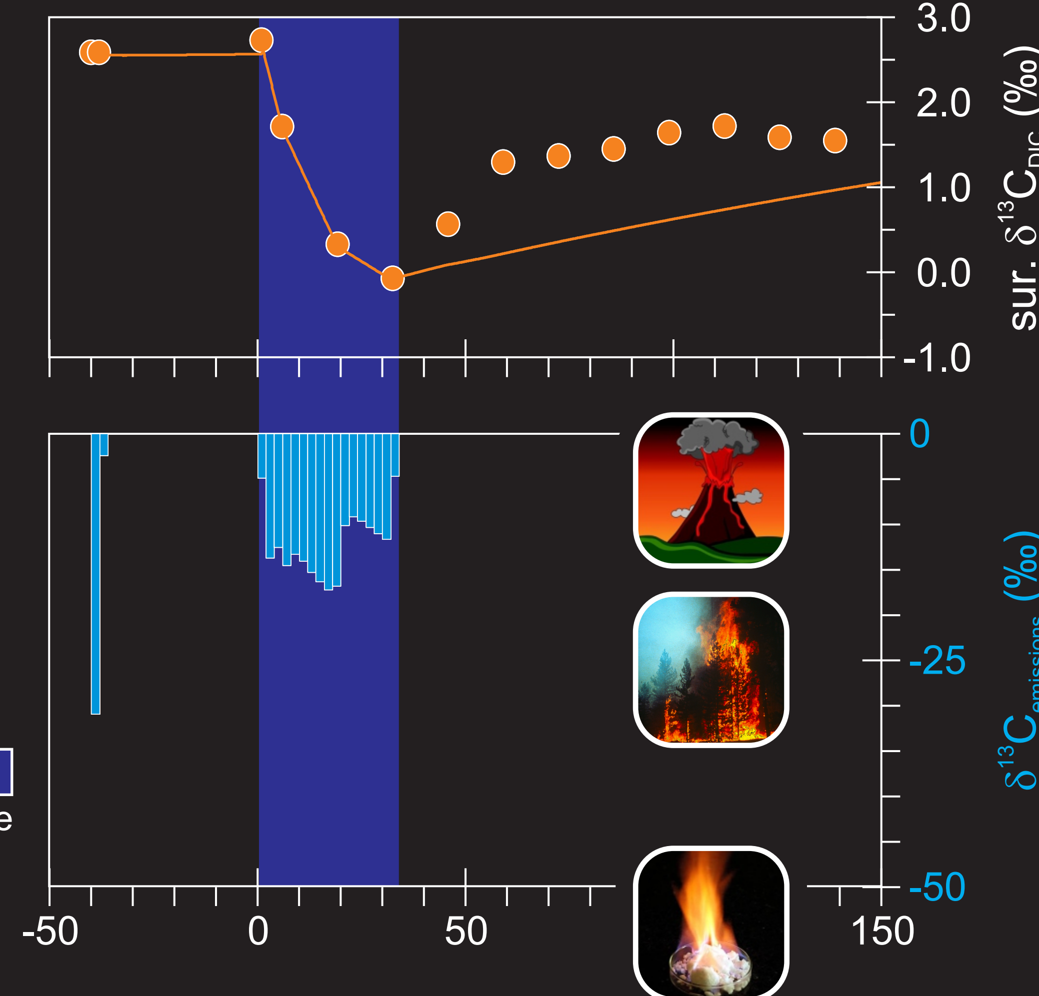

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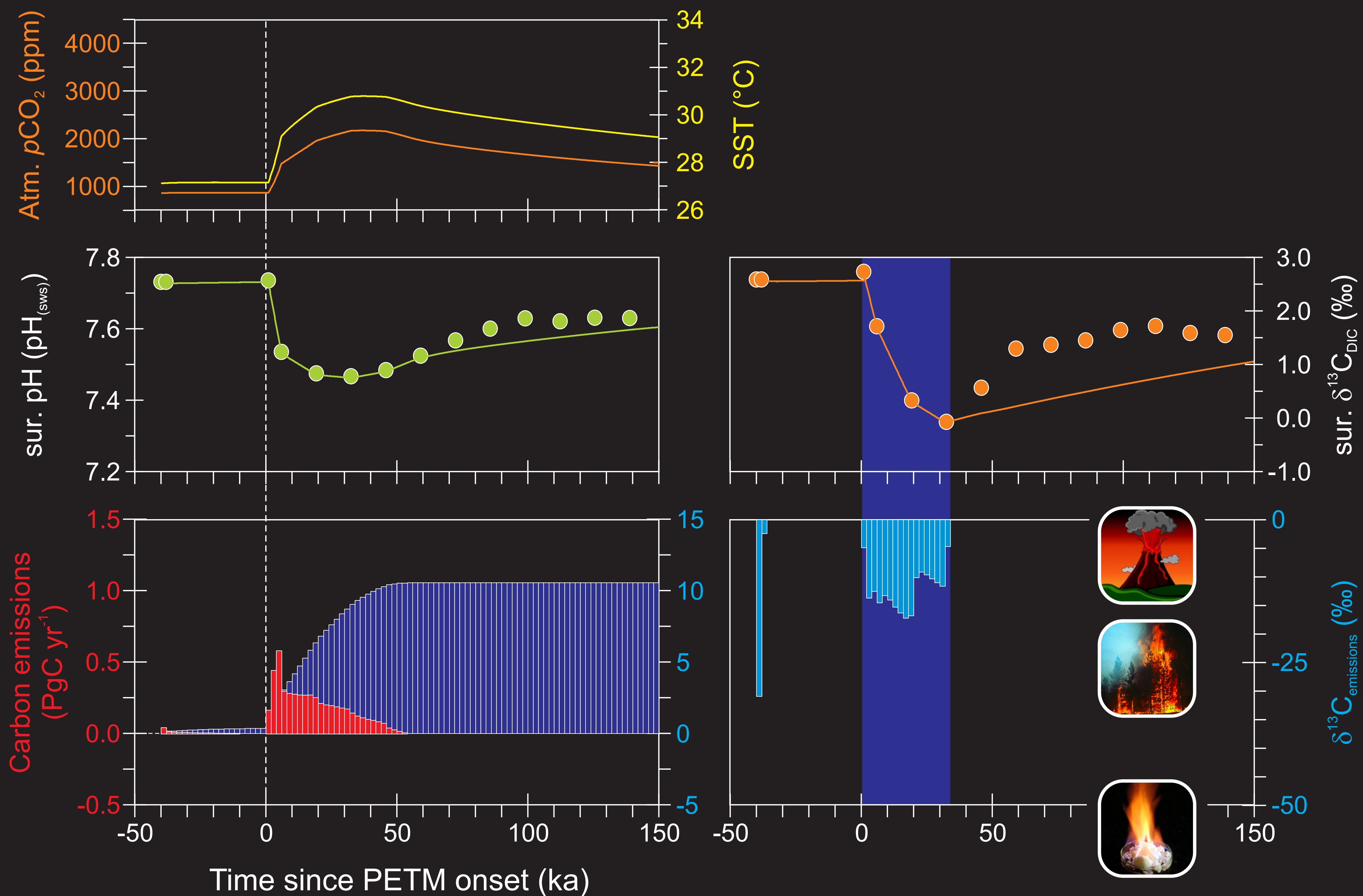
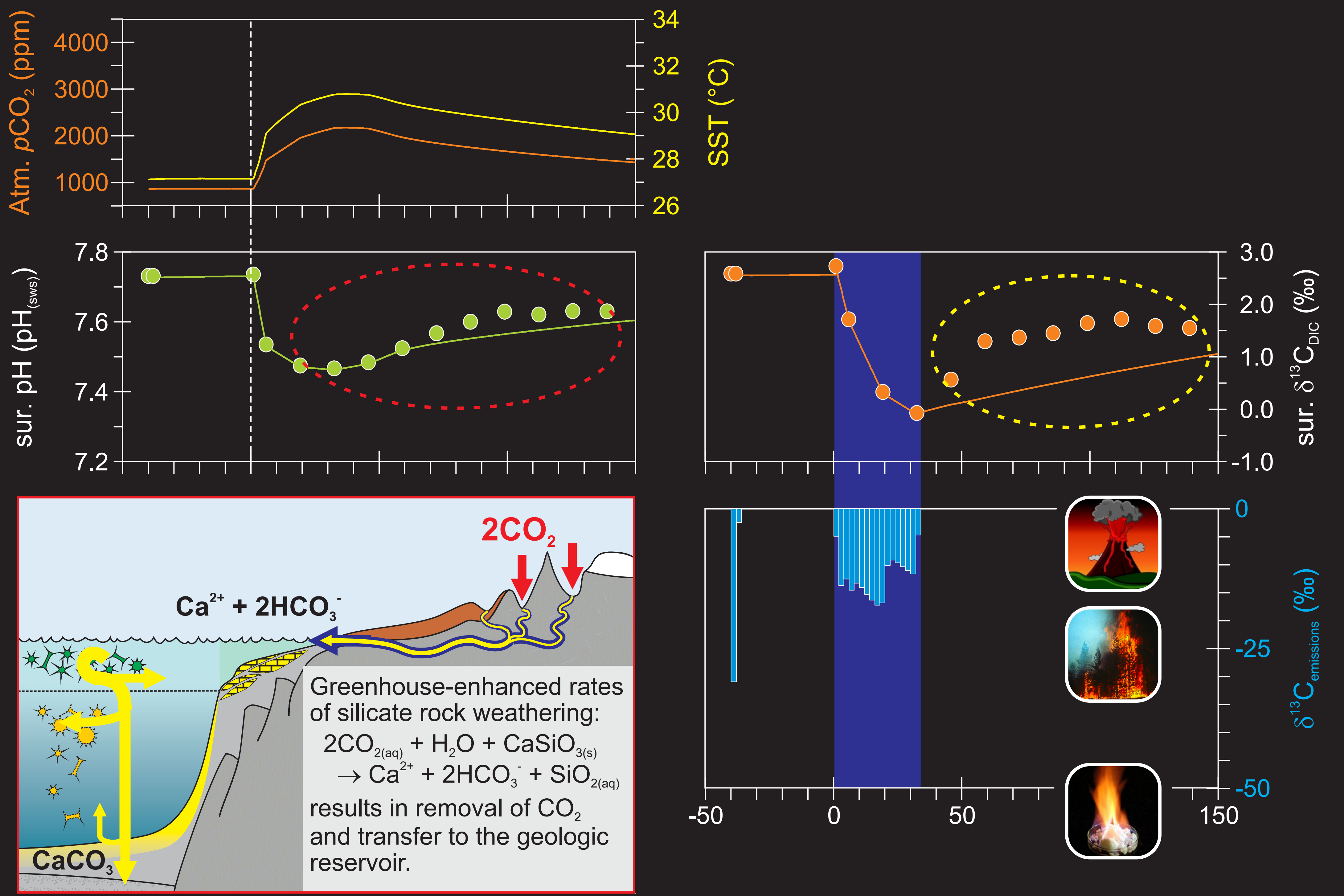


Assimilating surface ocean pH and δ13C



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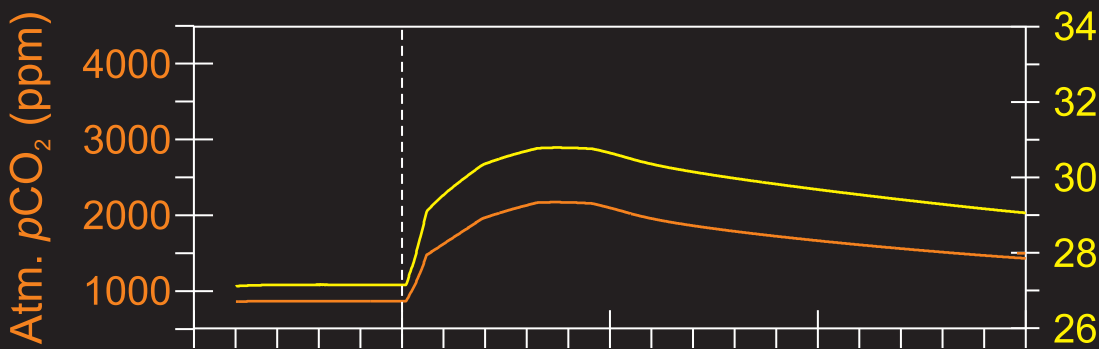
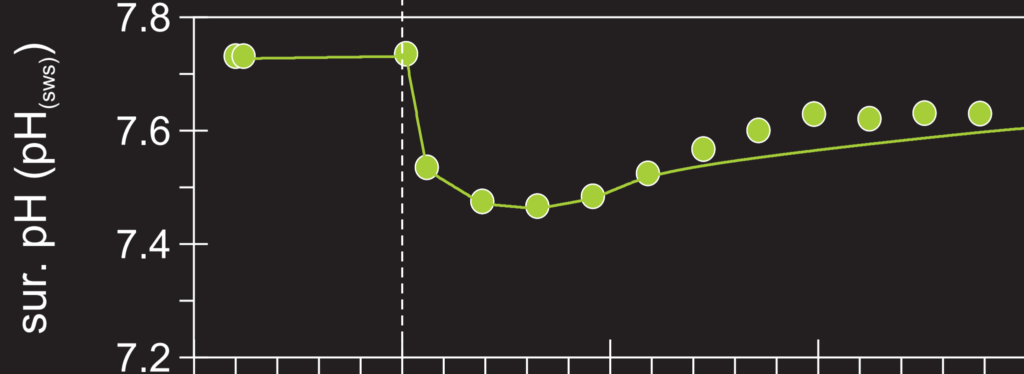
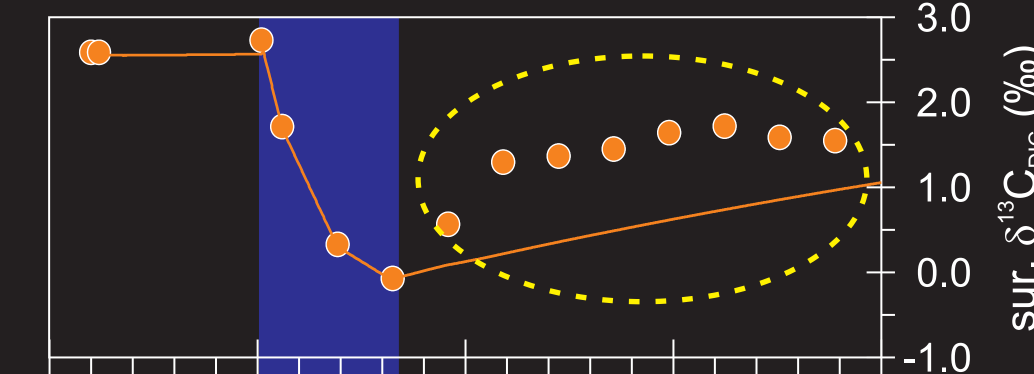
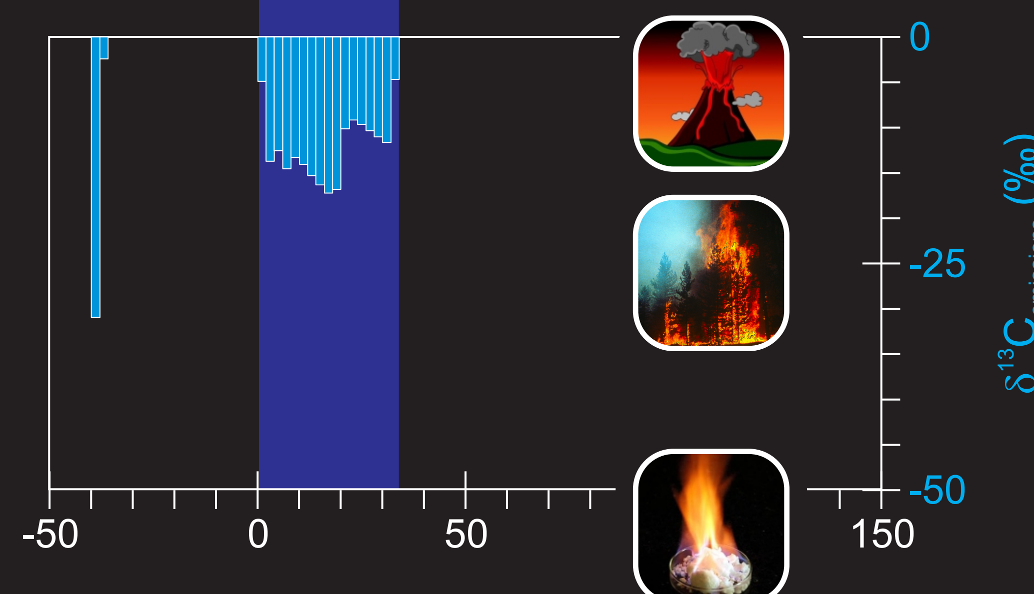


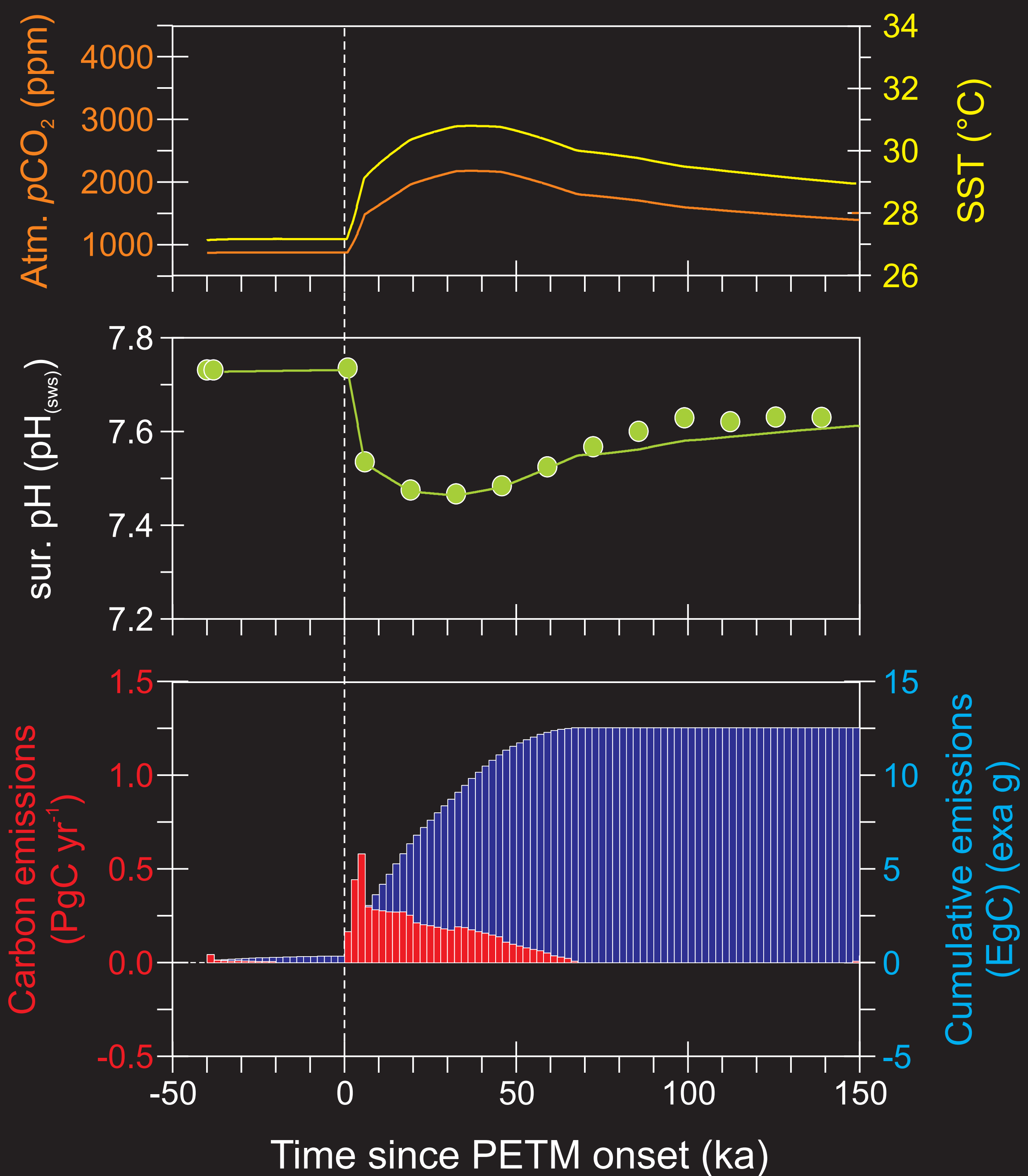




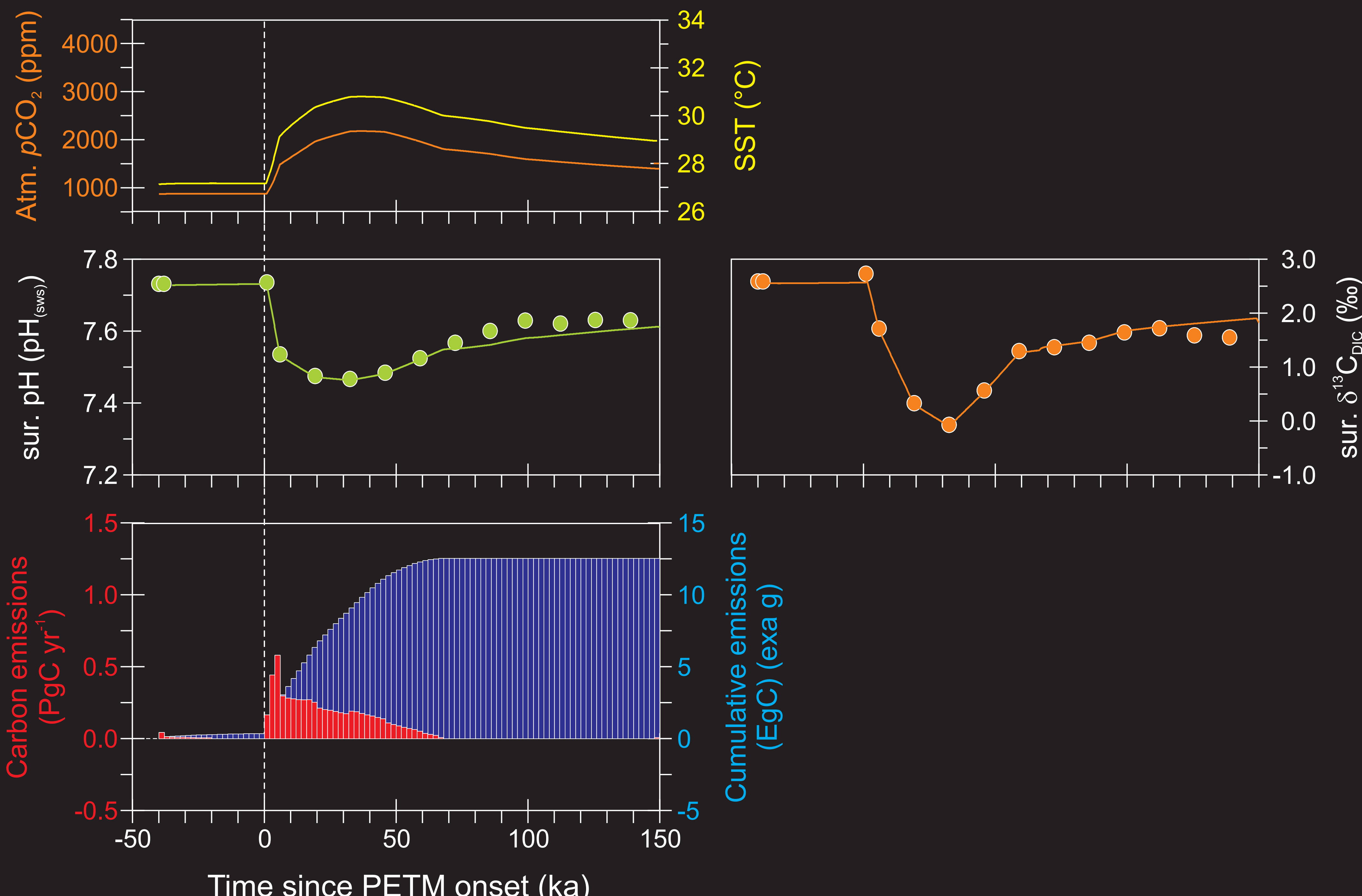
organic carbon preservation



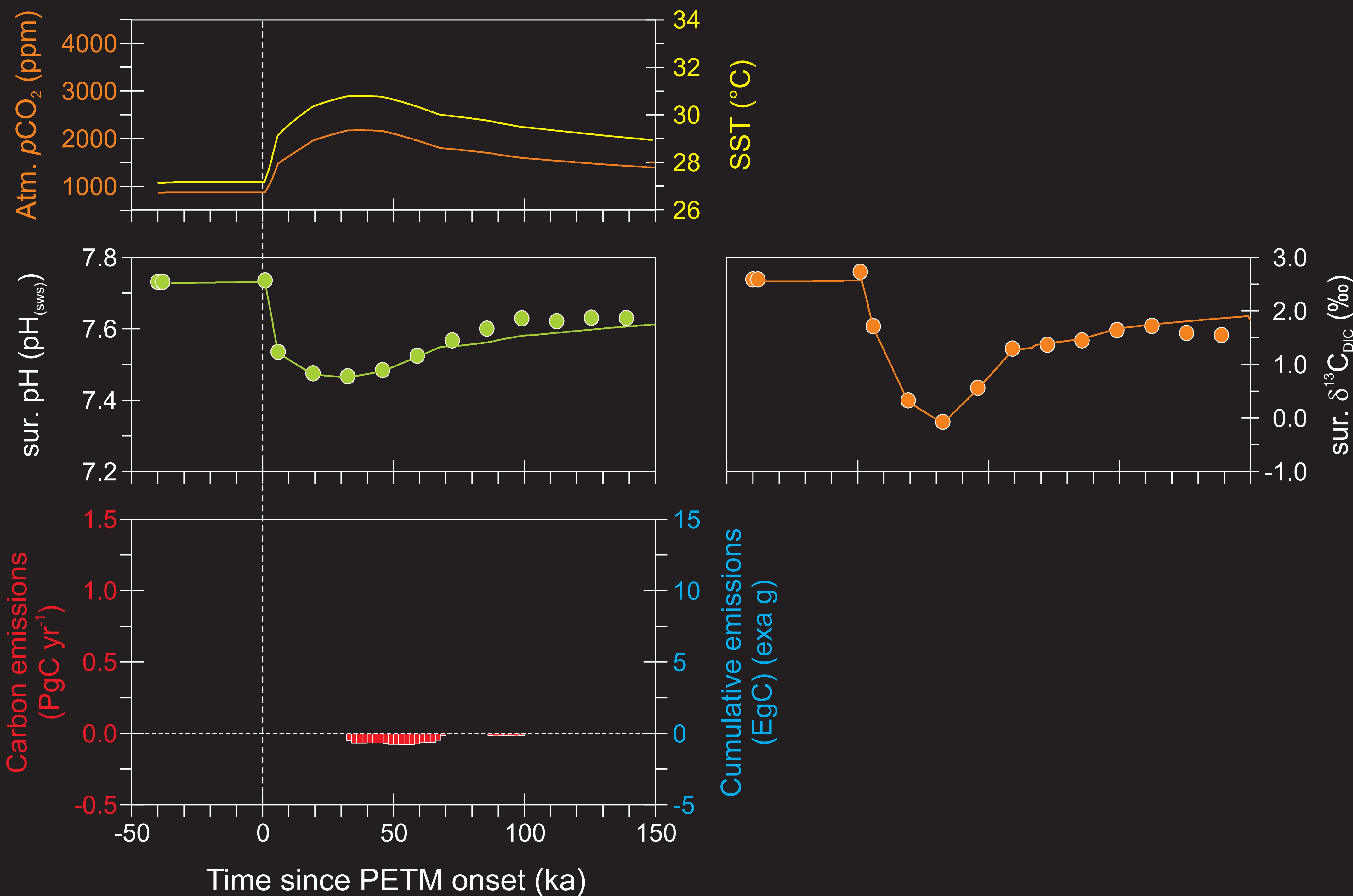
Assimilating surface ocean pH and $\delta^{13}C$



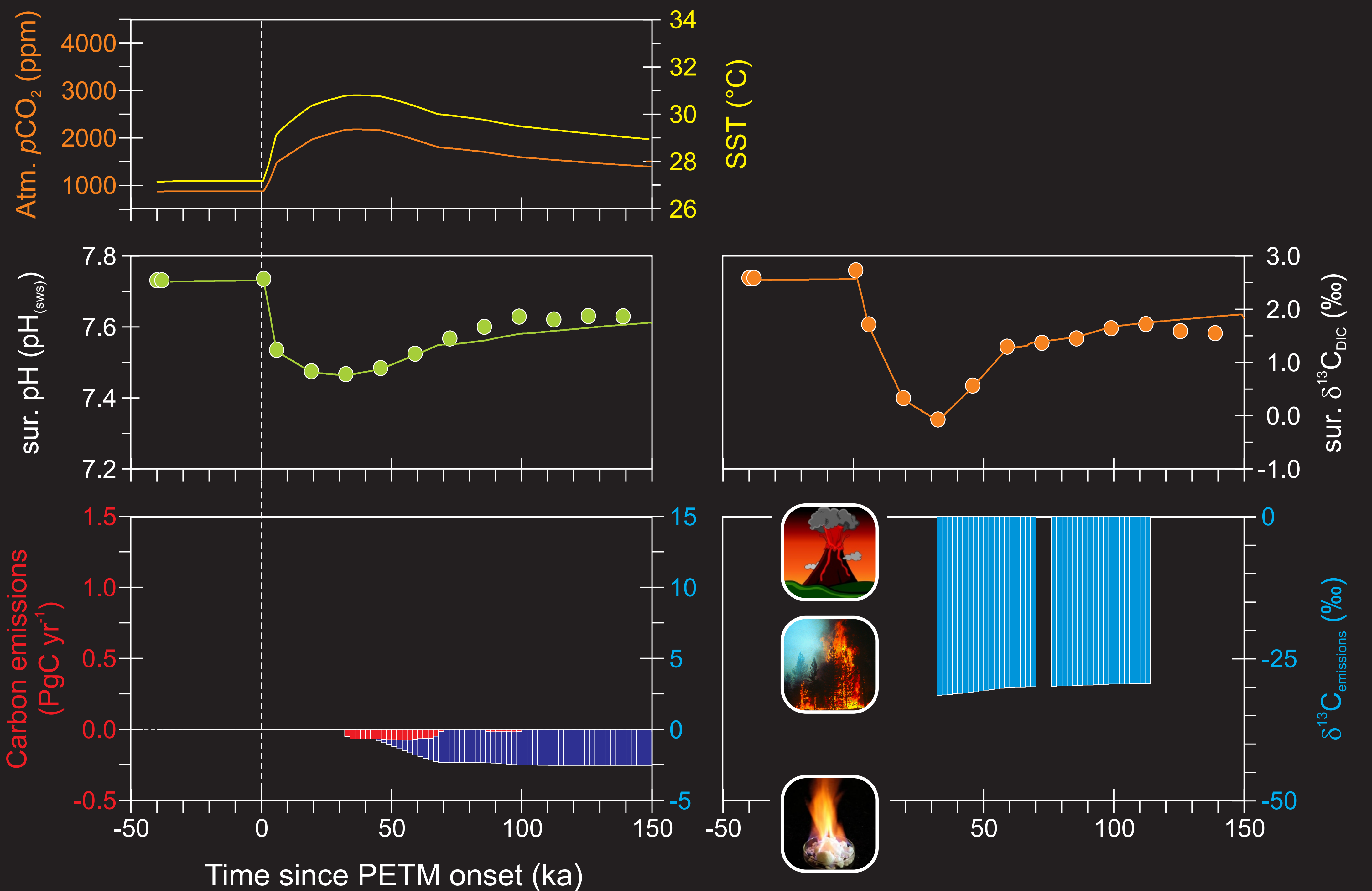
Assimilating surface ocean pH and $\delta^{13}C$



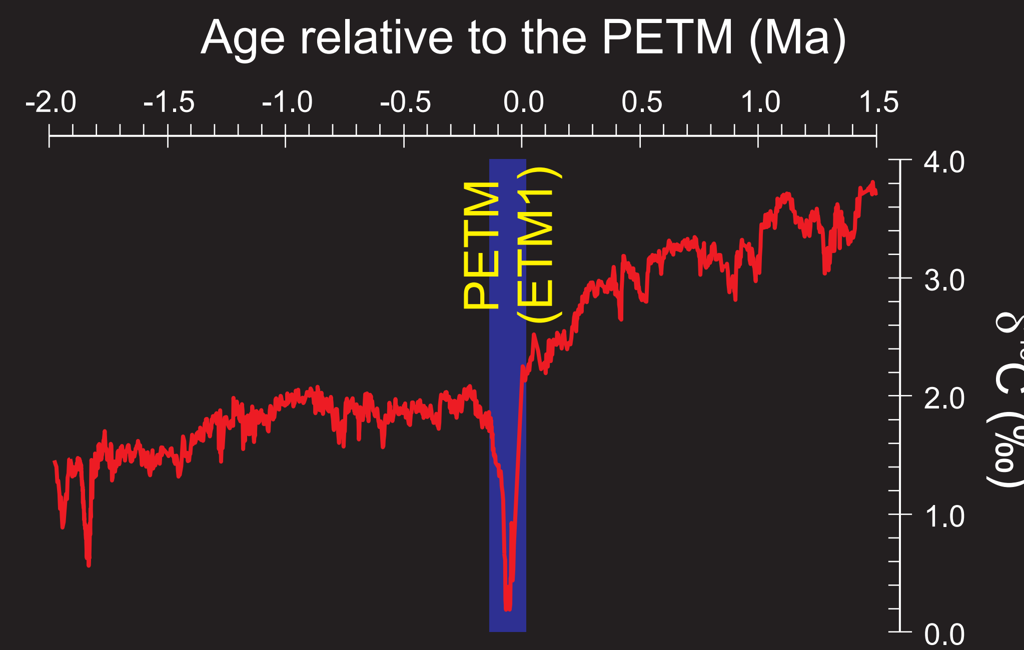
Assimilating surface ocean pH <u>and</u> $\delta^{13}C$



Assimilating surface ocean pH and δ^{13}C

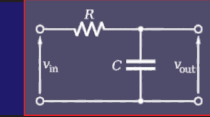


Decoding the marine geological record

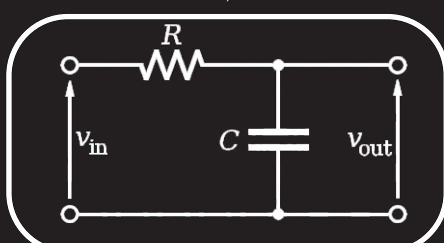


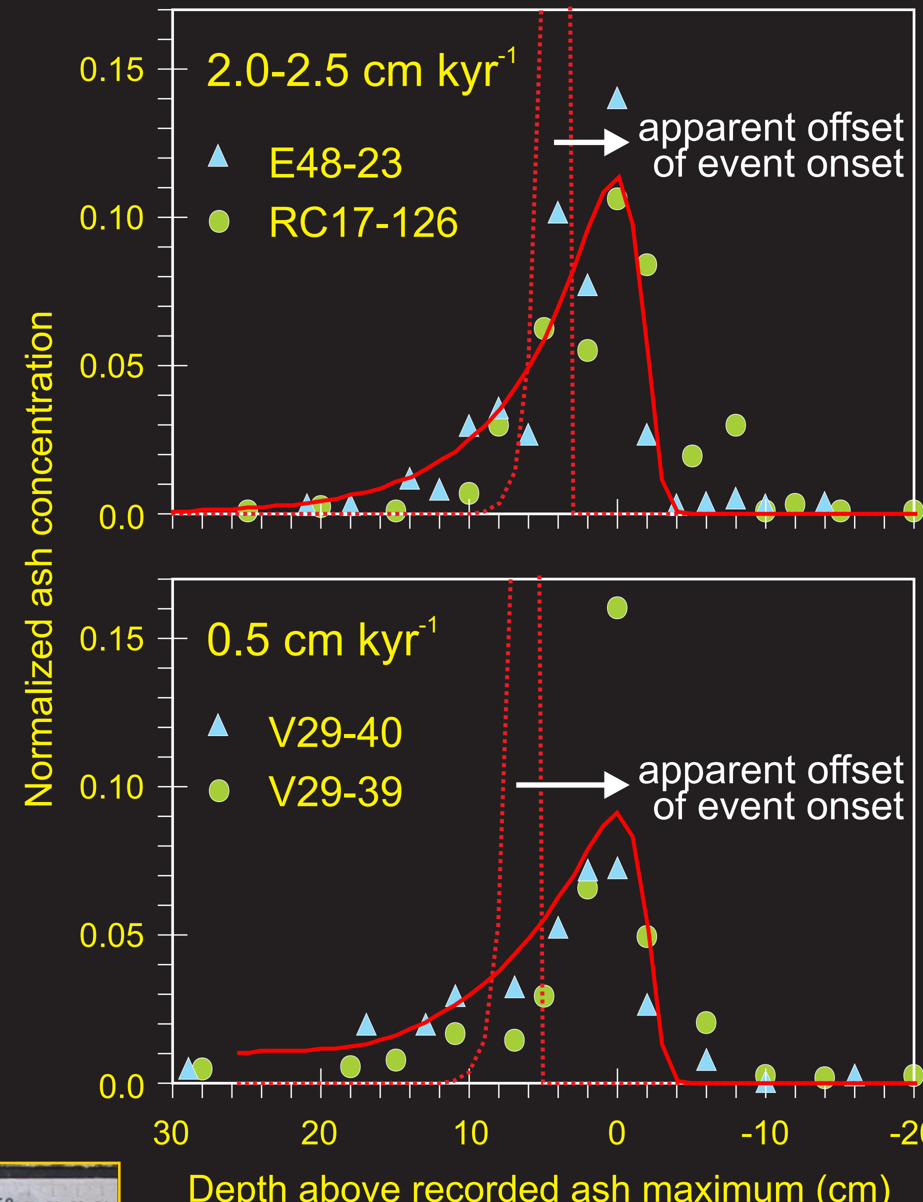
How much carbon?
(=> infer climate,
ecosystem sensitivity etc.)

Decoding the marine geological record

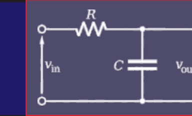


mixing
(bioturbation)

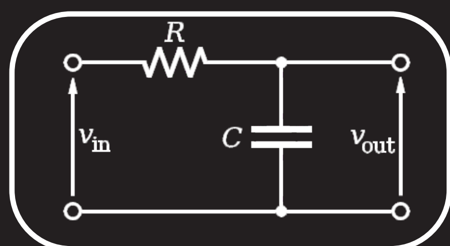




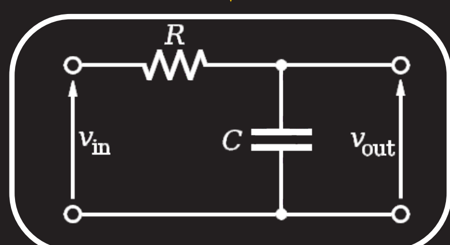
Decoding the marine geological record



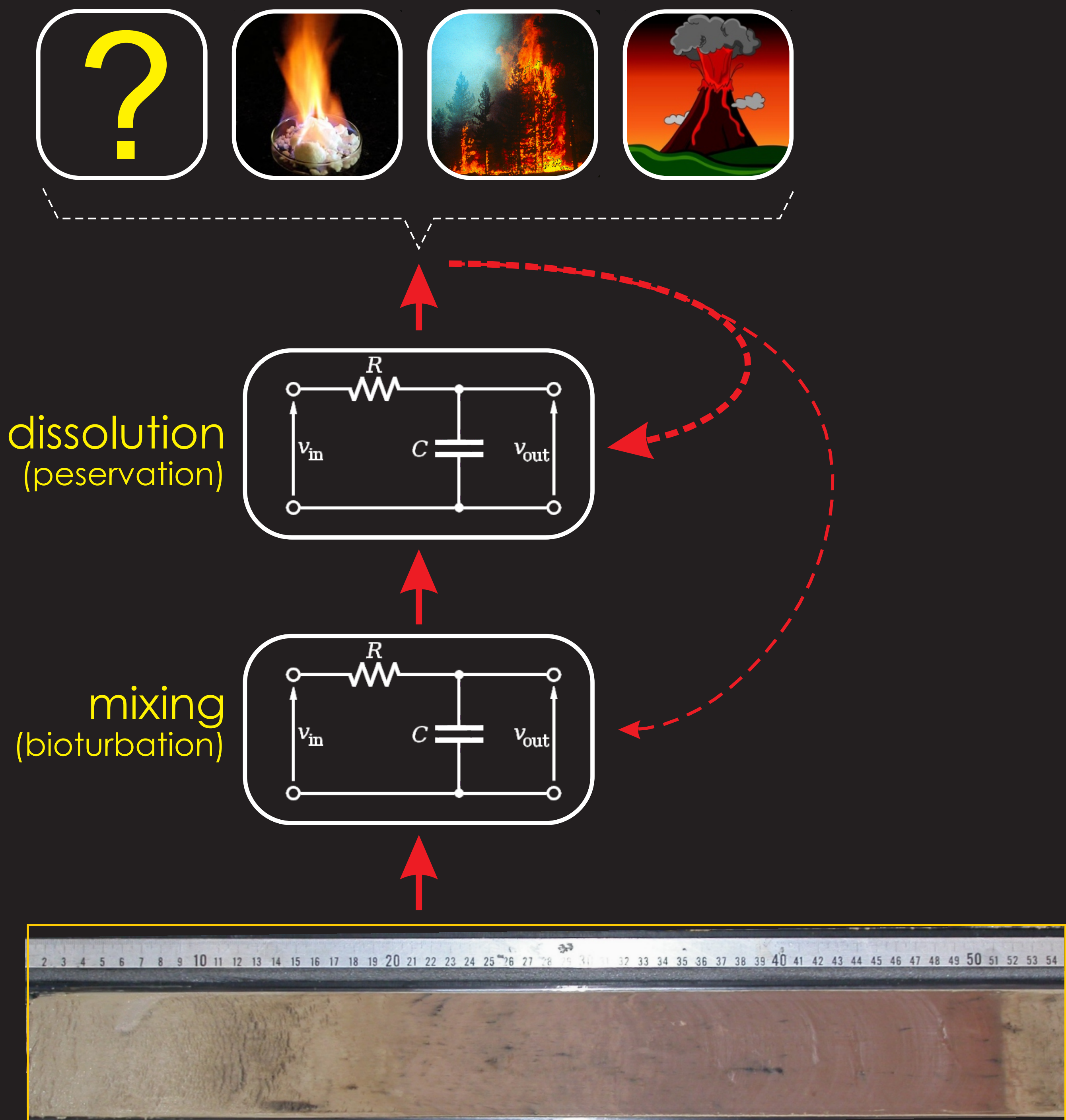
dissolution
(peservation)



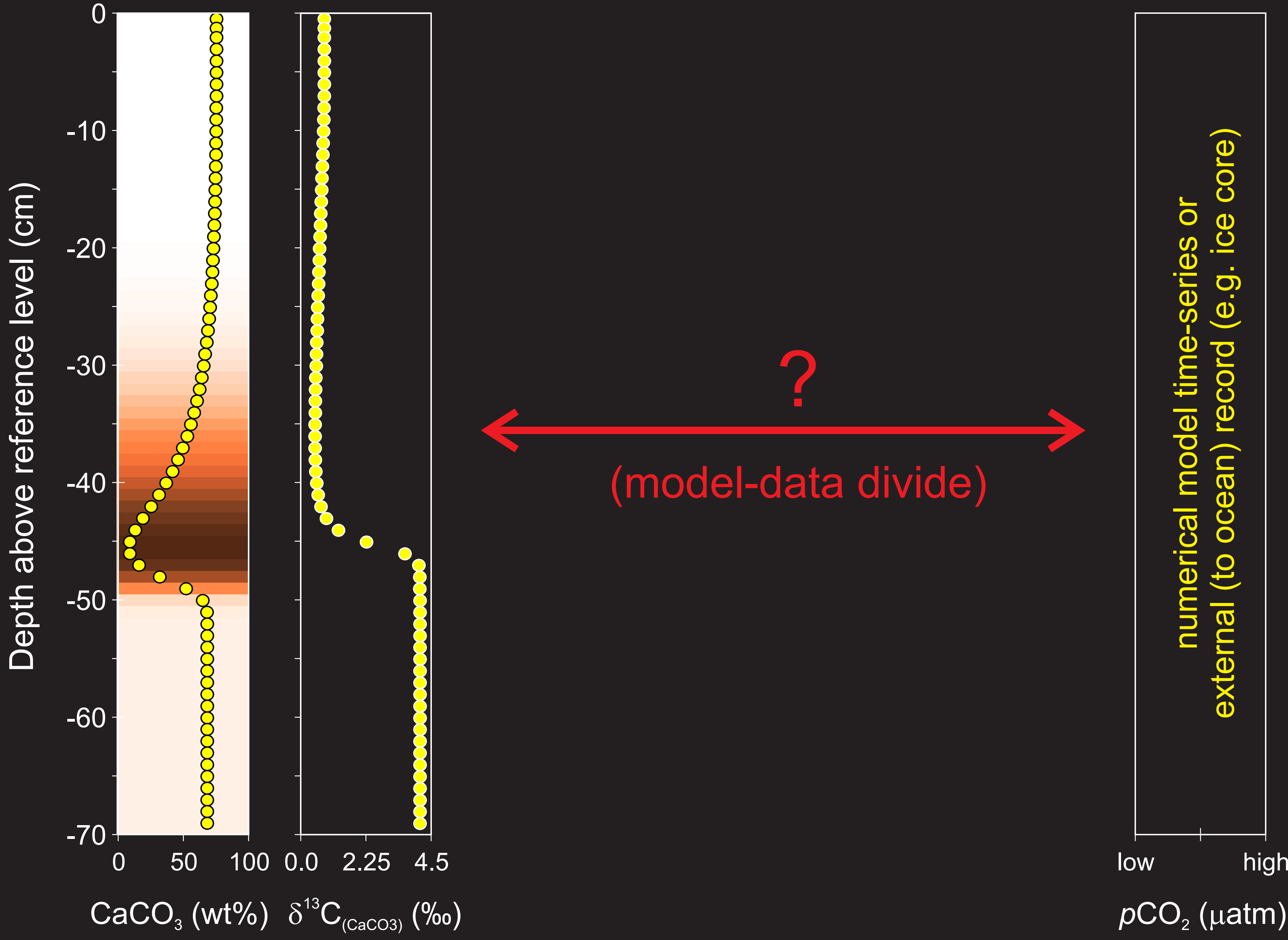
mixing
(bioturbation)



Decoding the marine geological record



Decoding the marine geological record



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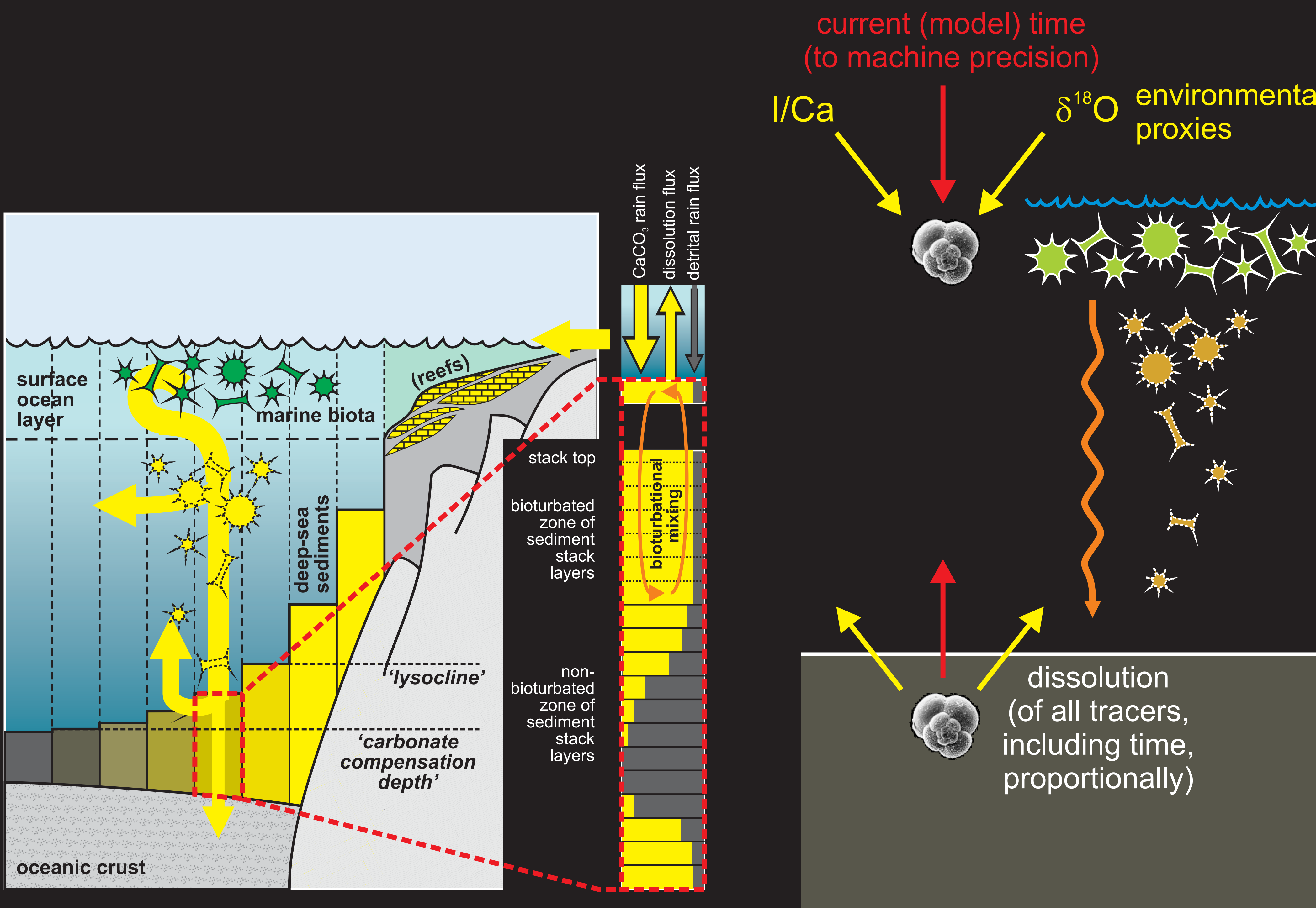
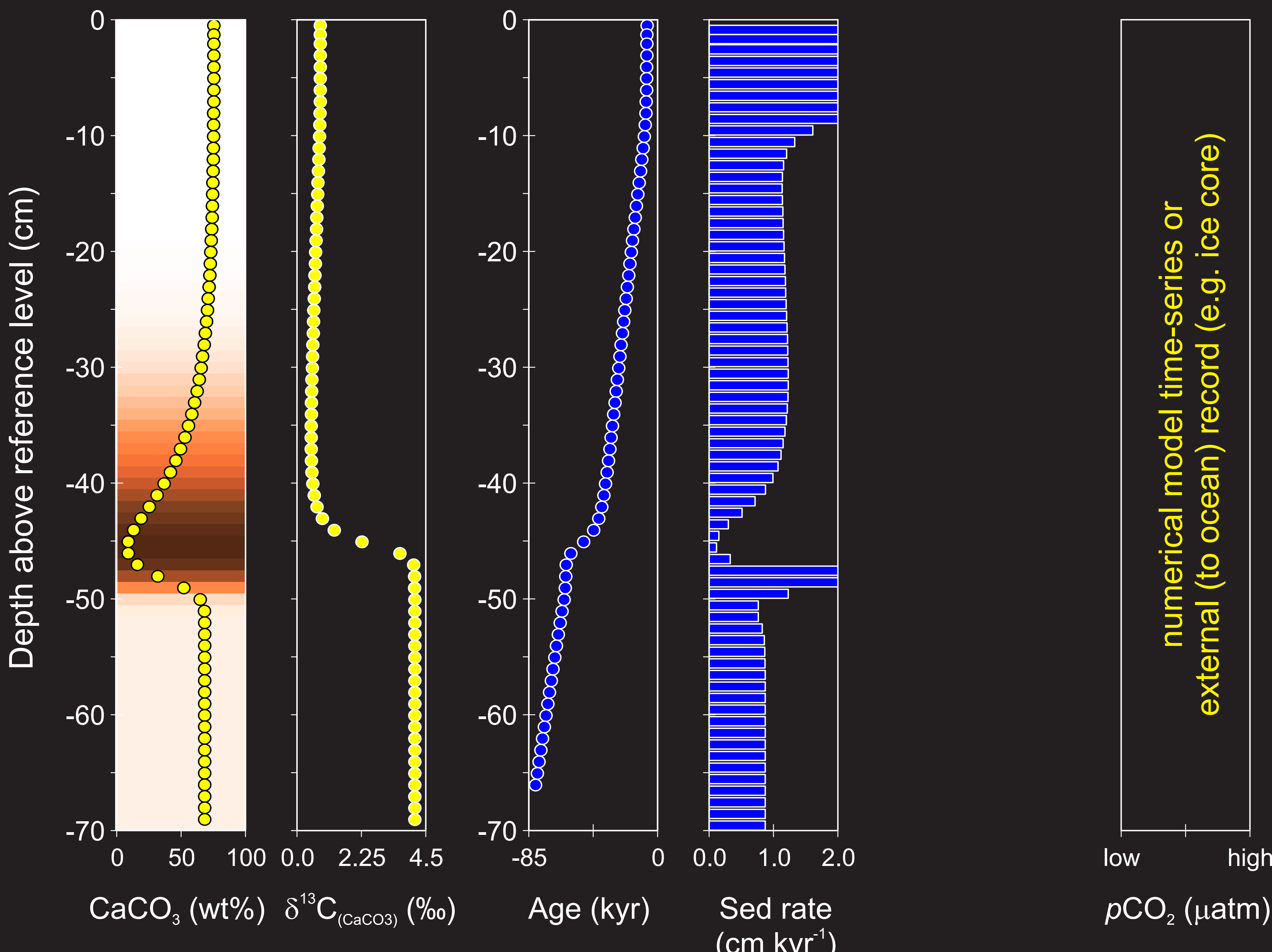
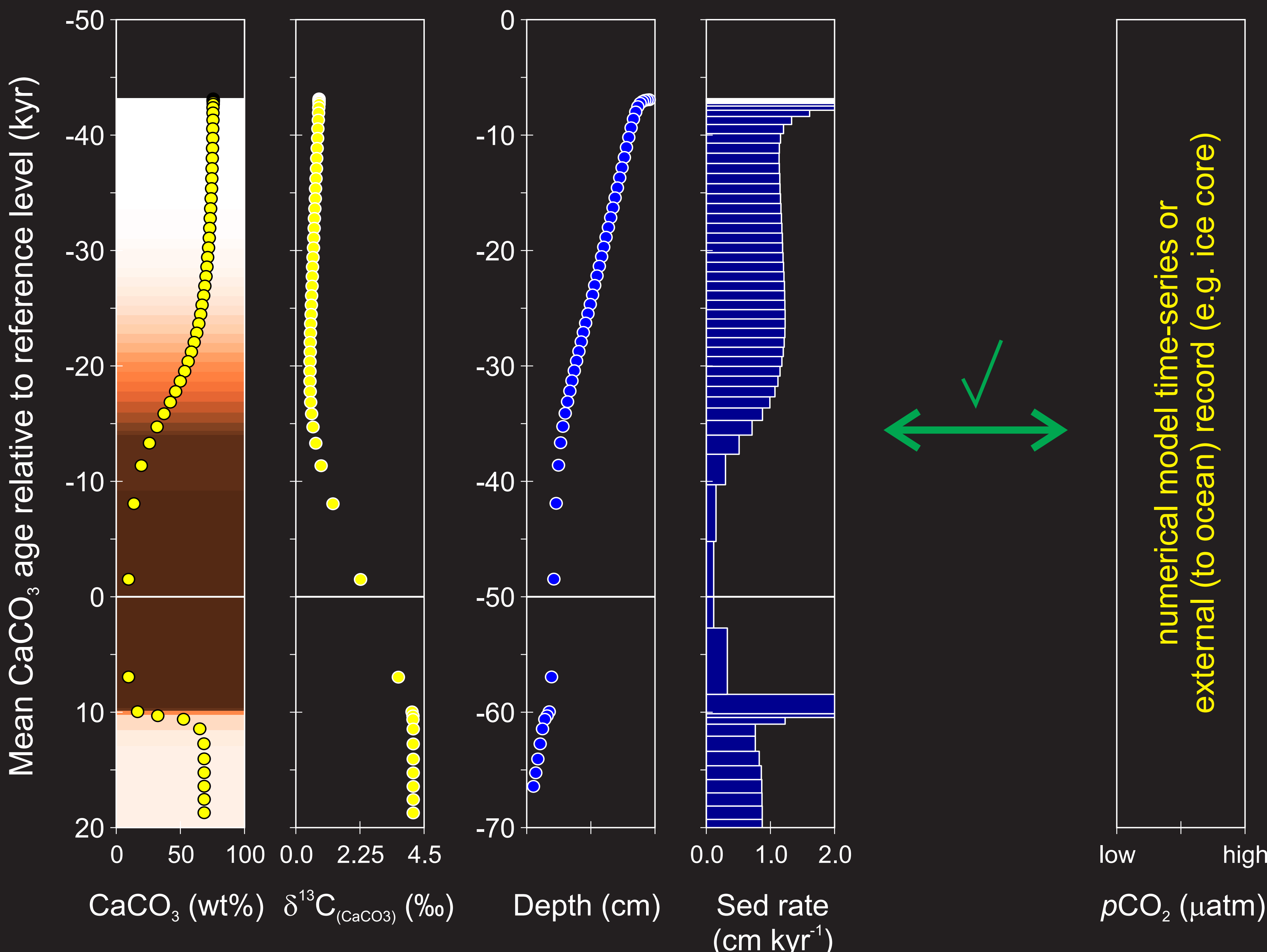


Decoding the marine geological record



Decoding the marine geological record



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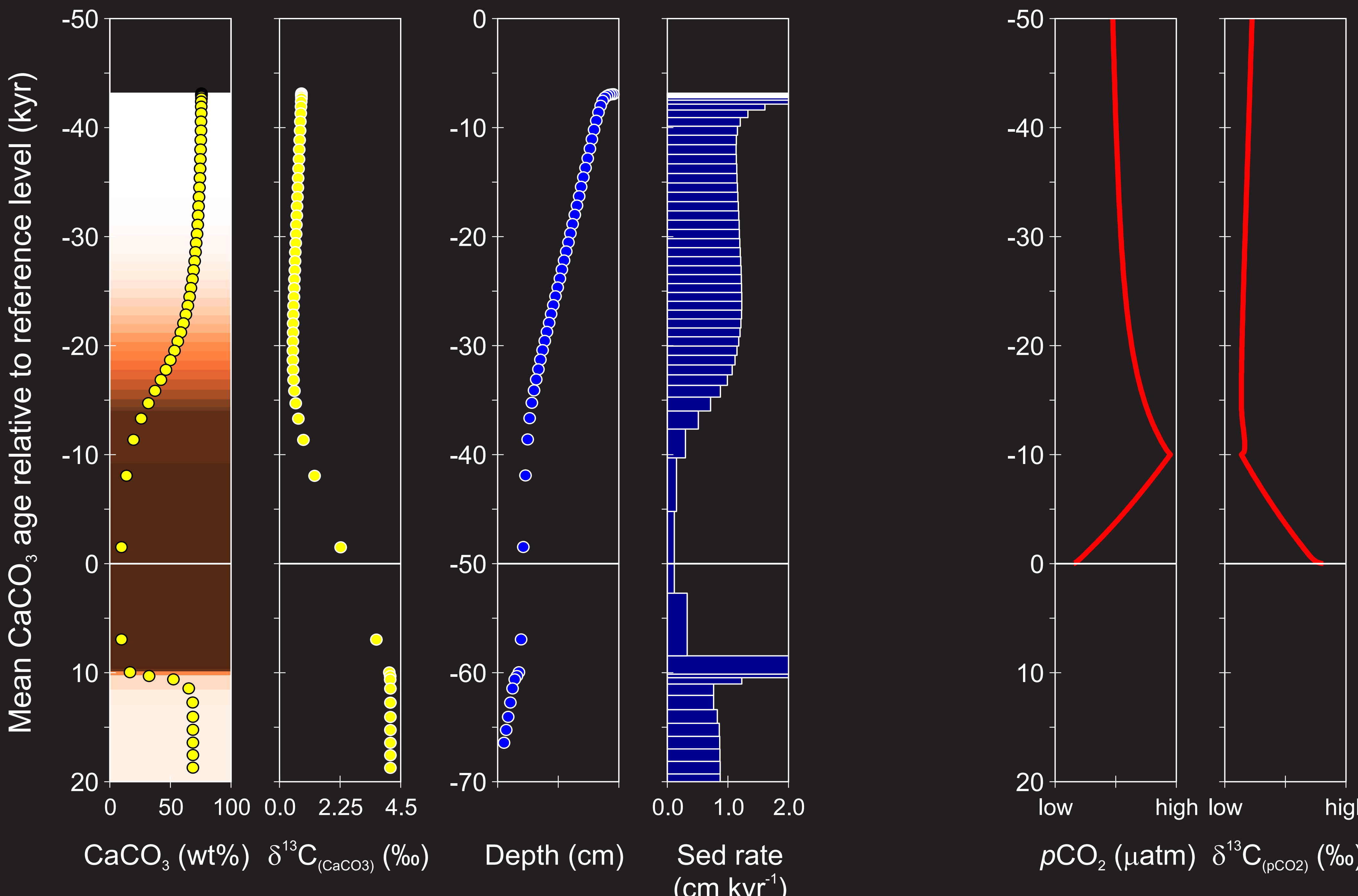
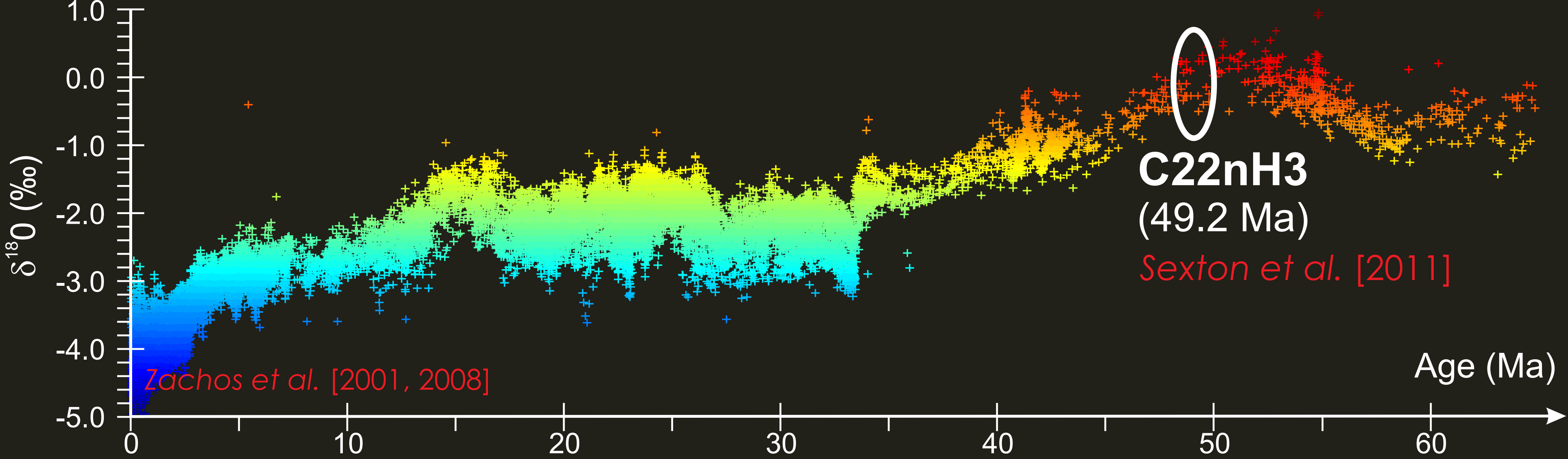
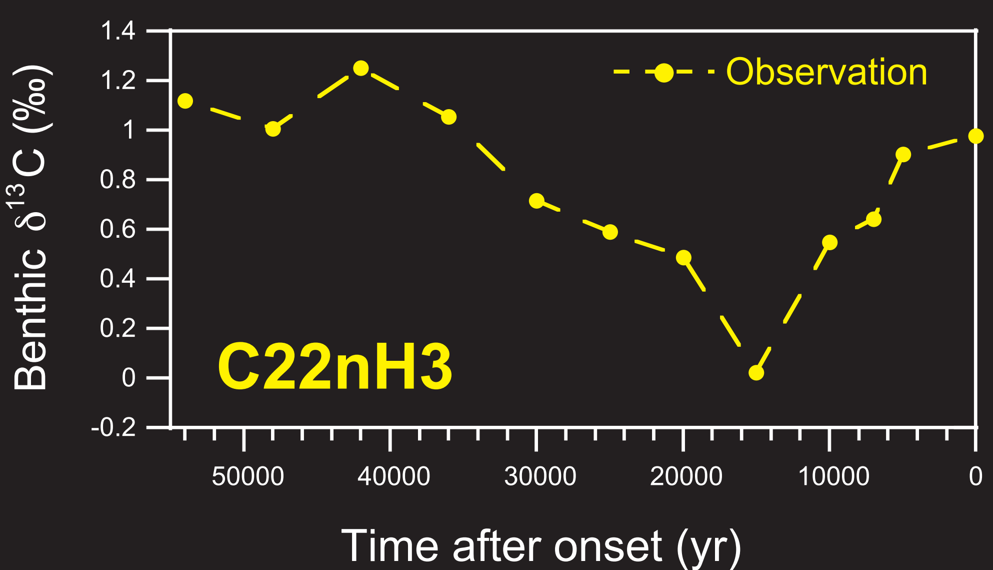


Decoding the marine geological record



Decoding the marine geological record



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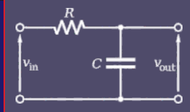
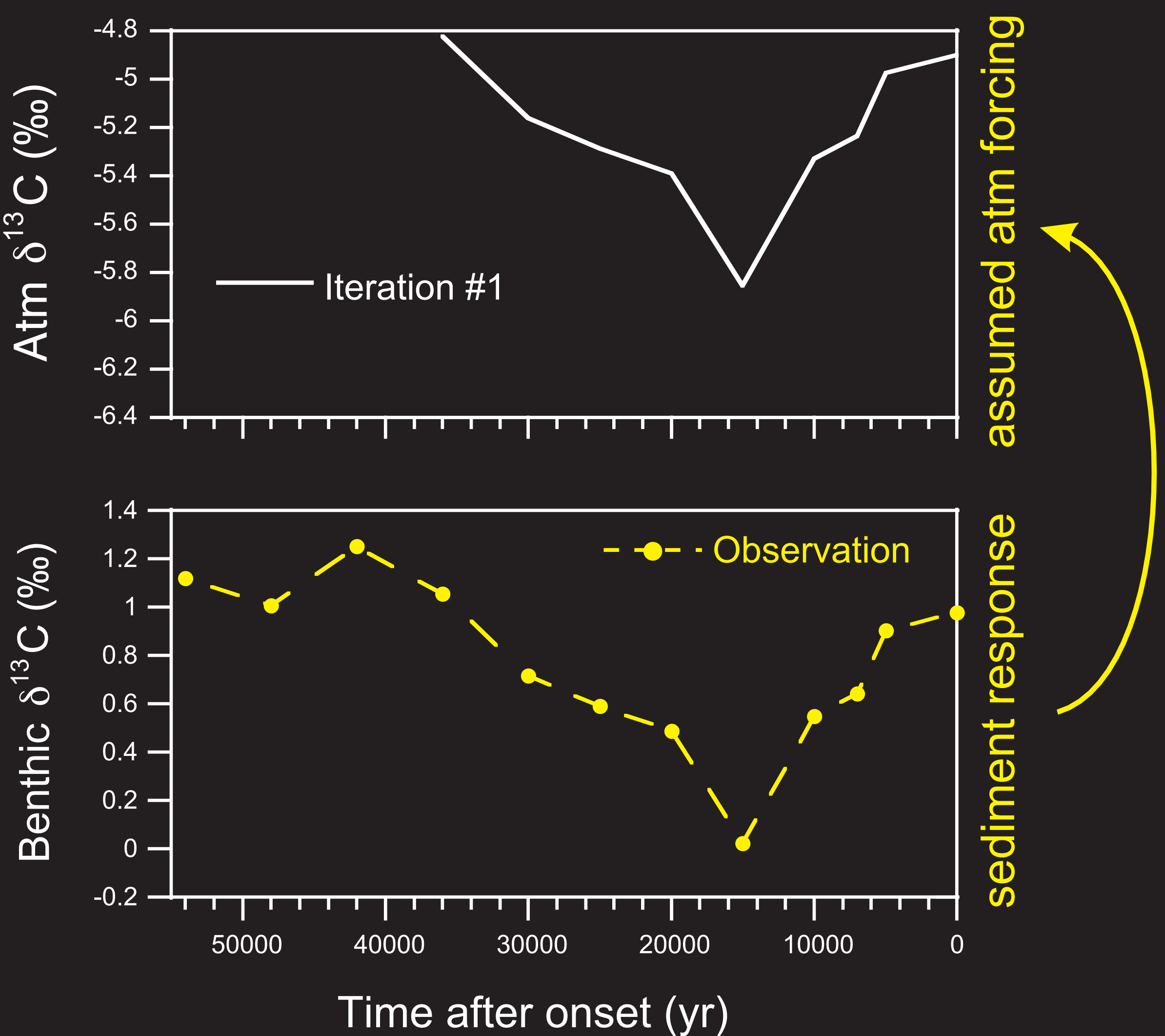
Decoding the marine geological record





Initial guess:
observed δ^{13}C record
==
the atmospheric forcing

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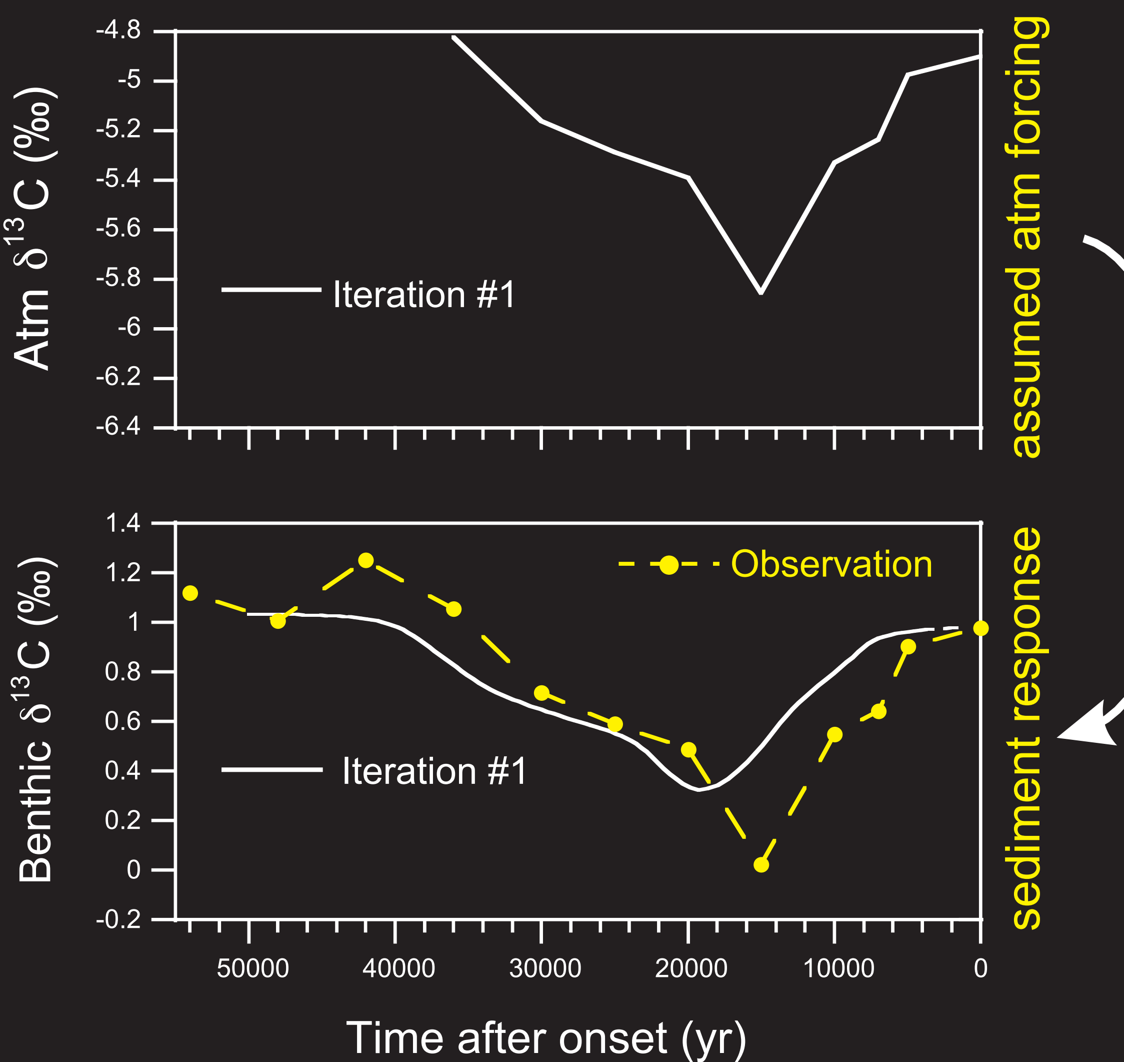
Decoding the marine geological record



Step #1
Invert 'guesstimated' atmospheric $\delta^{13}C$ record and calculate sediment expression

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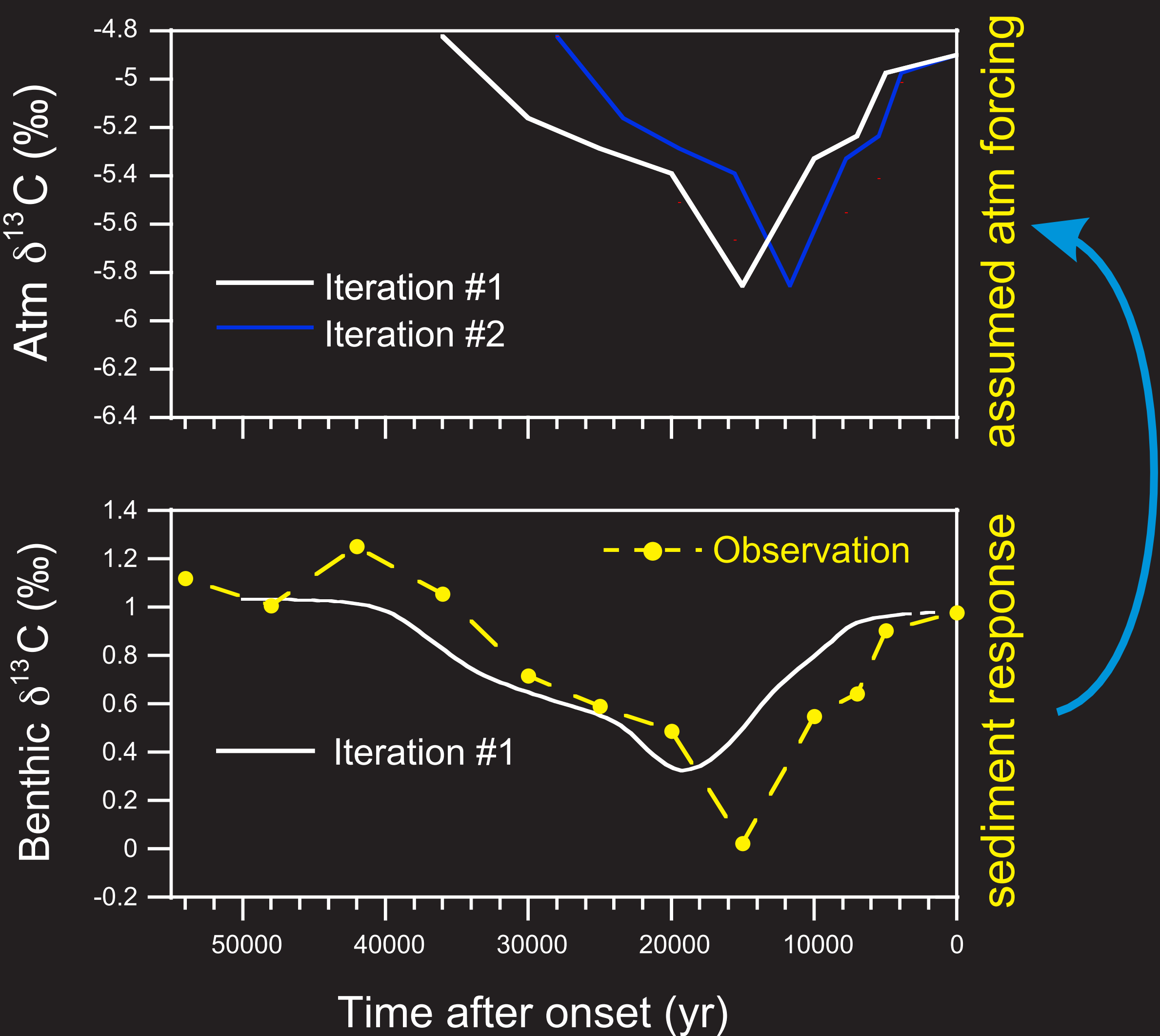
Decoding the marine geological record



Adjust atmospheric record:
Correct for distortion in time

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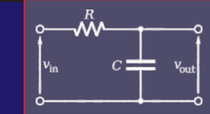

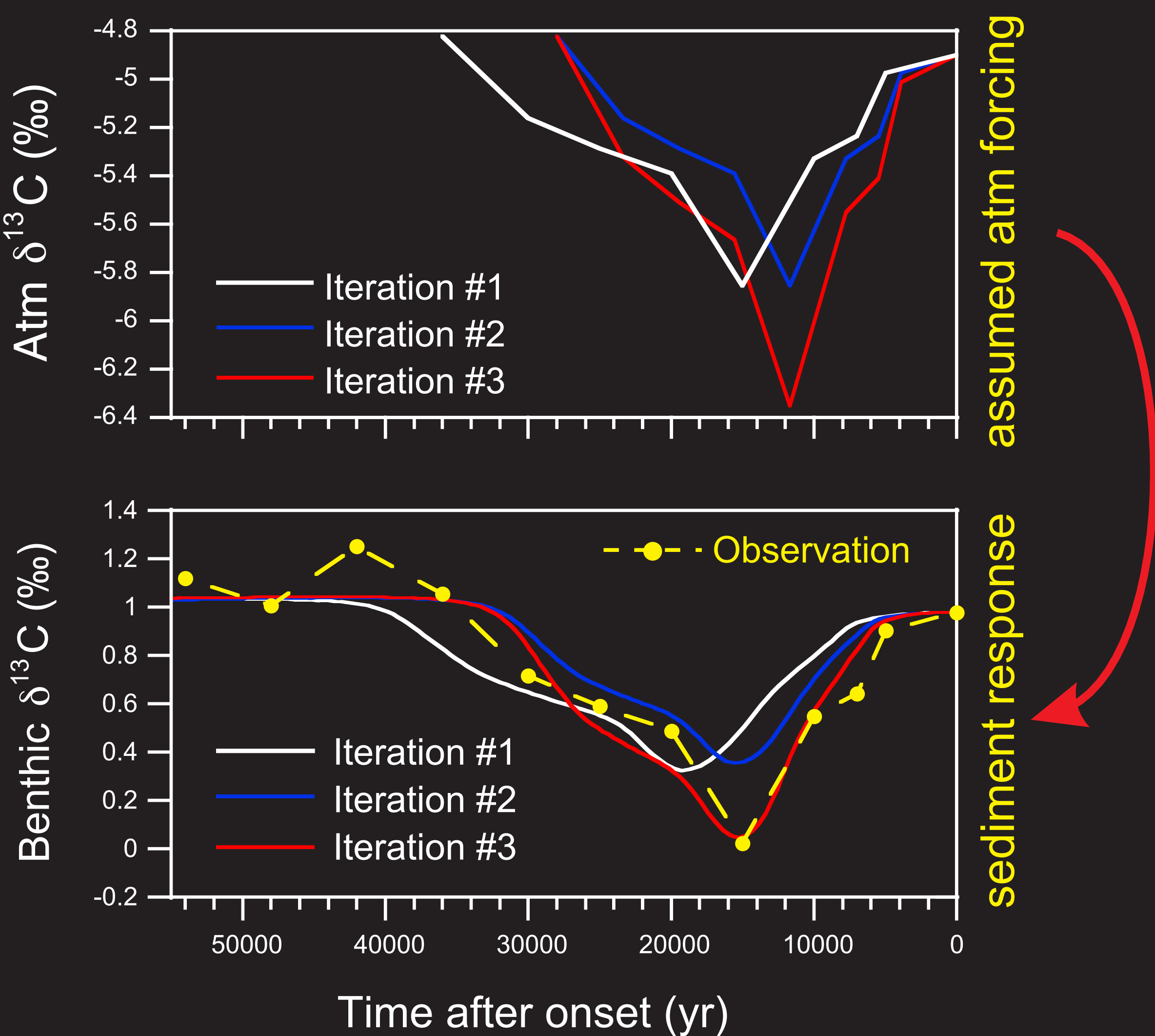

Step #2:
Invert adjusted
atmospheric δ^{13}C record;
then adjust forcing magnitude;

Step #3:
Invert the now twice-adjusted
atmospheric δ^{13}C record

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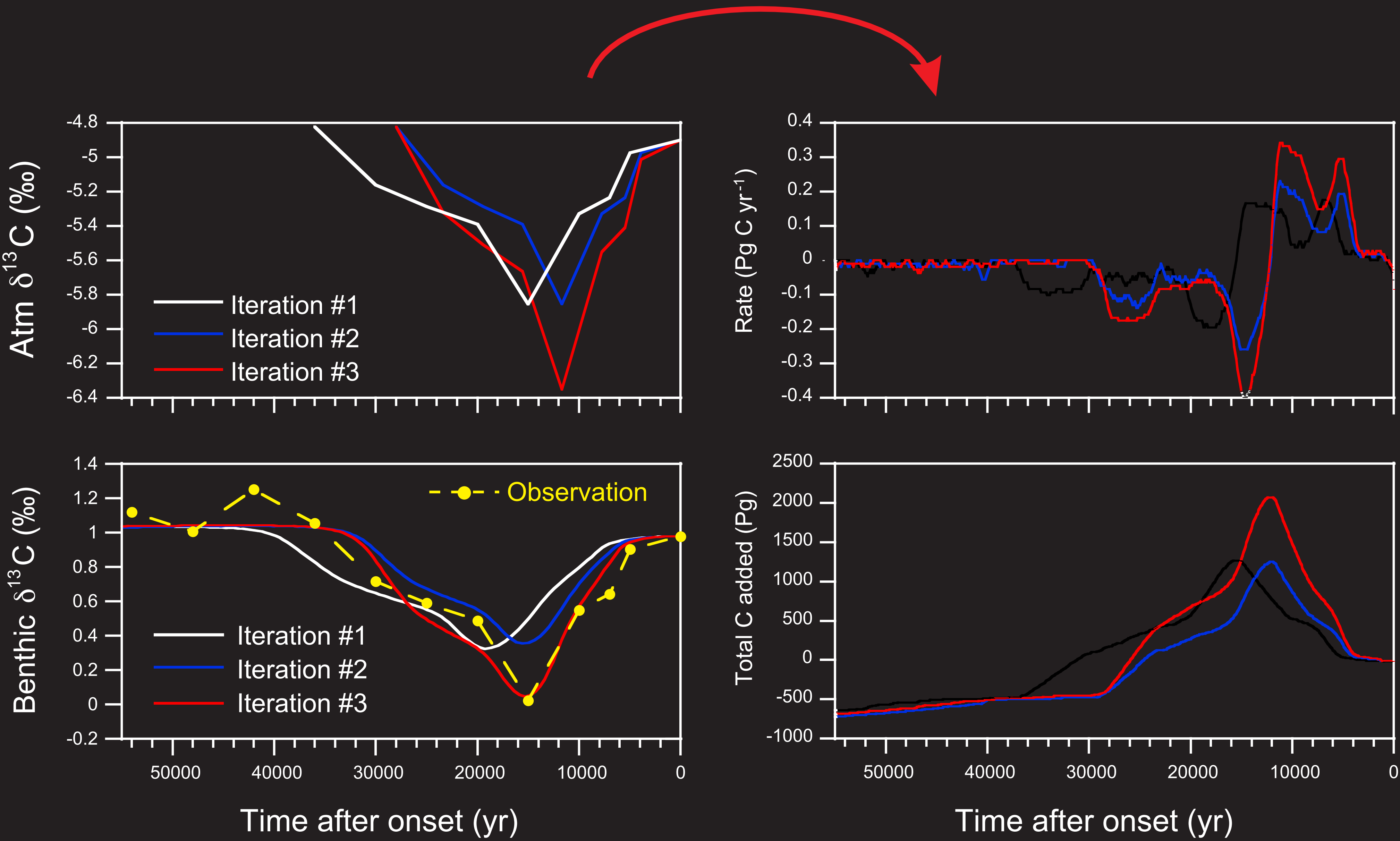
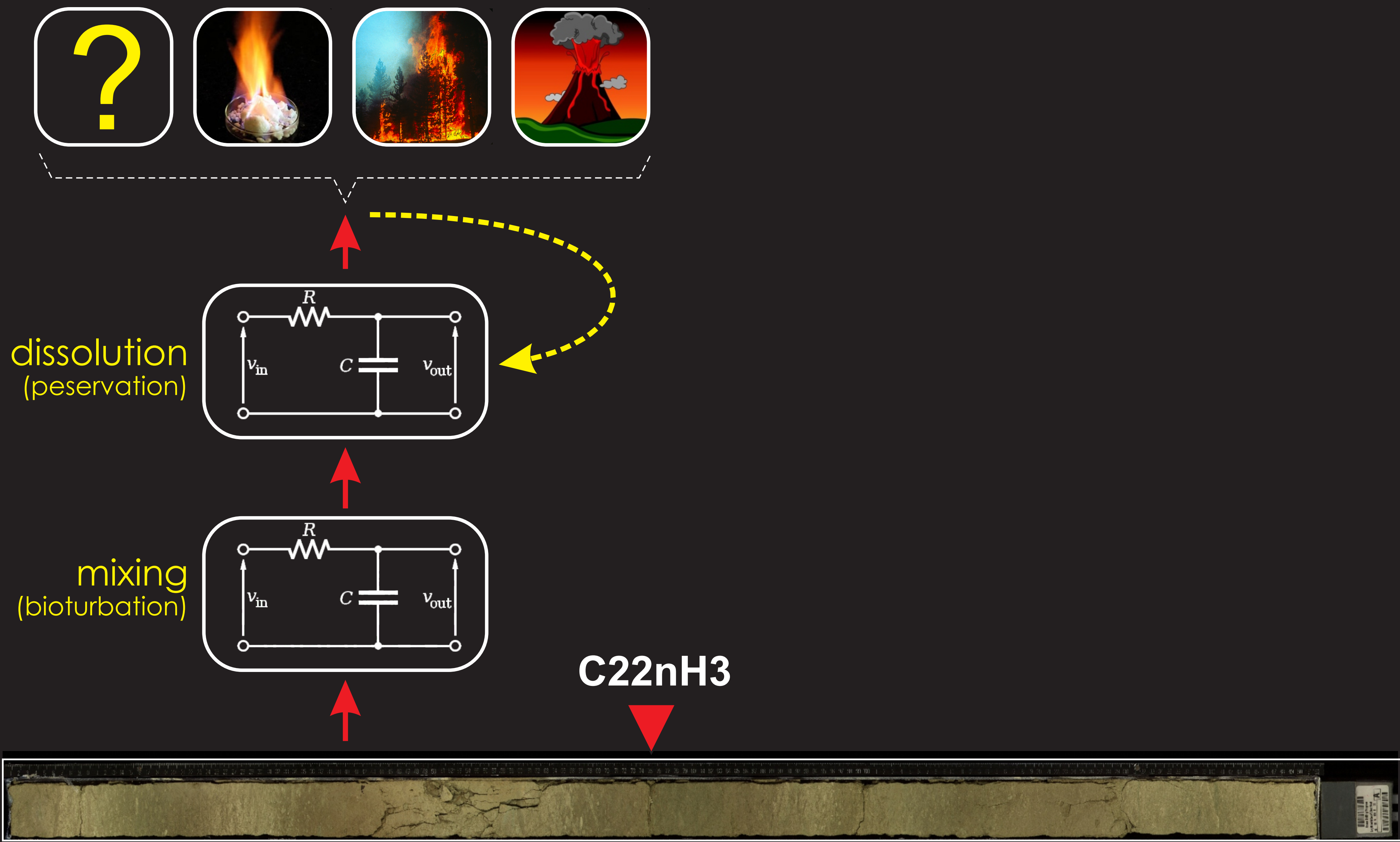
Decoding the marine geological record

Recover rates of CO_2 emissions



Decoding the marine geological record



Kirtland-Turner and Ridgwell [2013]

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