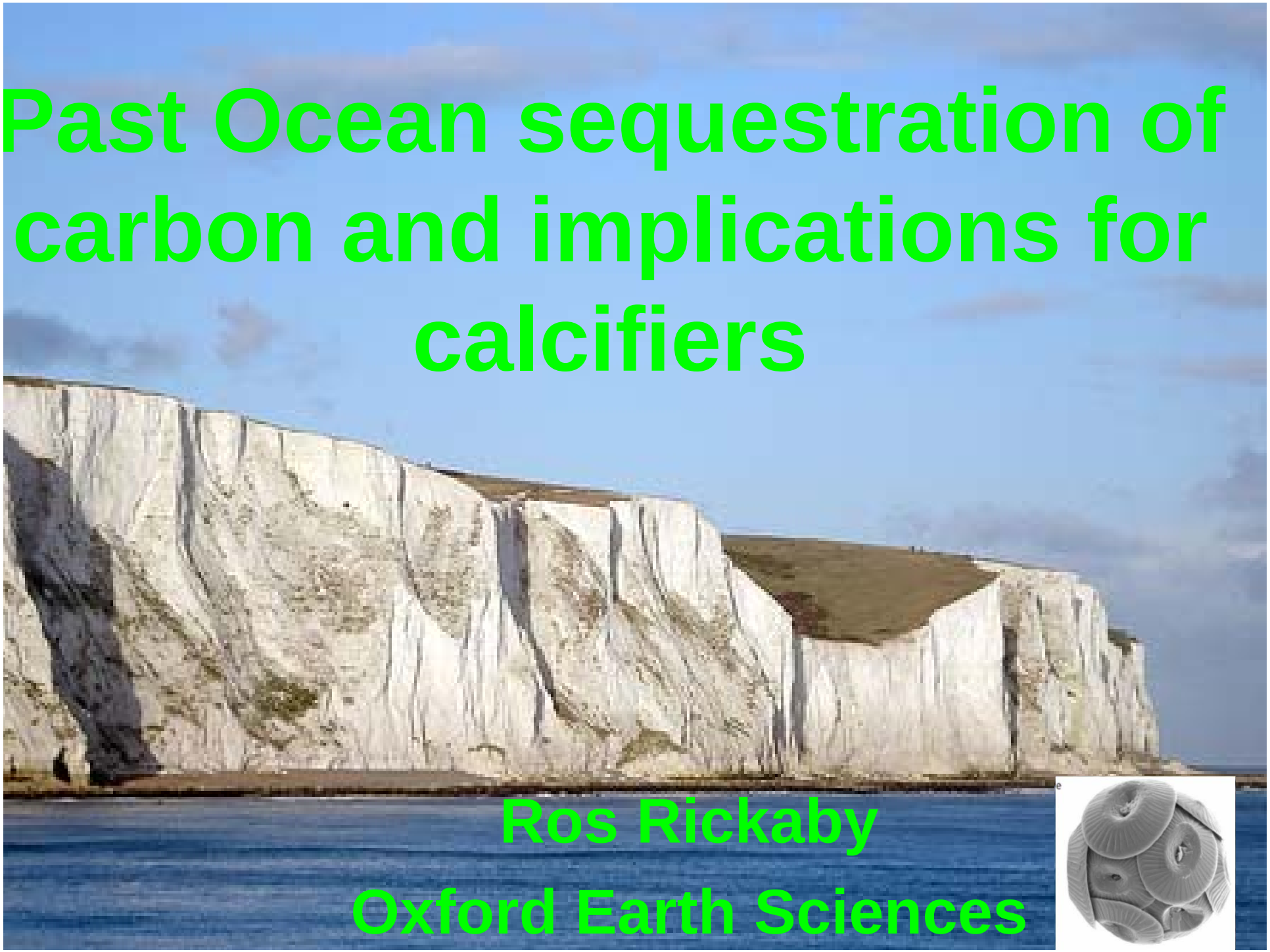
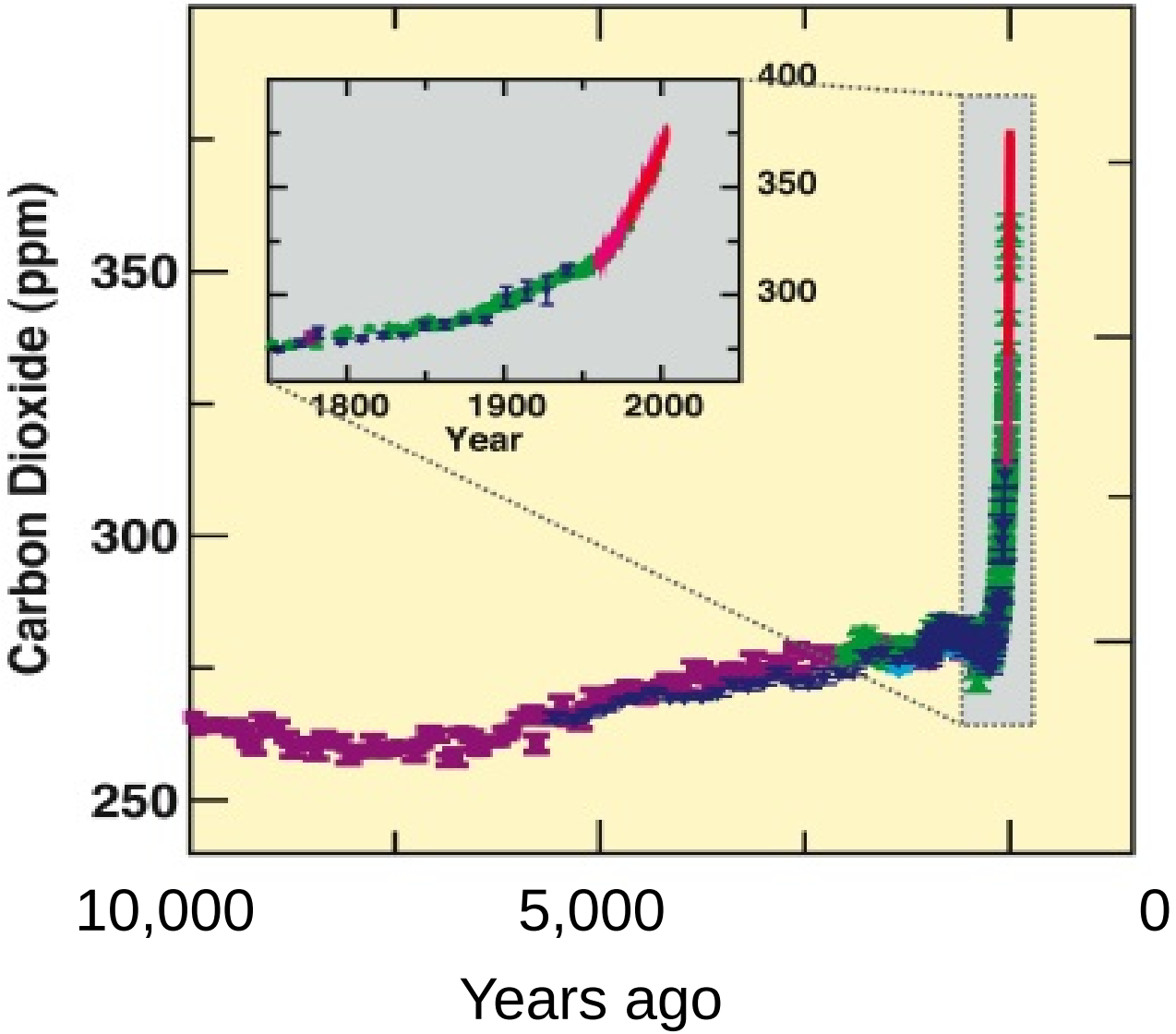
Past Ocean sequestration of carbon and implications for calcifiers

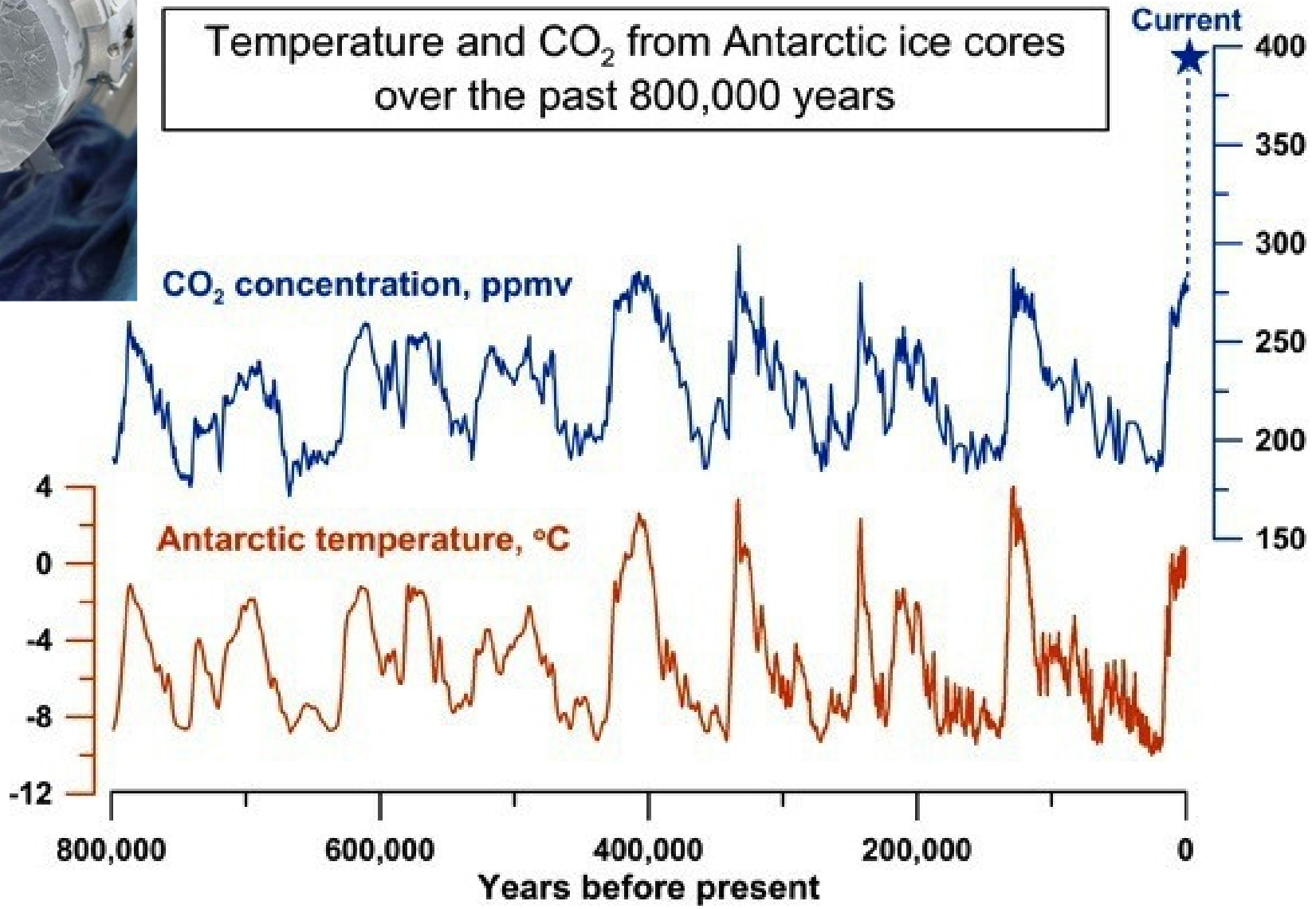


Ros Rickaby
Oxford Earth Sciences

The Kinetic Challenge



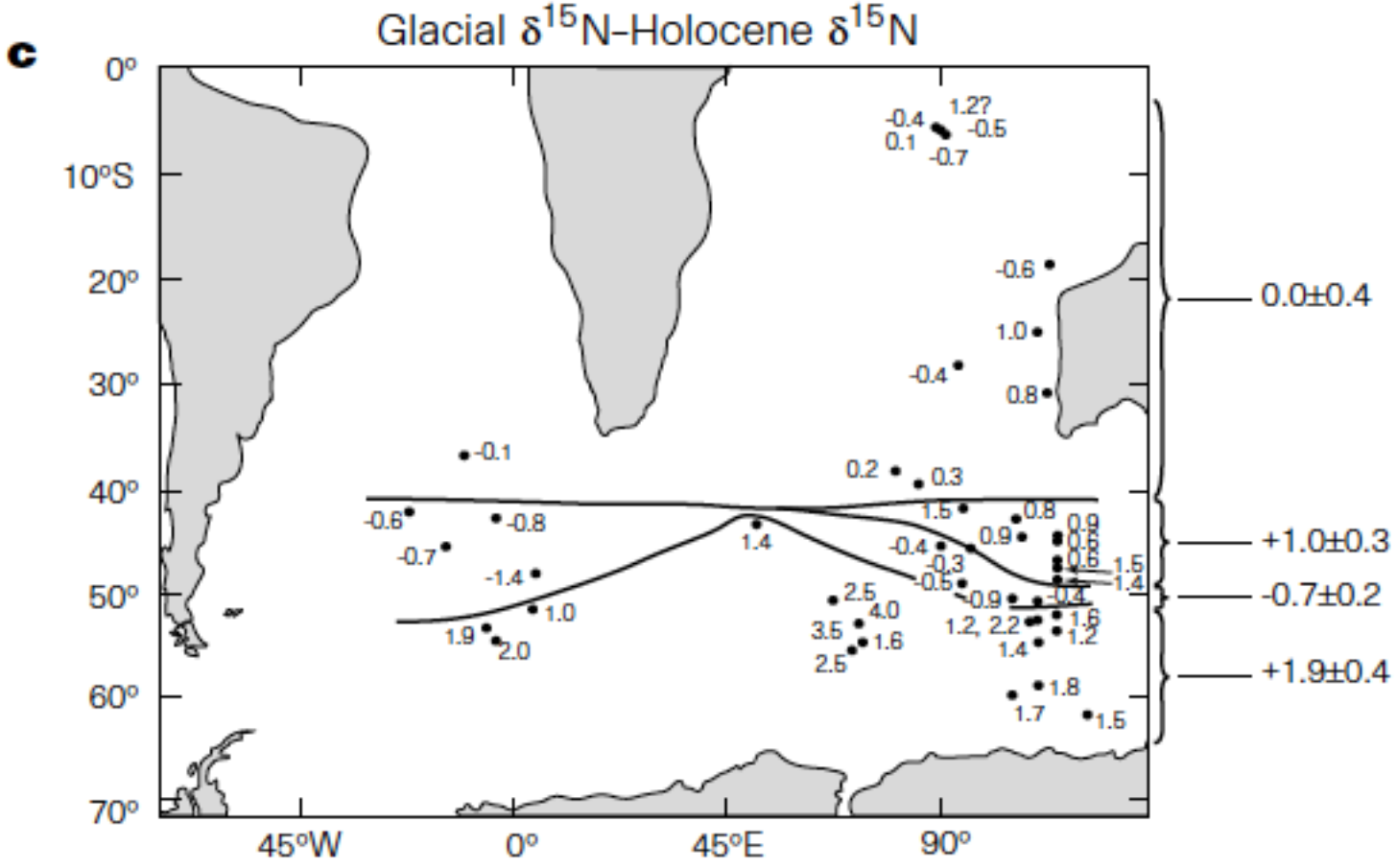
Temperature and CO_2 from Antarctic ice cores over the past 800,000 years



Contribution of Southern Ocean surface-water stratification to low atmospheric CO_2 concentrations during the last glacial period

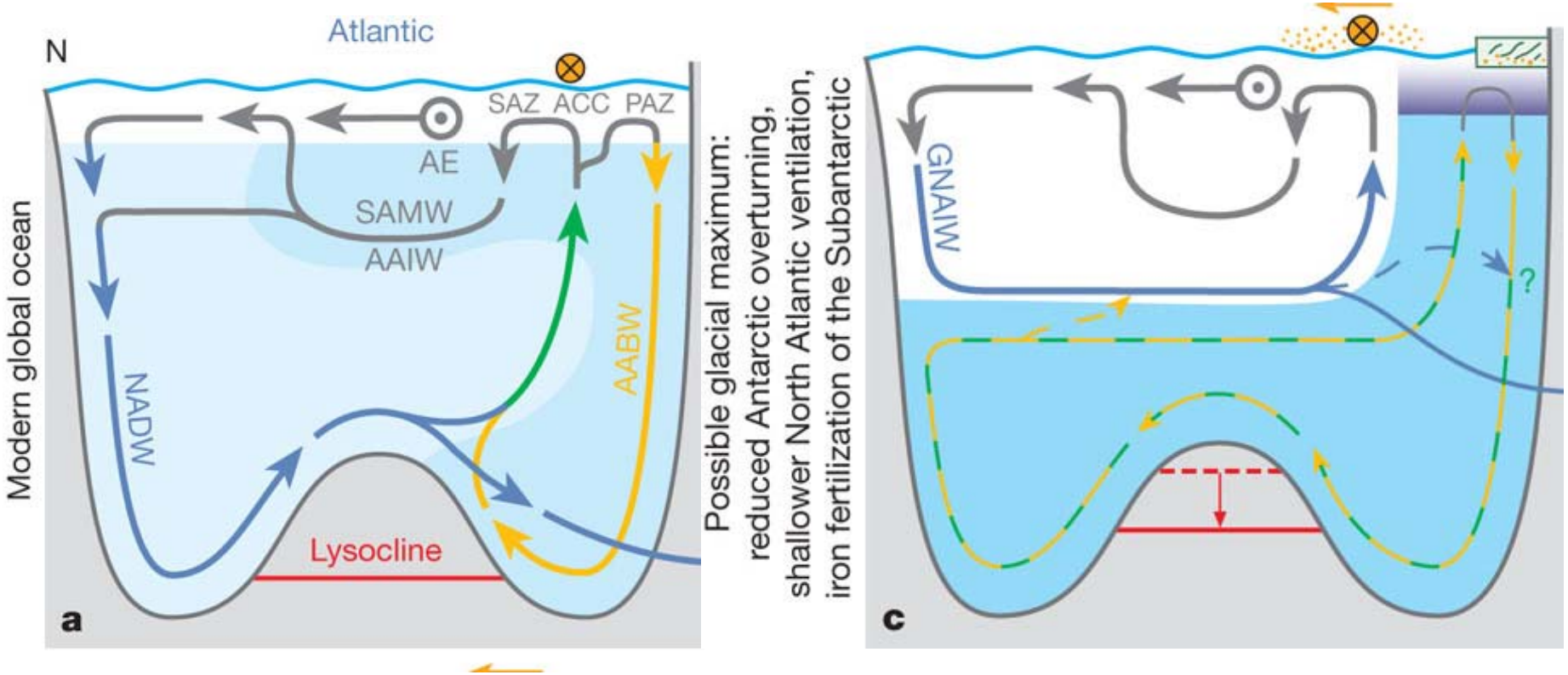
Roger François*, Mark A. Altabet†, Ein-Fen Yu‡, Daniel M. Sigman§, Michael P. Bacon*, Martin Frankǁ, Gerhard Bohrmann¶, Gilles Bareille# & Laurent D. Labeyrie*

Ltd 1997



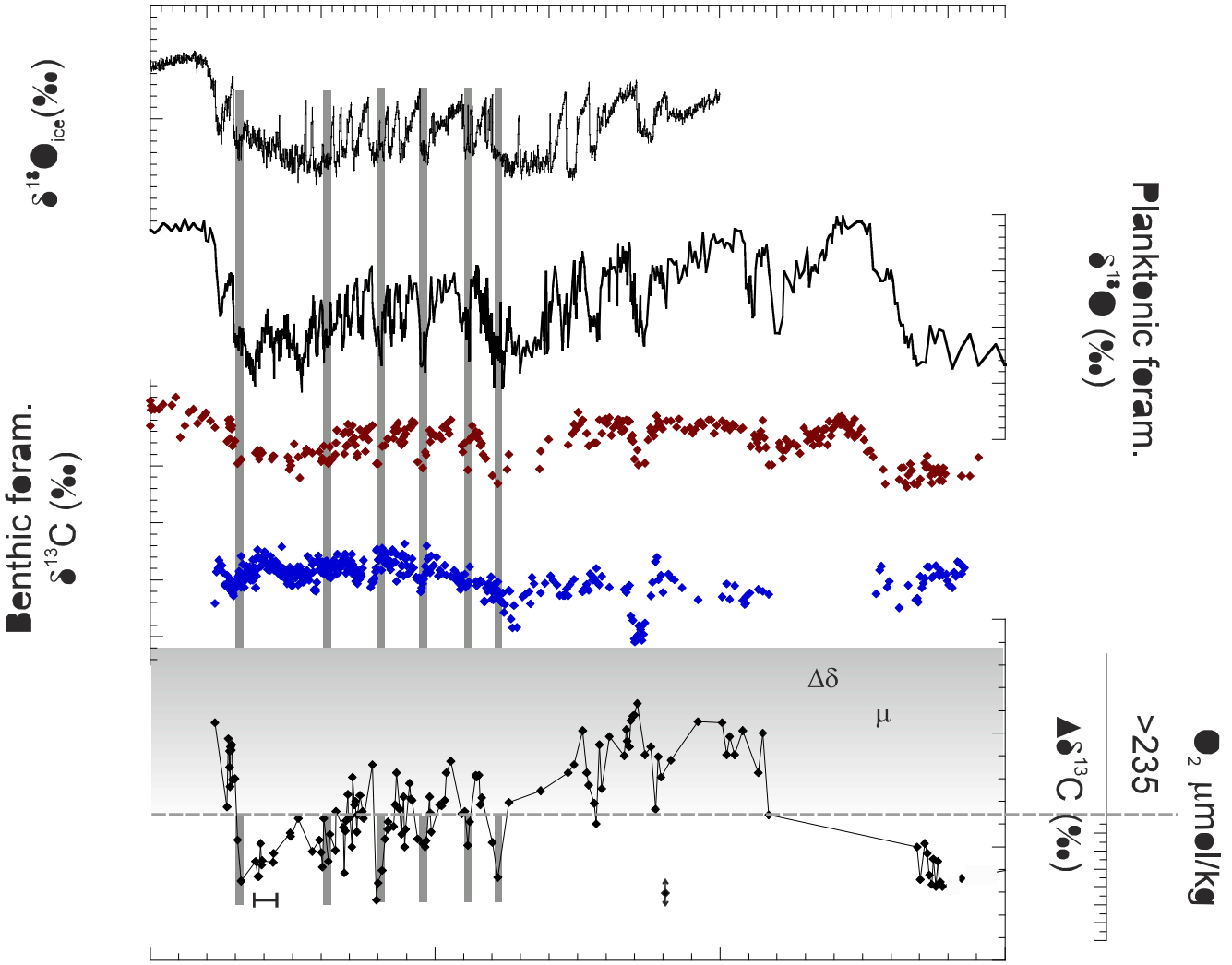
MODERN

POSSIBLE GLACIAL



CO_2 sequestration in the deep ocean via stratification

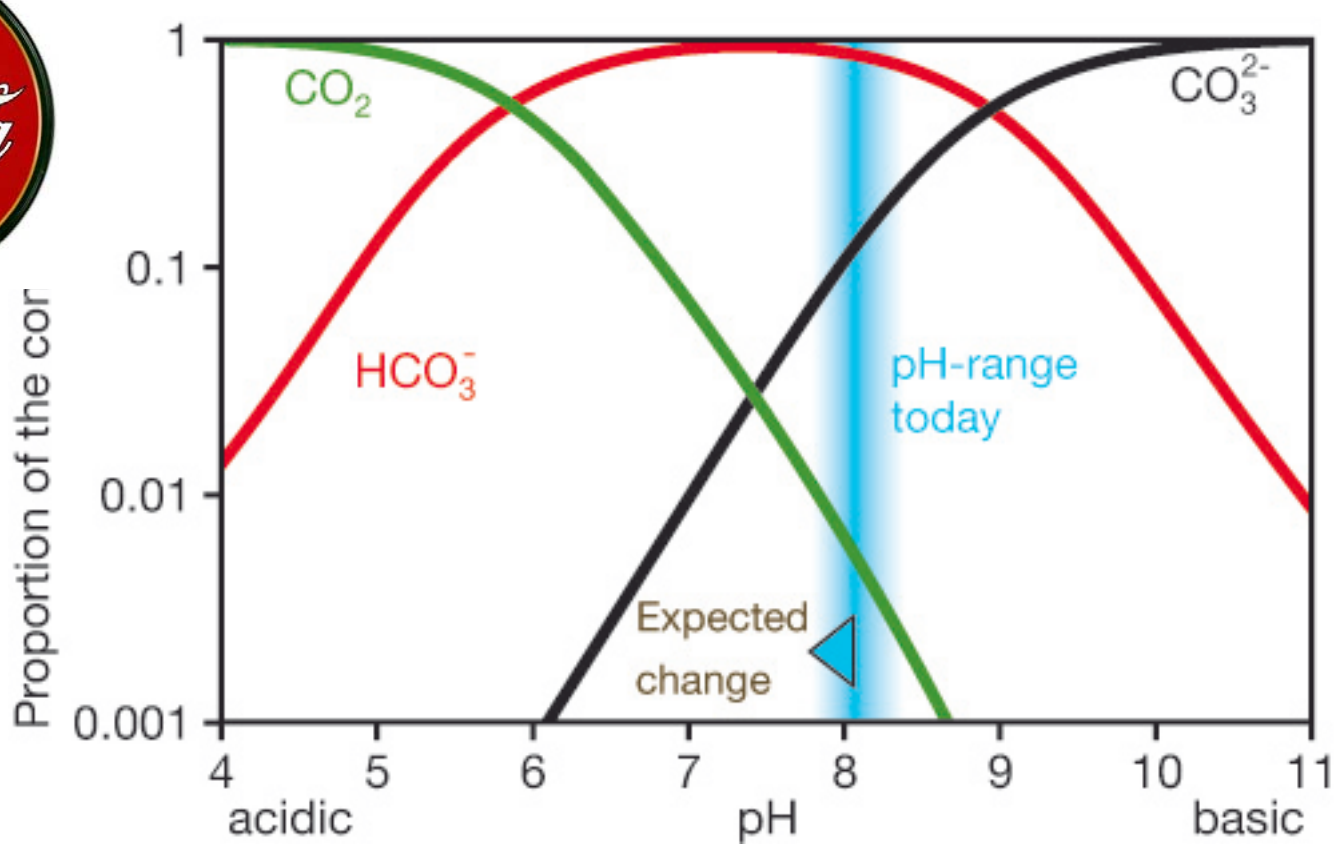
Sigman et al., 2010



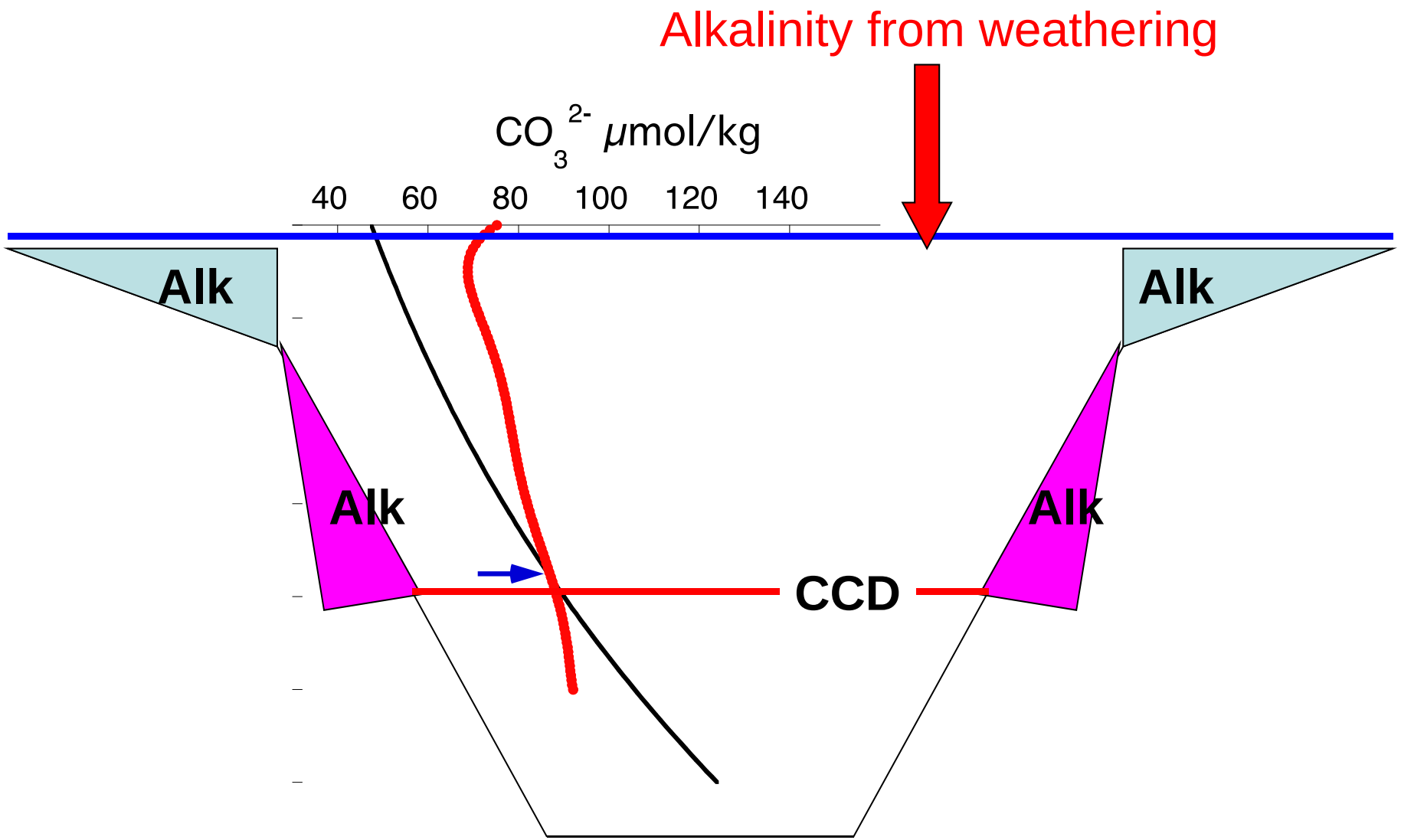
In revision

More respired CO_2 at depth leads to enhanced corrosion and release of alkalinity from $CaCO_3$ seds

$$CO_2 + H_2O = HCO_3^- + H^+ = CO_3^{2-} + 2H^+$$

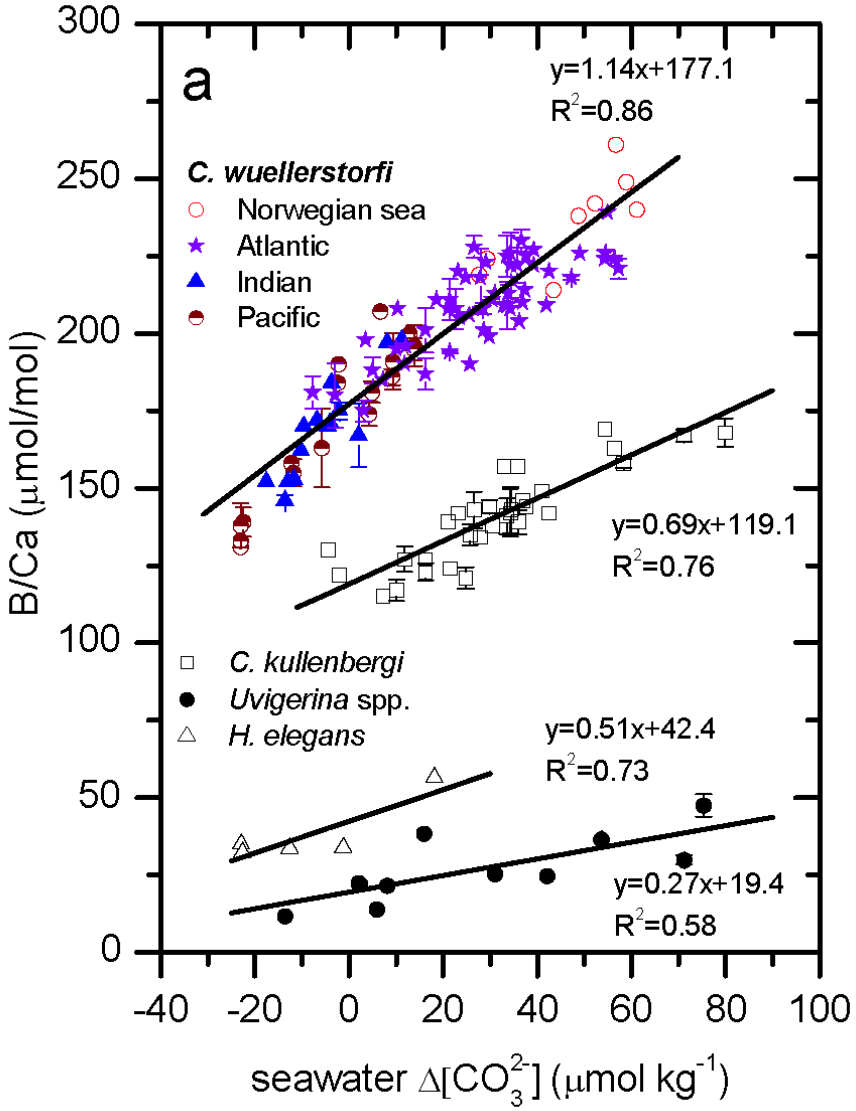


CO_2 (acid) + CO_3^{2-} (alkali) + $H_2O = 2HCO_3^-$



Alkalinity balance mediated by and reflected in deep ocean CO_3^{2-}

Berger et al., 1982; Opdyke and Walker, 1992

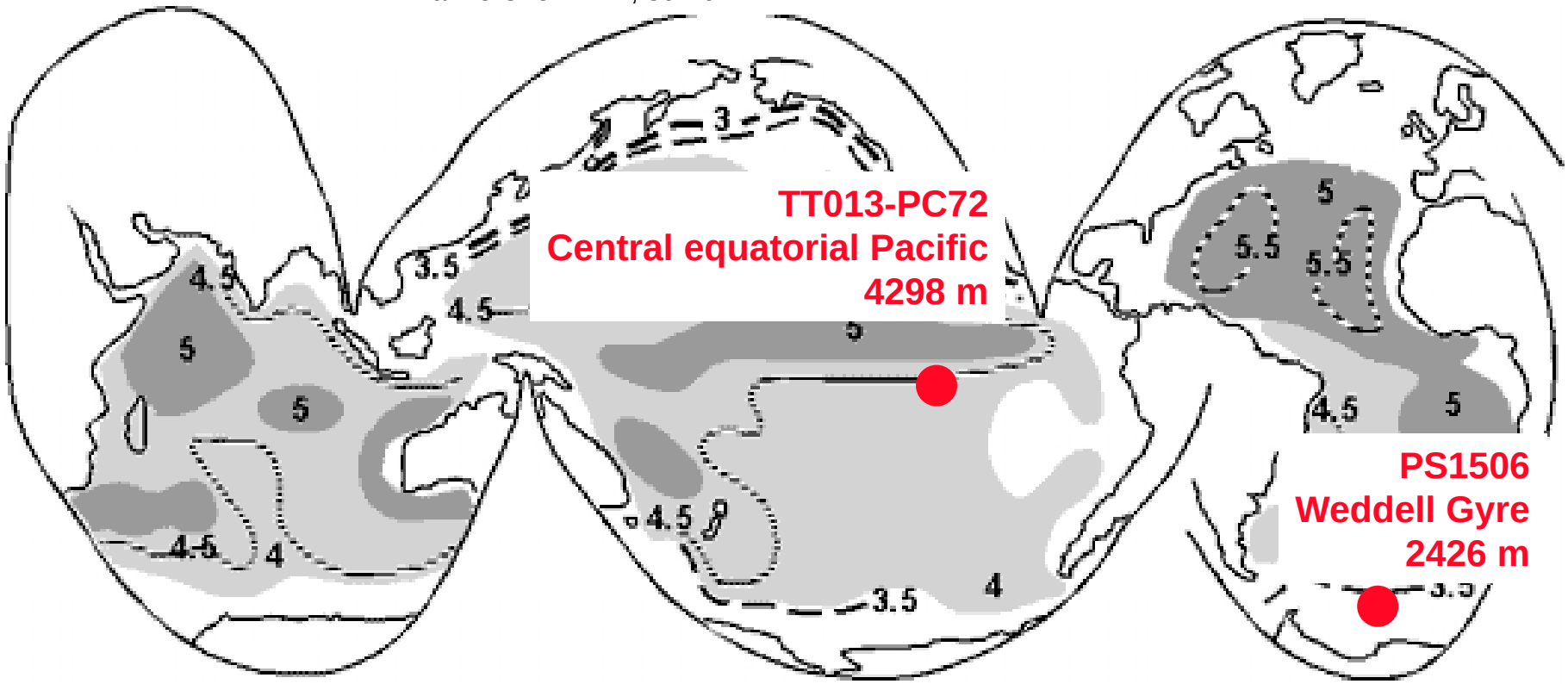


Yu J. and H. Elderfield (2007) Benthic foraminiferal B/Ca reflect deep water carbonate saturation state. Earth Planet Sci. Lett. 258, 73-86.

$$B(OH)_3 + OH^- \rightarrow B(OH)_4^-$$

$$B/Ca = \Delta(CO_3^{2-})$$

Anderson R.F., Fleischer M.Q., Lao Y, and G. Winckler (2008) Modern CaCO3 preservation in equatorial Pacific sediments in the context of late-Pleistocene glacial cycles. Marine Chem. 111, 30-46.



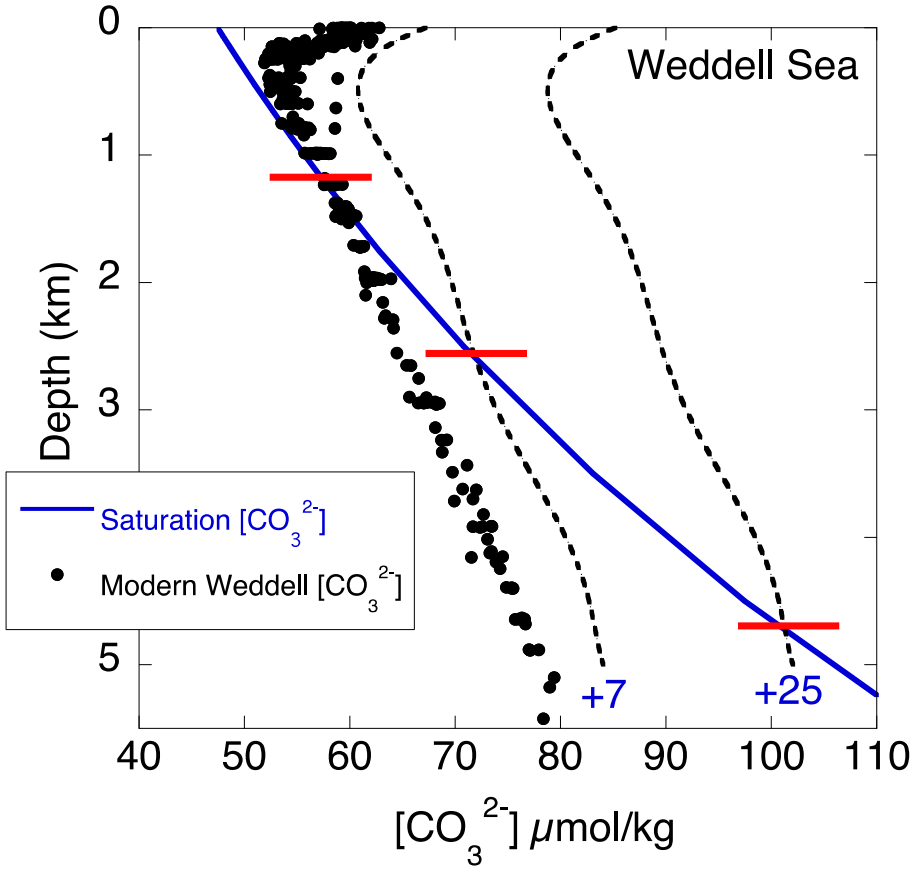
Topography of the calcium carbonate compensation depth (CCD), i.e., the depth in kilometers below which little or no CaCO3 accumulates

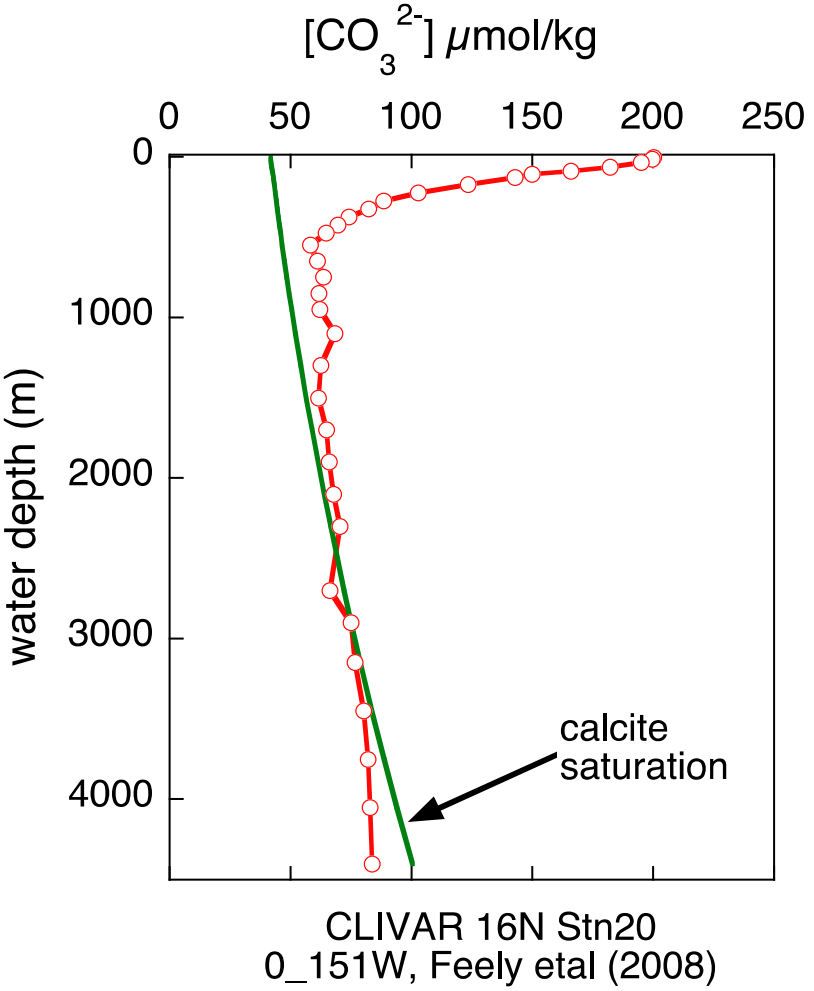
Rickaby, R. E. M., et al.,

Paleoceanography

doi:10.1029/2009PA001762

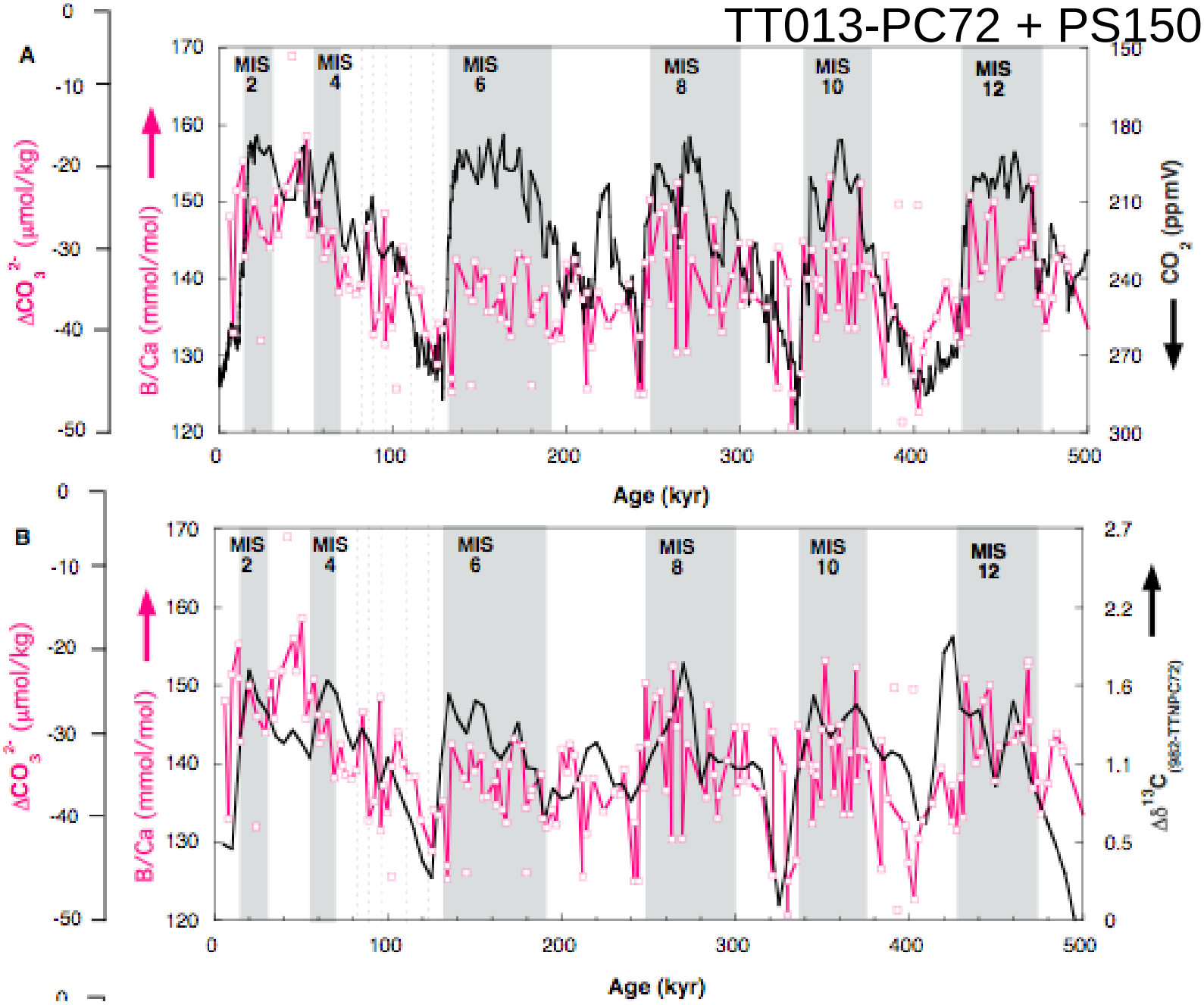
2010



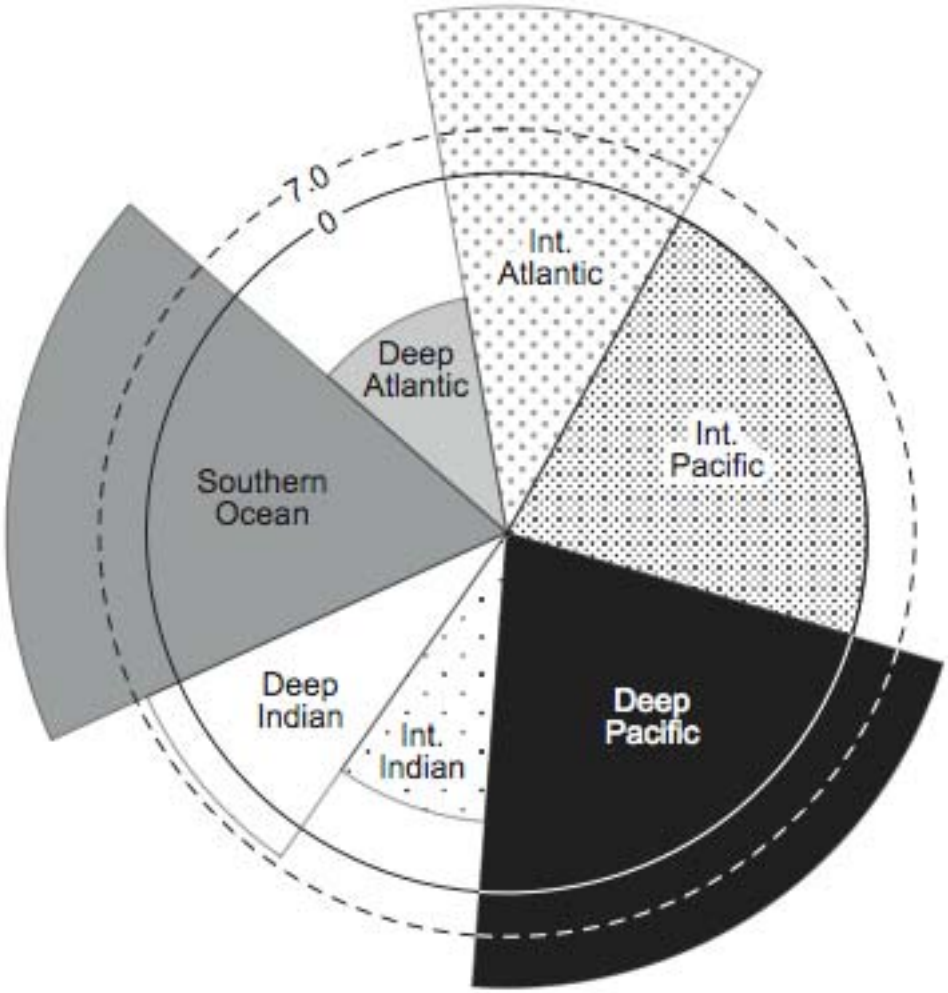


Core	PS1506 2426	TT013-PC72 4298m
Location	**Weddell Sea**	**central Equatorial Pacific Ocean**
Lat Long	68°73' S 5°51°W	0°011' S 139°0.4' W
Saturation Horizon	600-1000 m	2860 m
$\Delta[CO_3^{2-}]_{core\ depth}$	-7 µmol/kg	-14 µmol/kg
$[CO_3^{2-}]$ > 900m	60-80 µmol/kg	71.3 ± 8.0 µmol/kg

TT013-PC72 + PS1506



Rickaby, Elderfield, Yu and Anderson, in prep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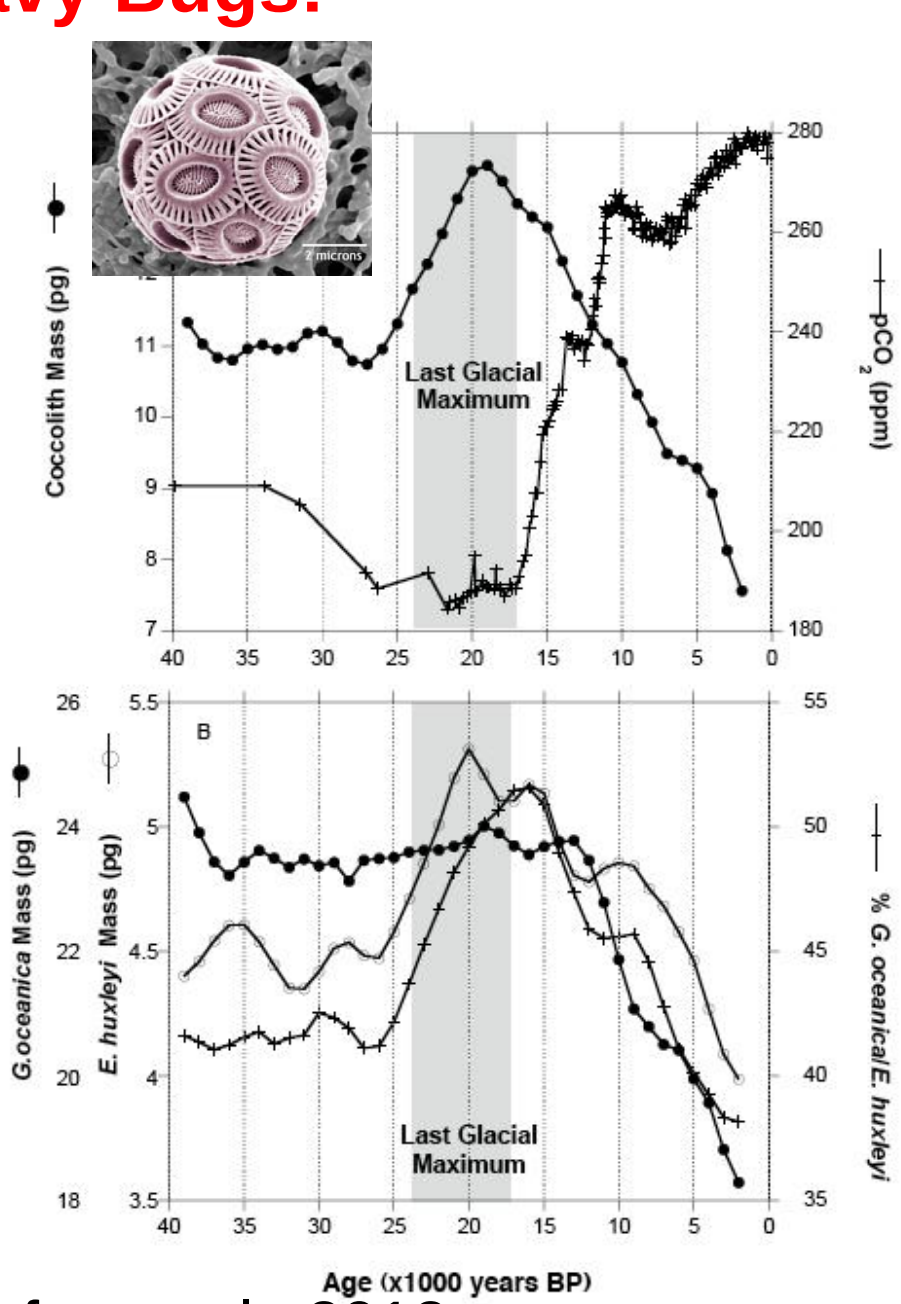
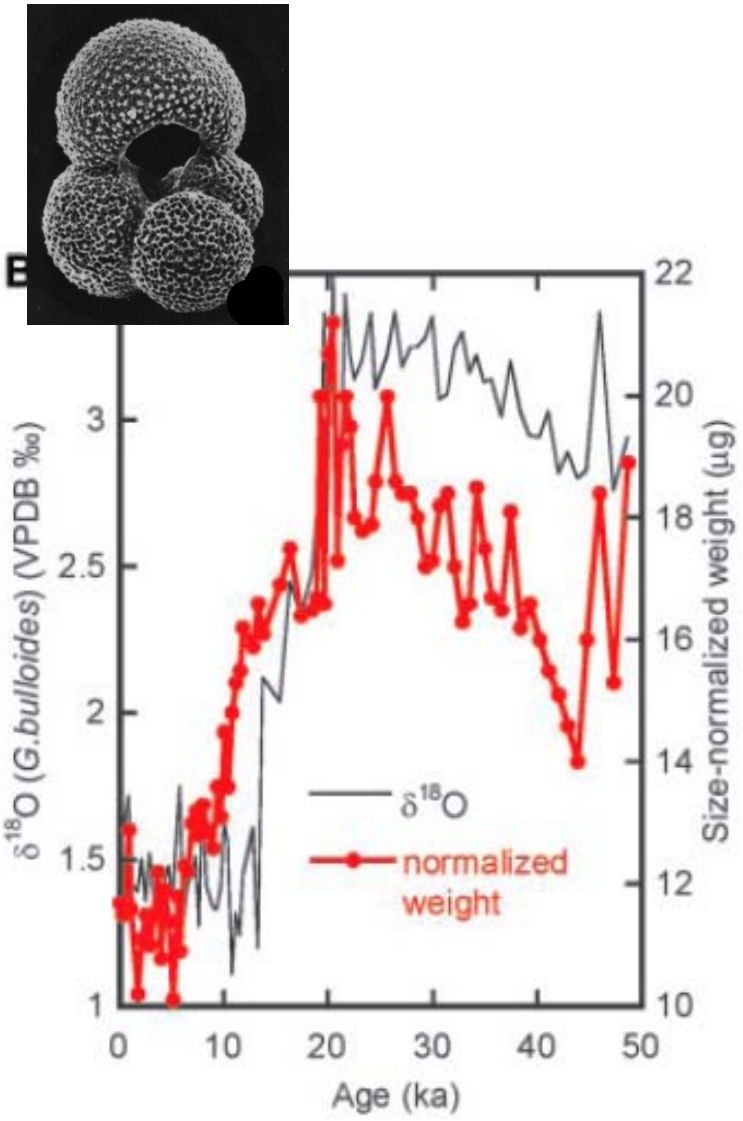
Heavy Bugs!

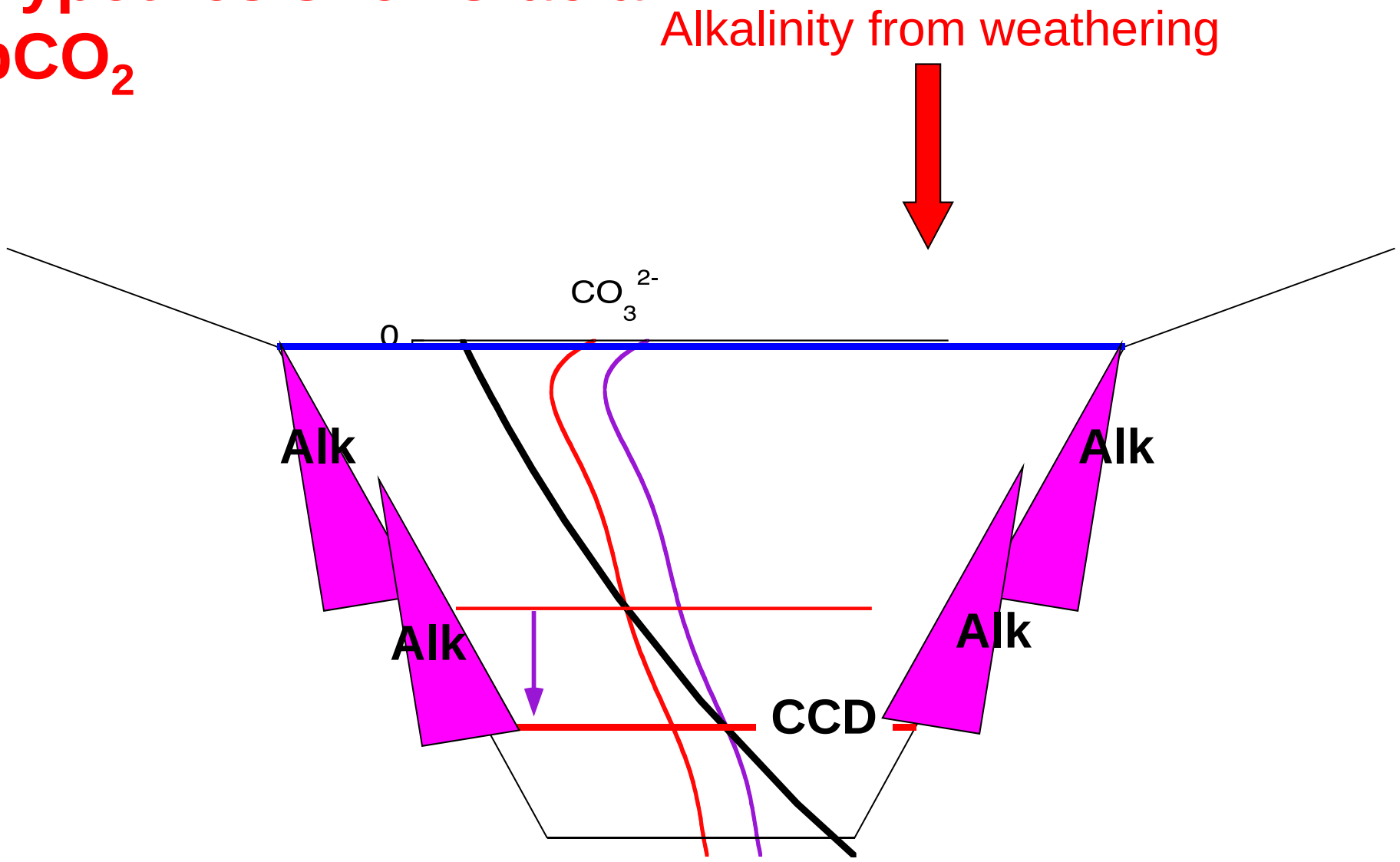


Beaufort et al., 2012

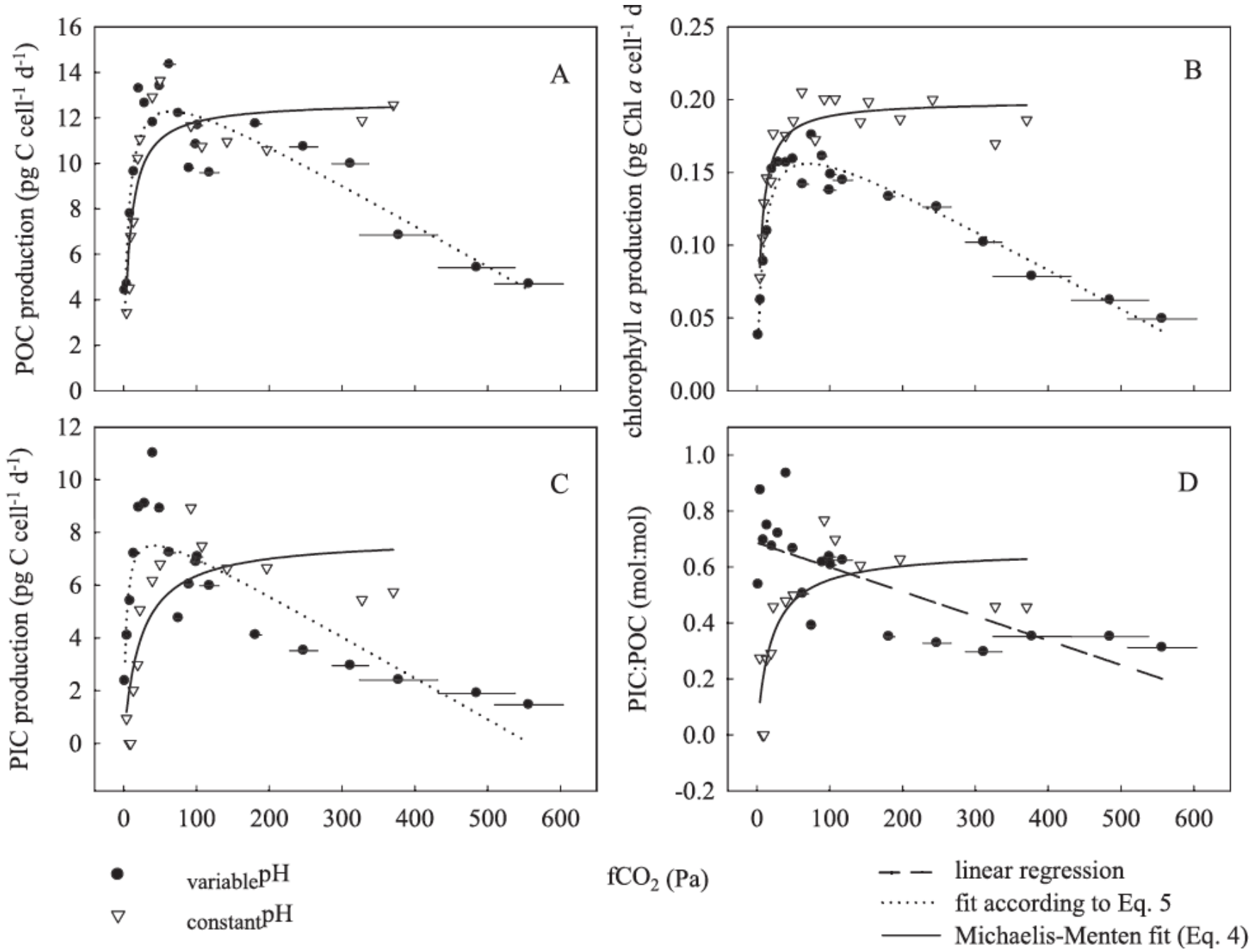


Barker and Elderfield, 2002

Hypothesis for Glacial pCO_2



Rickaby et al, *2010*



Bach et al., 2011

Conclusions

- The ocean was responsible for sequestering carbon during the last glacial period
- This resulted in lower O2 levels
- And similar or higher CO_3^{2-}
- More carbon in the ocean is generally good for calcifiers…as long as any pH chnge is mediated.