

Back to the Future:  
*What is the Relevance of Extreme Climates and  
Extinction events to Anthropogenic Global Warming?*

Andy Ridgwell

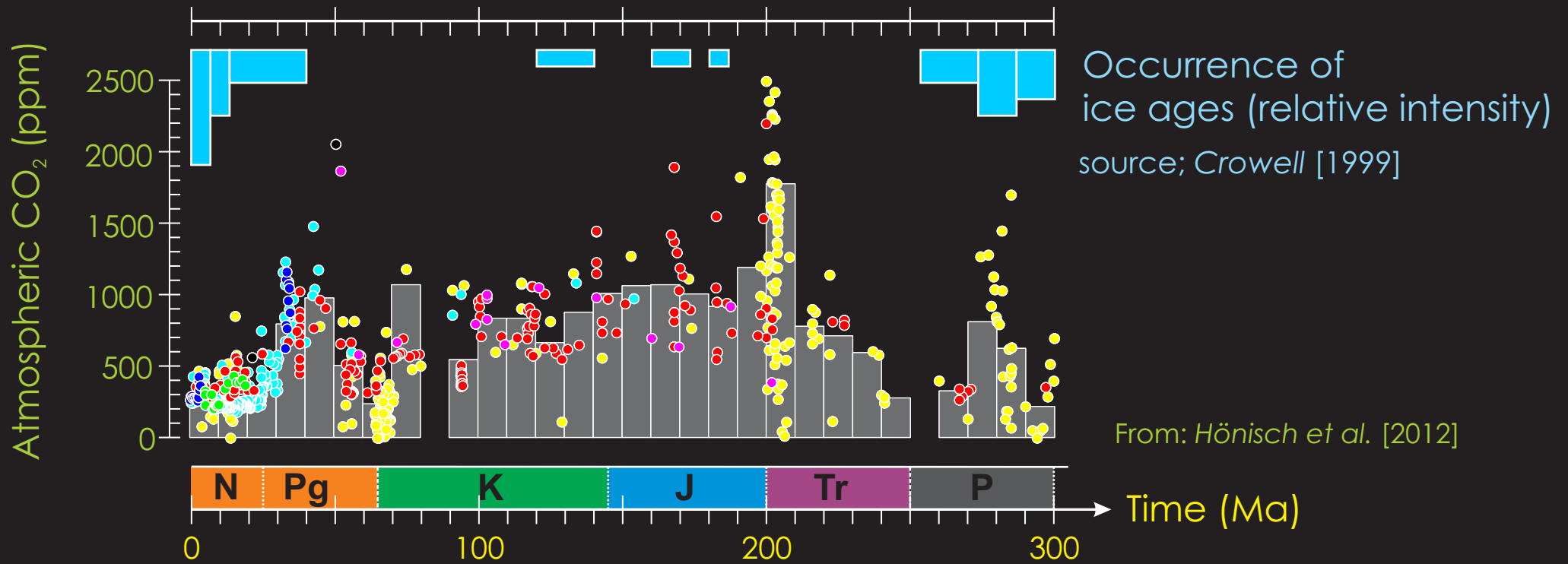
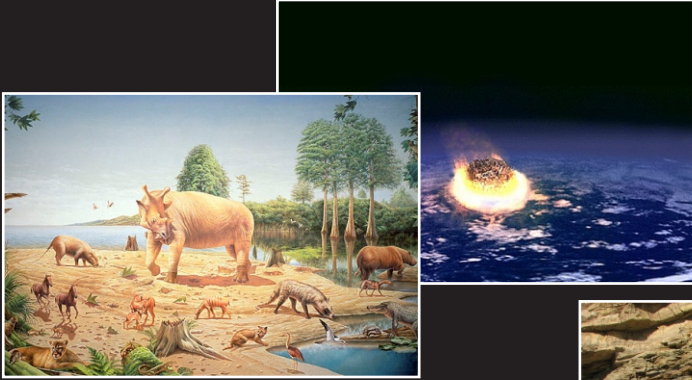
University of California – Riverside  
University of Bristol



vs.



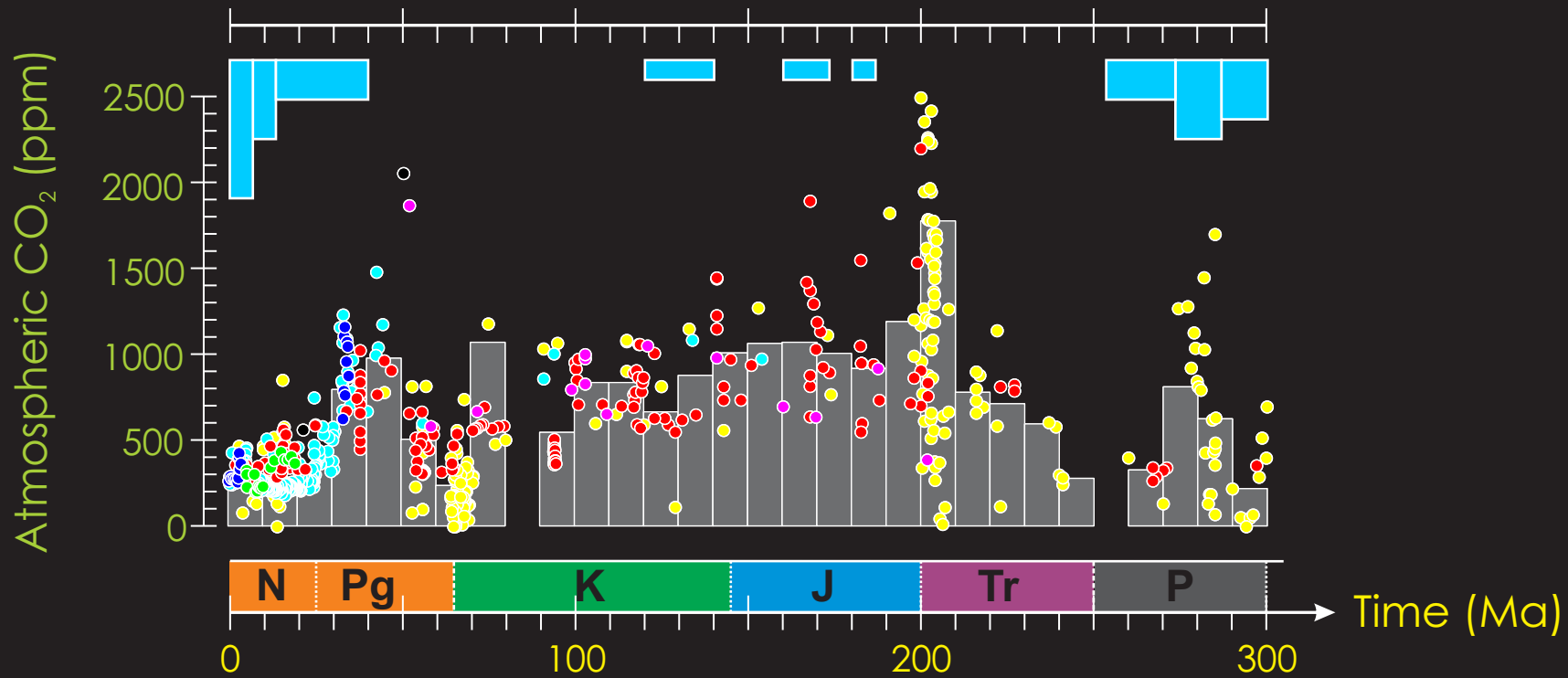
# Why?



Why?

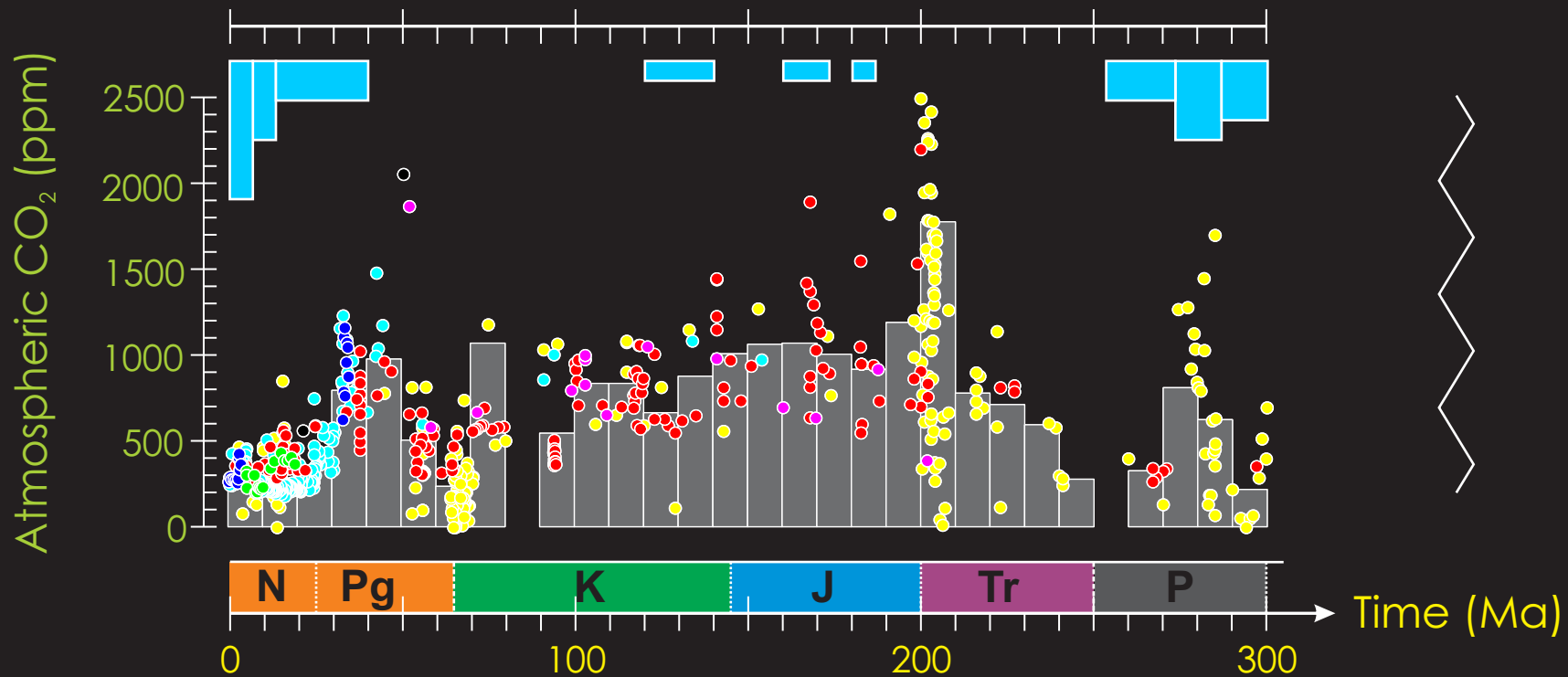


Reason #1 – *fun*





Reason #2 – for NSF-friendly ‘future relevance’(?)  
(the opposite of ‘fun’?)





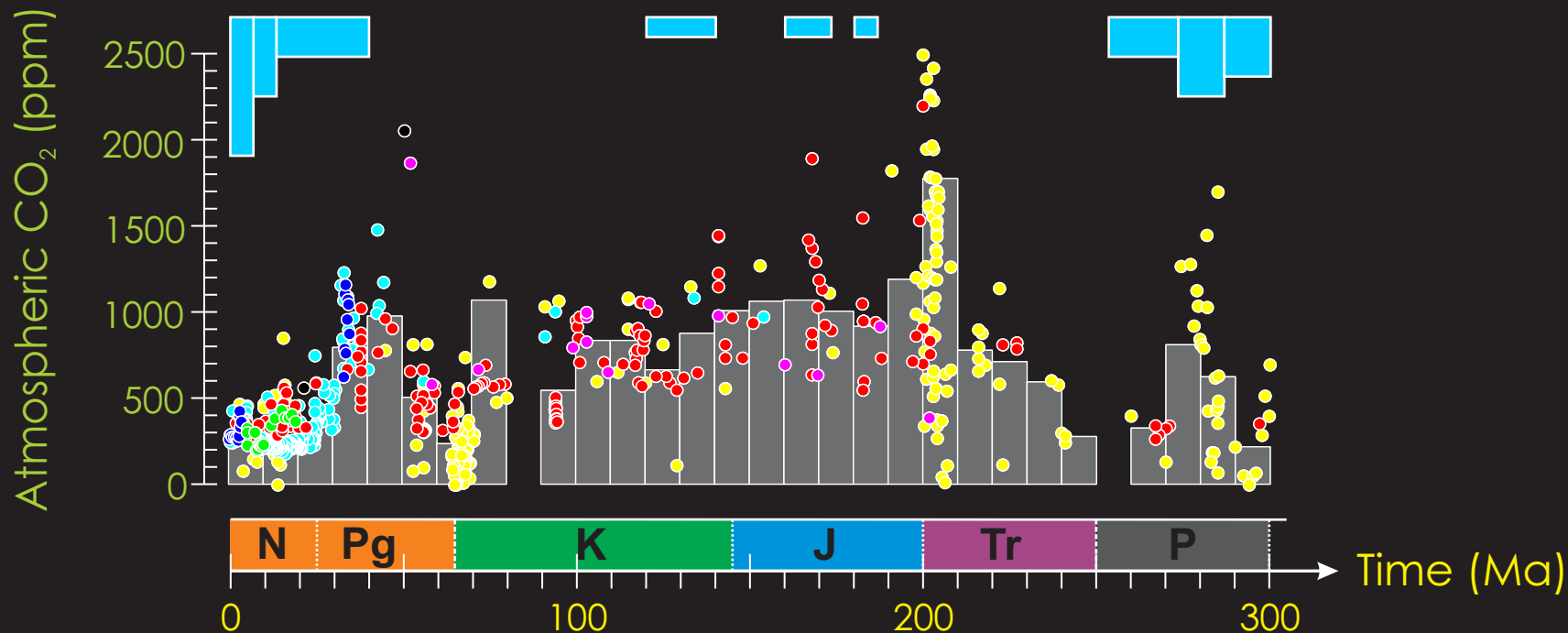
*what exactly* about 'the future'?

~~★ Outcome of the next Presidential 'Debate'?~~

~~★ Superbowl 2017?~~

★ Climate sensitivity.

(The equilibrium global mean annual surface air temperature warming associated with a doubling of atmospheric CO<sub>2</sub>.)





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★ (a) The strength of positive carbon cycle feedbacks with a warming climate (vegetation and soil carbon, peat, permafrost, methane hydrates), and the mechanistic nature of these feedbacks (e.g. increased carbon metabolism respiration vs. increased incidence of wildfires).

(b) The strength of negative carbon cycle feedbacks with a warming climate and higher atmospheric CO<sub>2</sub> (silicate weathering, weathered nutrient supply and availability, marine (or soil) organic carbon preservation and burial, deep-sea carbonate dissolution ('compensation')).



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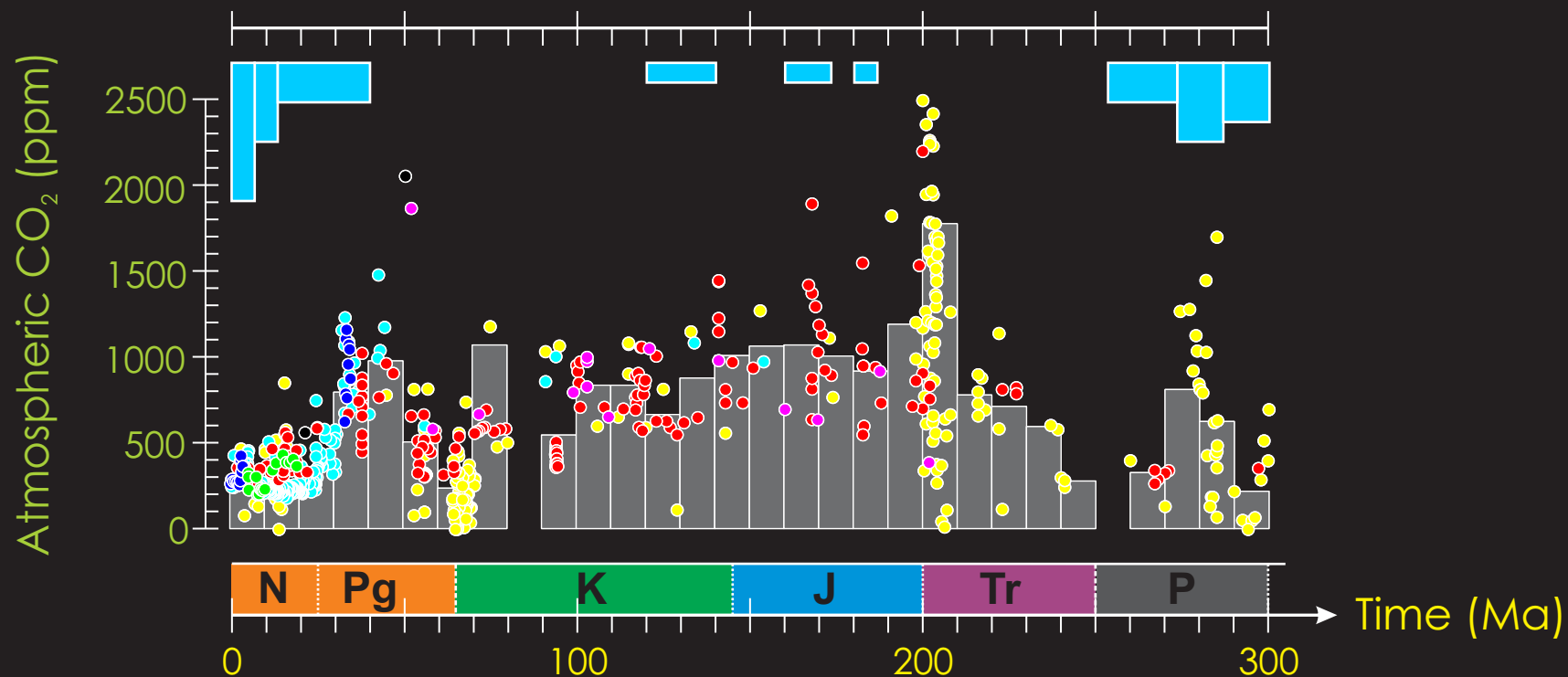
★ Ecological and extinction sensitivity to climate change and ocean acidification.

# Paleo-analogues – which ... ?



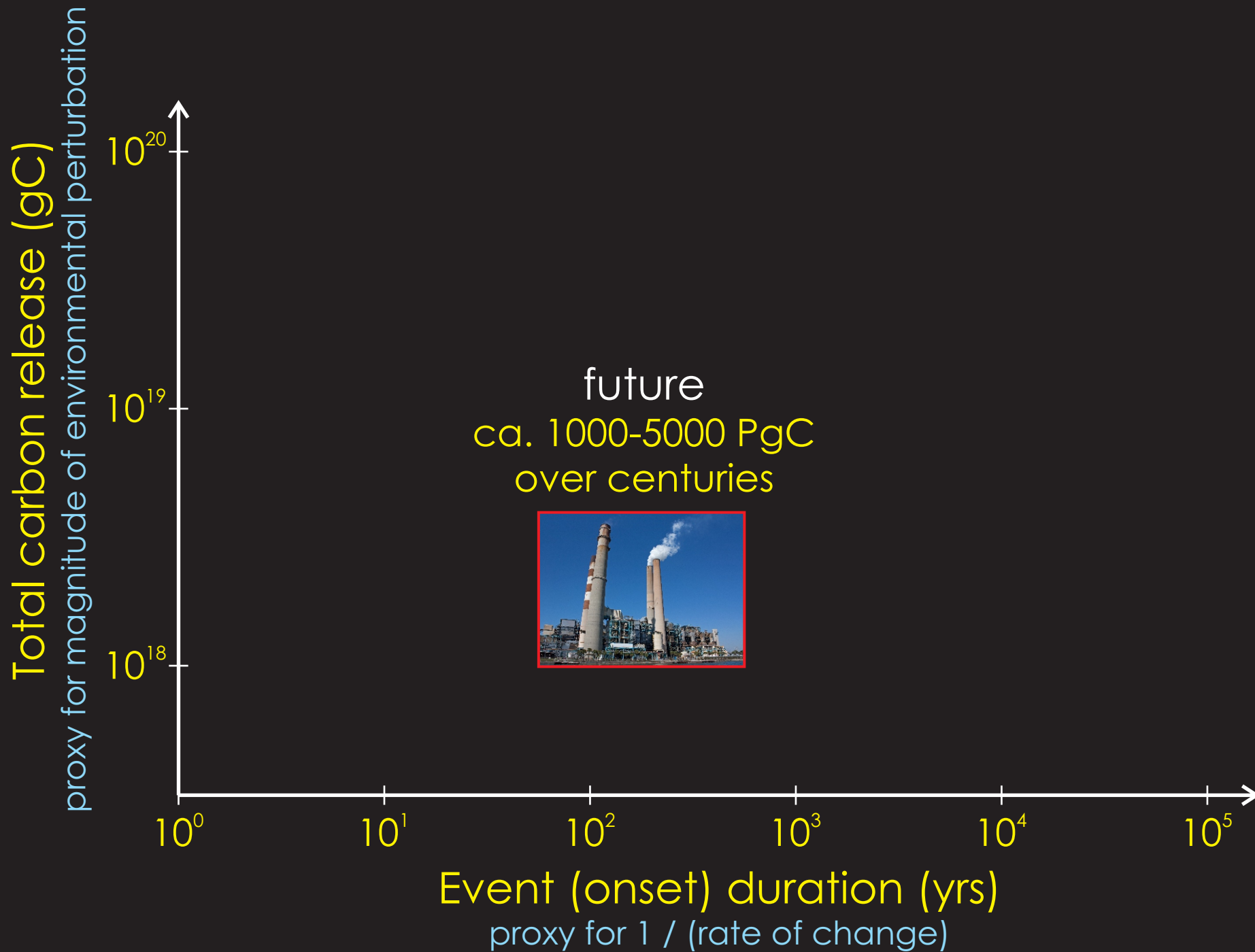
... can tell us about ...

- (1) Role of carbon cycle feedbacks?
- (2) Ecological sensitivity to environmental change?

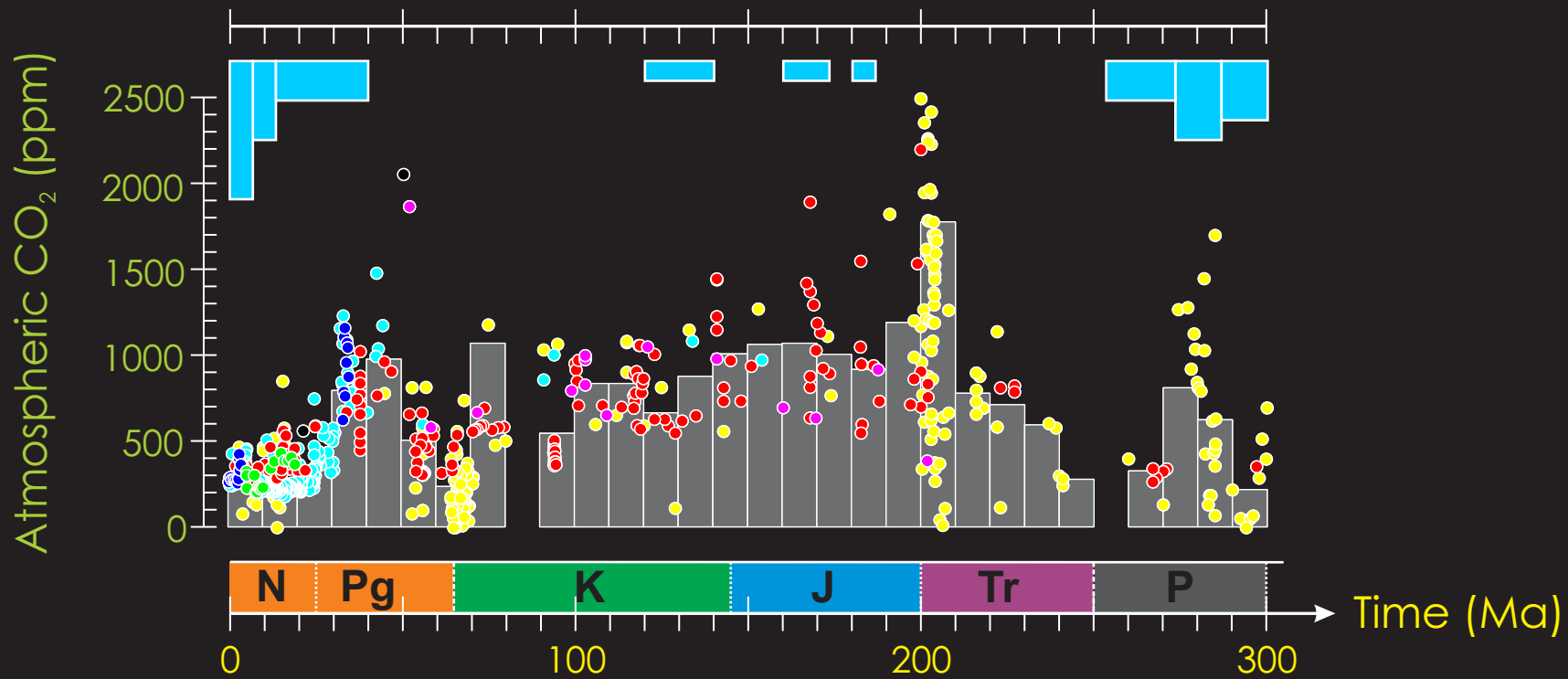
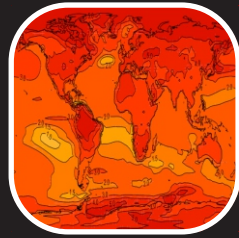




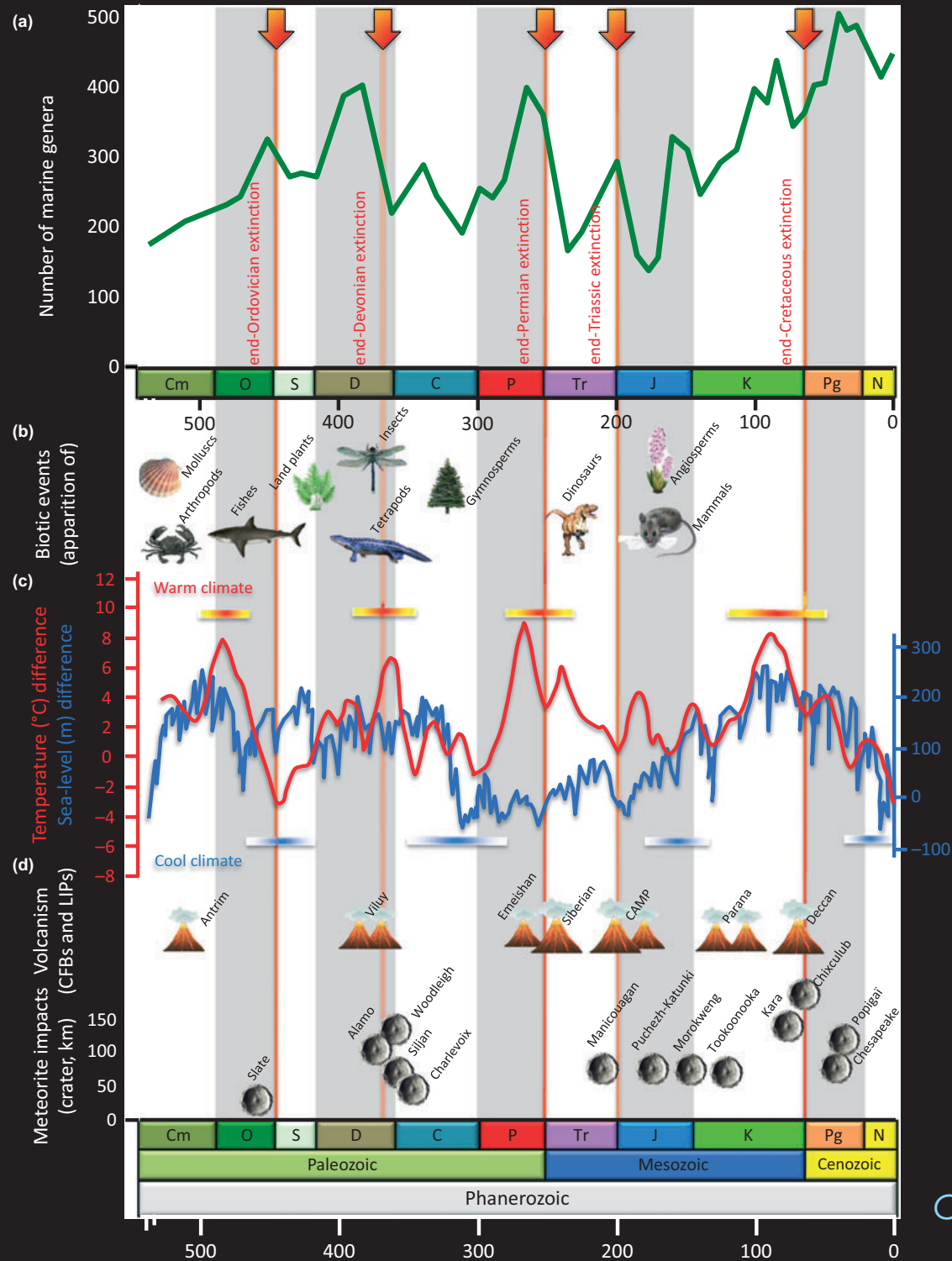
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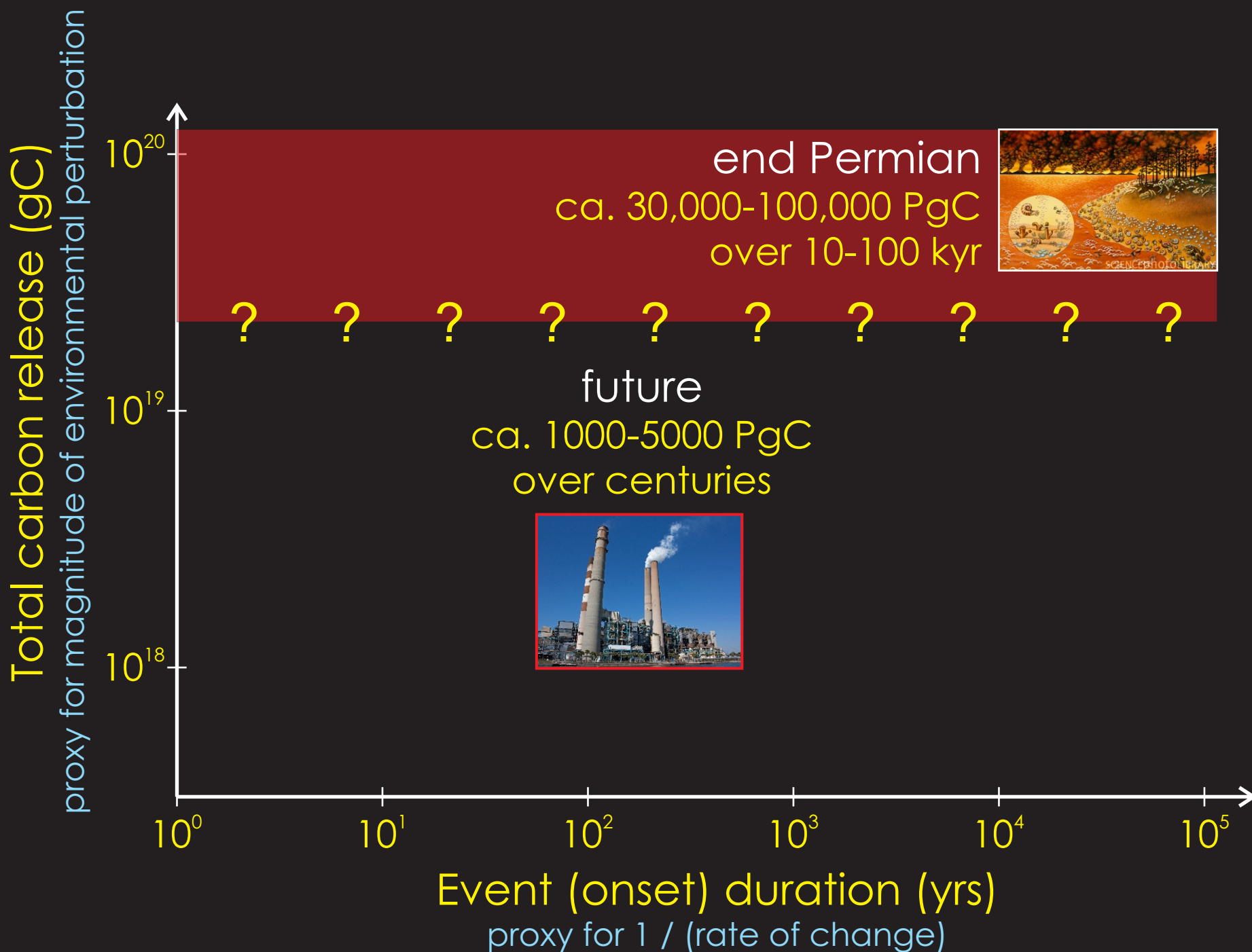


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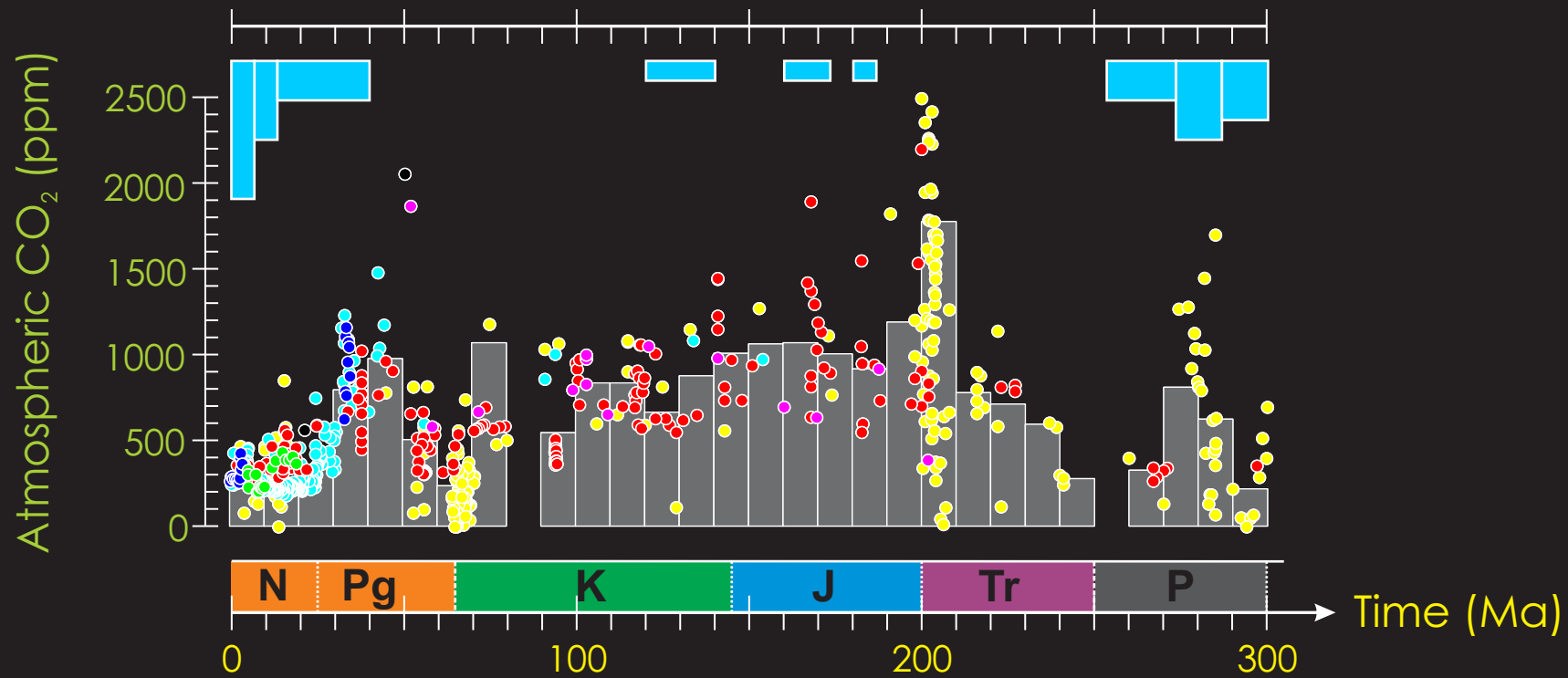


Condamine et al. [2013] (*Ecology Letters* 16)

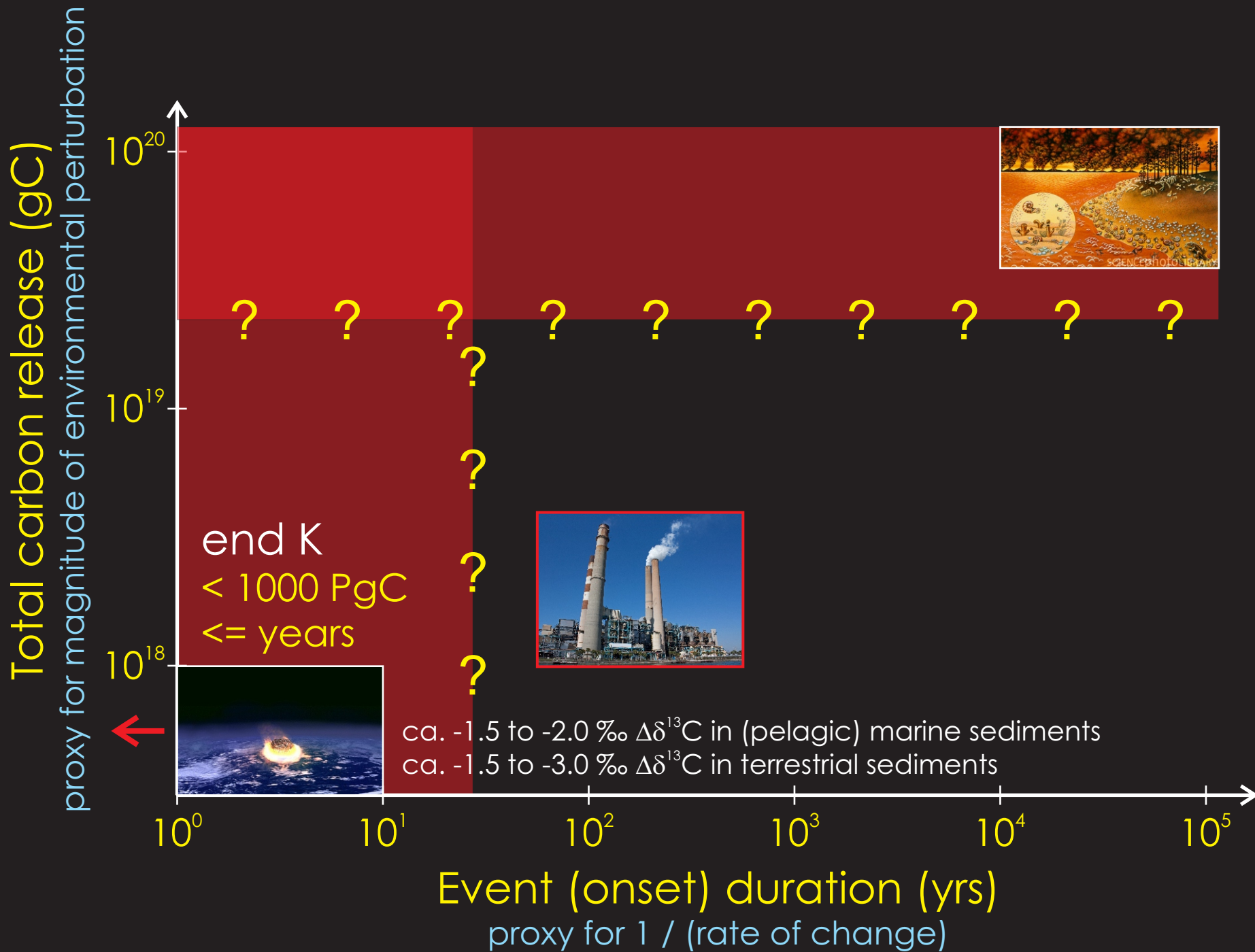
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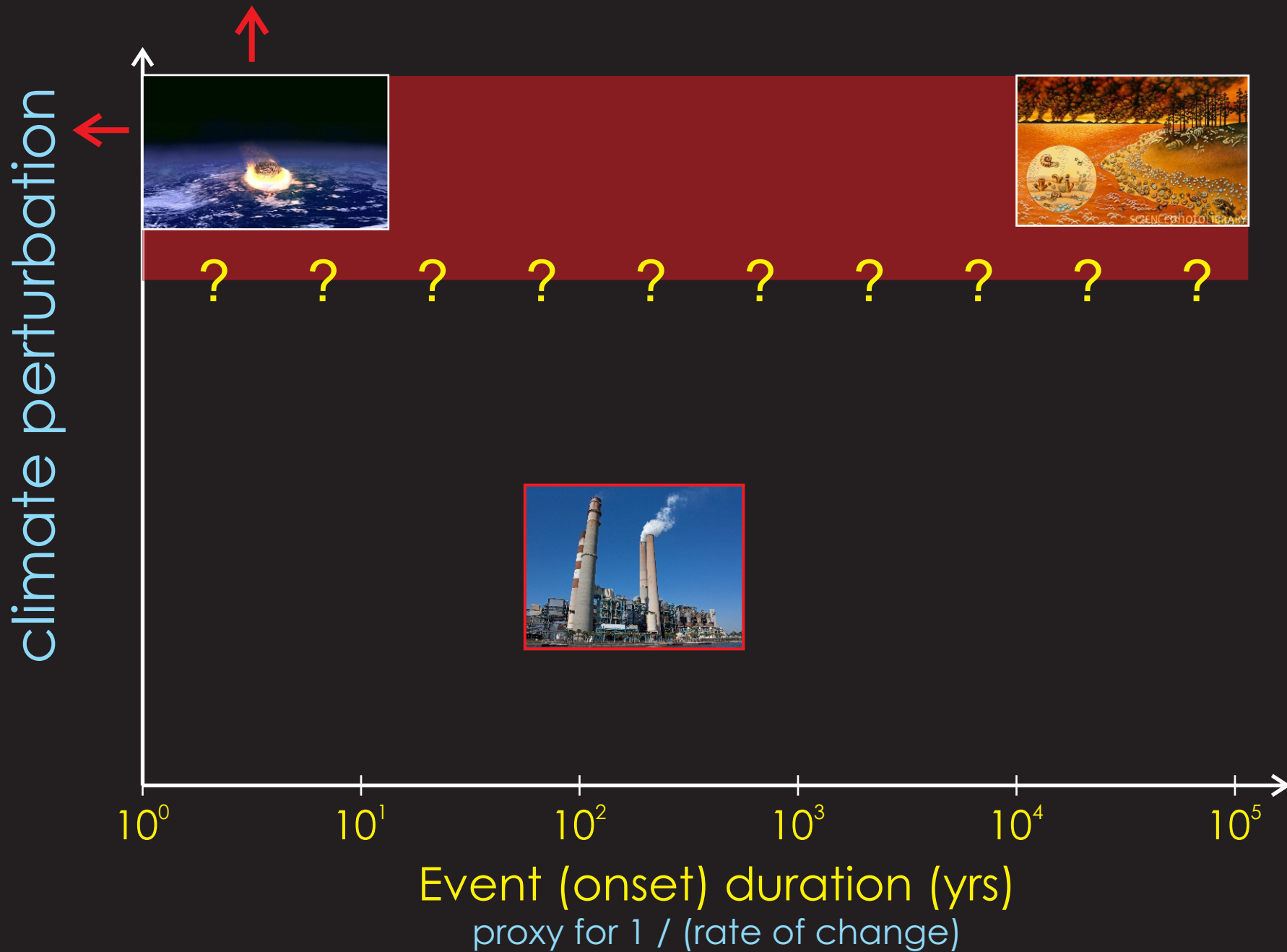
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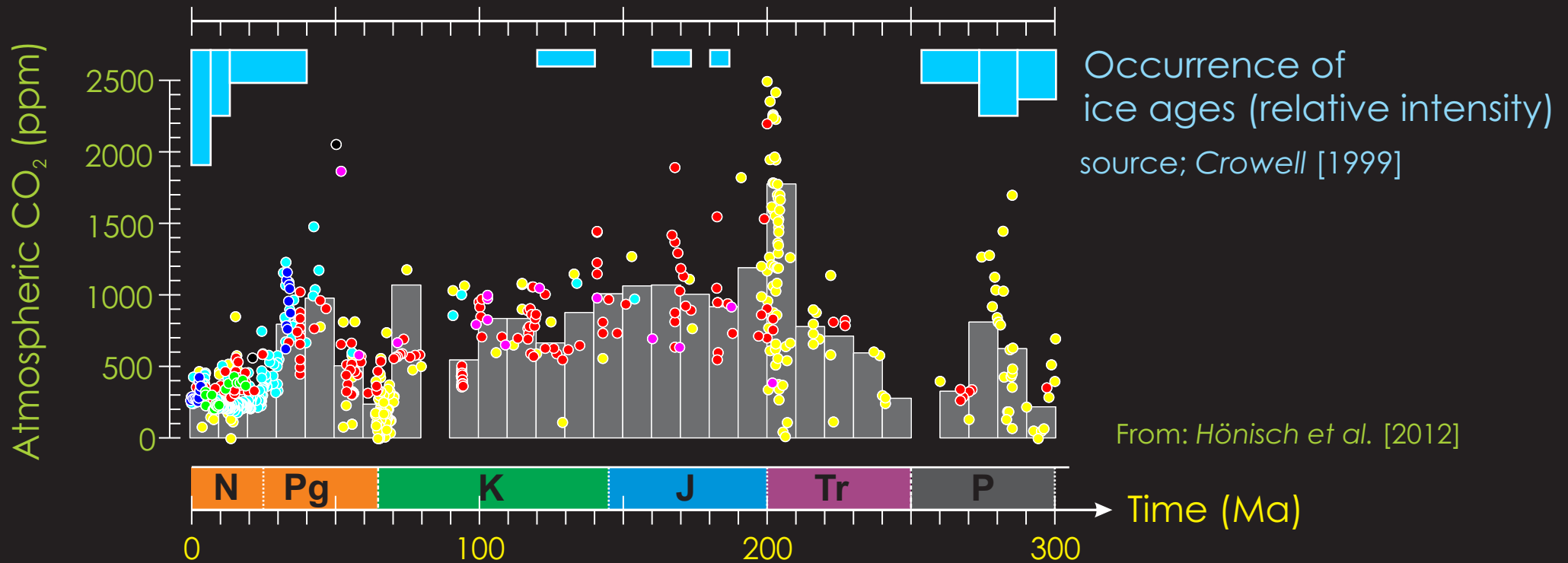
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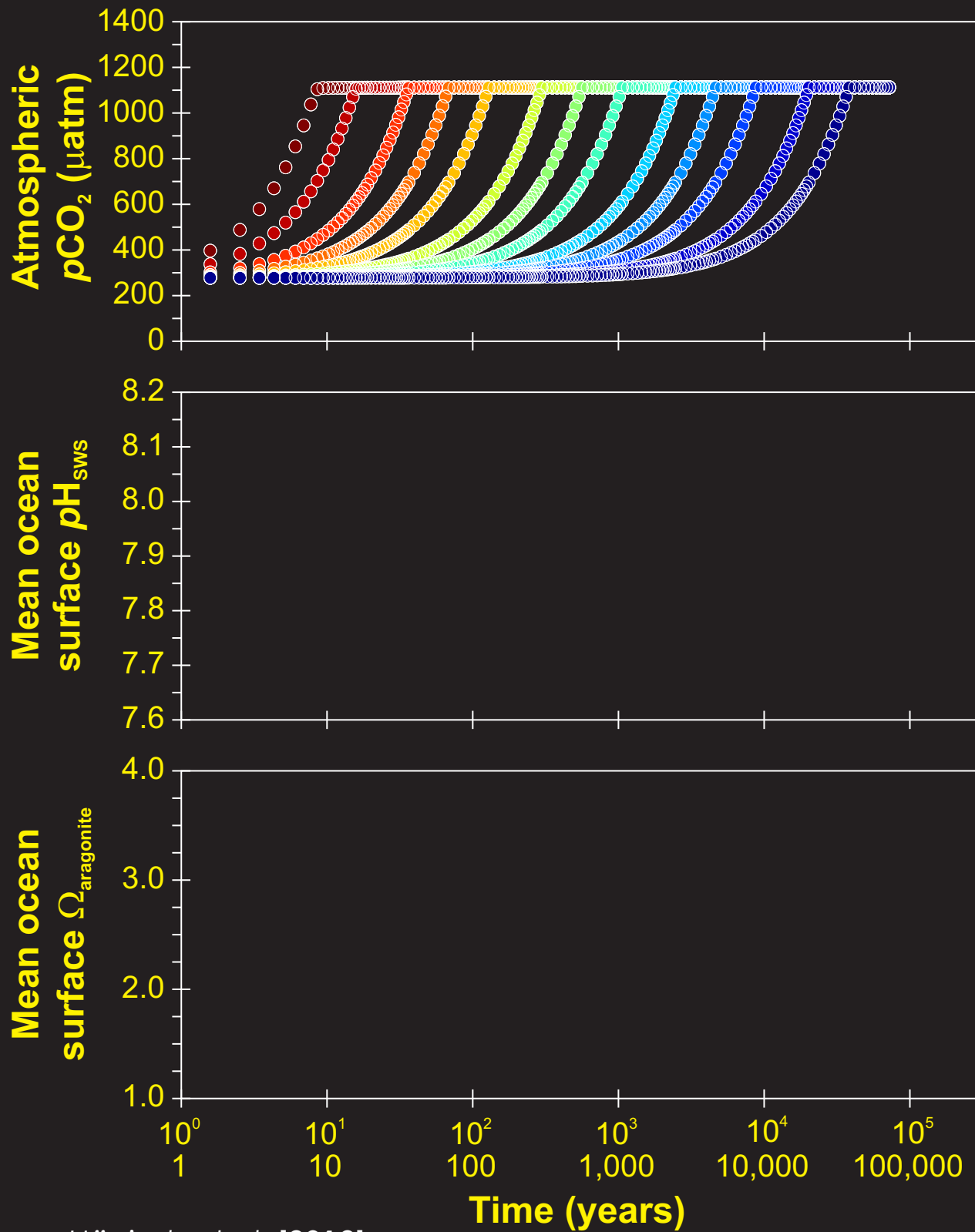
# Paleo-analogues – the question of rate



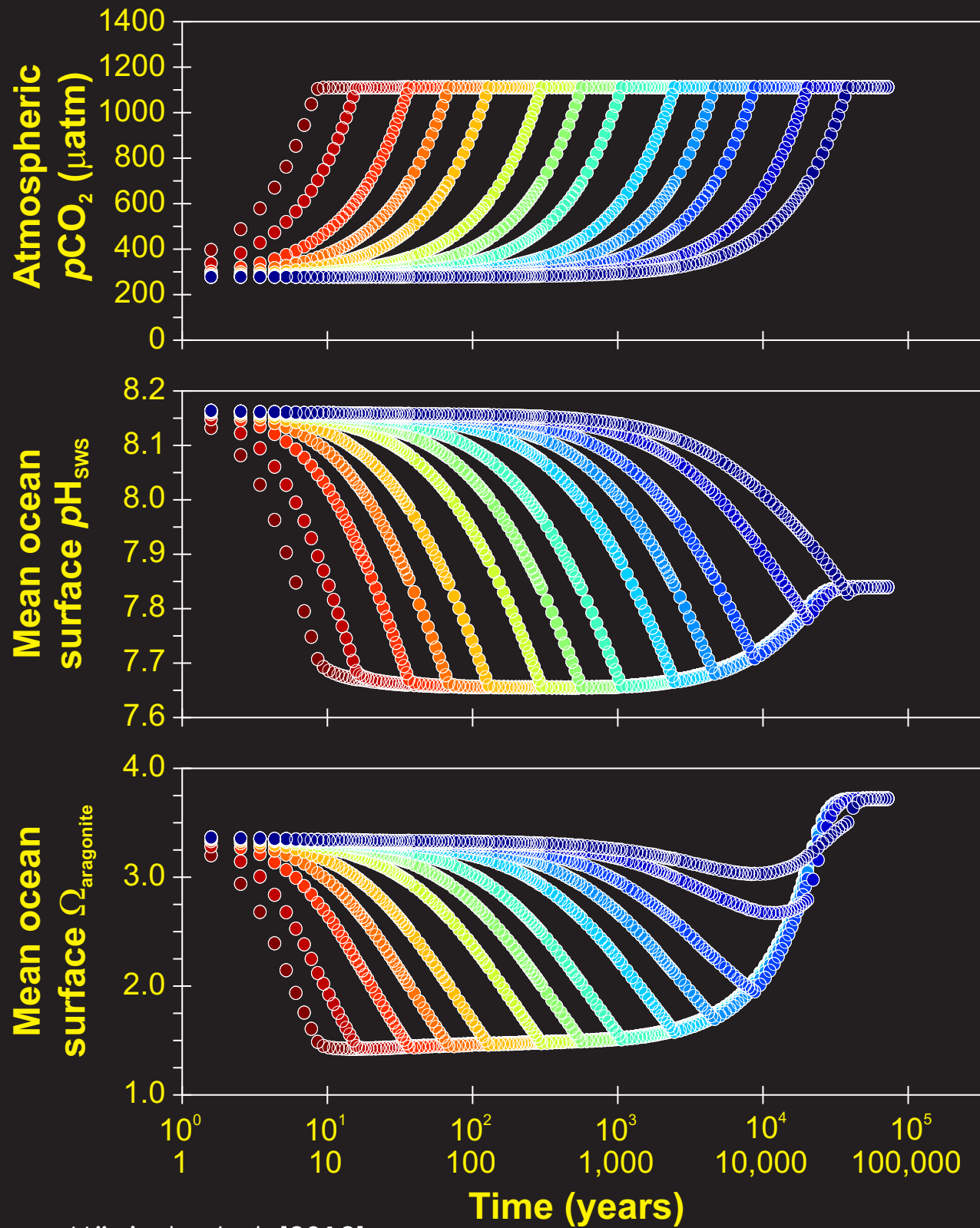
an OA analogue?





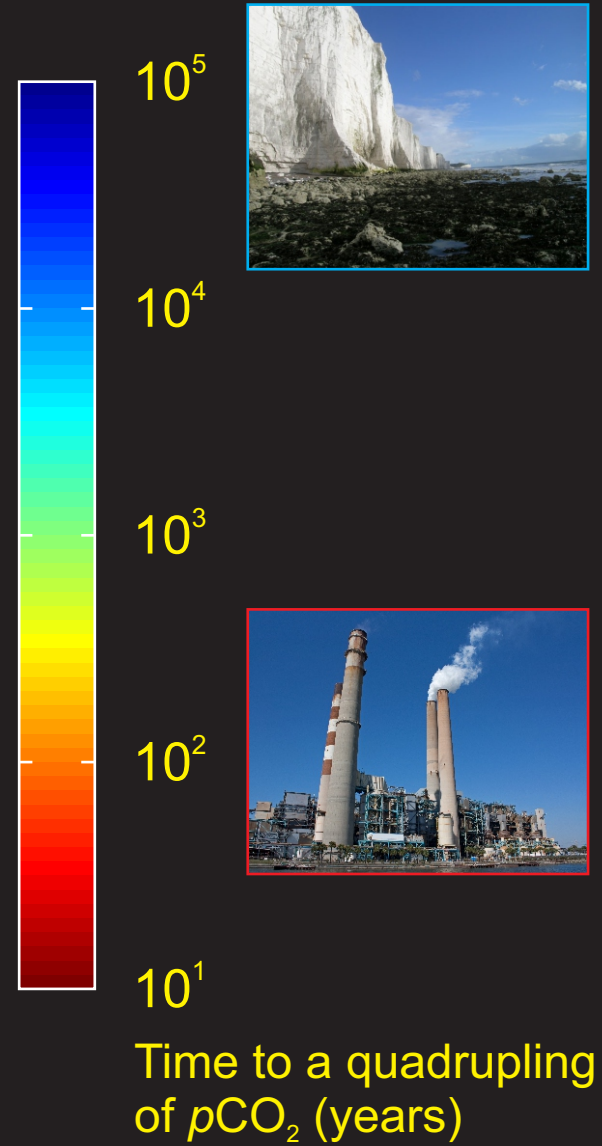
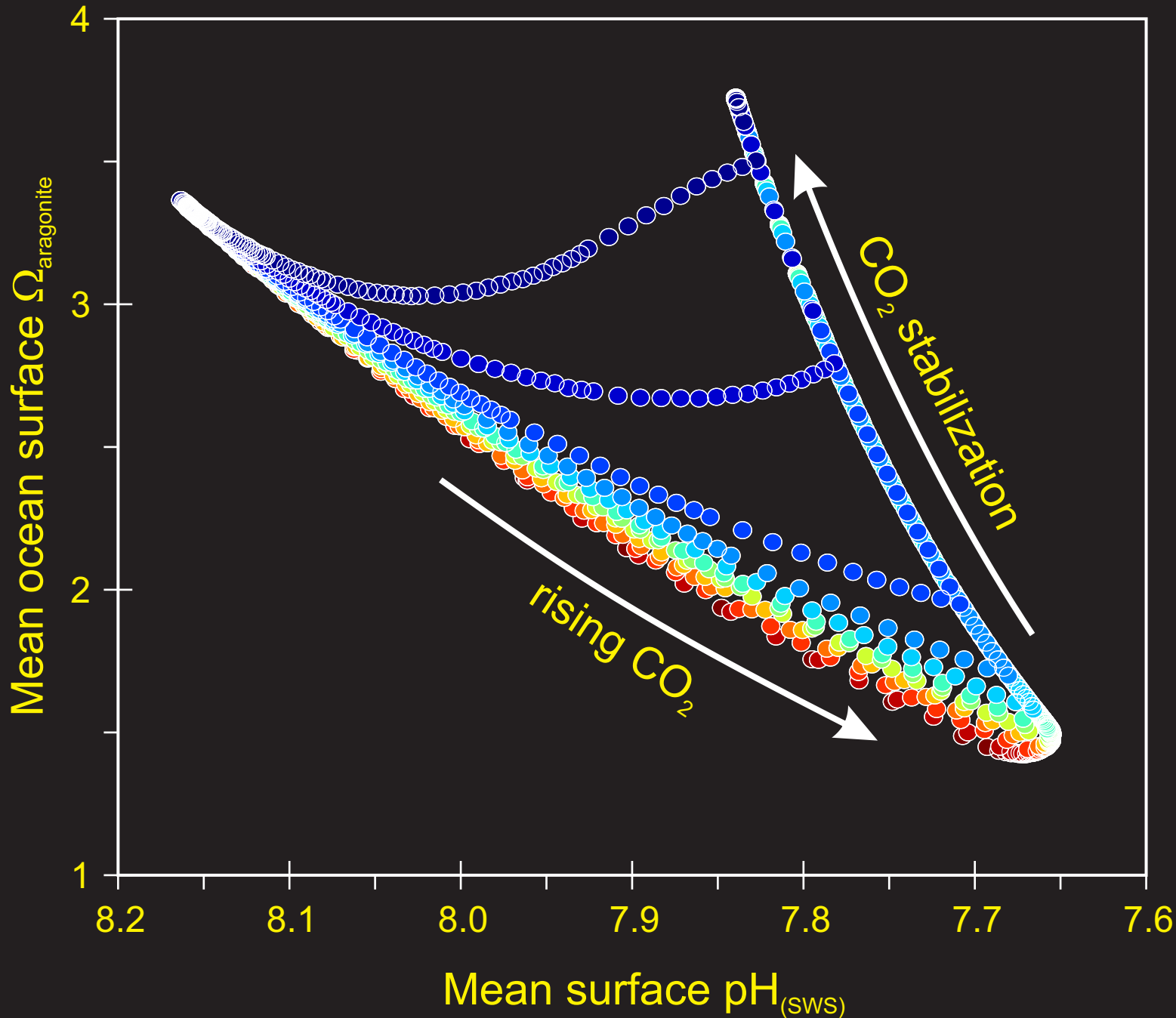


From: *Hönisch et al.* [2012]

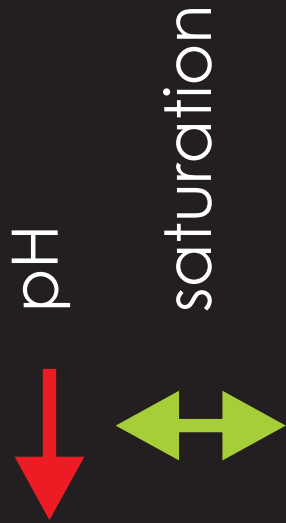


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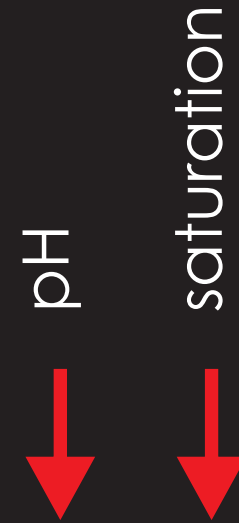
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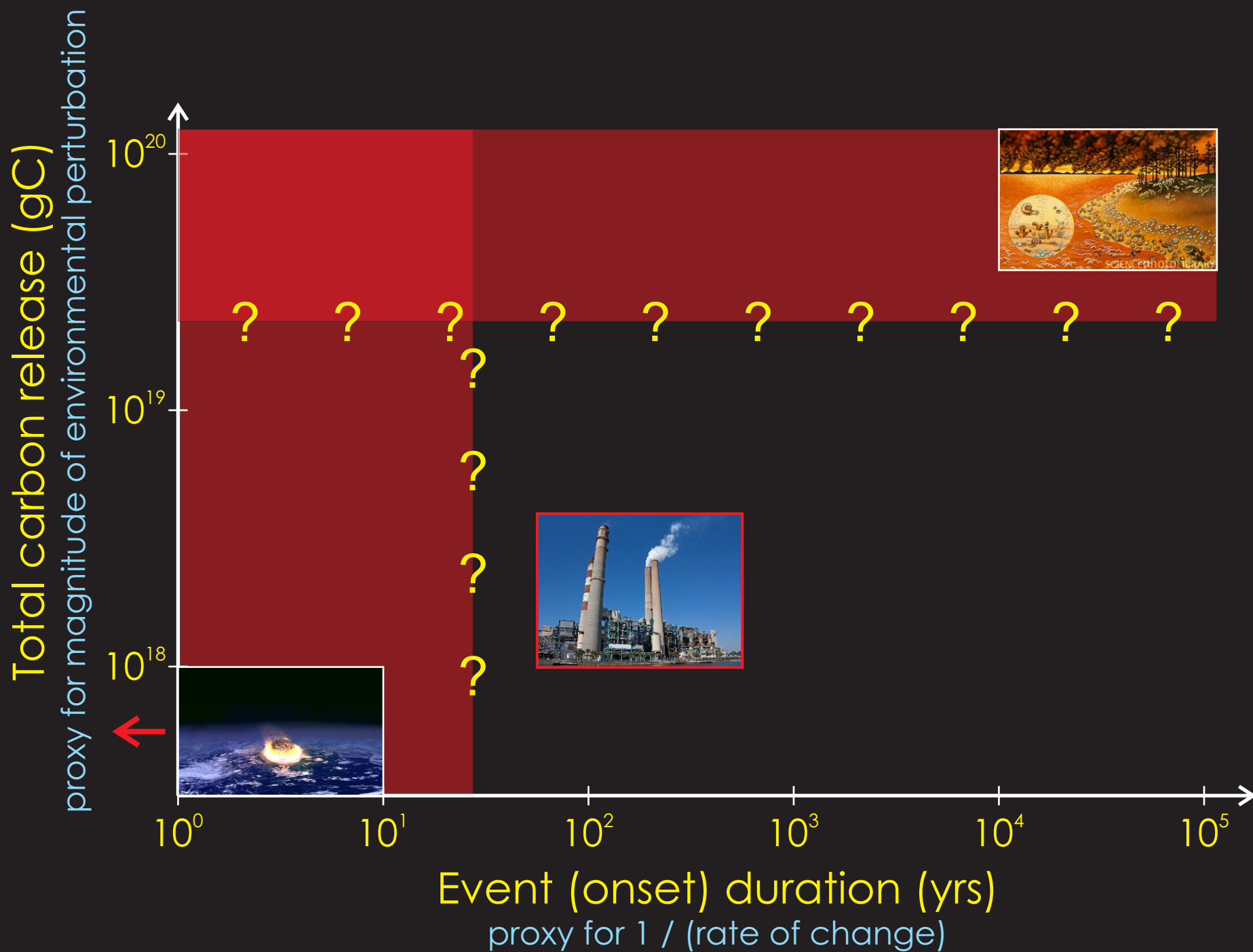
'slow'  
(quasi steady-state)



'fast'  
(geologically abrupt)

→  
Rate of change (magnitude of CO<sub>2</sub> emissions)

# Paleo-analogues – the PETM?

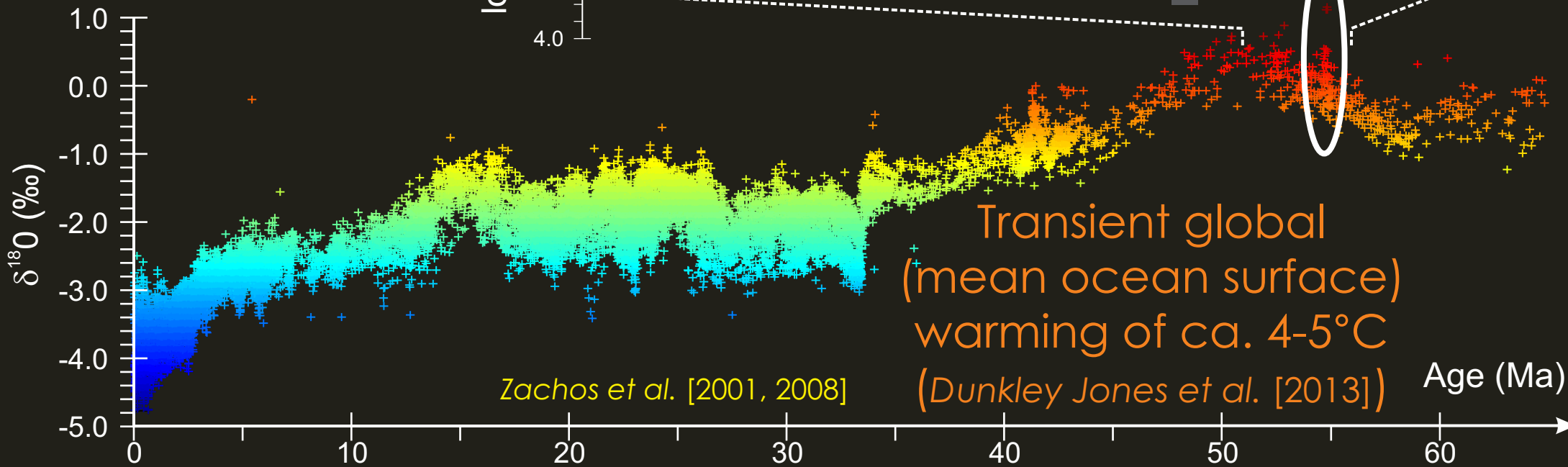
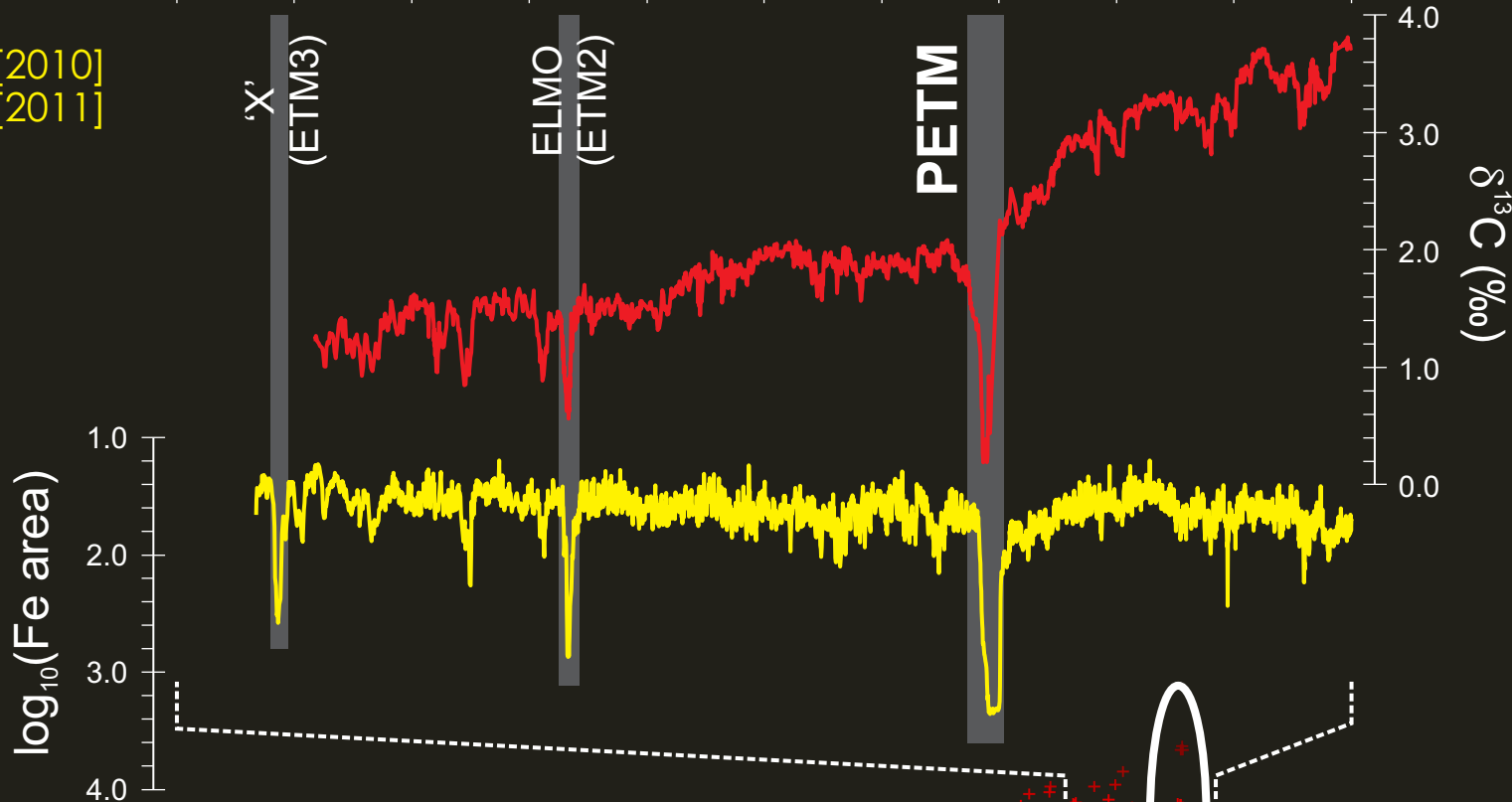
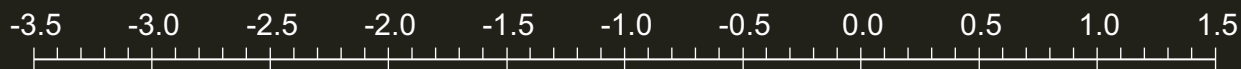


# Paleo-analogues – the PETM?



Age relative to the PETM (Ma)

Zachos et al. [2010]  
Lunt et al. [2011]



Zachos et al. [2001, 2008]

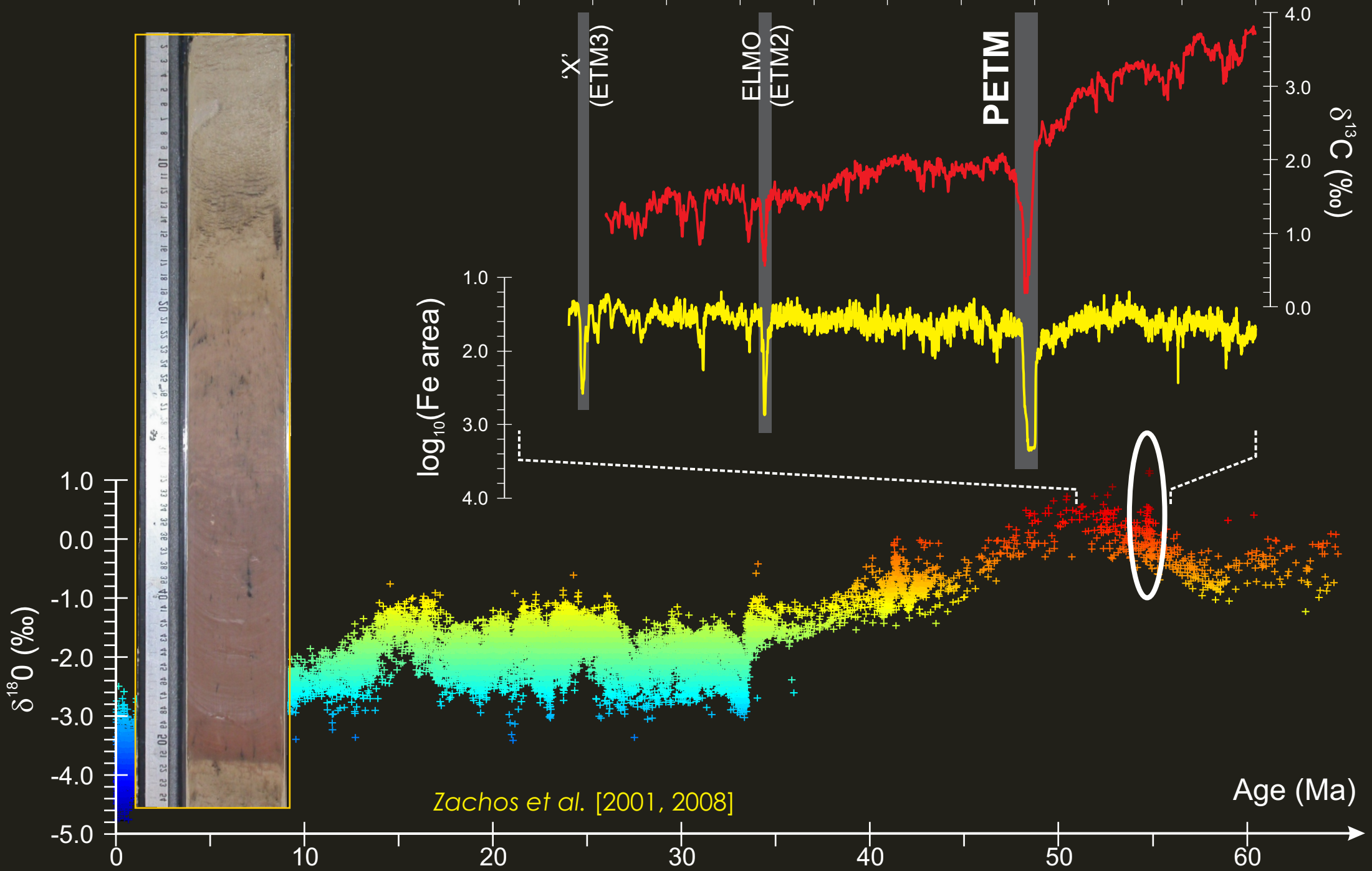
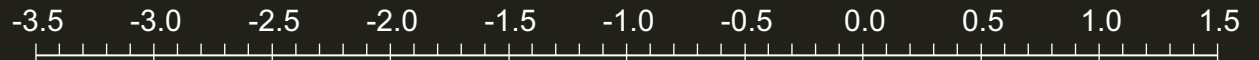
Transient global  
(mean ocean surface)  
warming of ca. 4-5°C  
(Dunkley Jones et al. [2013])

Age (Ma)

# Paleo-analogues – the PETM?



Age relative to the PETM (Ma)



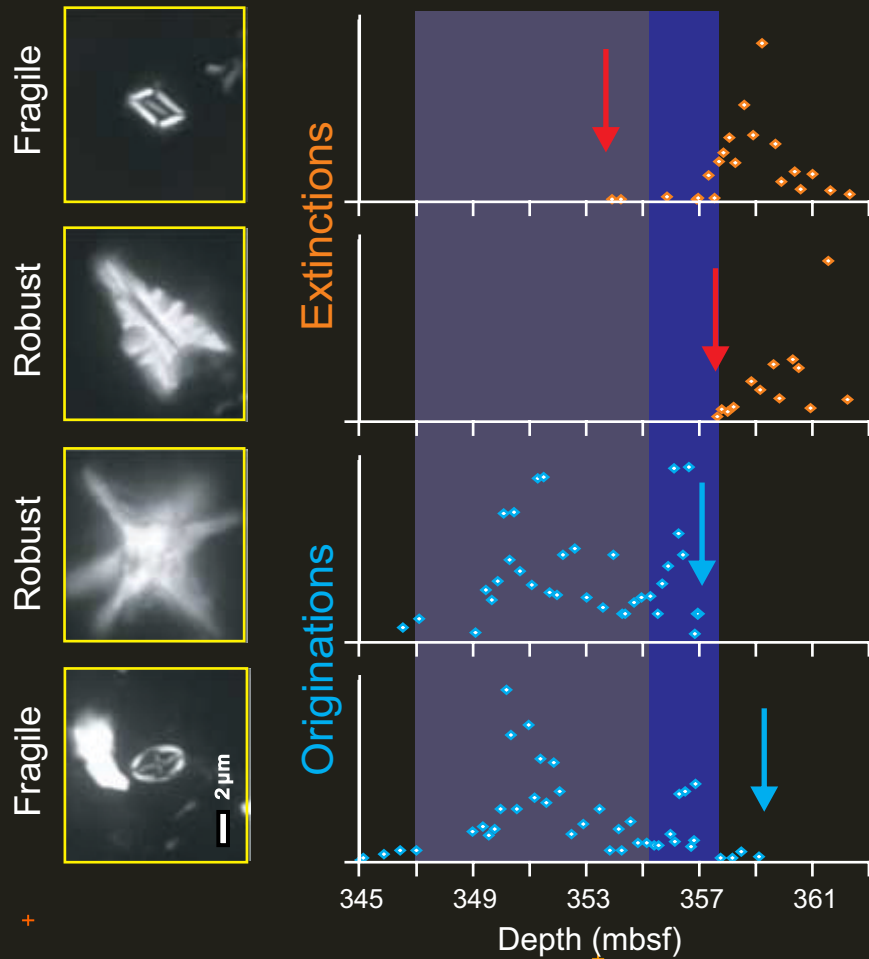
Zachos et al. [2001, 2008]

Age (Ma)

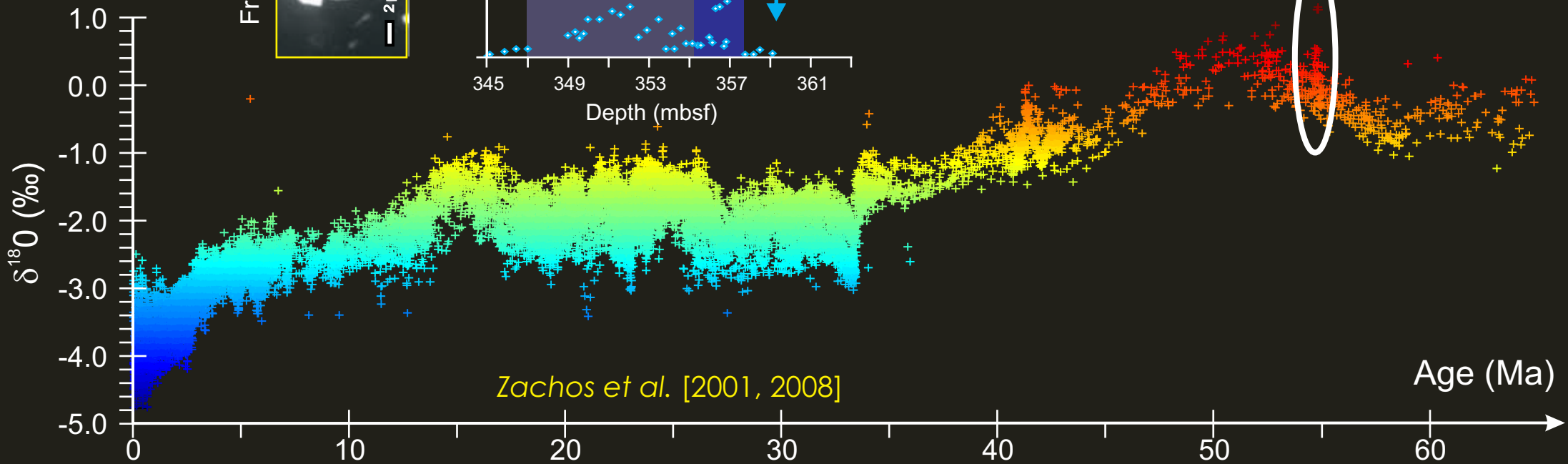
# Paleo-analogues – the PETM?



Gibbs et al. [2006] (Science)



observed nanoplankton assemblage response to environmental change across the PETM



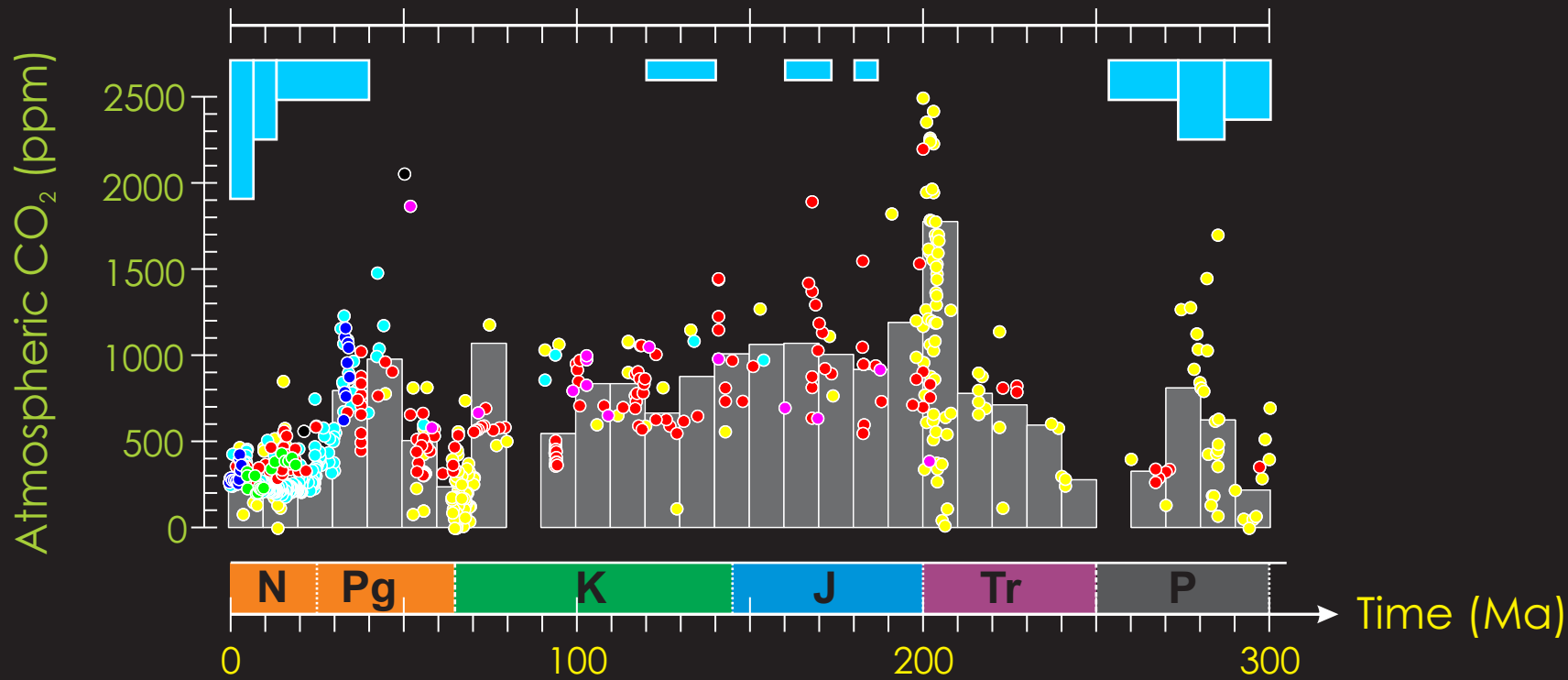


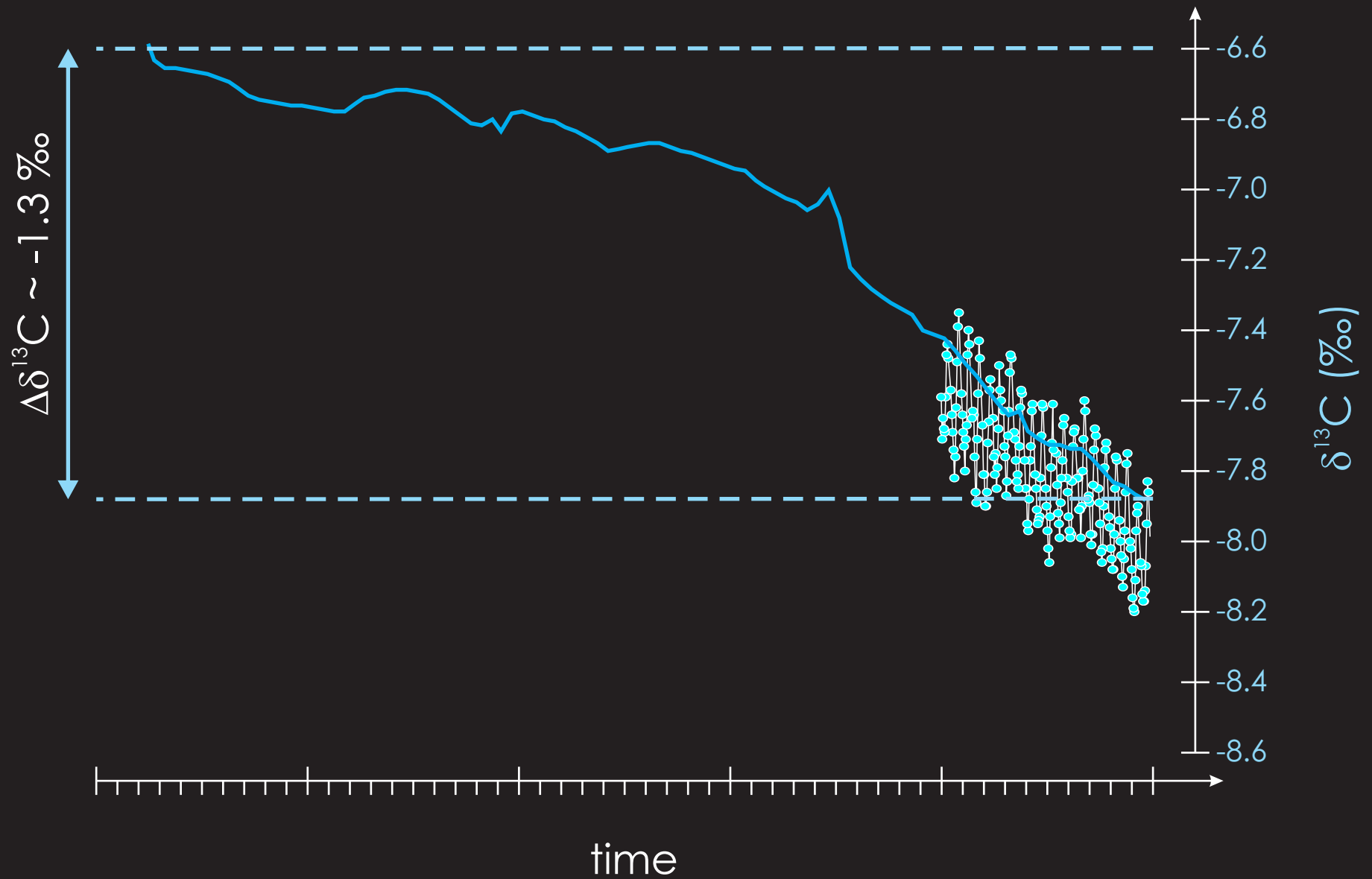
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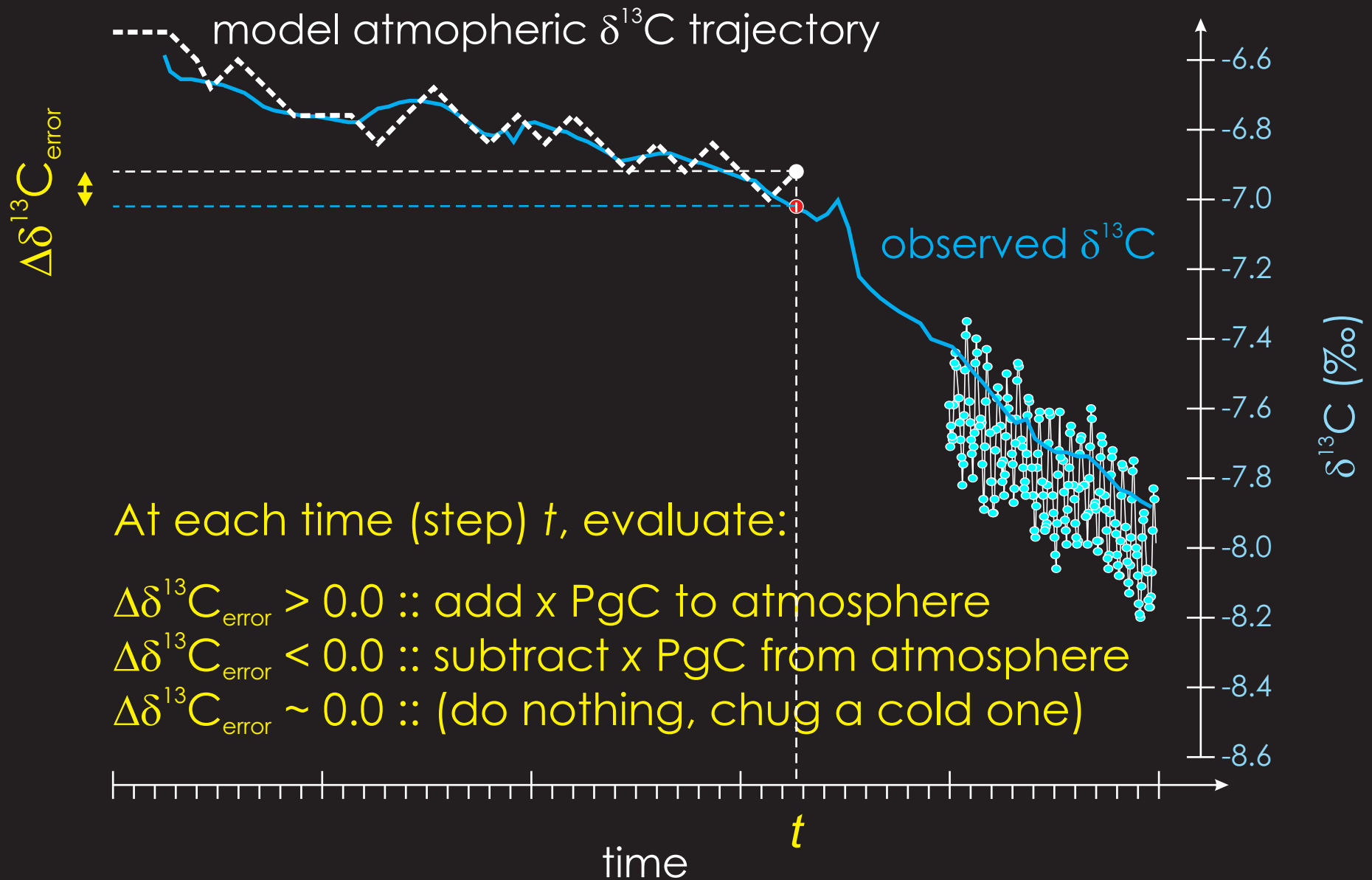


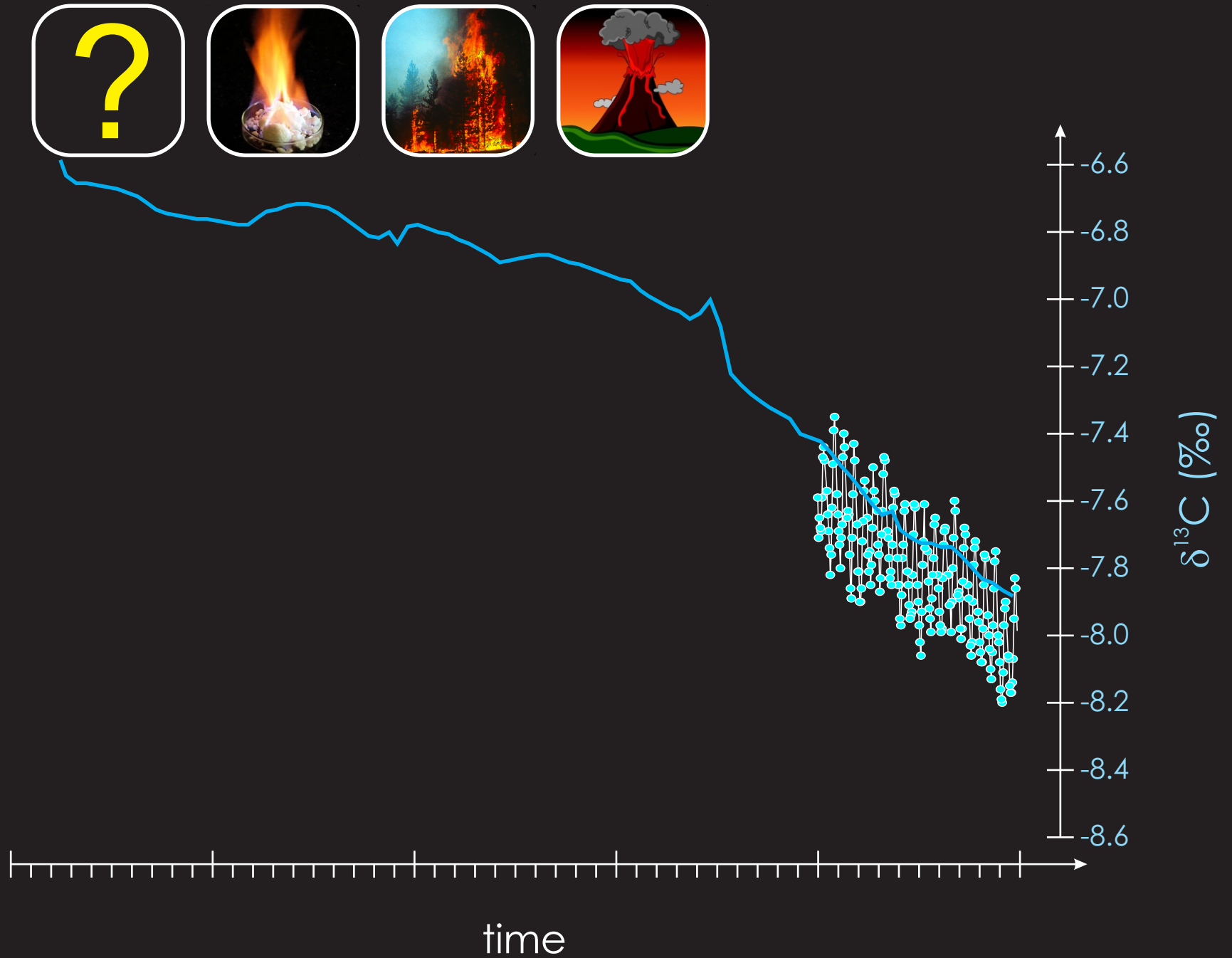
'triggers'

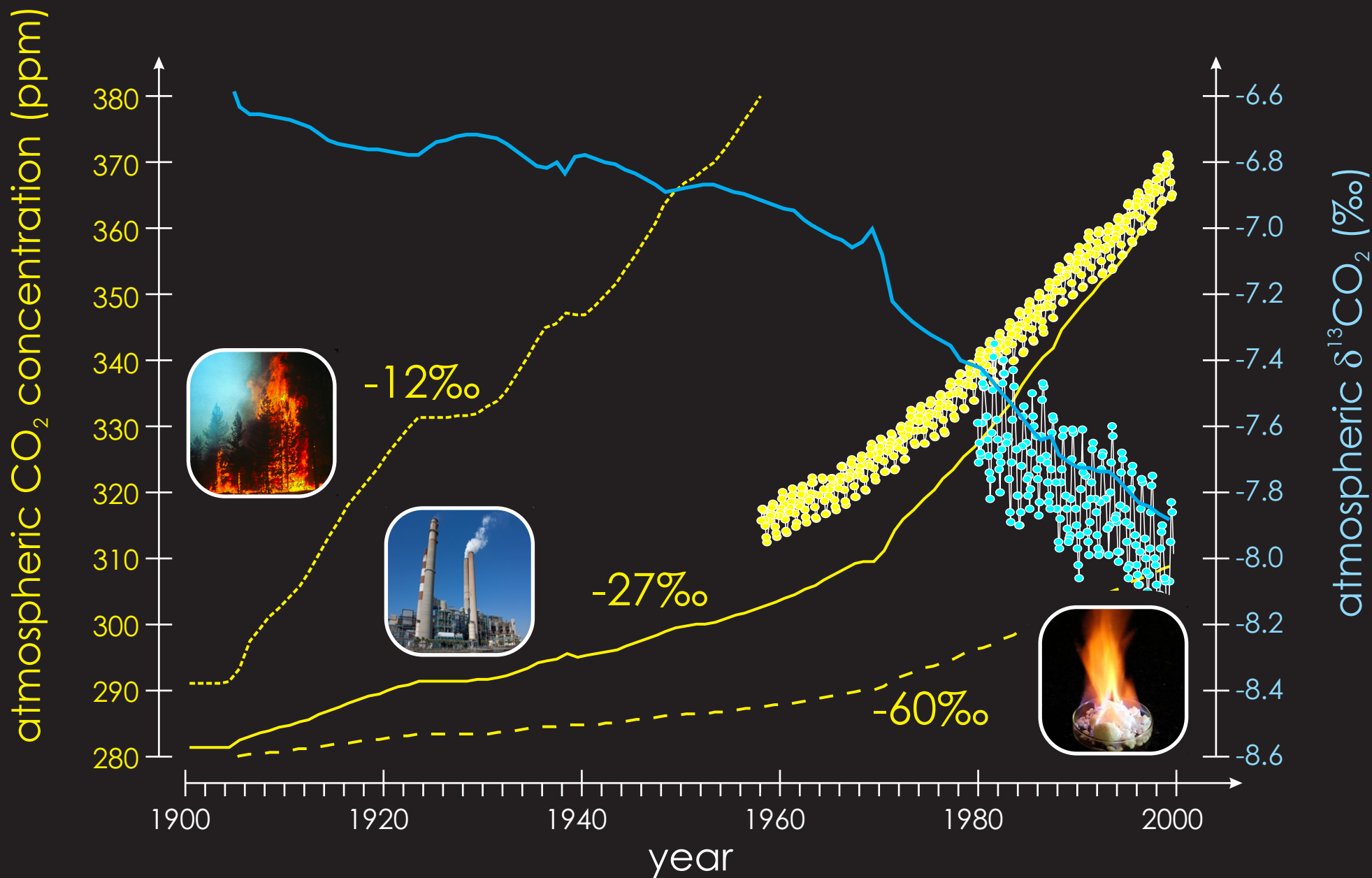
carbon cycle feedbacks

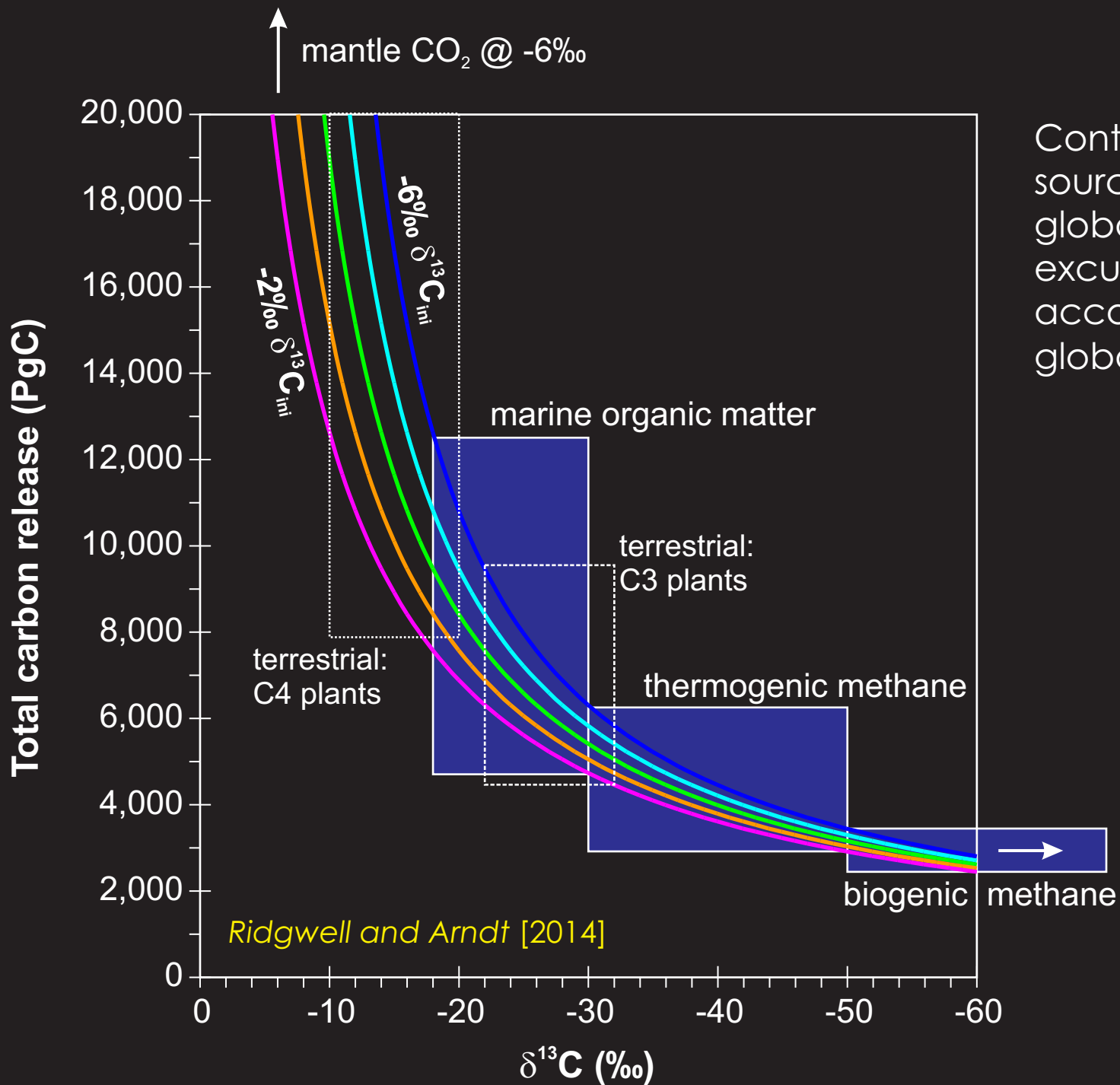






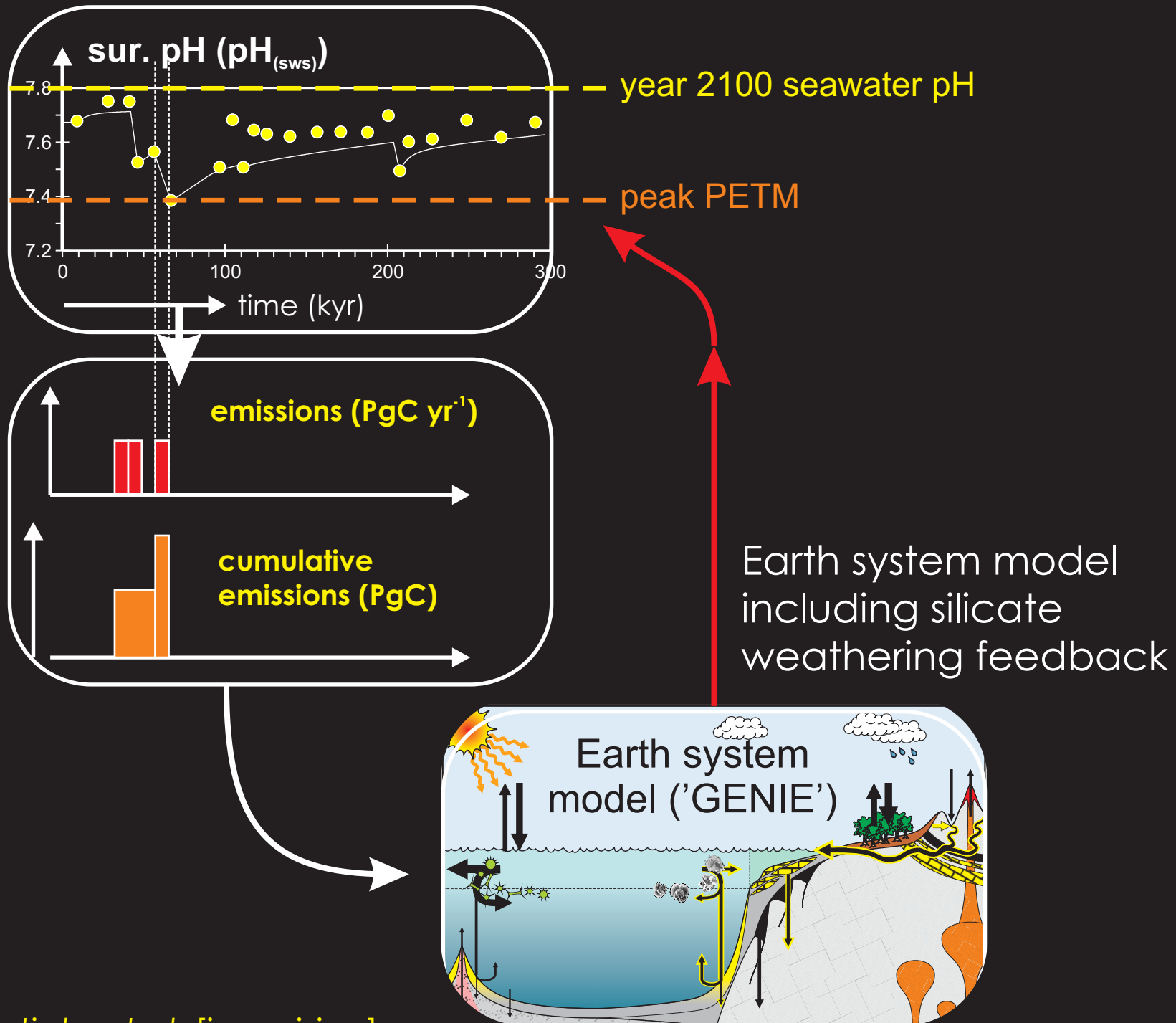




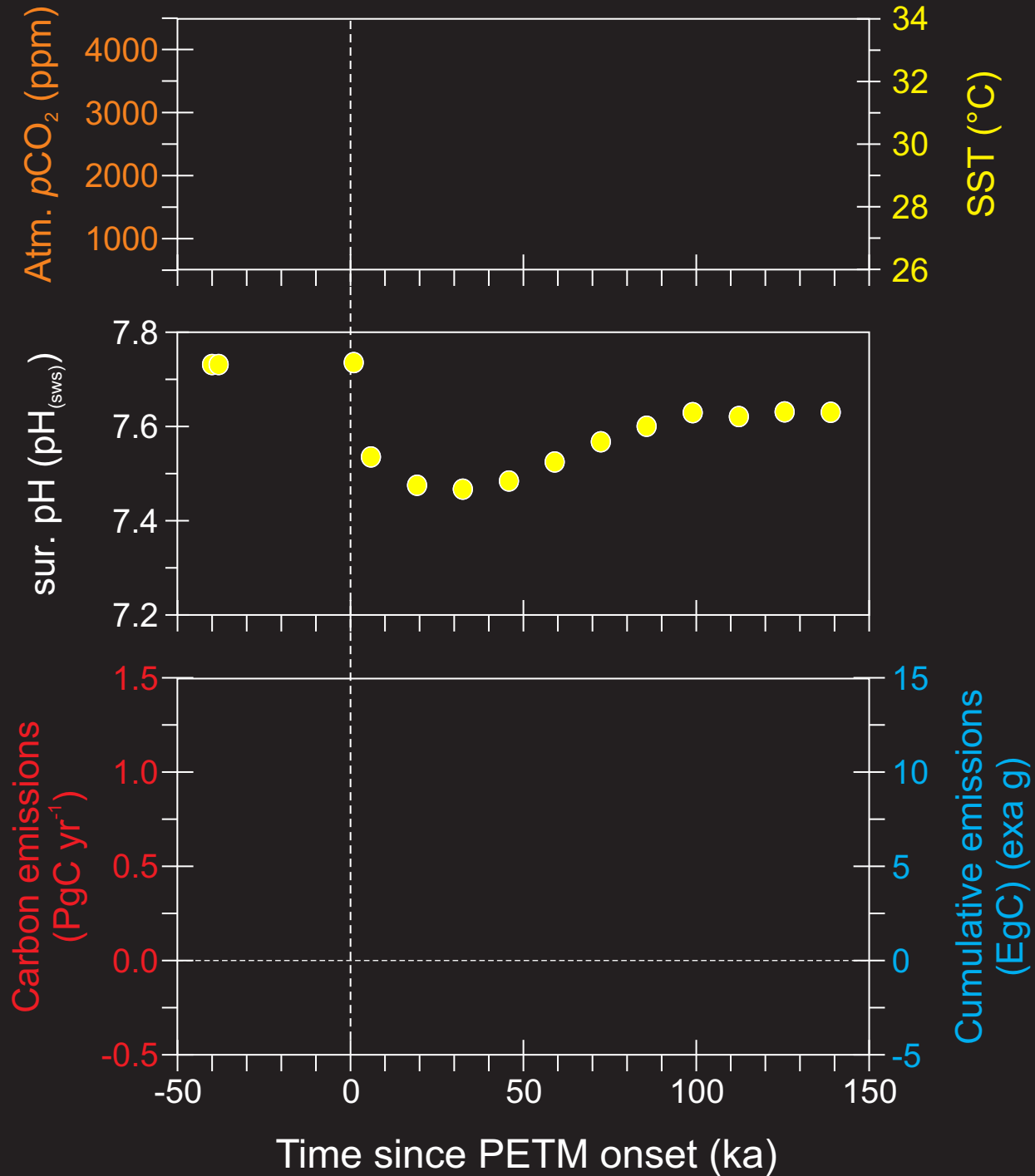


Contours of carbon release vs. source isotopic signature for a global -4‰ carbon isotopic excursion. Contours differ according to the initial mean global  $\delta^{13}\text{C}$ .

# Assimilating surface ocean pH change (only)

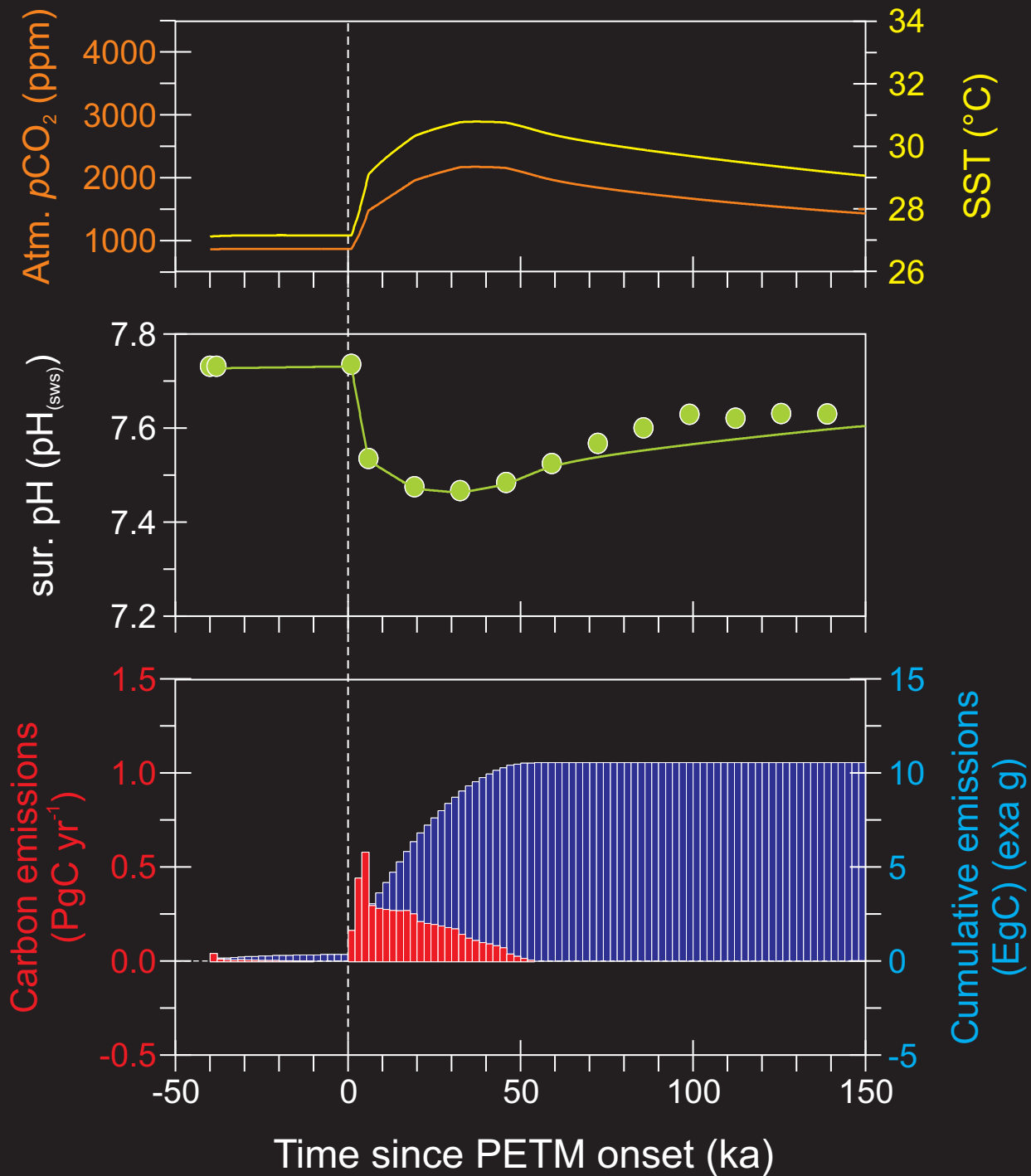


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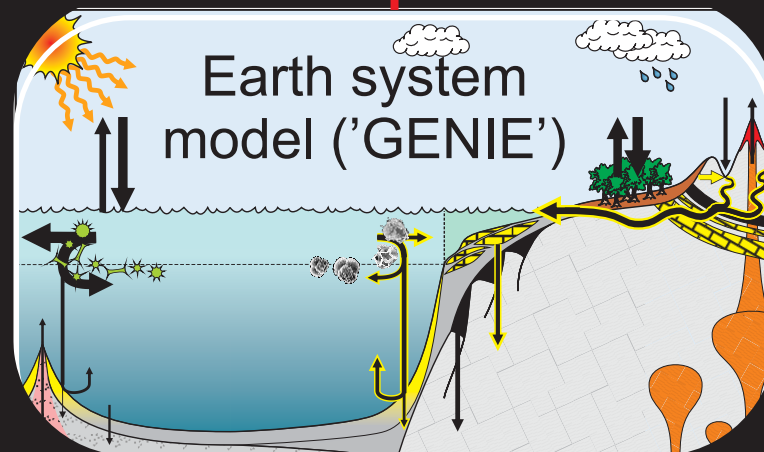
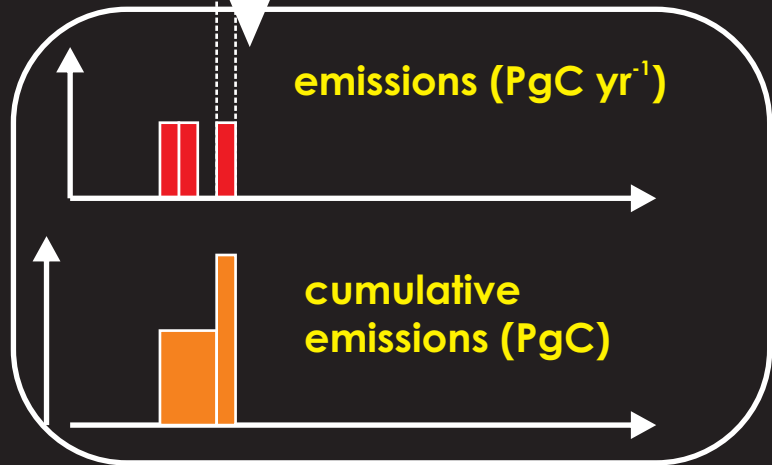
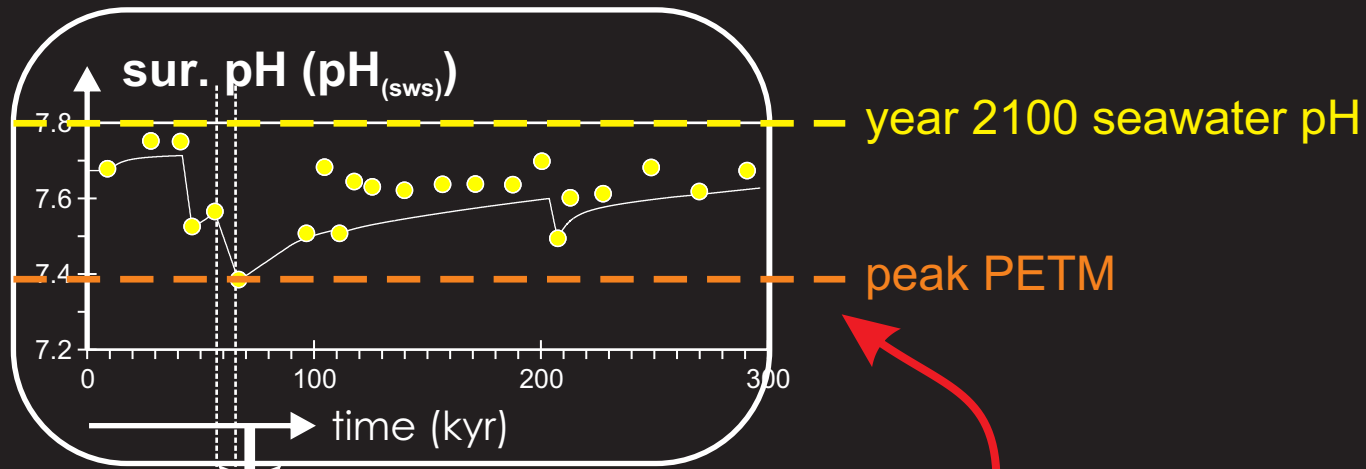




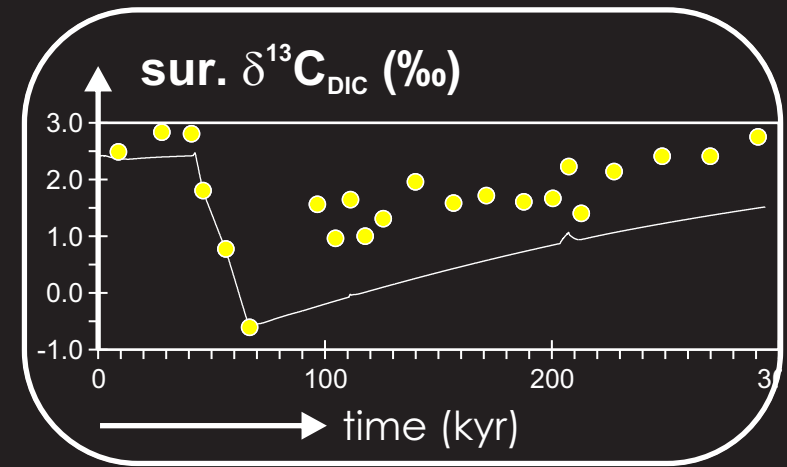
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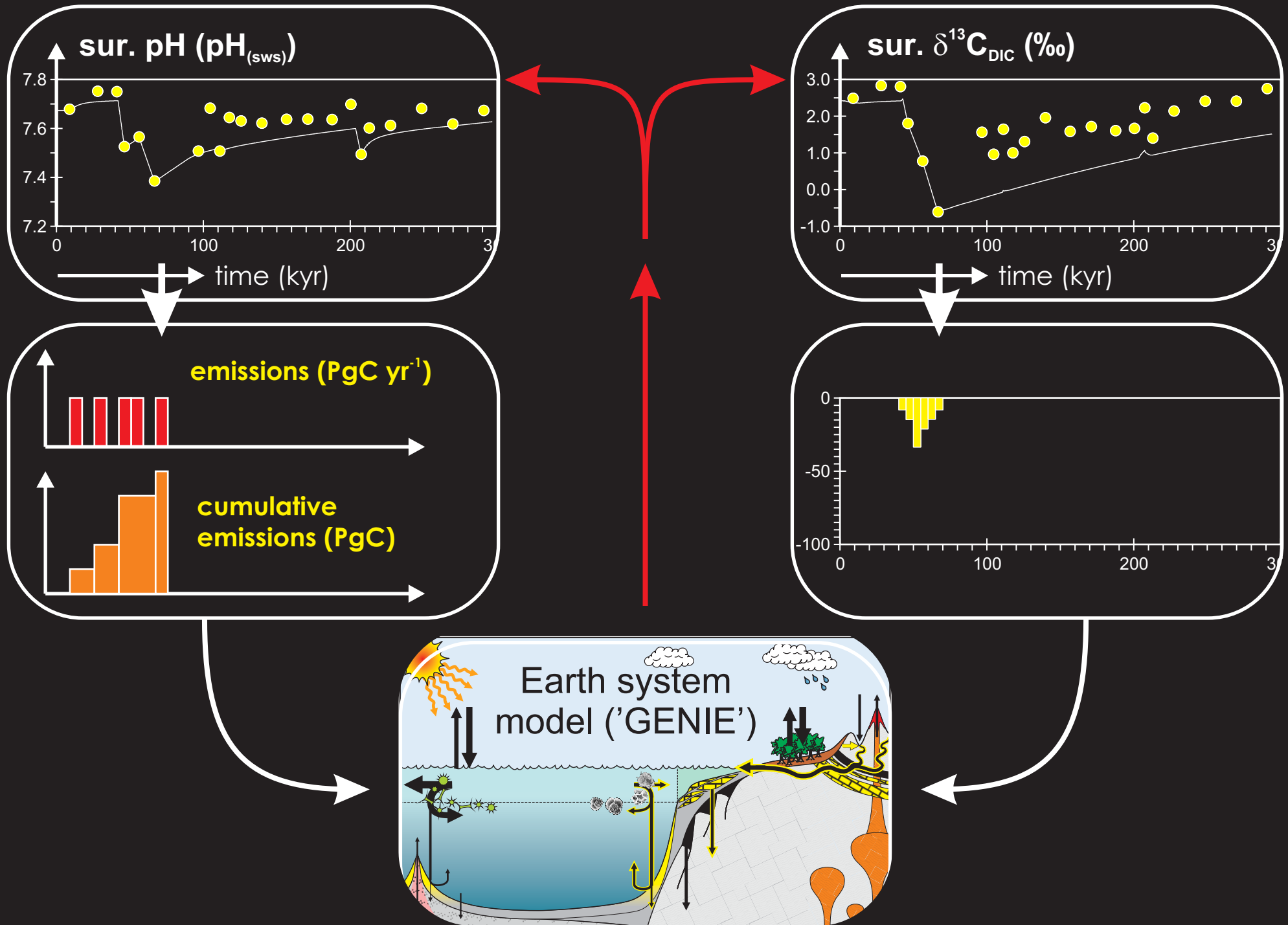
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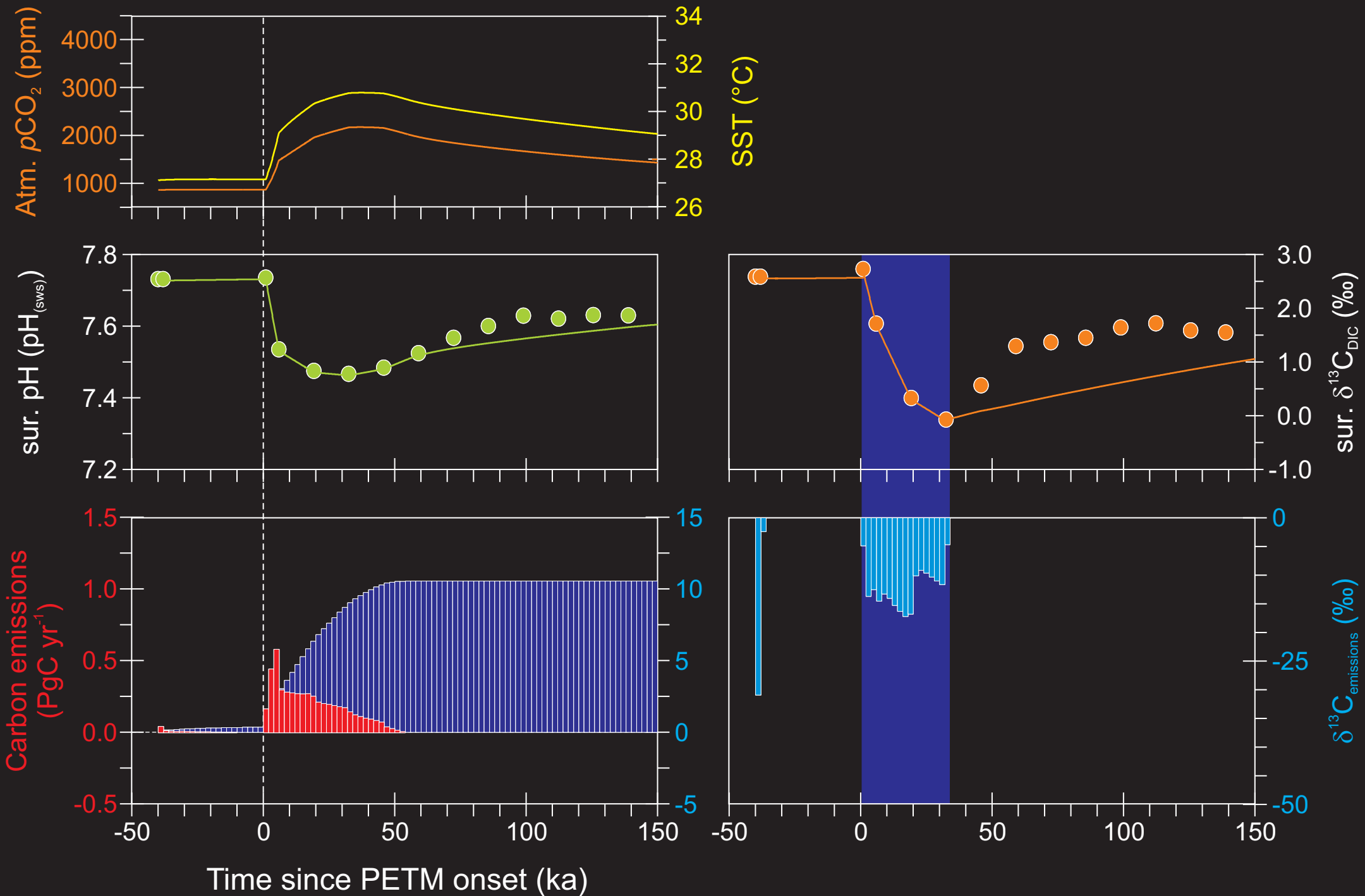
# Assimilating surface ocean pH and $\delta^{13}\text{C}$



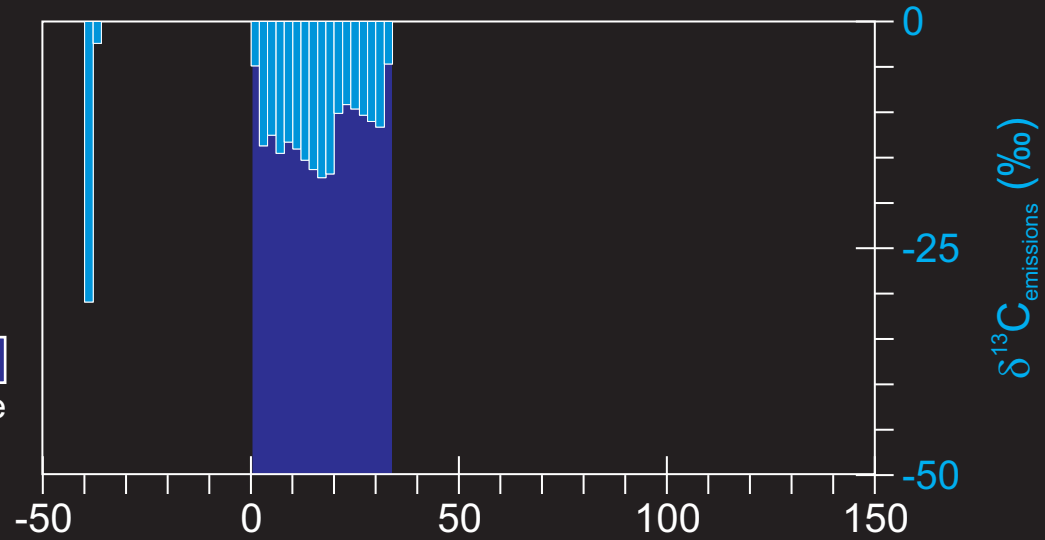
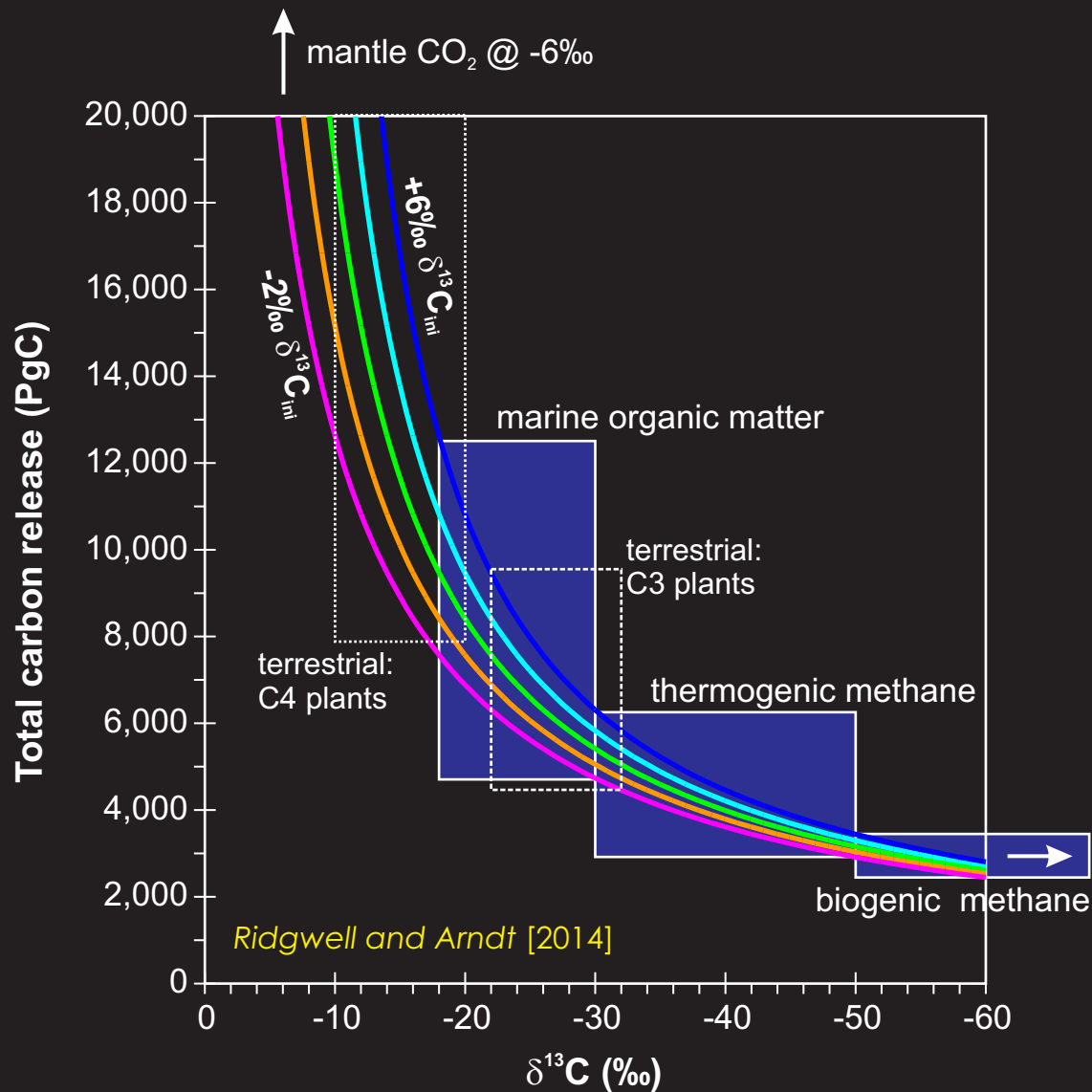
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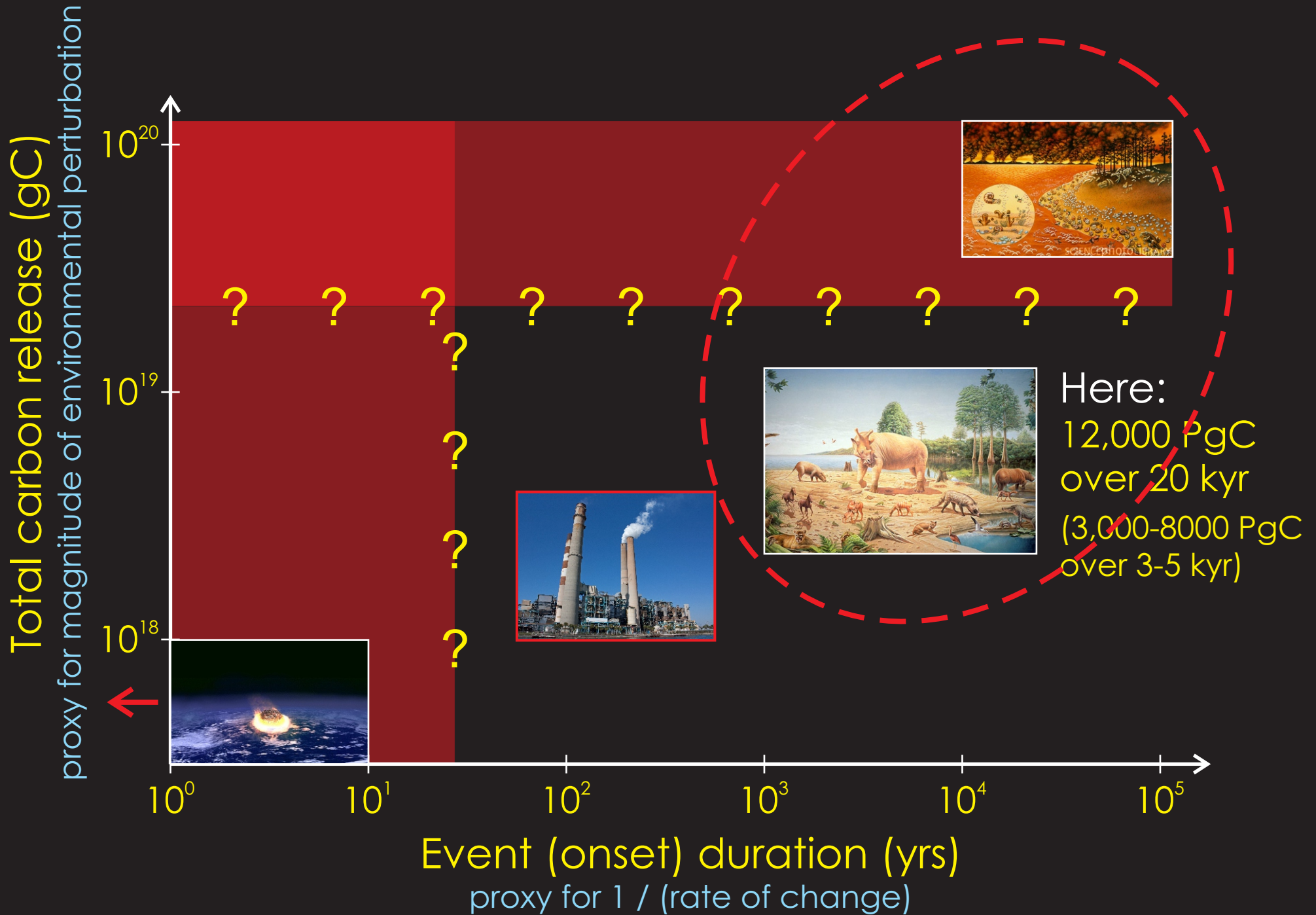
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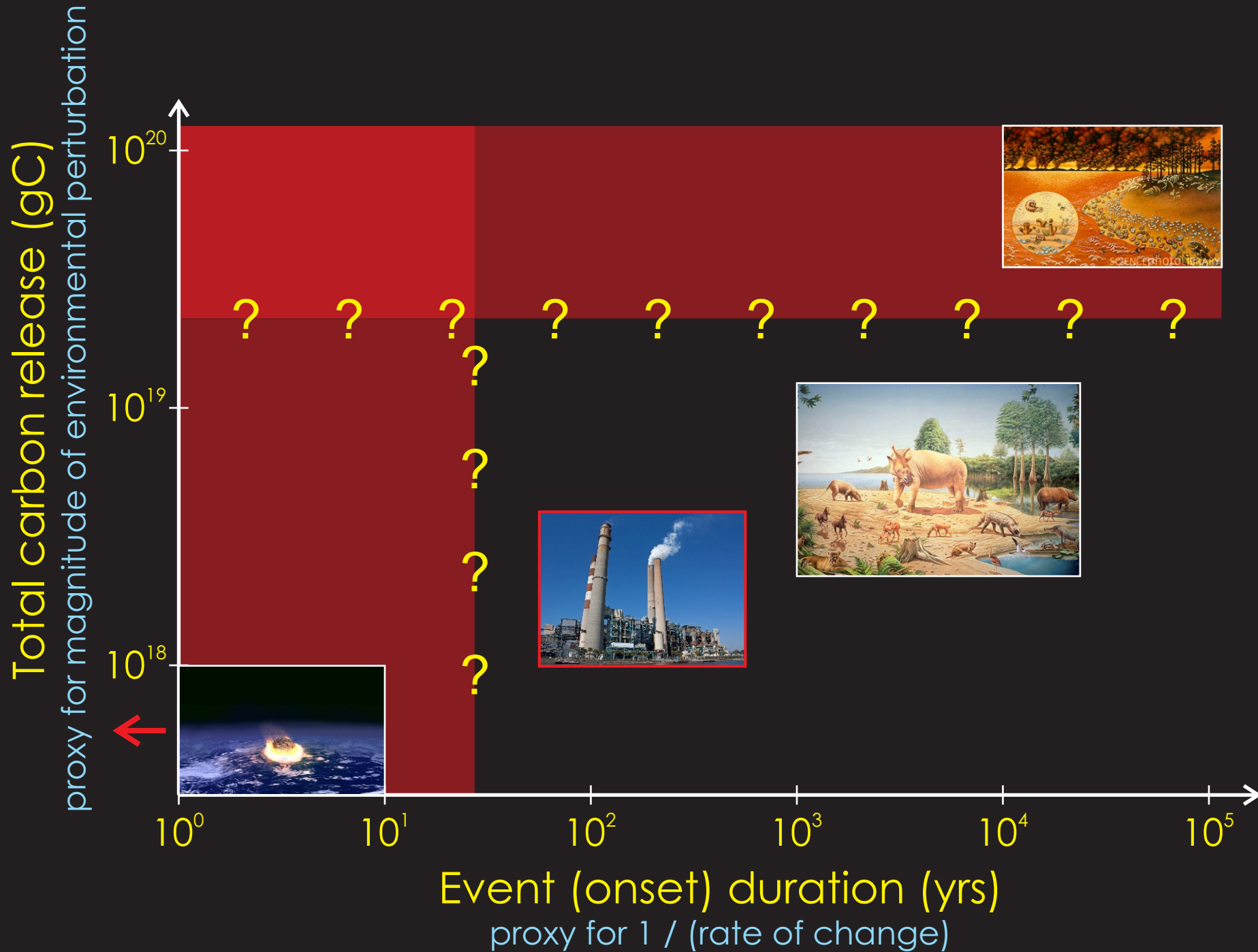
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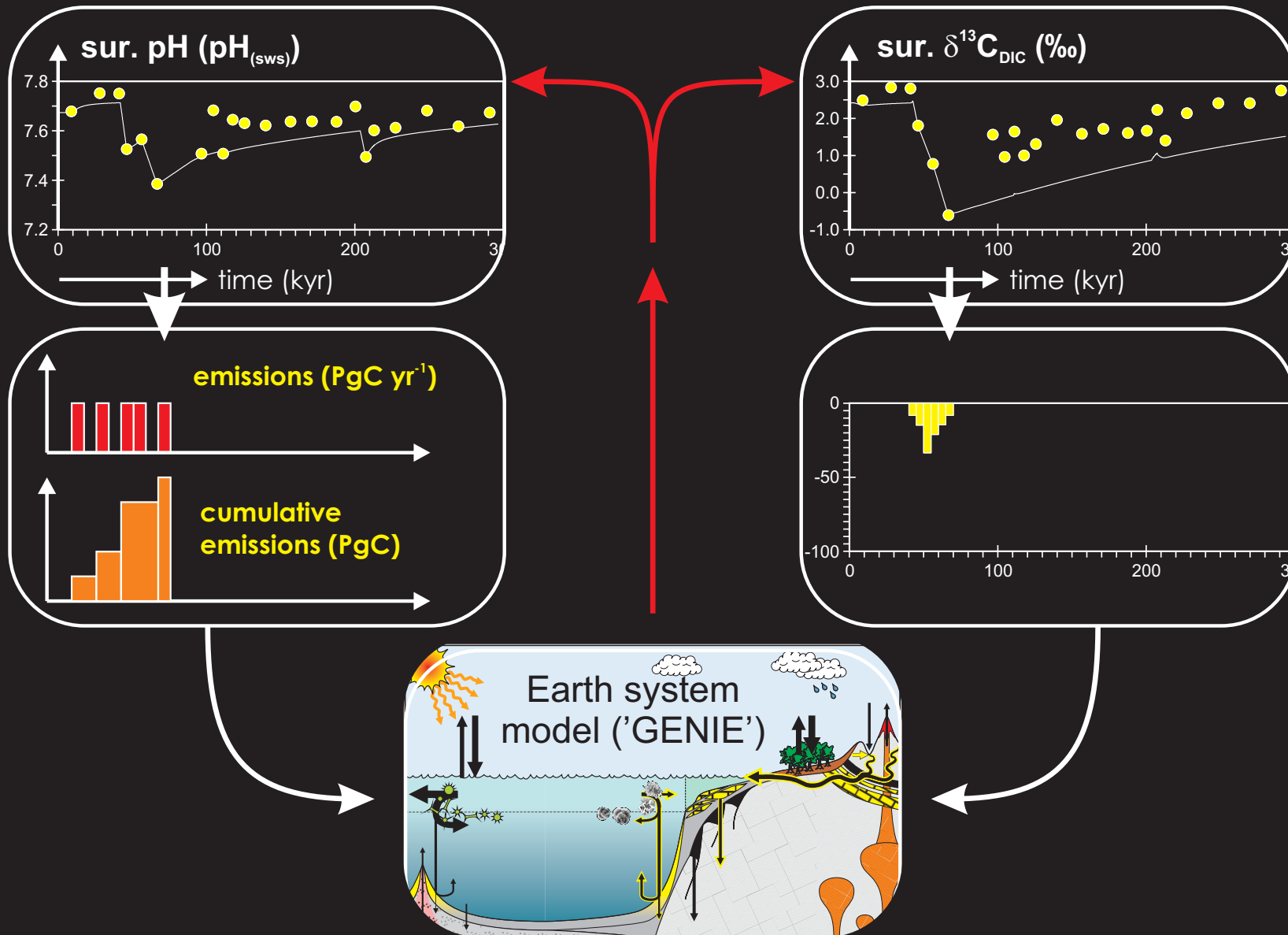


# Conclusions #1 – ecological sensitivities





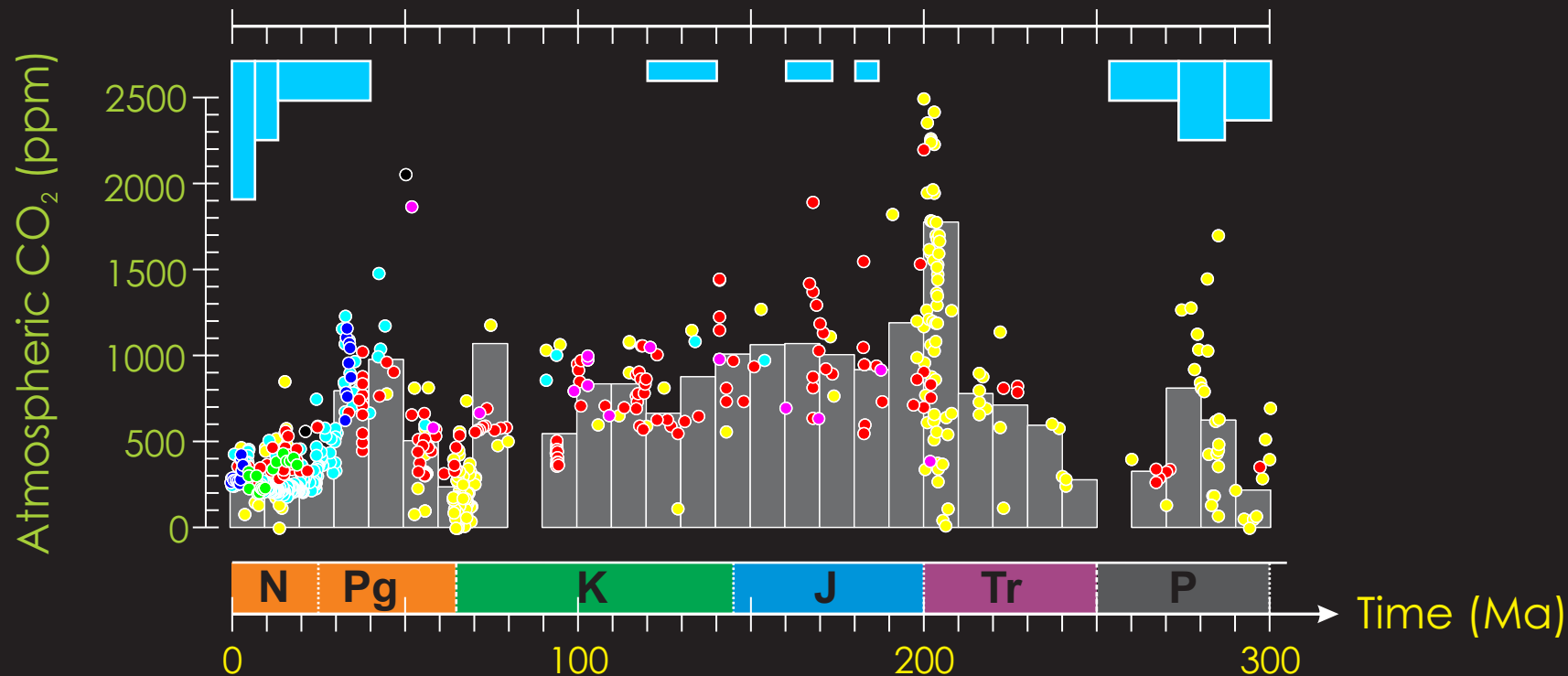
# Conclusions #2 – role of carbon cycle feedbacks





the 'ideal' event?

- ★ A transient environmental perturbation in the absence of massive volcanism and/or bolide impact ...
- ★ ... or sufficient proxy data to back-out the contribution of volcanism. (Not obvious (to me) how direct environmental change can be backed out of an impact-dominated event.)
- ★ Comparable onset time-scale to modern.



## Thanks to:

*Marcus Gutjahr [GEOMAR]*

*Gavin Foster [NOC]*

*Philip Sexton [The Open University]*

*Paul Pearson [Cardiff]*

*Sandy Kirtland Turner [UCR]*

The European Research Council

Heising-Simons Foundation



vs.

