UK Ocean Acidification Research Programme

Palaeo – OA Events

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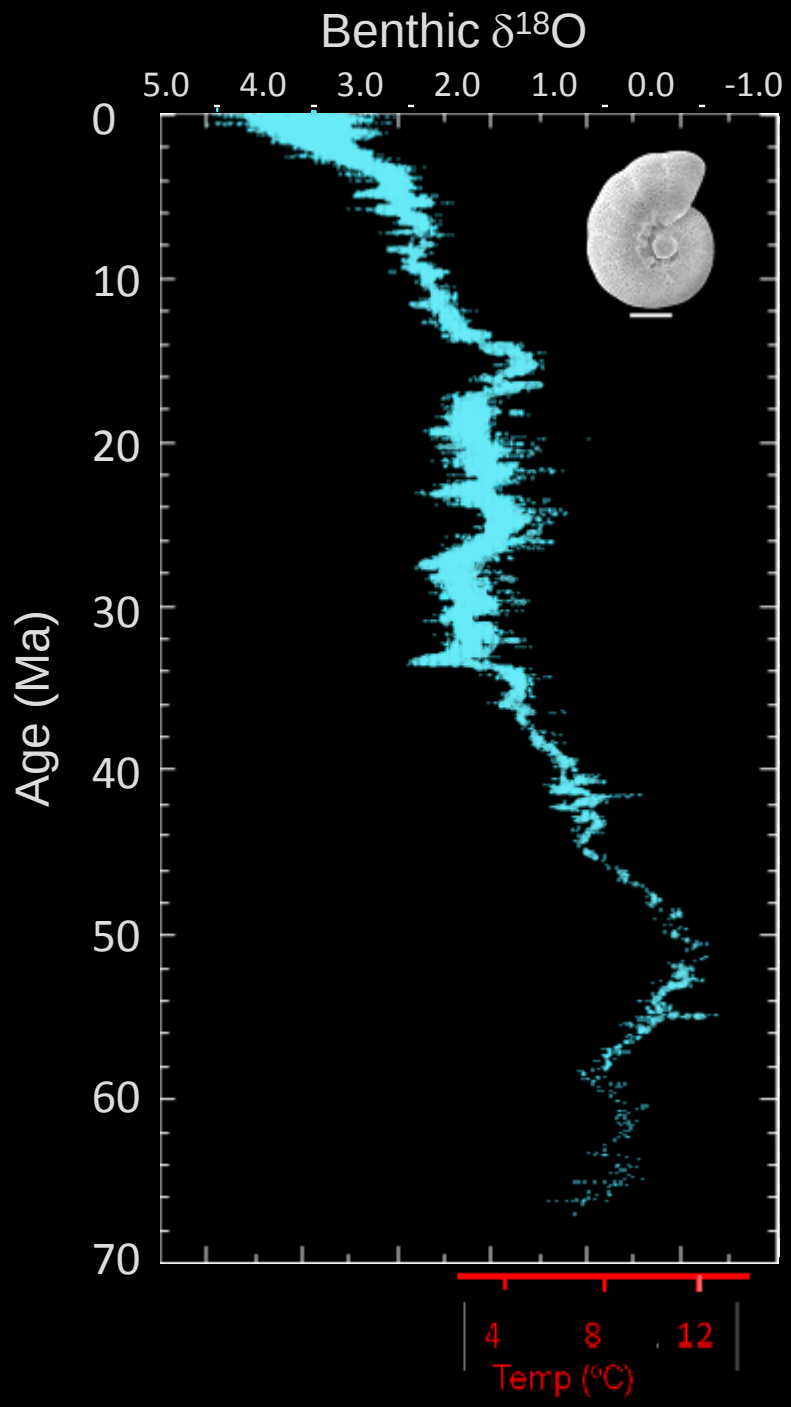
+ NERC Life & Climate – Descent into the Icehouse (Foster et al.)

"To ascertain the rate and amplitude of ocean acidification to which species and ecosystems can adapt and the threshold of acidification that would lead to enhanced evolutionary turnover and extinction of species"

- Large events – involving extinction
- Multiple events
- Establish pH variation through the water column
- Measure biotic effects
- Calcifying plankton – but also benthic & shelf taxa



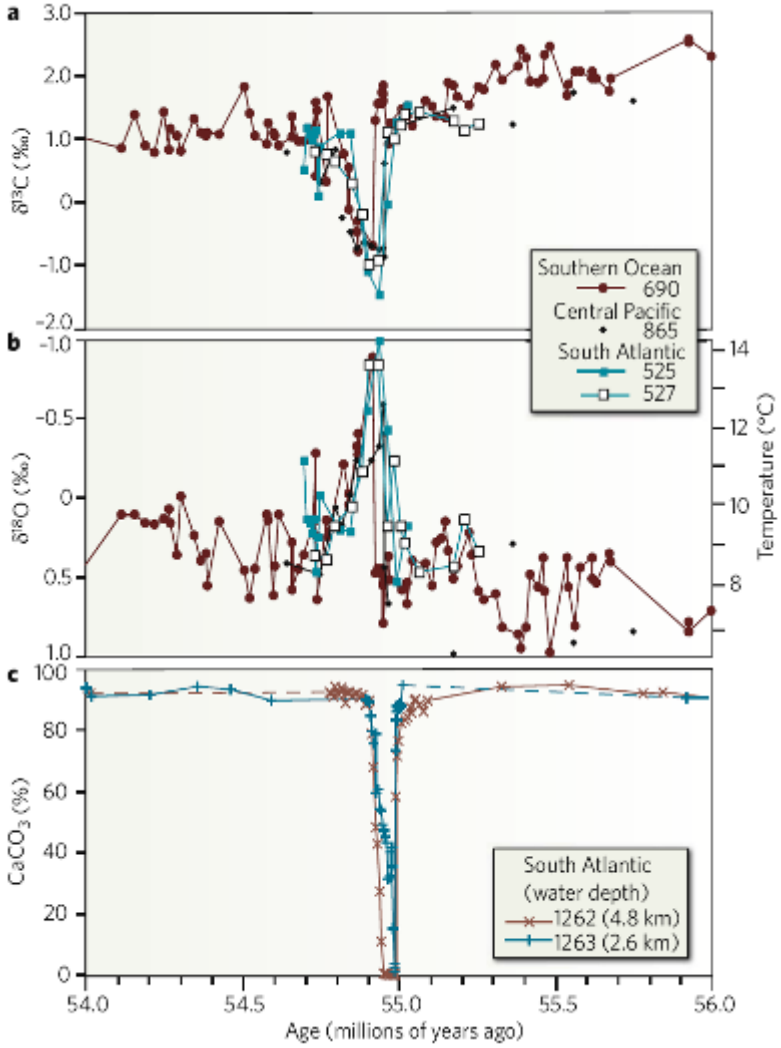
Deep sea
benthic foram
$\delta^{18}O$ compilation
(Zachos et al., 2008)

Paleogene
hyperthermals

Which Abrupt OA events?

PETM Leg 208

Zachos et al. (2008)

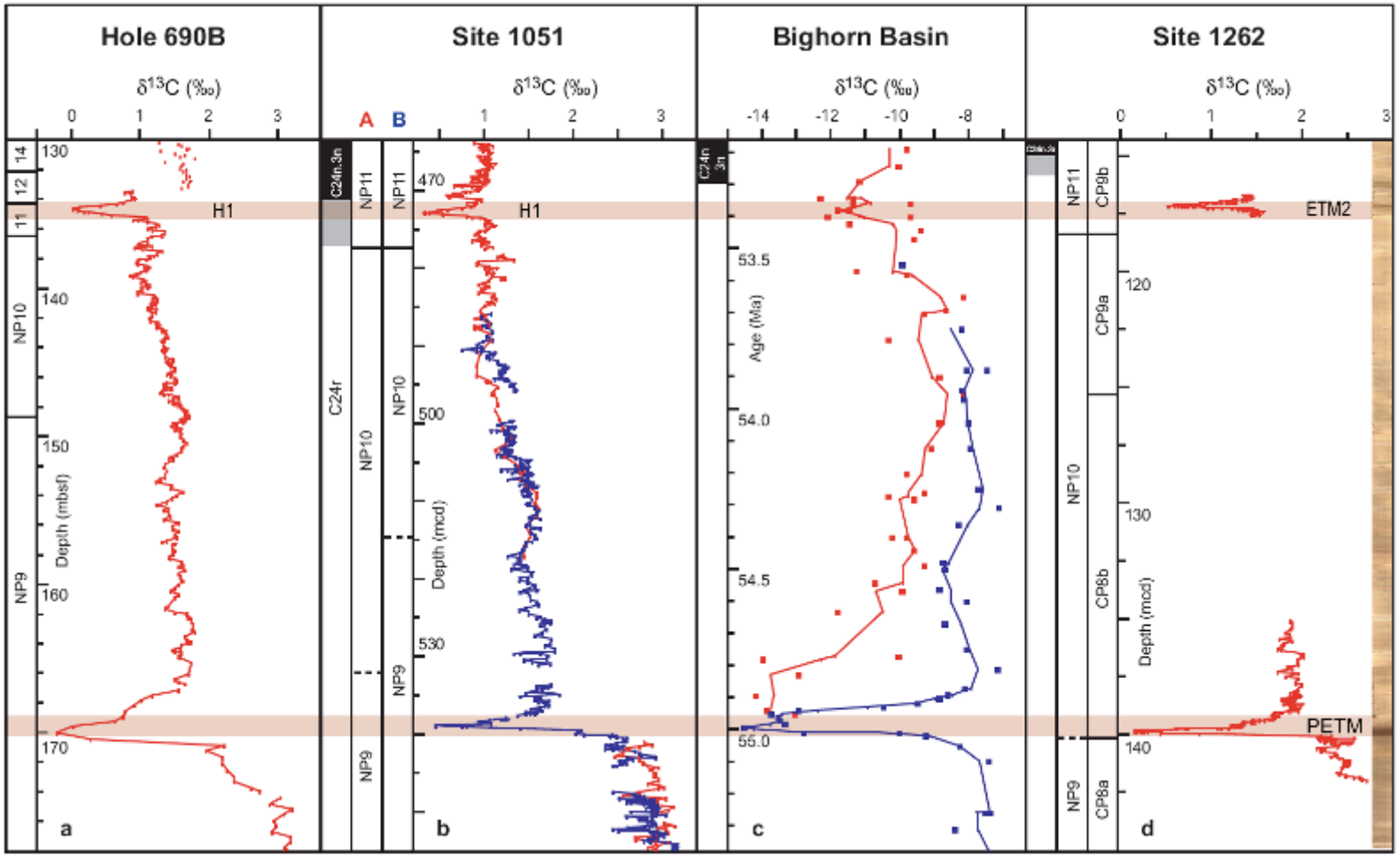


Palaeocene-Eocene Thermal Maximum (PETM)

- Short lived (120-220 kyr) global warming episode (deep sea T increased by 5-8 ^{o}C)
- δ^{13}C anomaly – 3000-7000 Gt C (0.3-7 Gt C per year)
- Deep sea acidification and lysocline shoaling
- Dramatic terrestrial and marine biotic response

The less extreme hyperthermals

- comparable in character to PETM but less extreme in magnitude and duration
- $\delta^{13}C$ anomalies ~1 ‰ (PETM = >3 ‰)

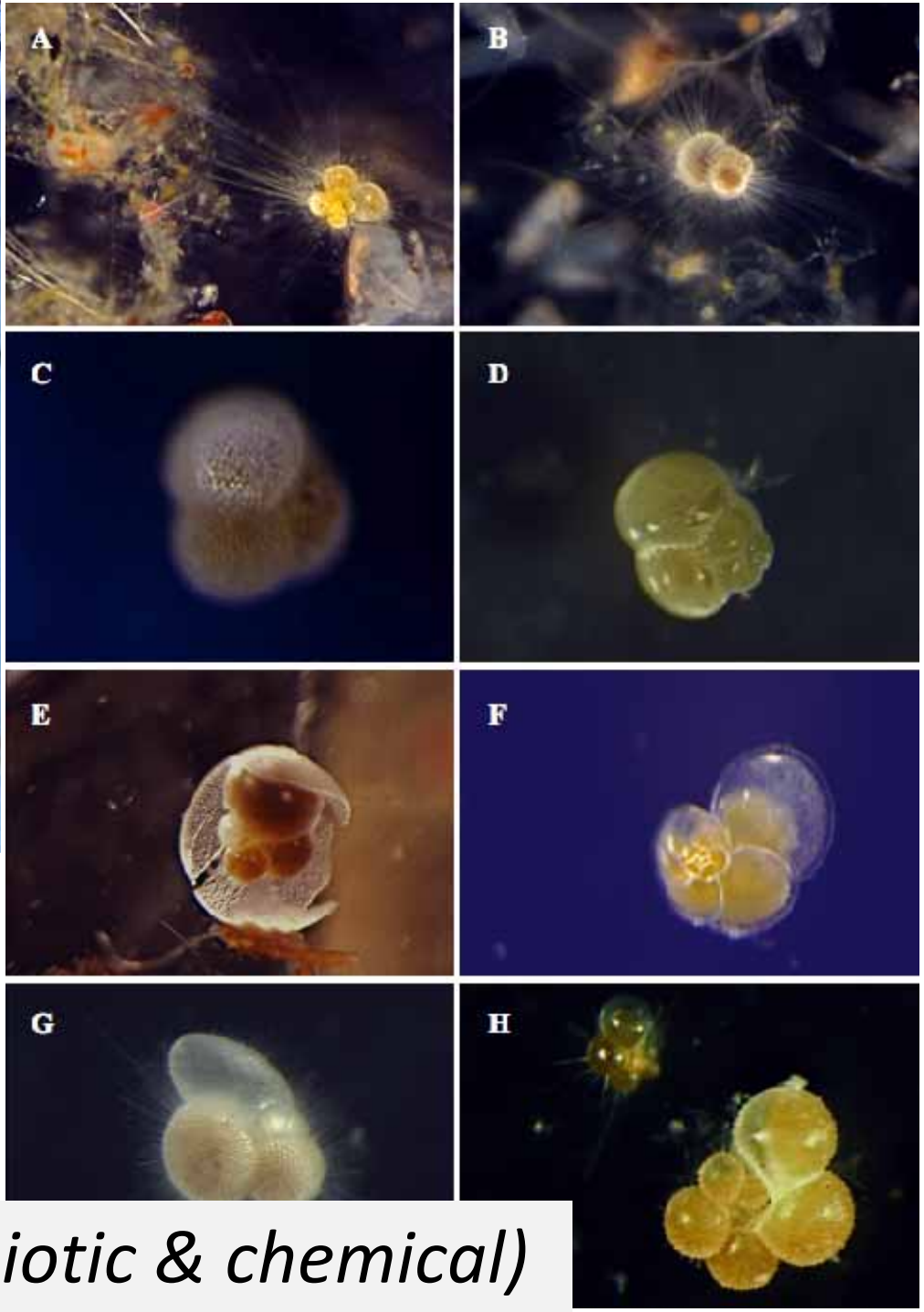


Lourens et al., 2005

Paleocene – Eocene hyperthermals

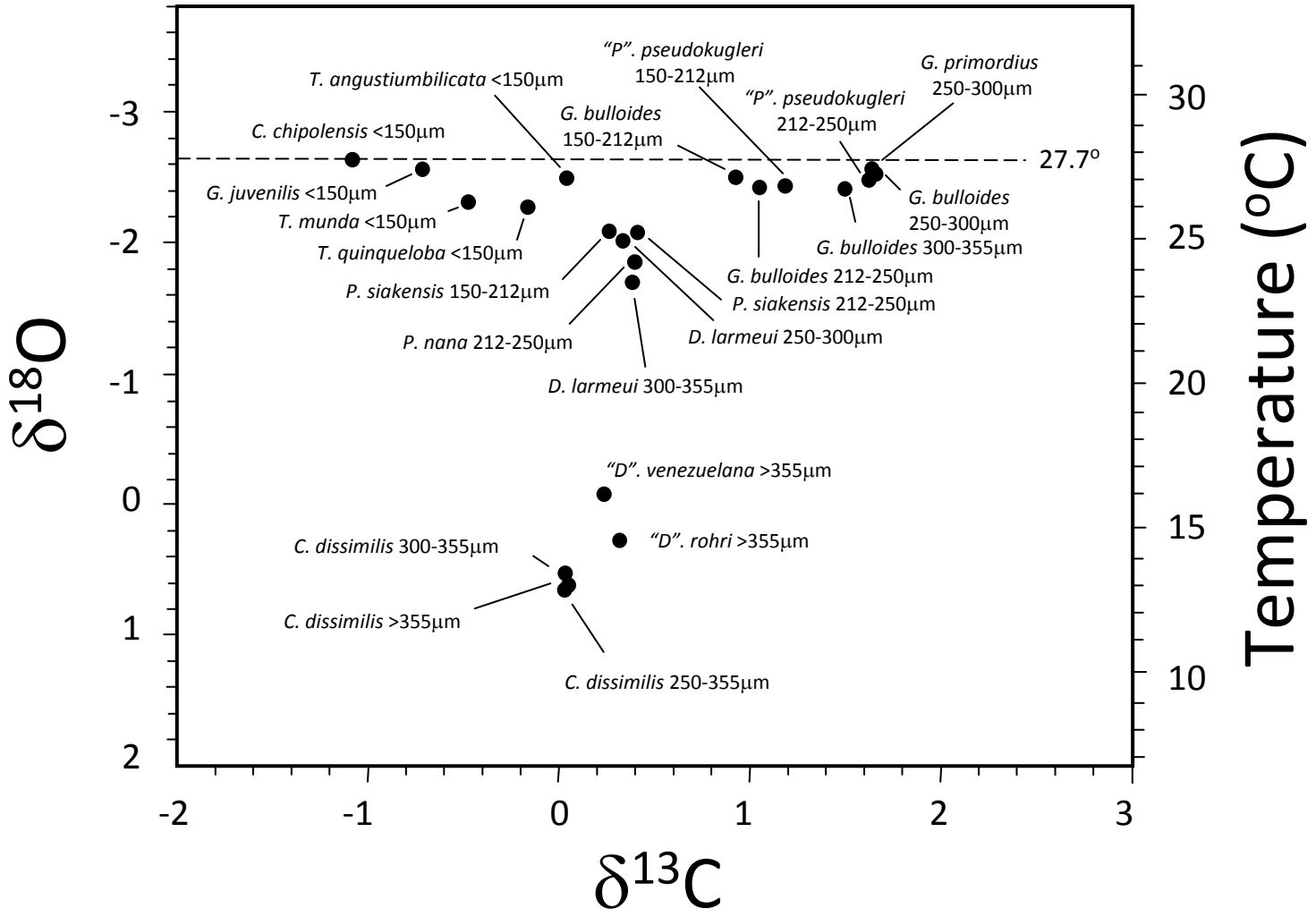
PETM Leg 208

- PETM, ETM2, MECO + smaller events
- "Paradox of the PETM" – relatively muted biotic response?
- Rate of CO_2 injection vs surface ocean recycling
- Water column pH variability

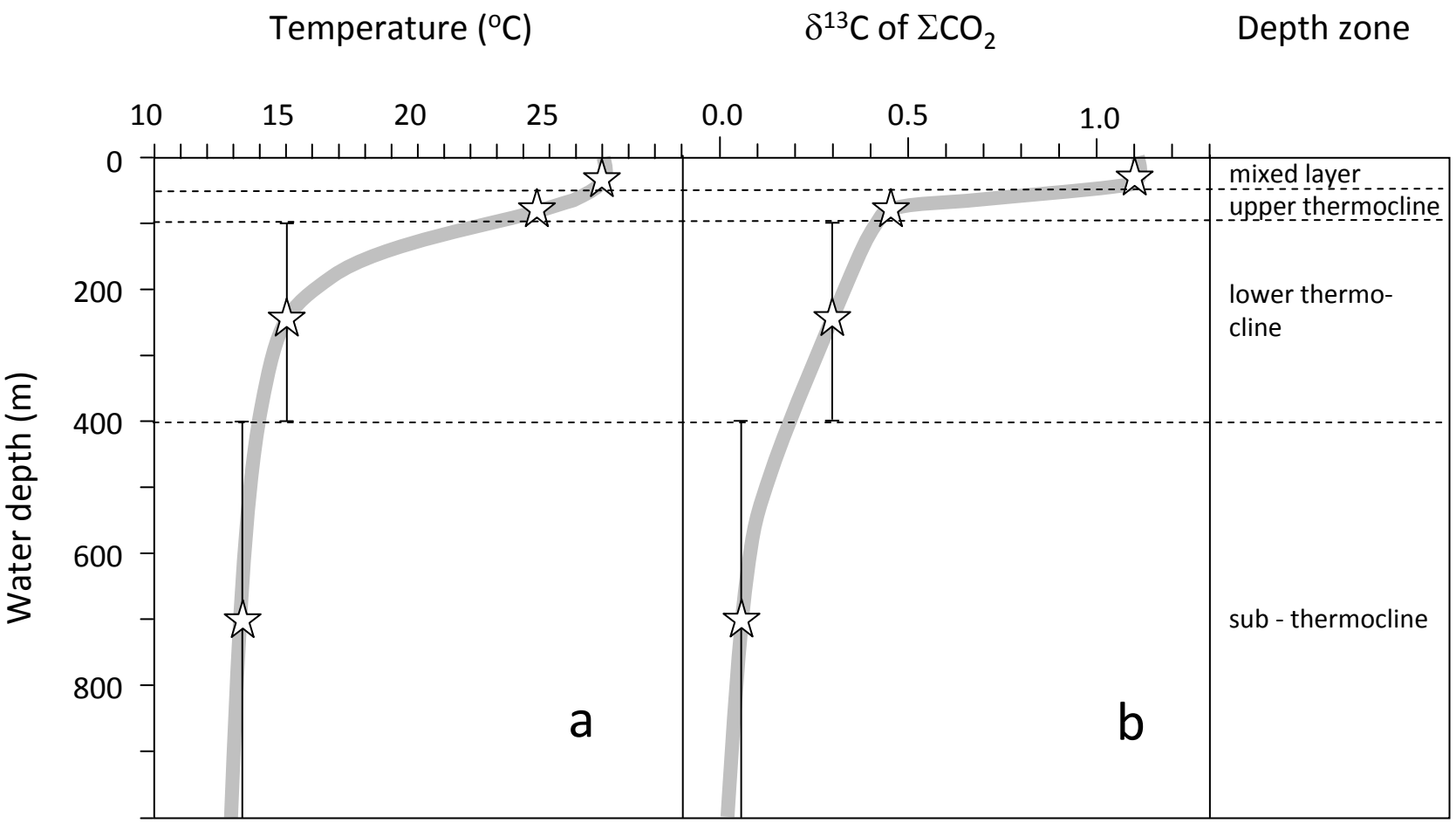


Water column profiling (biotic & chemical)

WP1: Water column profiling (biotic & chemical)



Oligocene of Trinidad - Pearson & Wade (2009)



Pearson & Wade (2009)

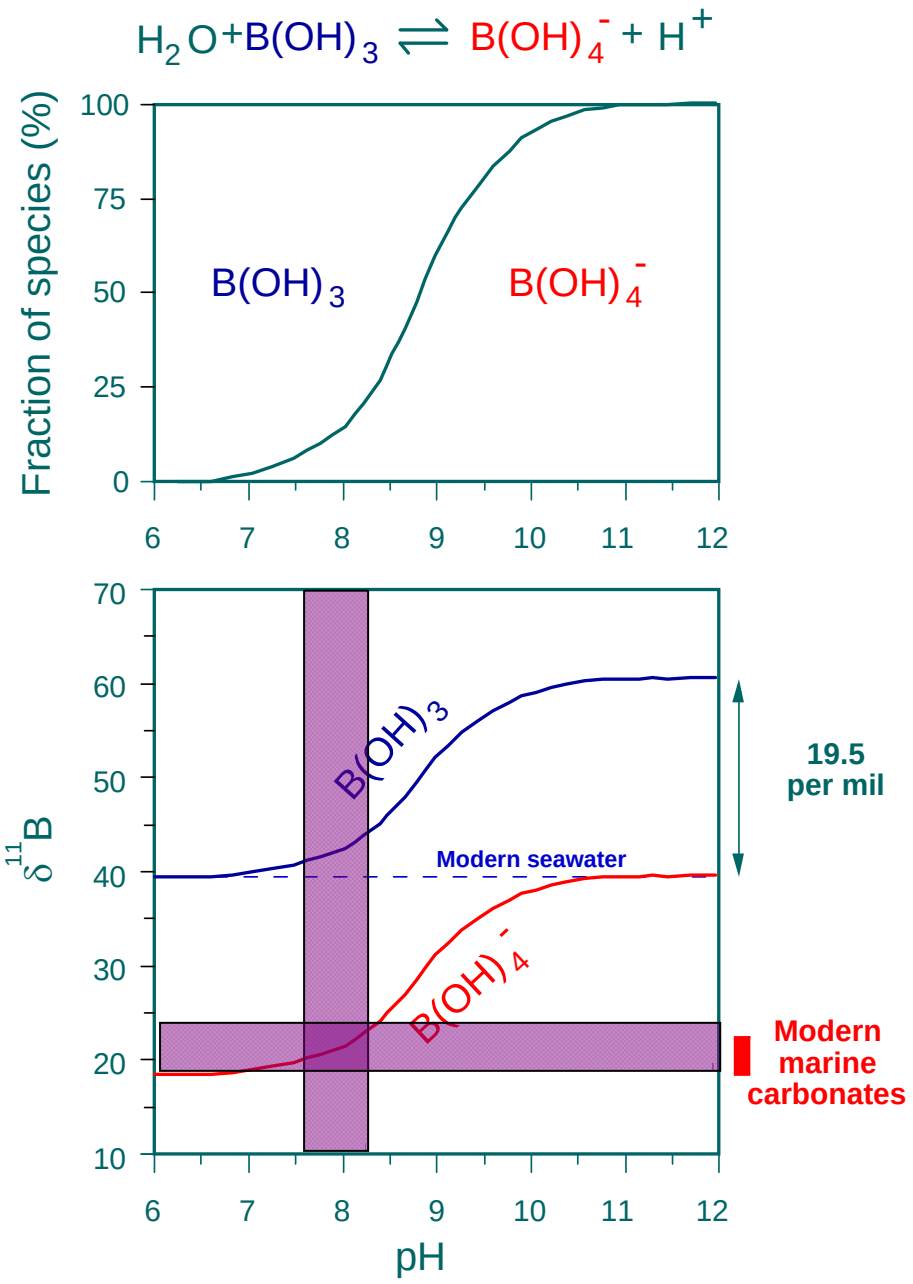
Boron isotopes

Seawater $\delta^{11}B$

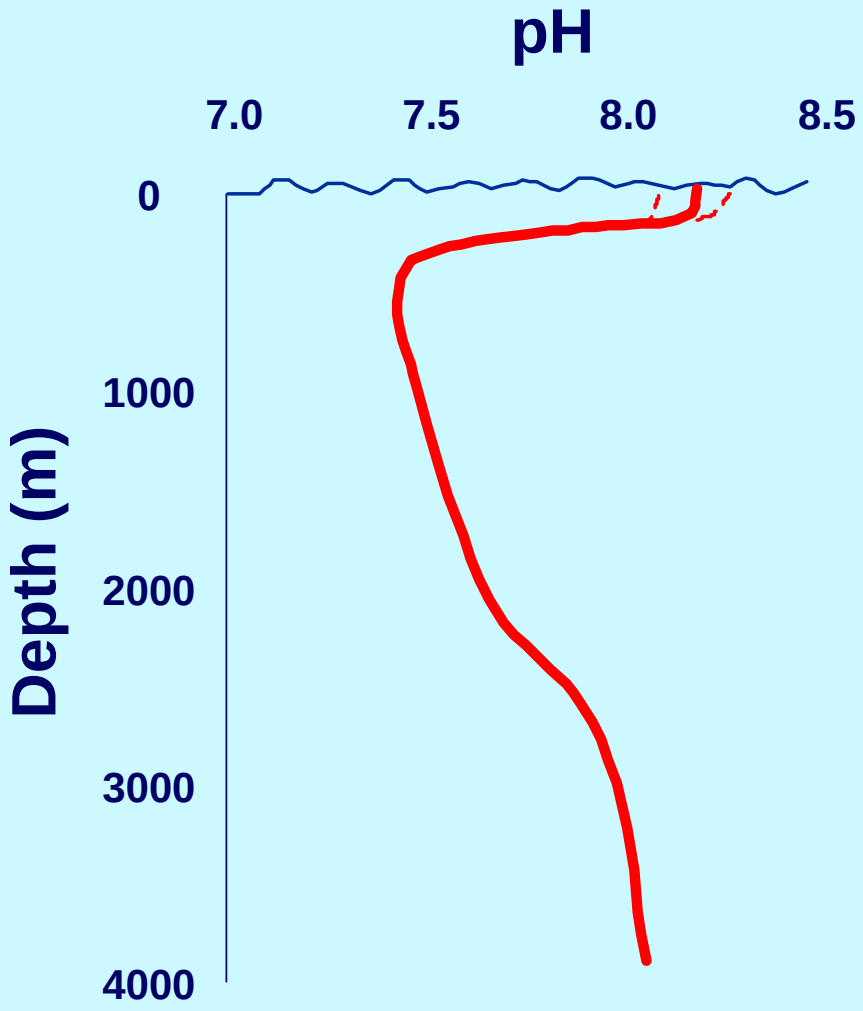
= +39.5‰

Residence time

~ 15 m.yr.

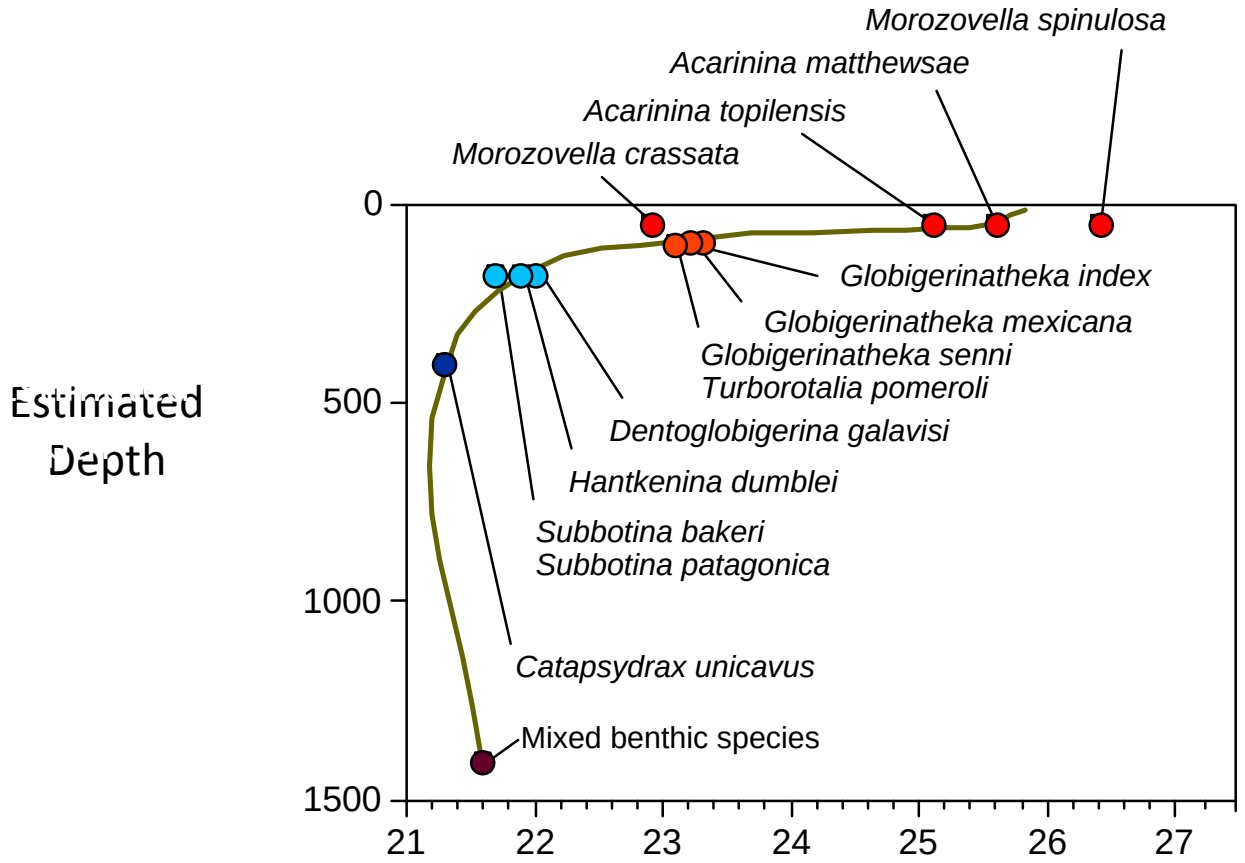


Schematic pH profile in the ocean



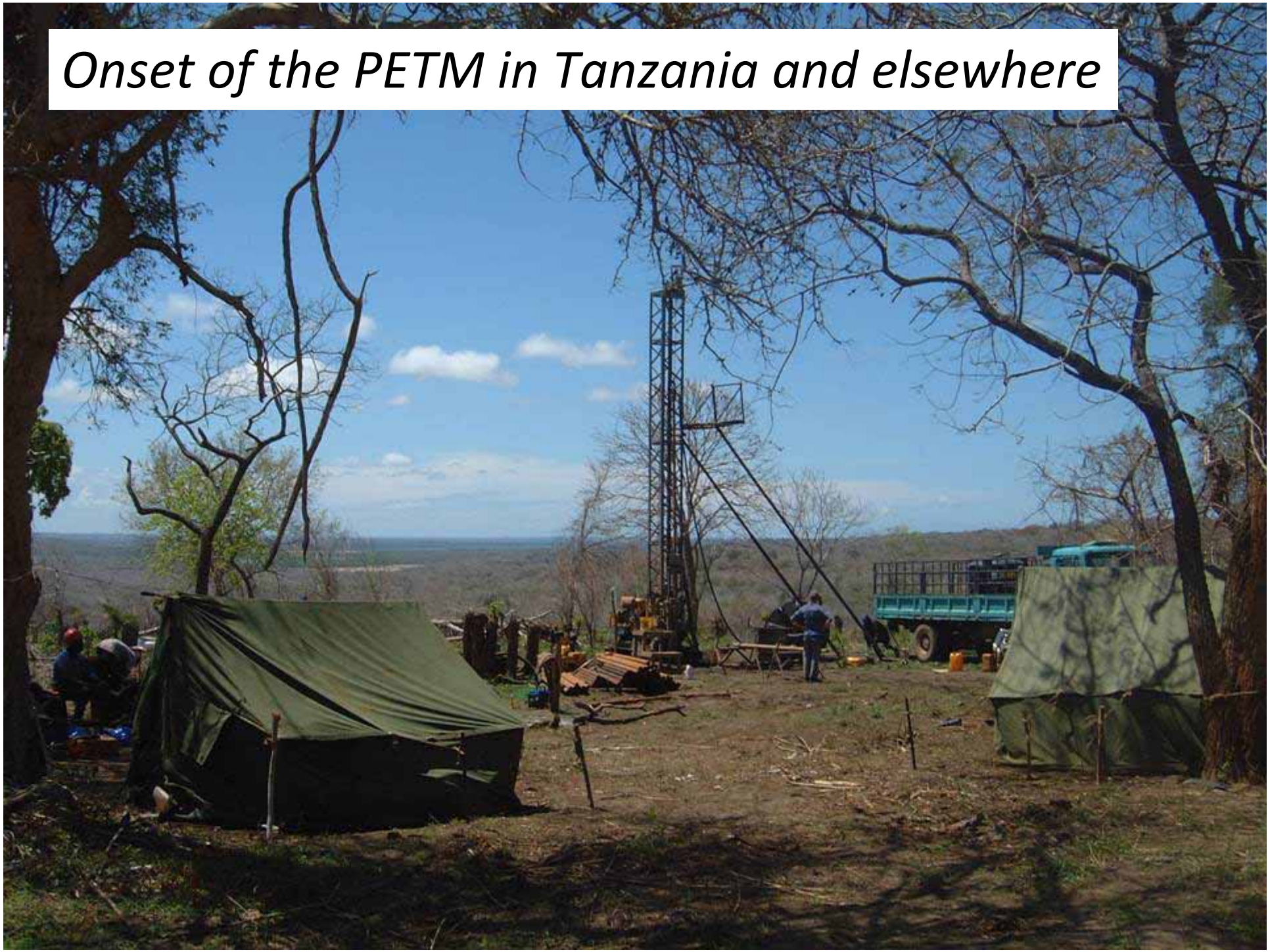
	Processes
Mixed layer	Primary production, carbonate ppt, turbulent mixing
Thermocline	
Intermediate water mass	Respiration, re-mineralization
	Aragonite dissolution
Deep water mass	Calcite dissolution

Middle Eocene $\delta^{11}B$ vs. relative depth



Pearson & Palmer (1999)

Onset of the PETM in Tanzania and elsewhere




~500m water depth

Earth and Planetary Science Letters

journal homepage: www.elsevier.com/locate/epsl

Large terrestrial and marine carbon and hydrogen isotope excursions in a new Paleocene/Eocene boundary section from Tanzania

Luke Handley [a,*], Paul N. Pearson [b], Ian K. McMillan [b], Richard D. Pancost [a]

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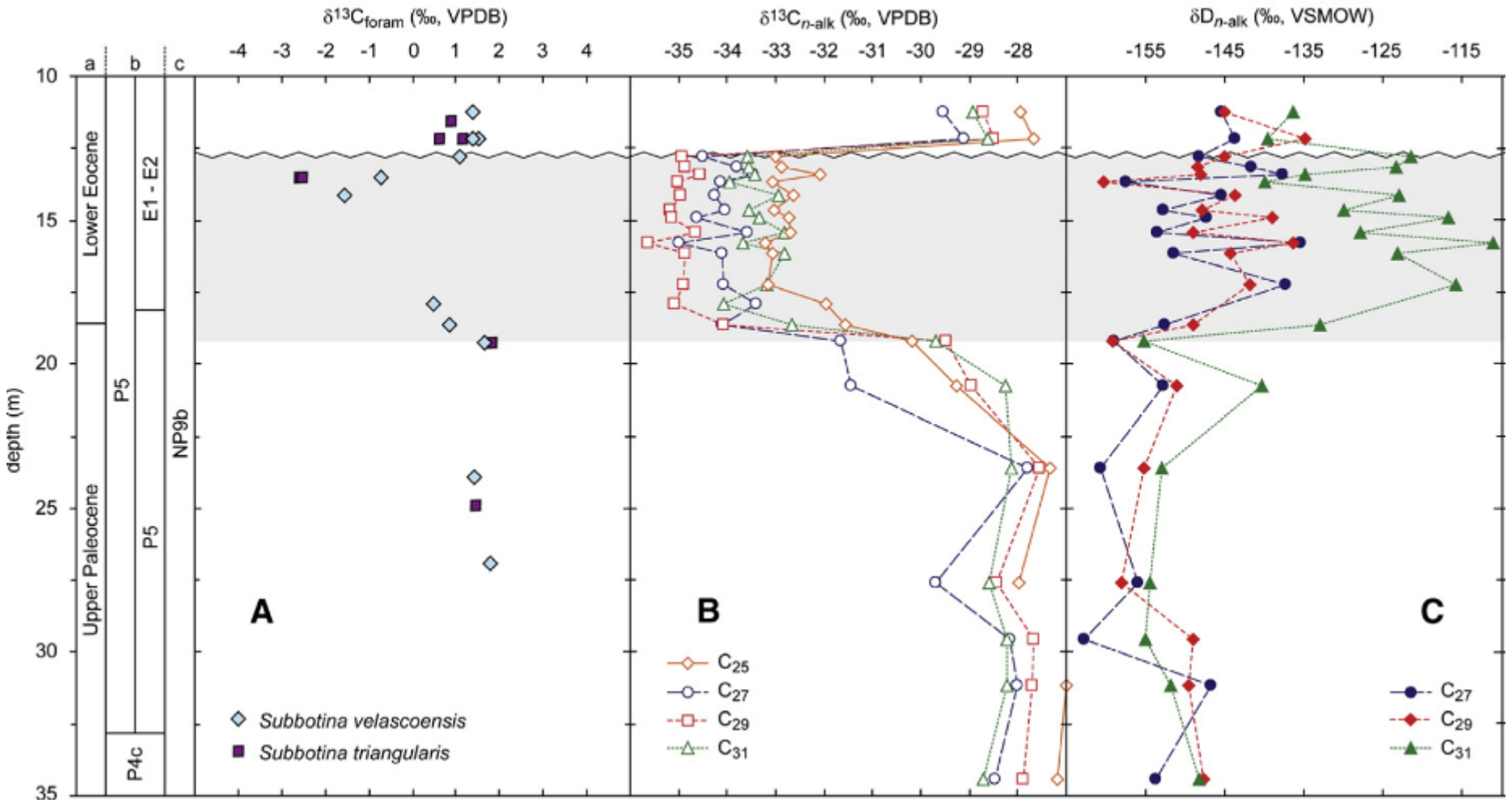
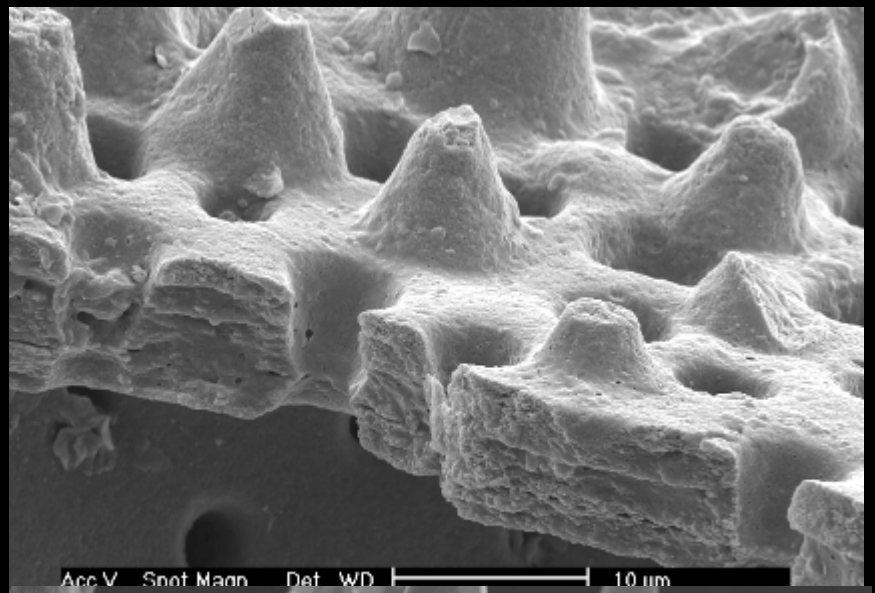
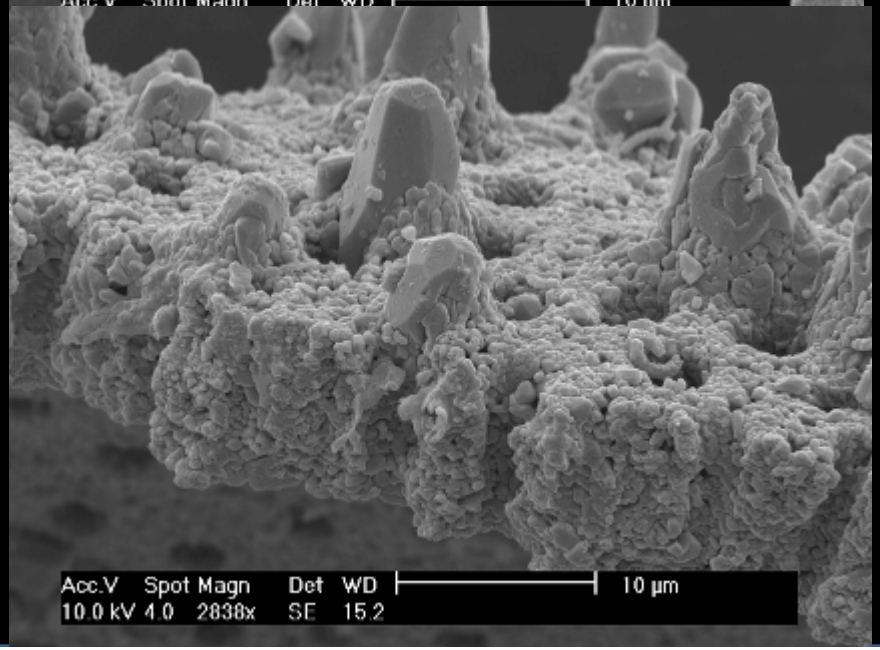
[b] School of Earth, Ocean and Planetary Sciences, Cardiff University, Park Place, Cardiff CF10 3YE, UK

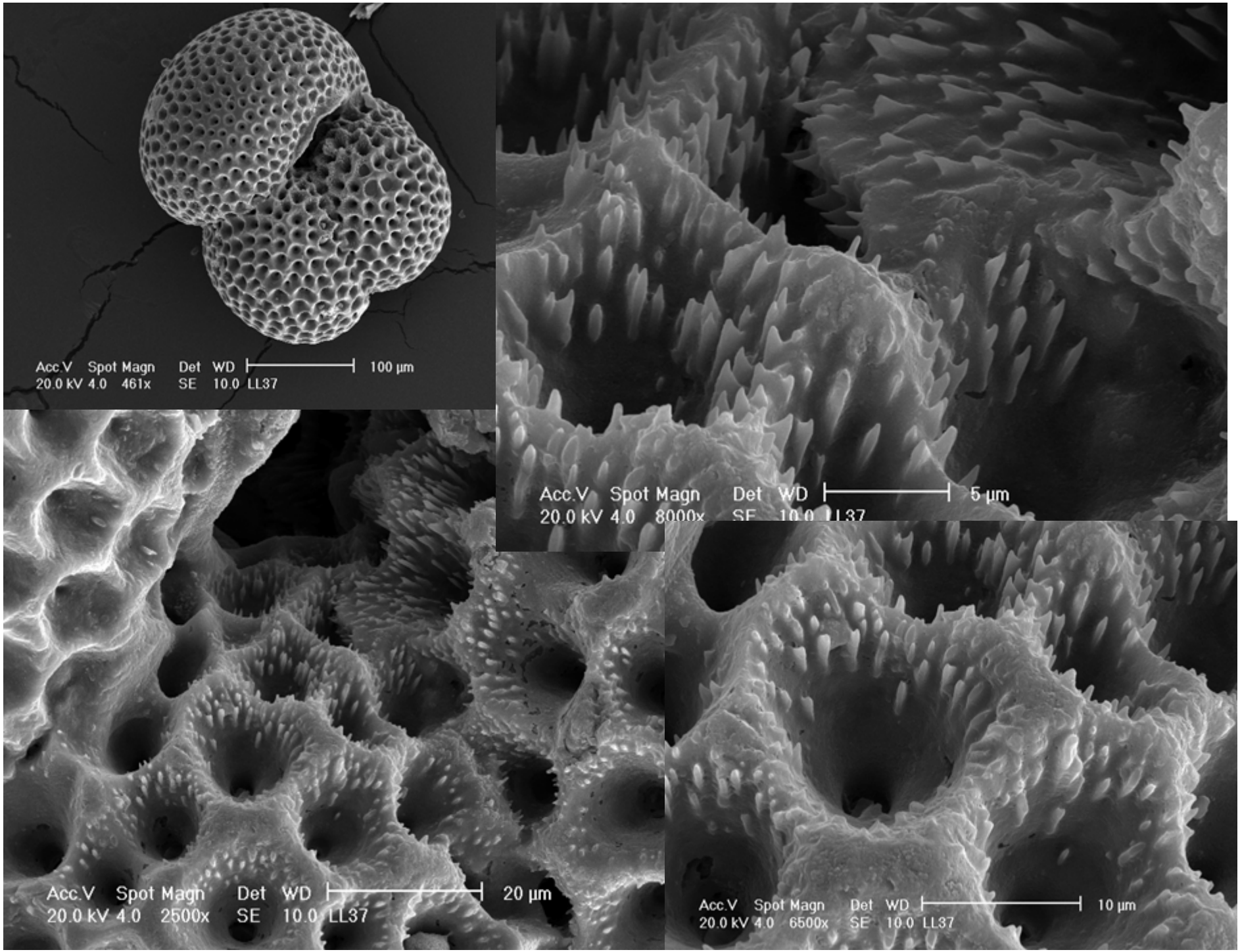


Tanzania: ‘Glassy’ preservation of foraminifera

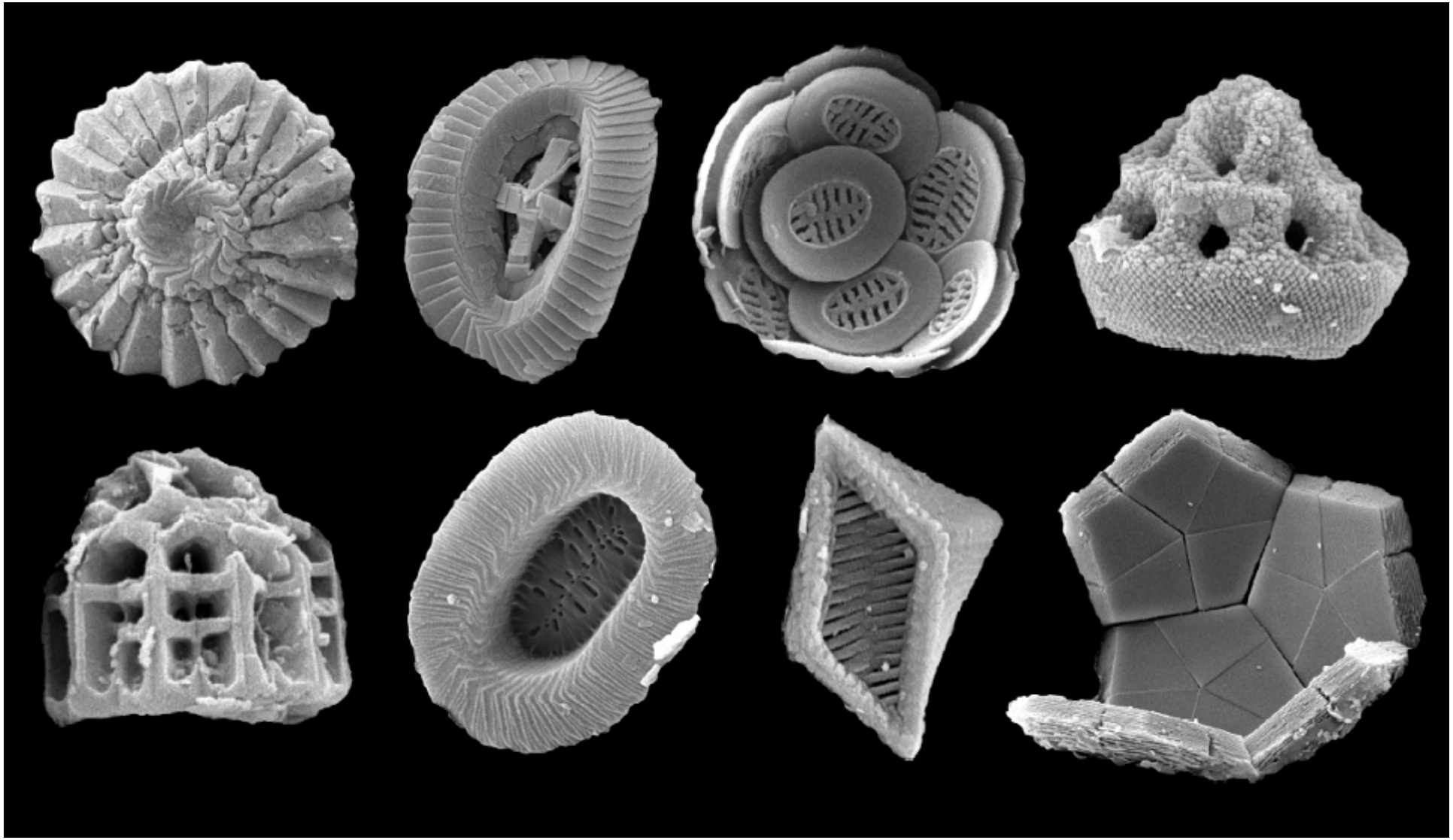
Cribrohantkenina inflata






Acc.V Spot Magn Det WD 100 µm
20.0 kV 4.0 461x SE 10.0 LL37
Acc.V Spot Magn Det WD 5 µm
20.0 kV 4.0 8000x
Acc.V Spot Magn Det WD 20 µm
20.0 kV 4.0 2500x SE 10.0 LL37
Acc.V Spot Magn Det WD 10 µm
20.0 kV 4.0 6500x SE 10.0 LL37

PETM nannofossils (Paul Bown)



PETM biotic turnover

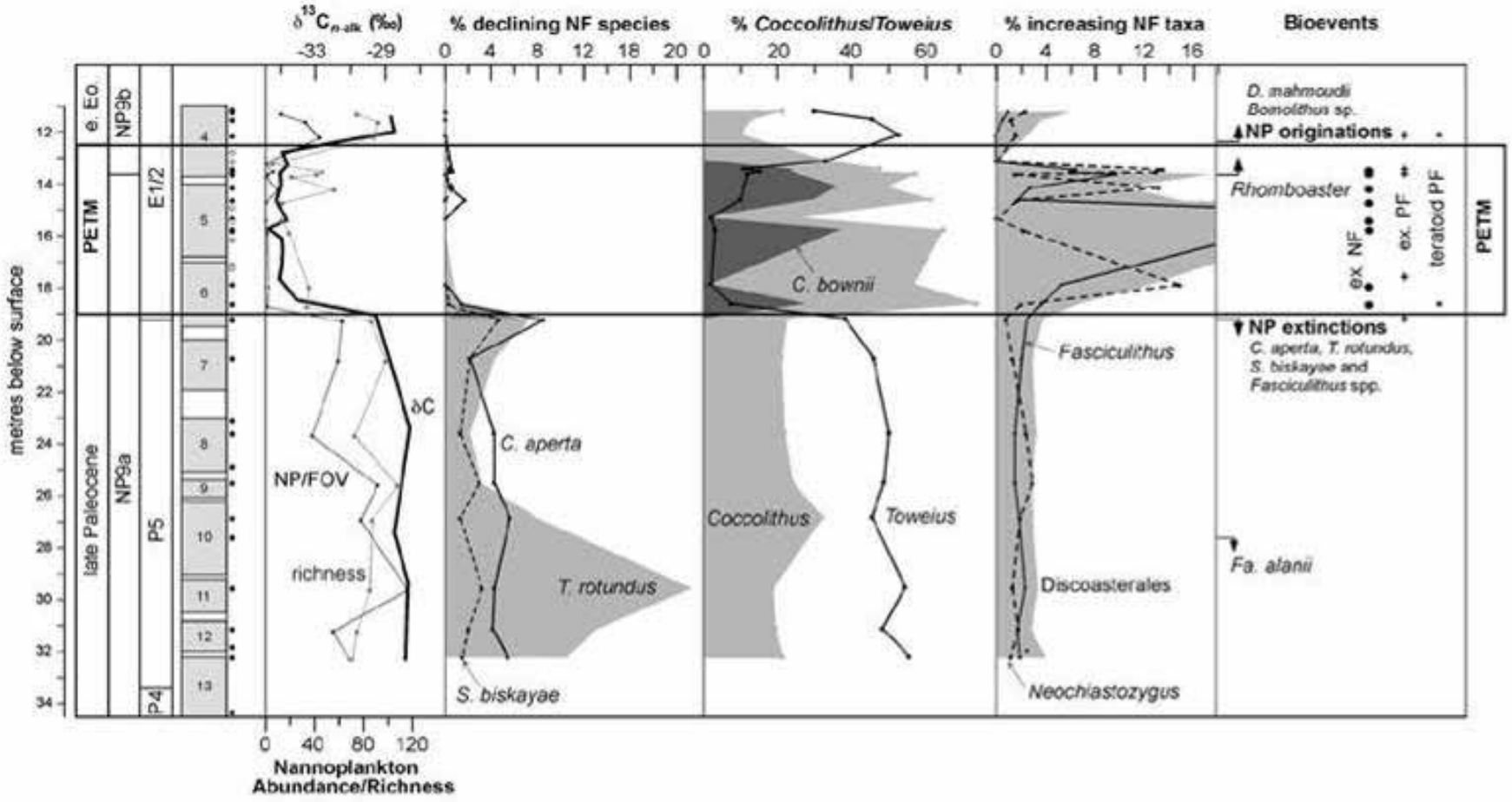
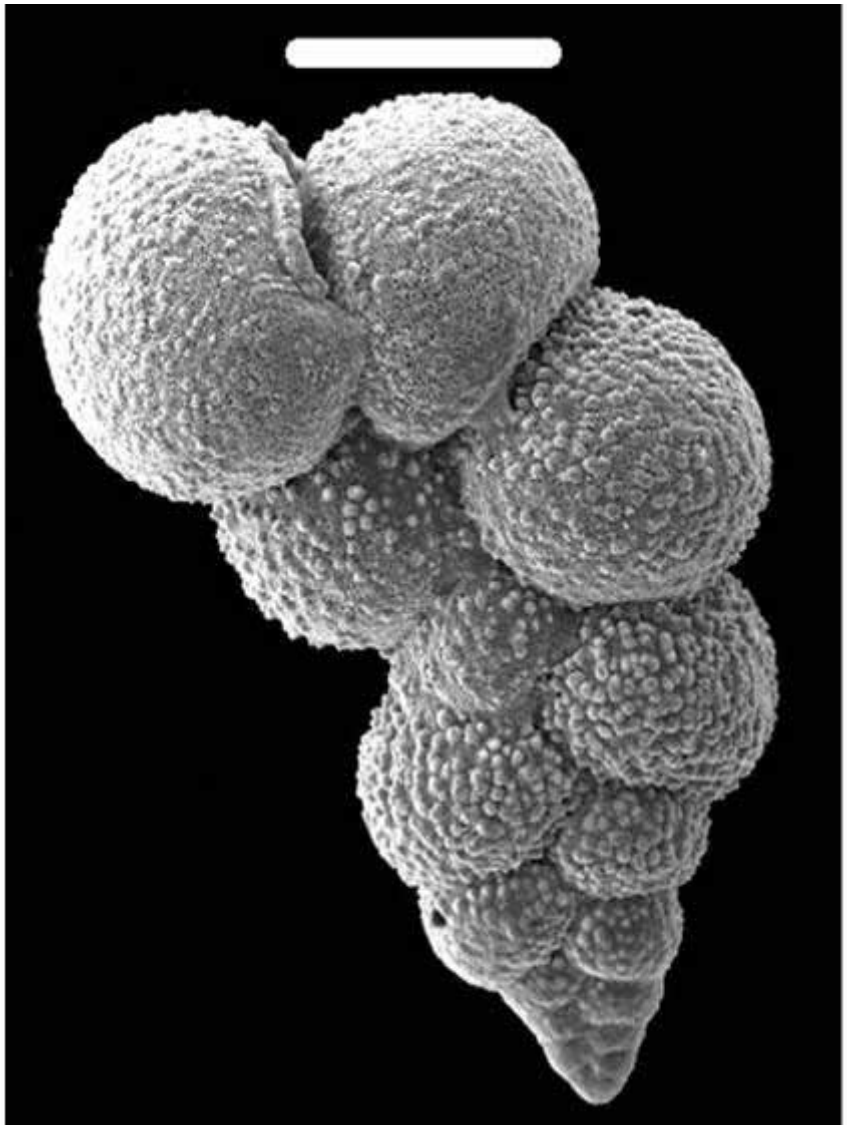


Figure 6. Selection of initial low-resolution data on biotic response to PETM in nannofossils and planktonic foraminifera. A: nannoplankton abundance against stable isotope excursion. B: Declining Excursion nannossil taxa (NF). C: Example species. D: Increasing excursion taxa; E: outline bioevents Including excursion and teratoid planktonic foraminifera from (Bown & Pearson, 2009)

PETM teratology



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Caveats:

Small number of events, each of which is unique

Temperature, nutrients, food supply, stratification, ocean circulation ….