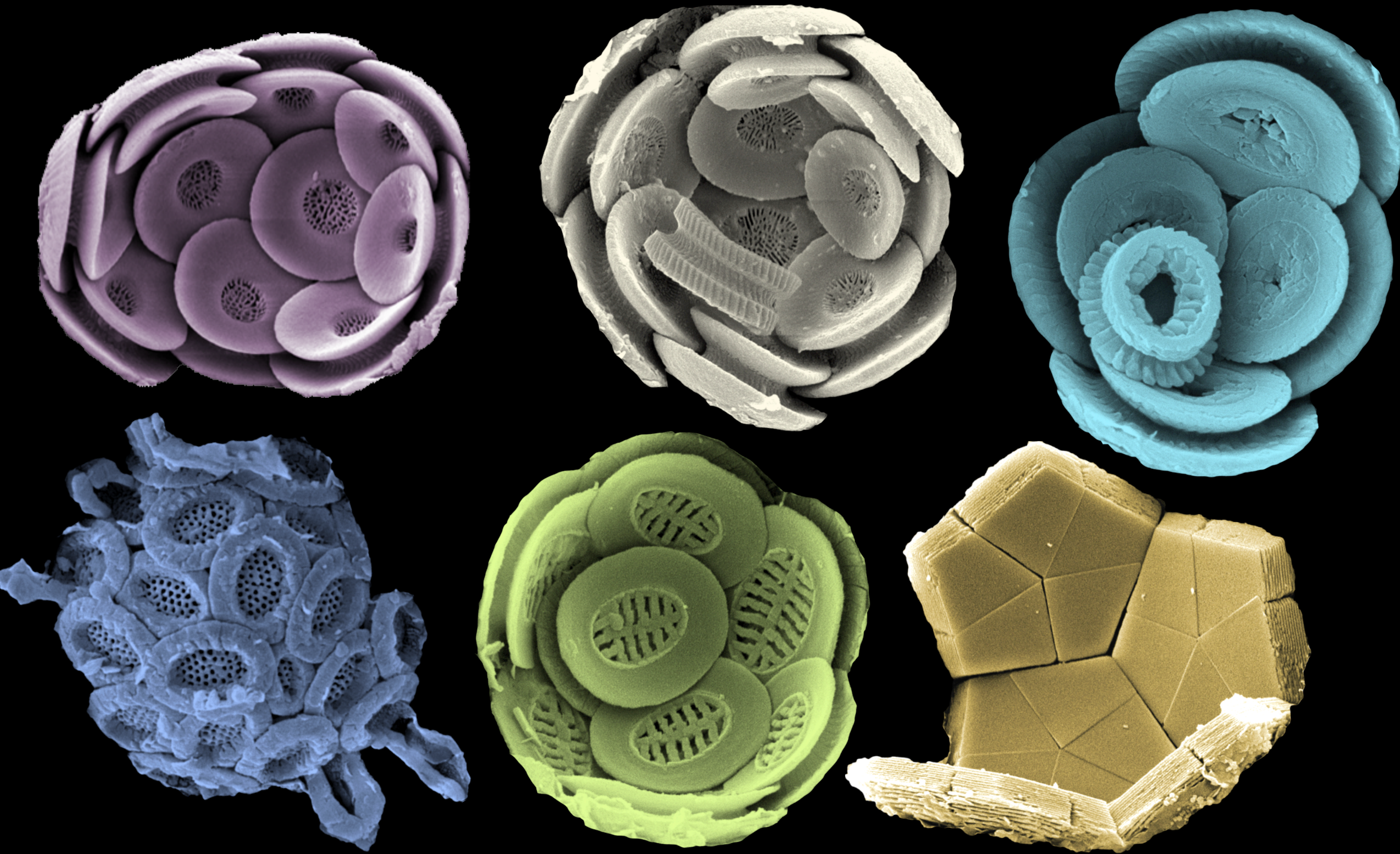
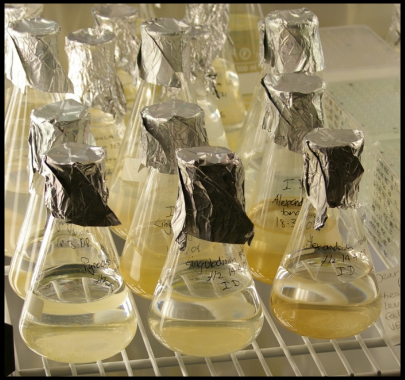
Coccolithophores and OA – past and present



Samantha Gibbs, NOCS, University of Southampton
Paul Bown, University College London

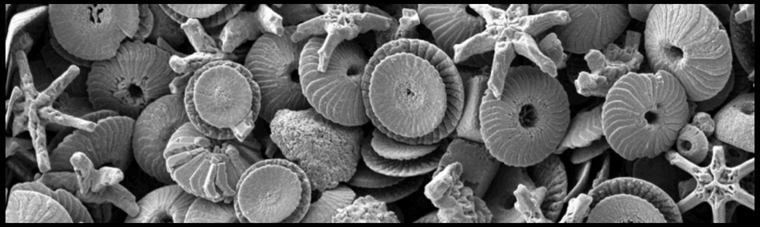
Information useful for understanding OA?



Modern, living cells

PIC, POC, cell size, malformation <u>and</u> RATES

??



Fossils

Global patterns of species change

Taxonomic composition and abundance

Ecosystem perturbation and recovery

Adaptational timescales

Maximising use of palaeo records

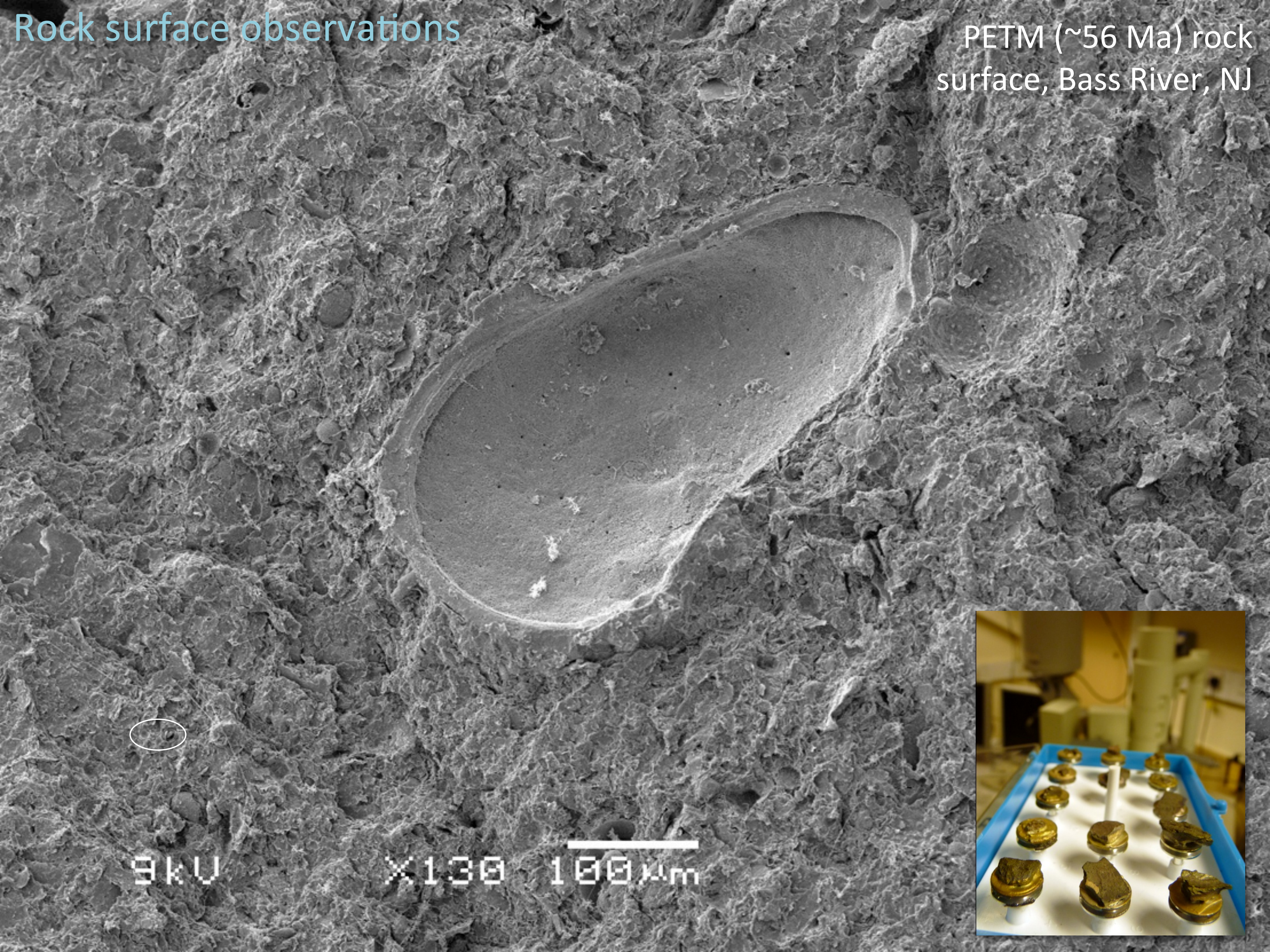
Talking the same language

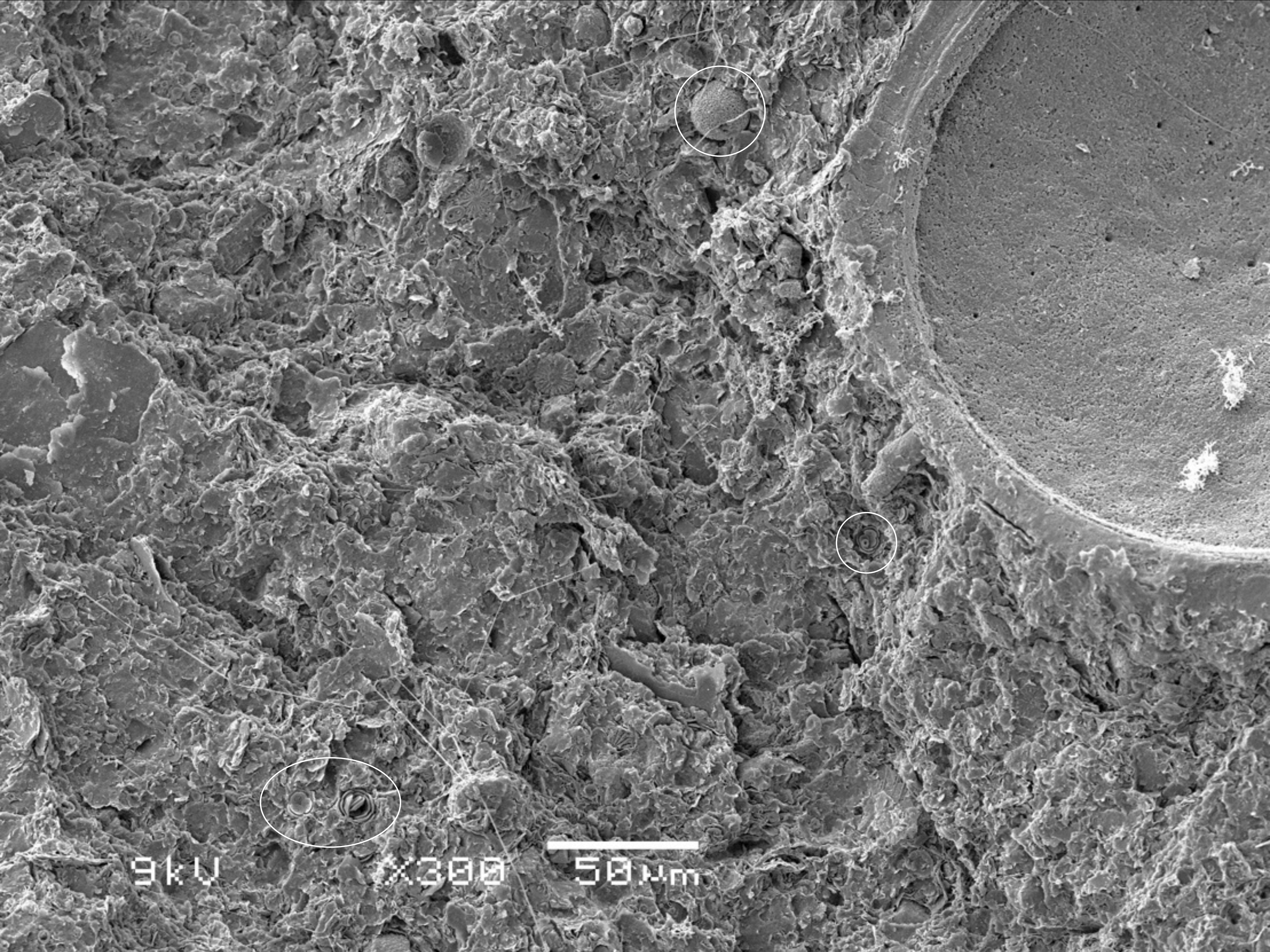
How?

Best preserved material
New approaches for comparing with modern
Targeting biomineralisation

To understand OA impacts first must understand the skeleton

Rock surface observations

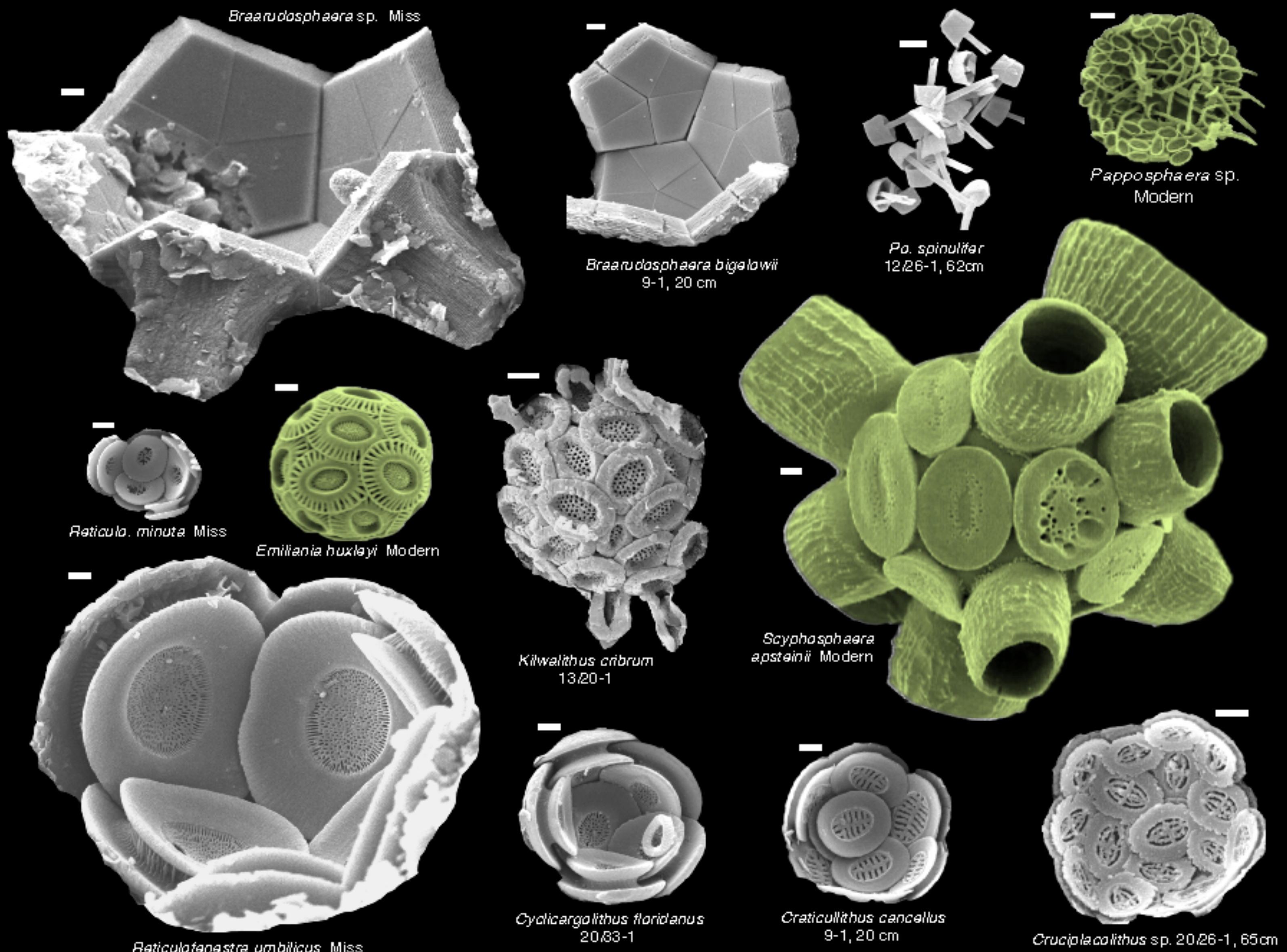



9kV
X300
50μm

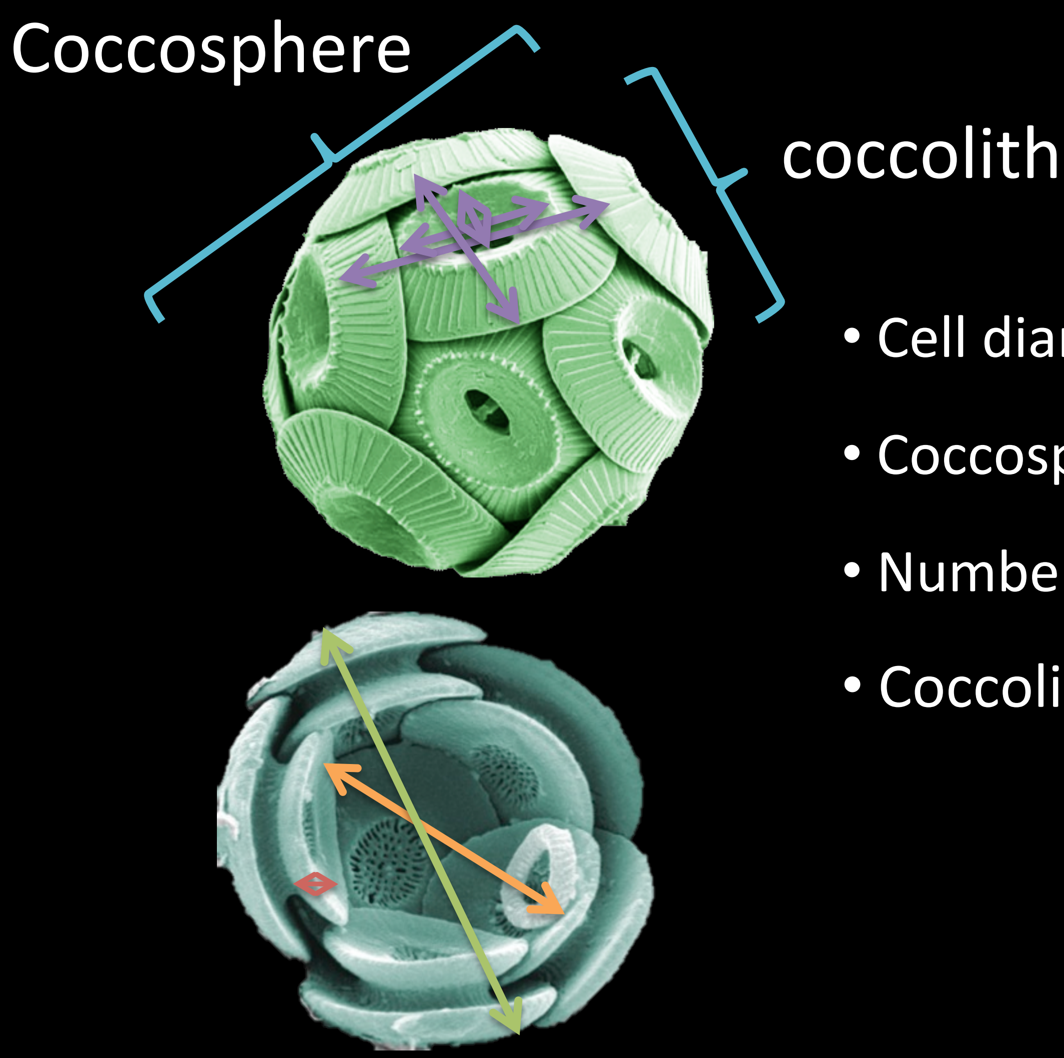

9kV X3,000 5μm

1. Fossil coccospheres

An untapped archive of cellular calcification and morphology

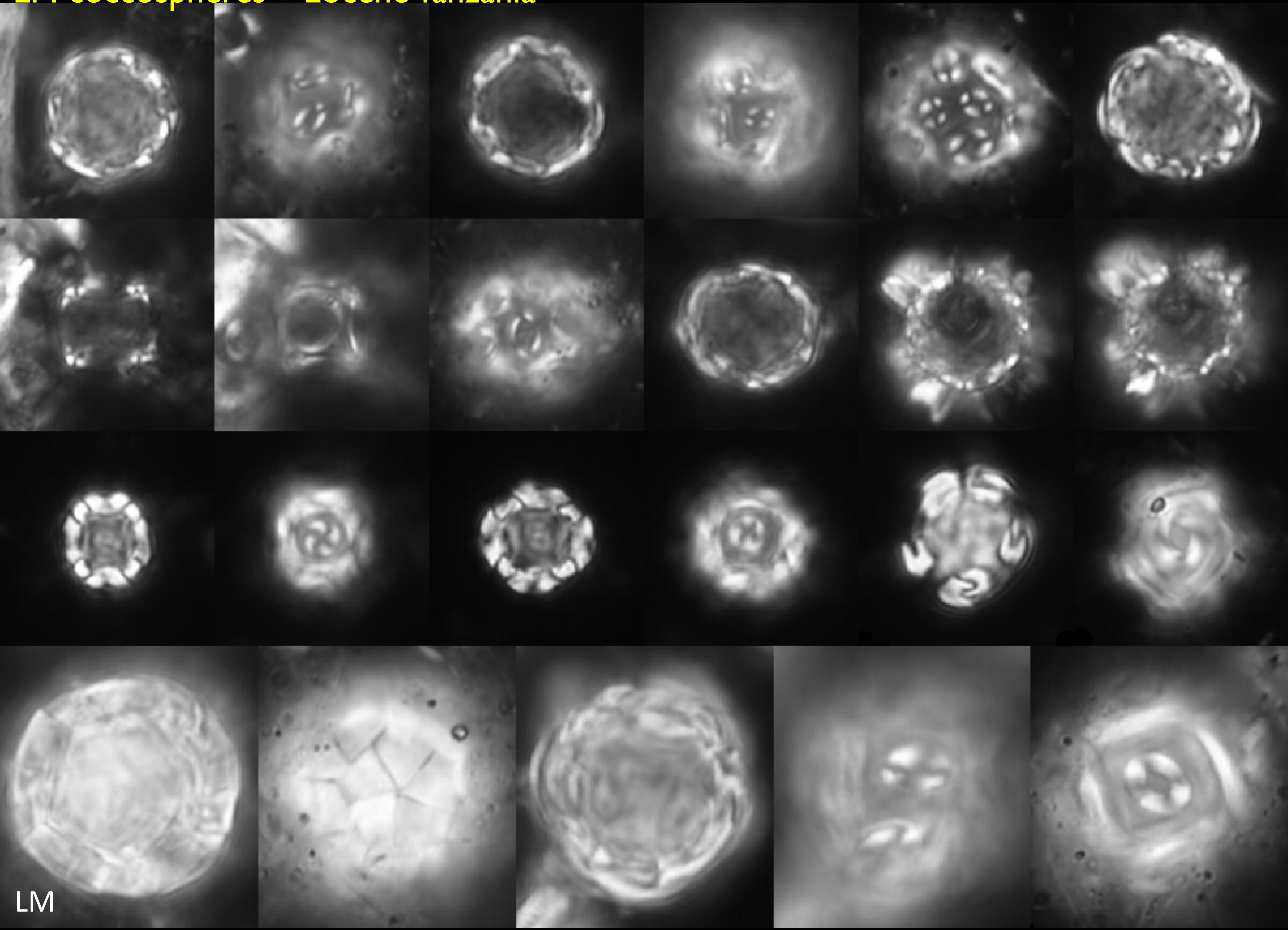


Coccosphere data

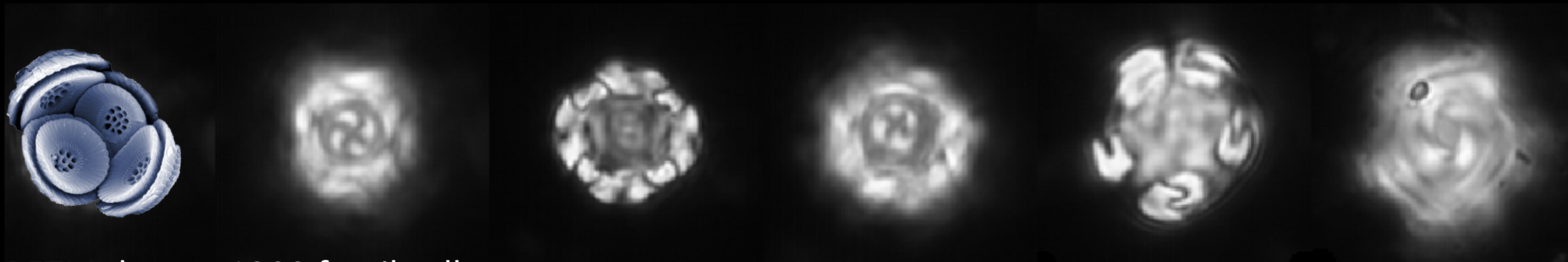


- Cell diameter
- Coccosphere diameter
- Number of coccoliths
- Coccolith length and widths

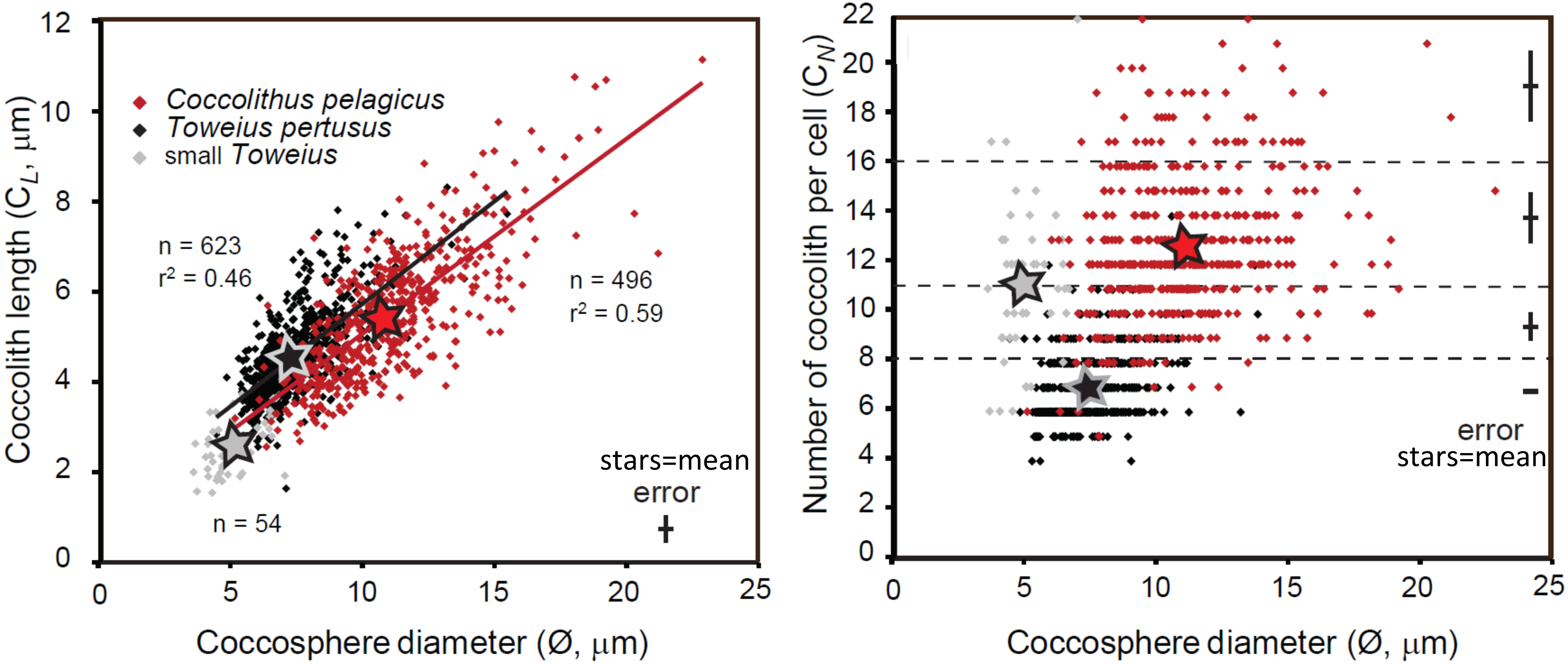
LM coccospheres – Eocene Tanzania



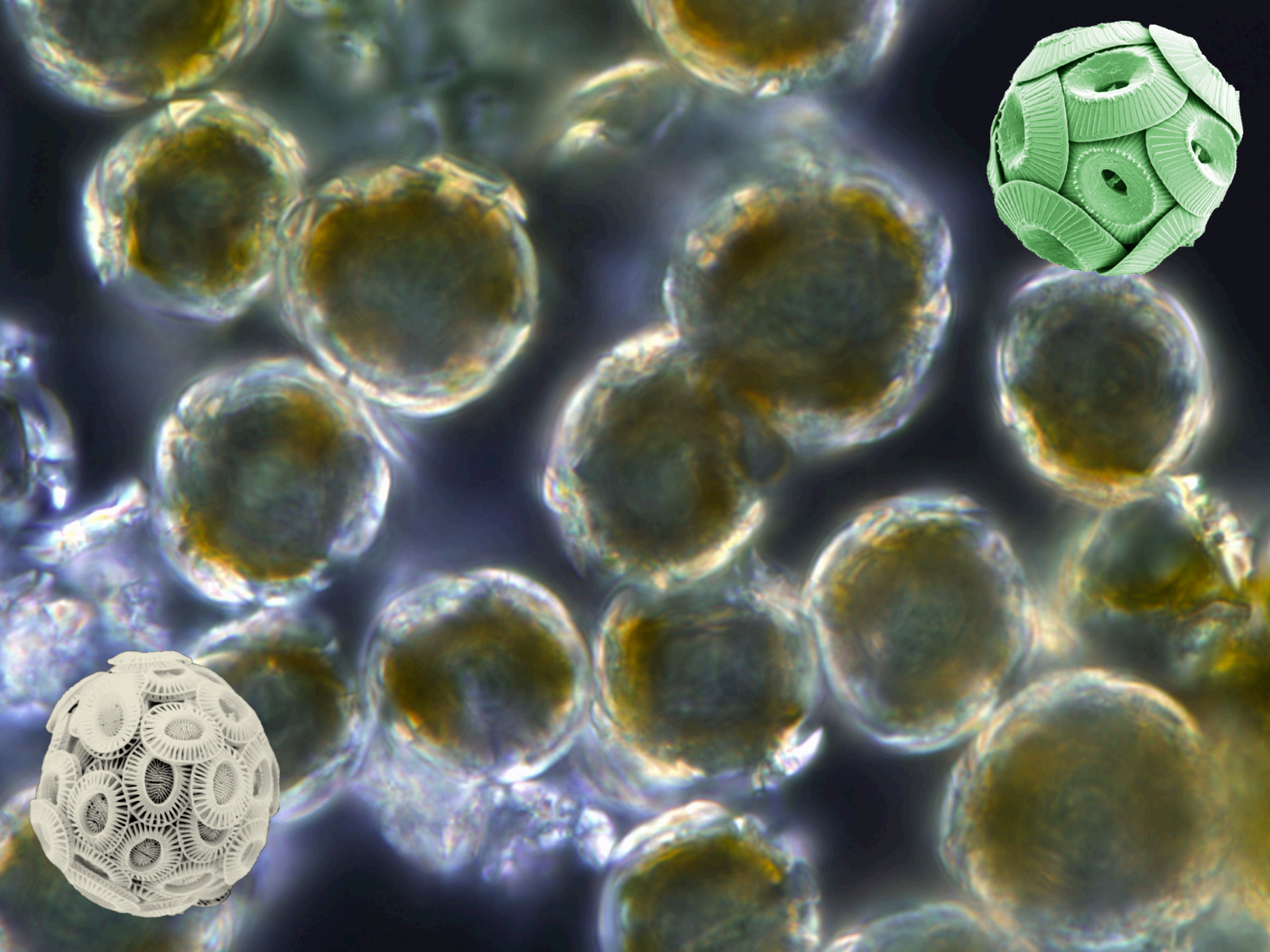
Coccosphere geometry from fossils



PETM data - ~1200 fossil cells



Gibbs et al. *Nature Geo* 2013



Coccosphere geometry from living cells

Batch culture *C. pel. braarudii*

recently divided

8-9 coccoliths

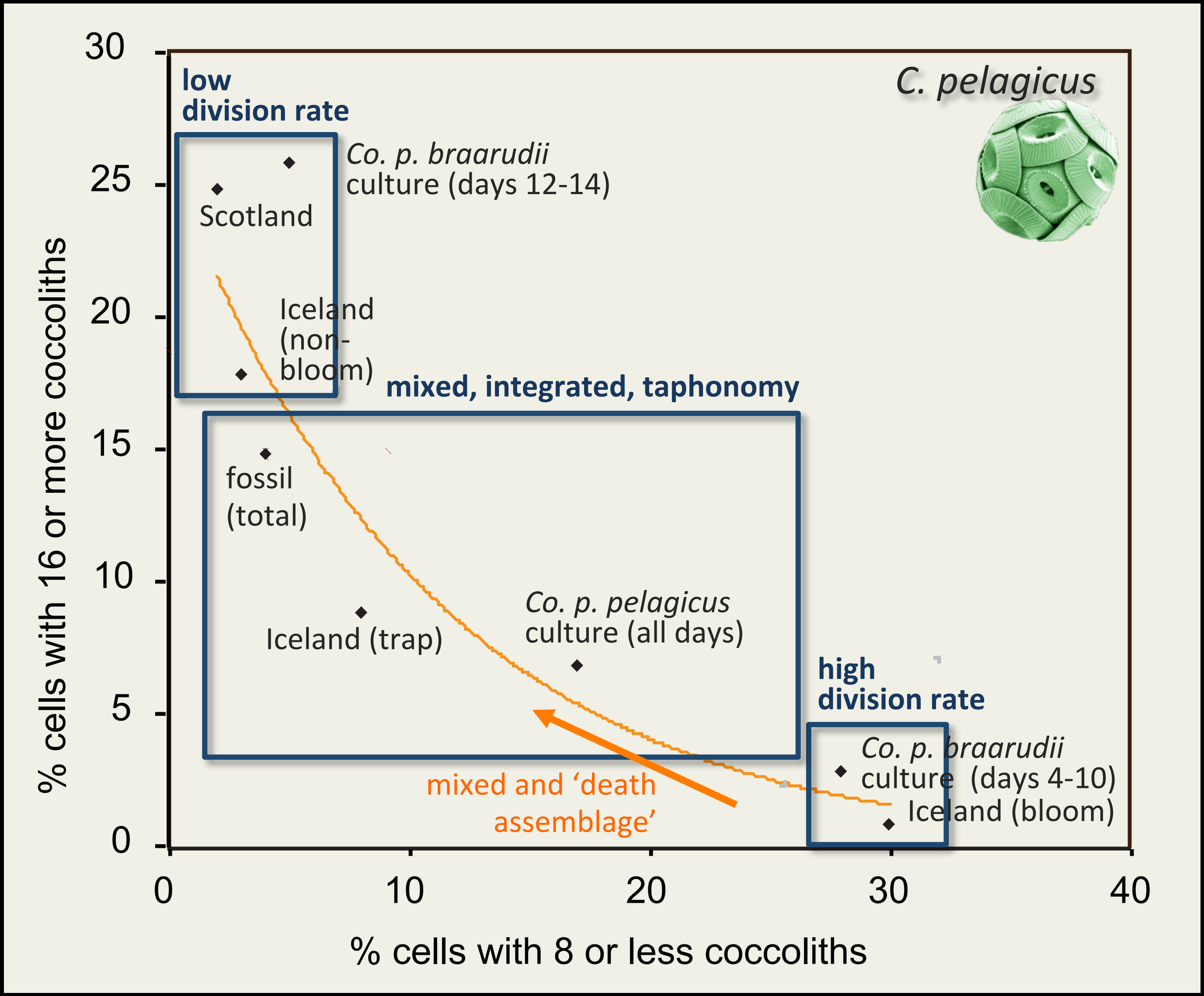
~12 coccoliths

non-dividing

~20 coccoliths

PETM and coccospheres

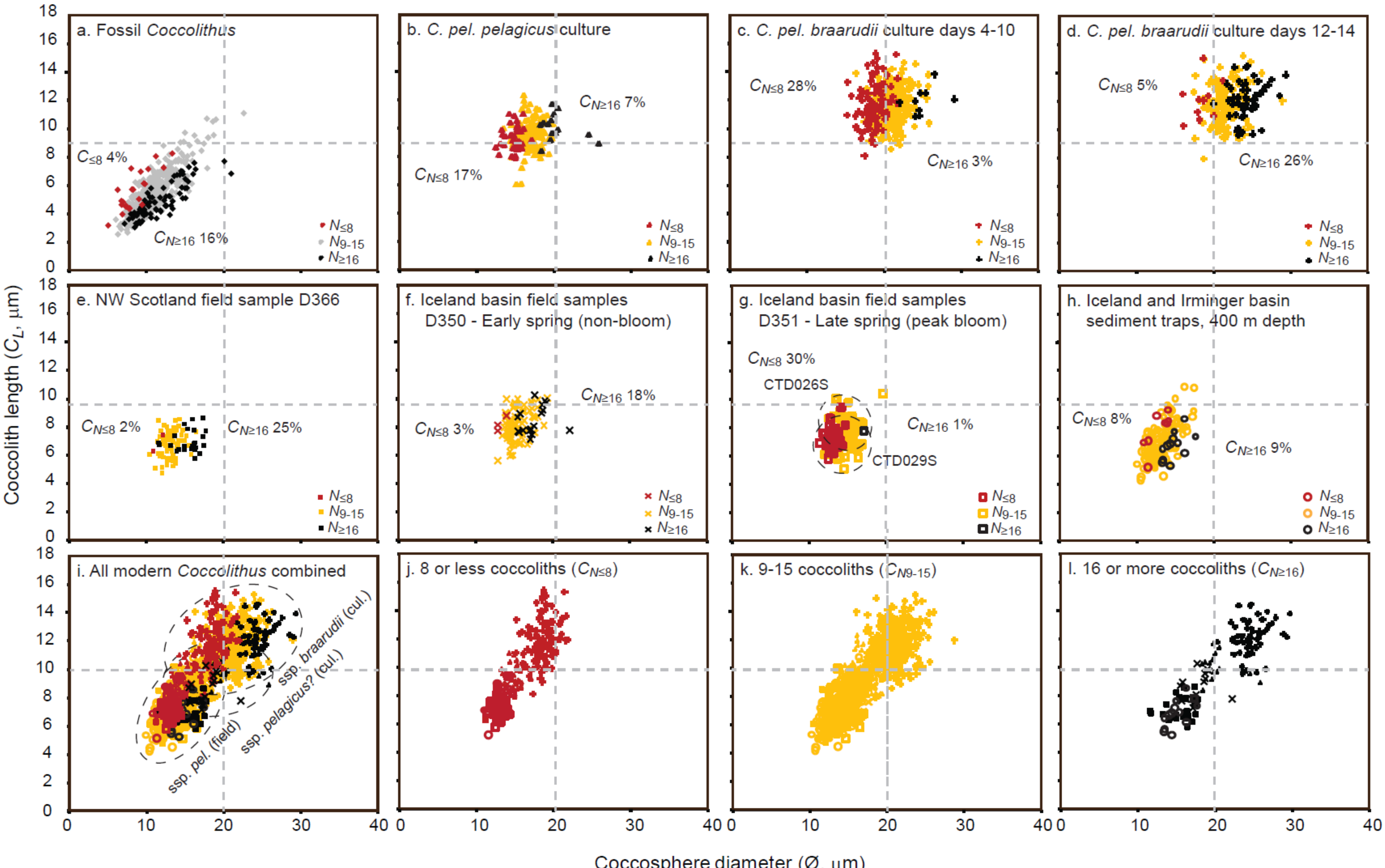
Fossils + cultures + plankton samples + sediment traps



Gibbs et al. *Nature Geo*2013

Coccosphere geometry – size, liths and growth rates

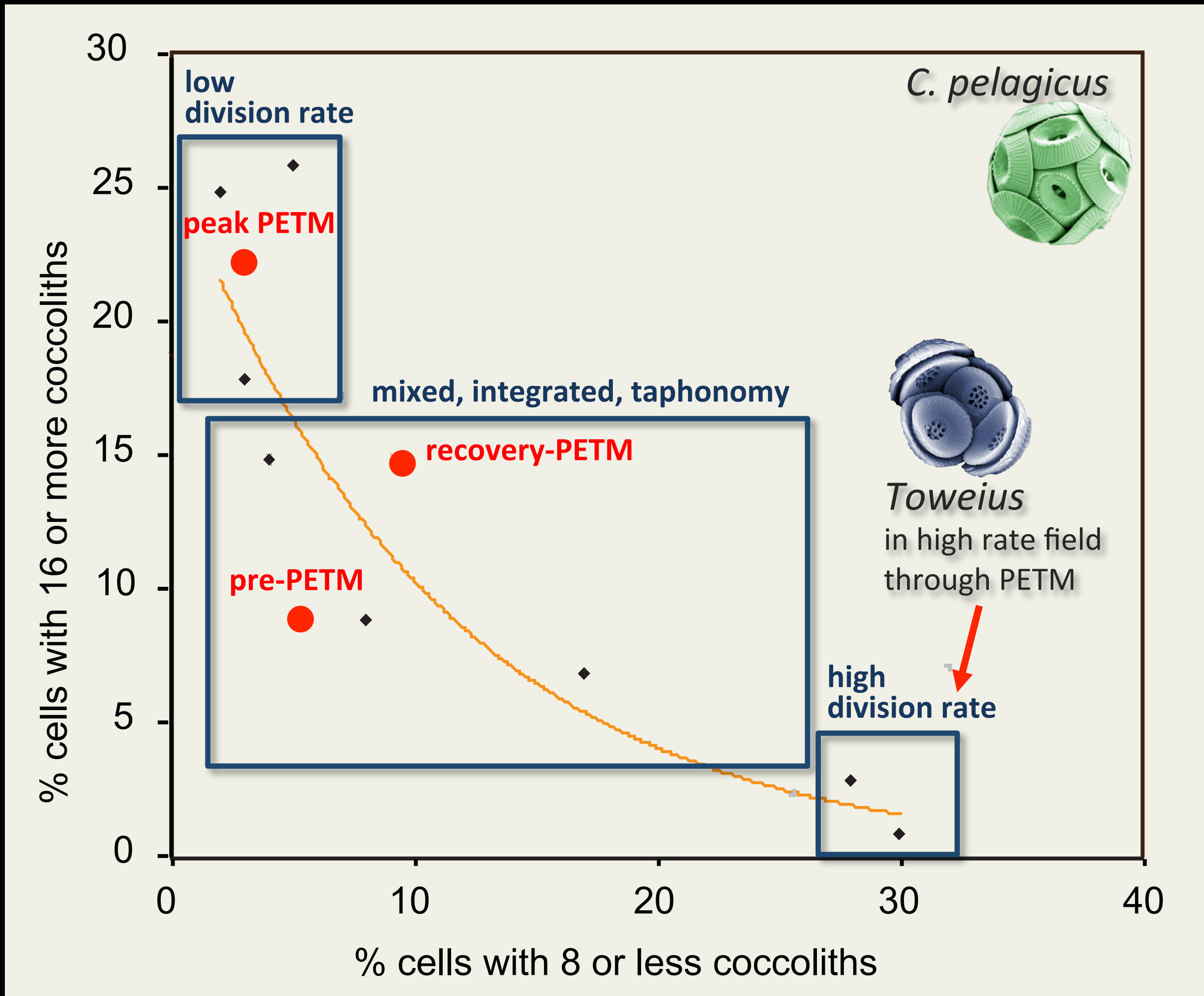
Fossils + cultures + plankton samples + sediment traps



Gibbs et al. *Nature Geo* 2013

PETM and coccospheres

PETM




nature
geoscience
MARCH 2013 VOL 6 NO 3
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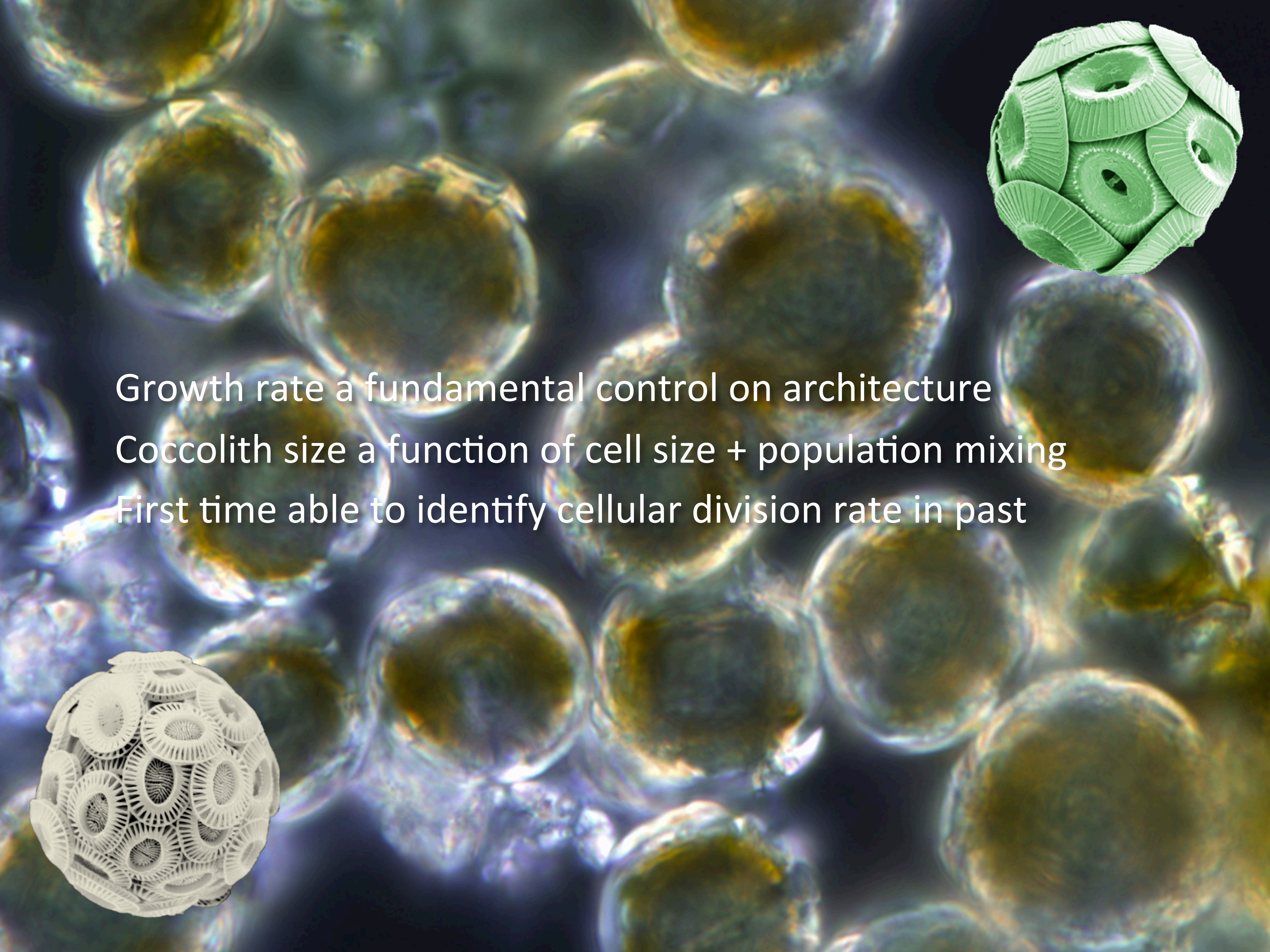
MAURITIA UNVEILED
An Indian Ocean continent
OCEANIC NITROGEN LOSS
Organic export matters
LUNAR WATER
Sourced from antiquity
Antarctic Bottom Water
tracked to the sea-ice edge



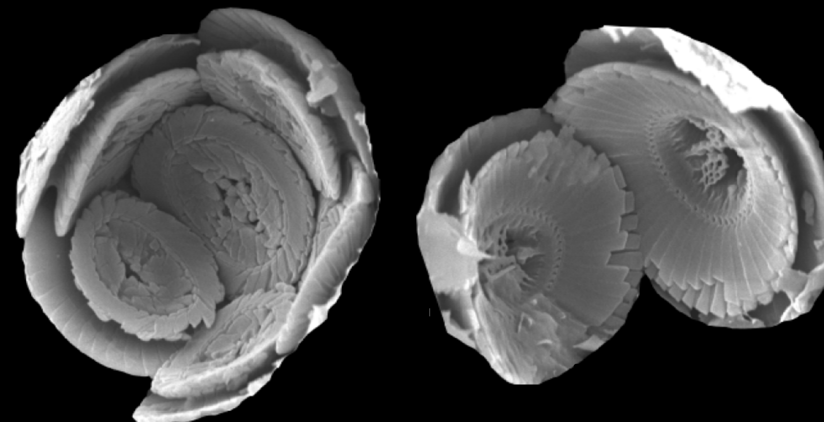
Growth rate a fundamental control on architecture

Coccolith size a function of cell size + population mixing

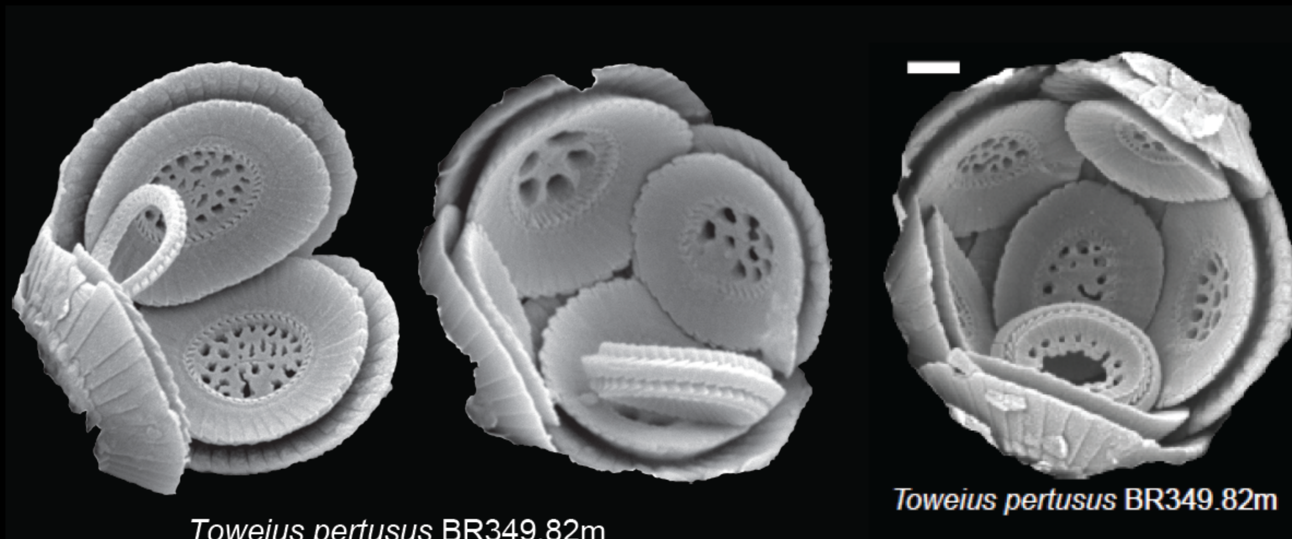
First time able to identify cellular division rate in past

What else can we gain from these remarkable coccospheres?

- Malformation?



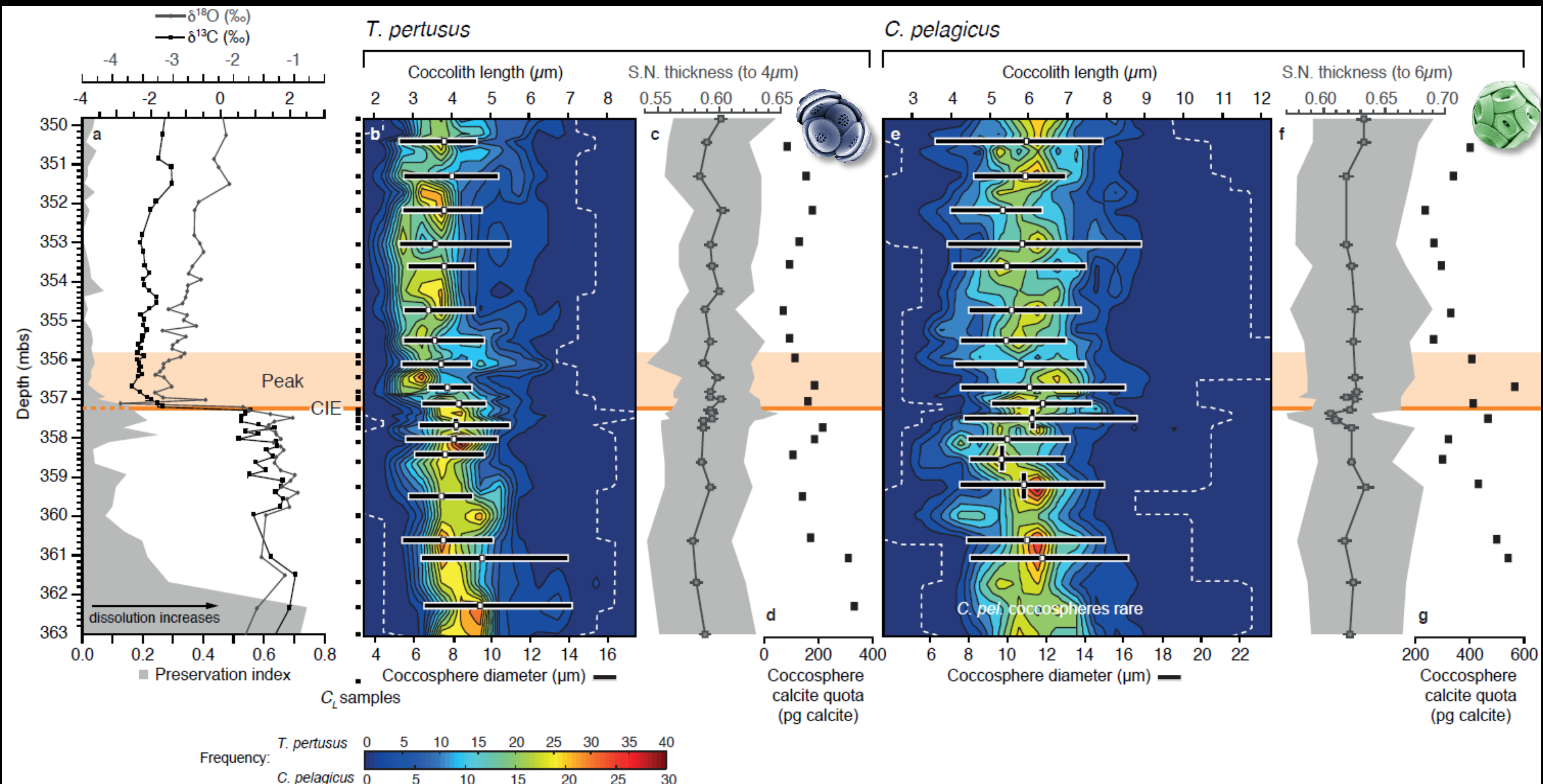
- Development : Problems calcifying? Protococcolith rings



Reconstructing ontogenies for extinct species

2. Coccolith thickness and cellular carbon quotas

thickness data - size normalised, taxon specific



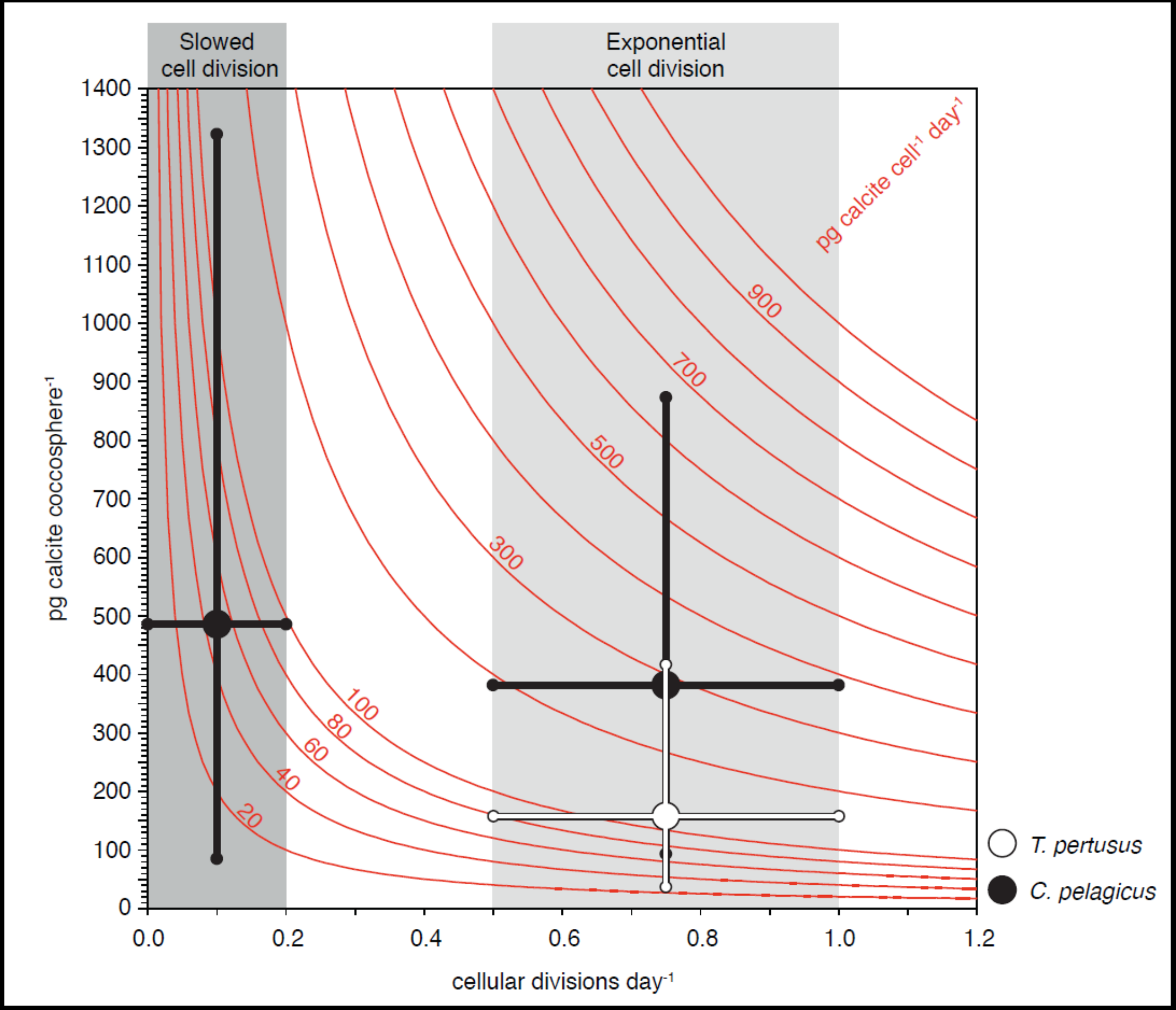
O'Dea et al. in prep

Talking the same language…….

Bits of the jigsaw

Cellular carbon quota + estimates of division levels

first estimates of cellular calcite production rate



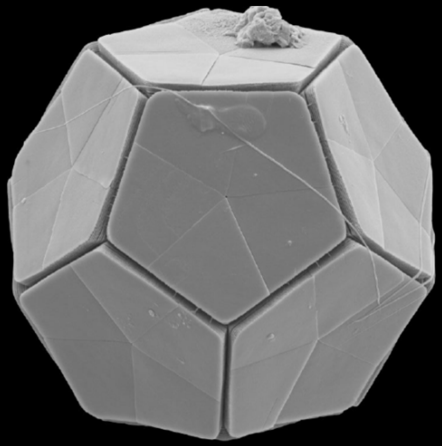
So how does this help us understand OA responses?

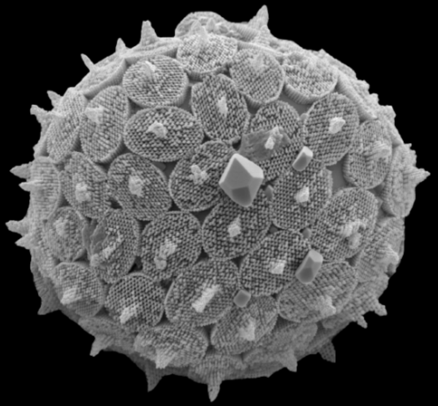
- First records of cell size, PIC quotas, PIC production anywhere in the fossil record (+ Rosie Sheward Phd)
- Little sensitivity in dominant PETM coccolithophores (NB, intracellular calcifiers)
- Potentially large changes in calcification that are unrelated to OA
- Contrasting evolutionary histories of the two lineages - ability to maintain high growth rates?

Have we cracked OA responses?

3. Intra- versus extracellular calcifiers

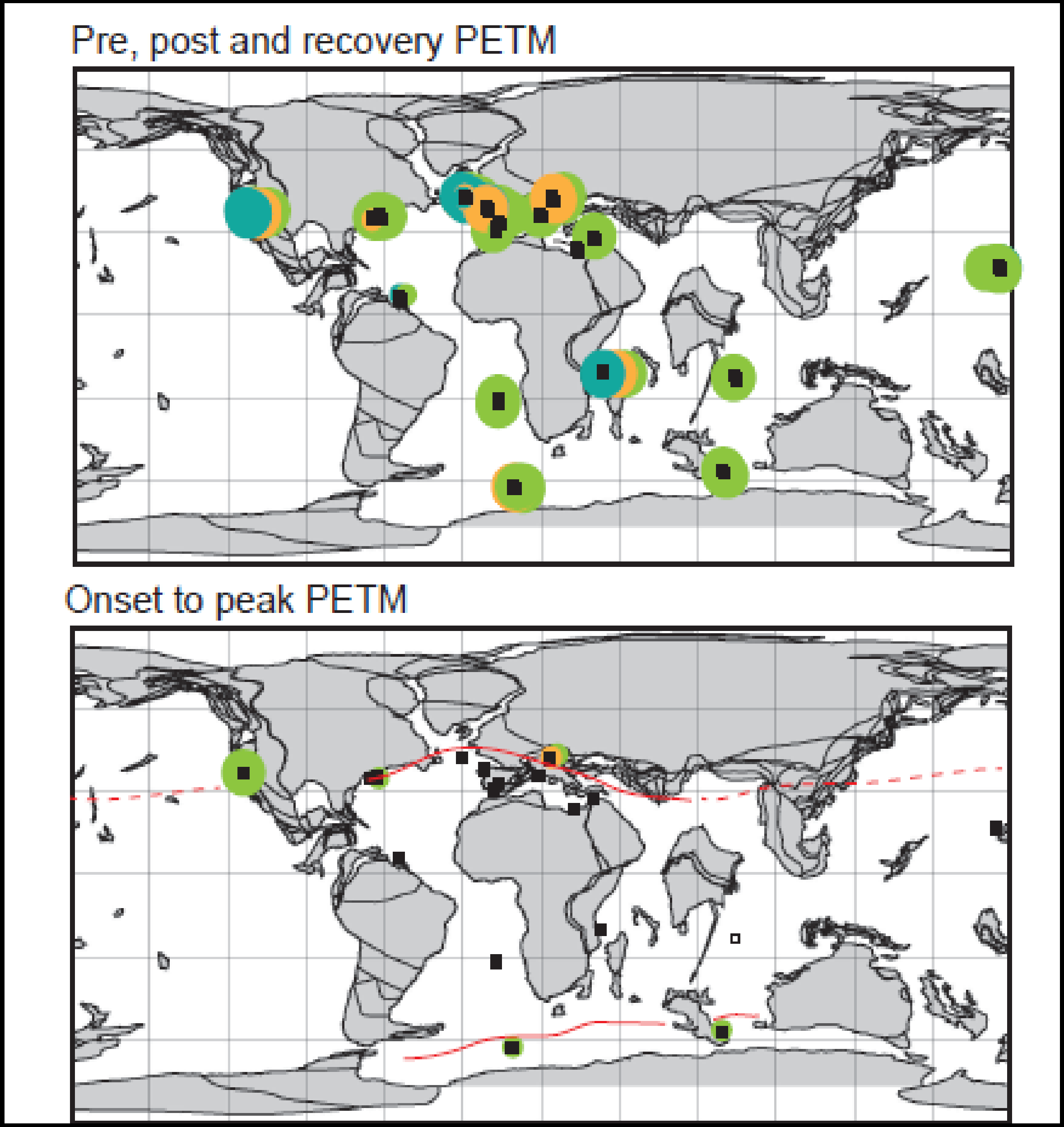
- Life-cycle sensitivity to OA?





With Alex Poulton and group (NOCS & SOES), and Jeremy Young (UCL)
+ modelling with Fanny Monteiro and Andy Ridgwell (Bristol)

Braarudosphaera and holococcolith occurrence across PETM

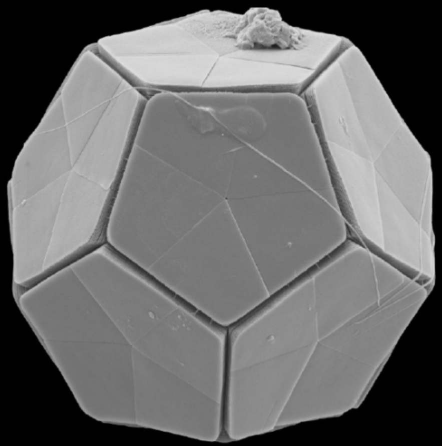


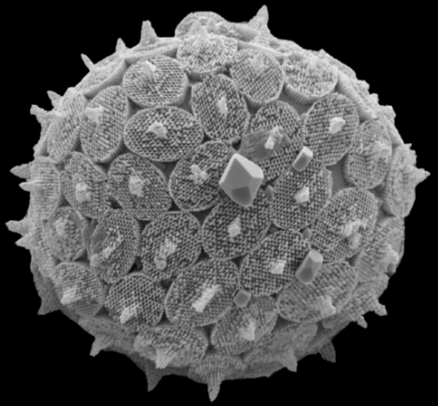
Gibbs et al. in prep

Have we cracked OA responses?

3. Intra- versus extracellular calcifiers

- Life-cycle sensitivity to OA?
- 6 months PDRA pilot study (AVA)
  UKOA with surface water consortium
  Standard grant proposal (2 July)
- Lith thickness and direct measurements of *Braarudosphaera* (see Jeremy's talk)





With Alex Poulton and group (NOCS & SOES), and Jeremy Young (UCL)
+ modelling with Fanny Monteiro and Andy Ridgwell (Bristol)

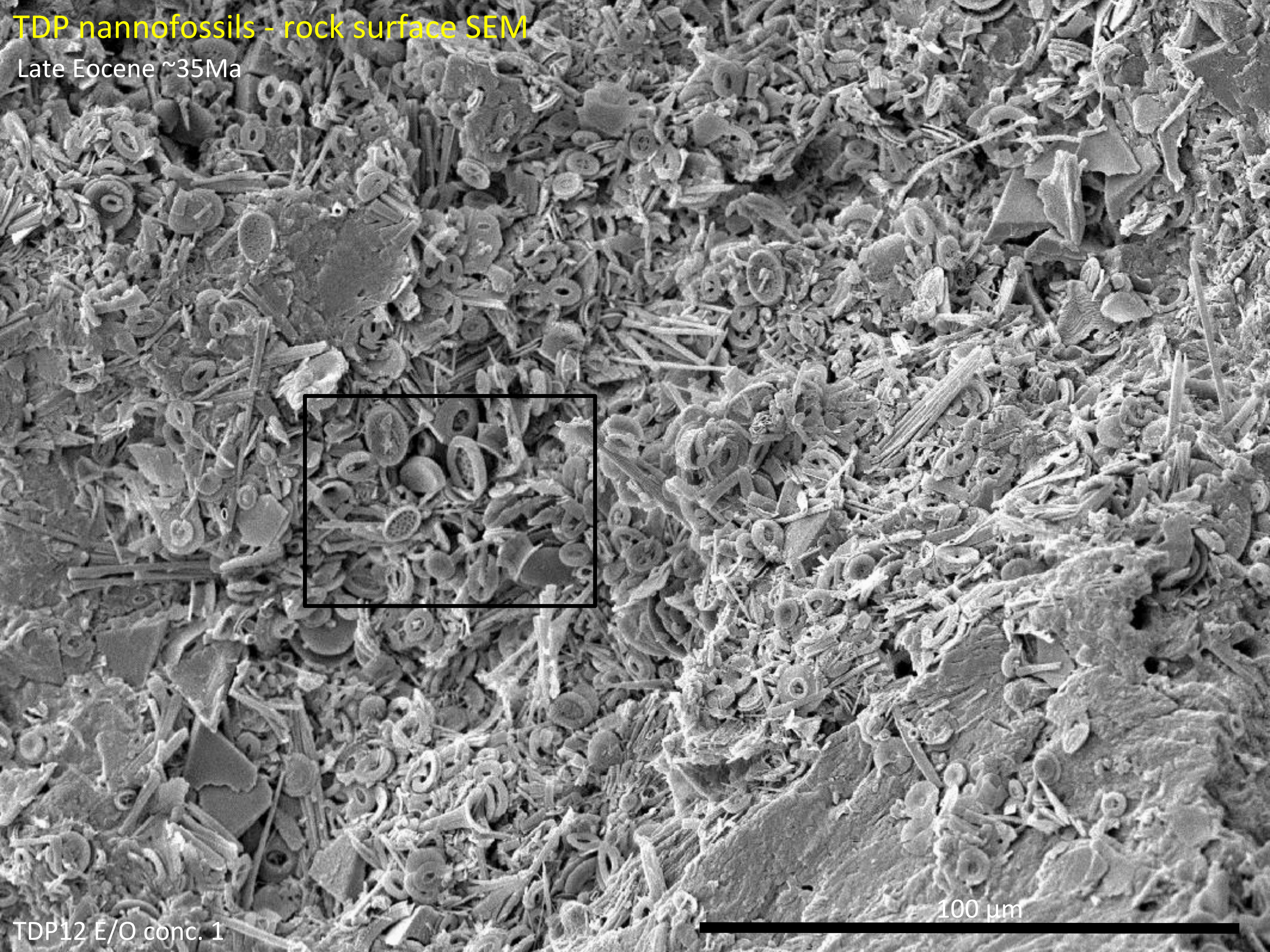
A huge step forward………

- New approaches to understanding architecture (modern and palaeo)
- Integrated experiments with modern and fossil
- Growth rate vs OA sensitivity?

Talking the same language?

More broadly as a consortium

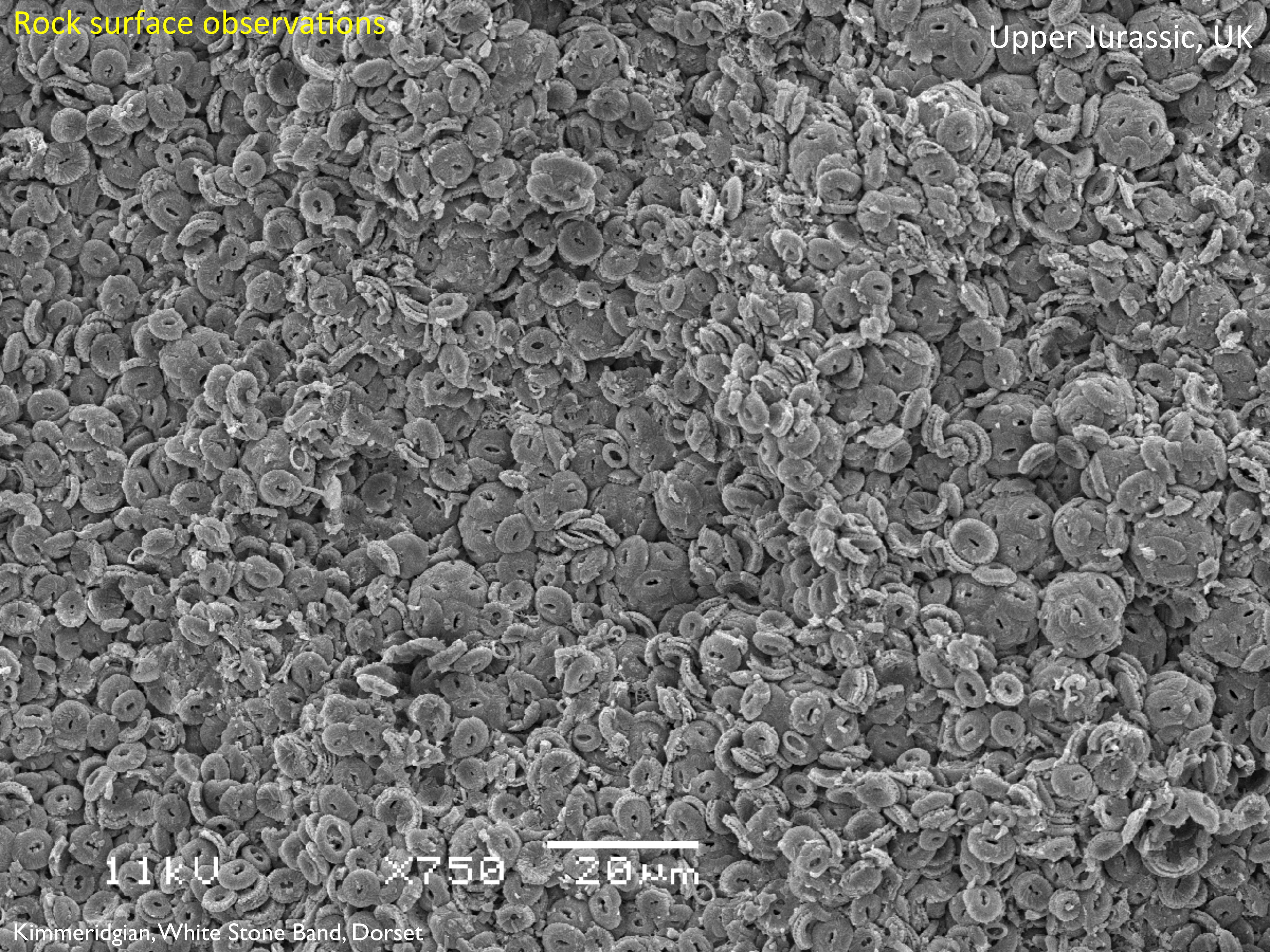
- Constraining past OA levels
- Multistressor appreciation
- Disentangling some degree of OA sensitivity
- Threshold responses


TDP nannofossils - rock surface SEM
Late Eocene ~35Ma
100 µm
TDP12 E/O conc. 1


TDP nannofossils - rock surface SEM
Late Eocene ~35Ma
image width ~ 1/30 mm
5 µm
TDP12 E/O conc. 1
undisturbed, unaltered pellets/aggregates


Rock surface observations
Upper Eocene, Tanzania


Rock surface observations
Upper Eocene,
Mississippi


Rock surface observations
Upper Jurassic, UK
11kV X750 20µm
Kimmeridgian, White Stone Band, Dorset


Rock surface observations
Upper Jurassic, UK
11kV X2,200 10µm
Kimmeridgian, White Stone Band, Dorset

With thanks to Alex Poulton, Jeremy Young, Paul Wilson, Gavin Foster, Eelco Rohling, Chris Daniels, Sarah O'Dea, Jason Hopkins, Heather Jones, Geoff Thiemann and Cherry Newsam.

Royal Society, NERC and UKOA (including DECC and DEFRA).

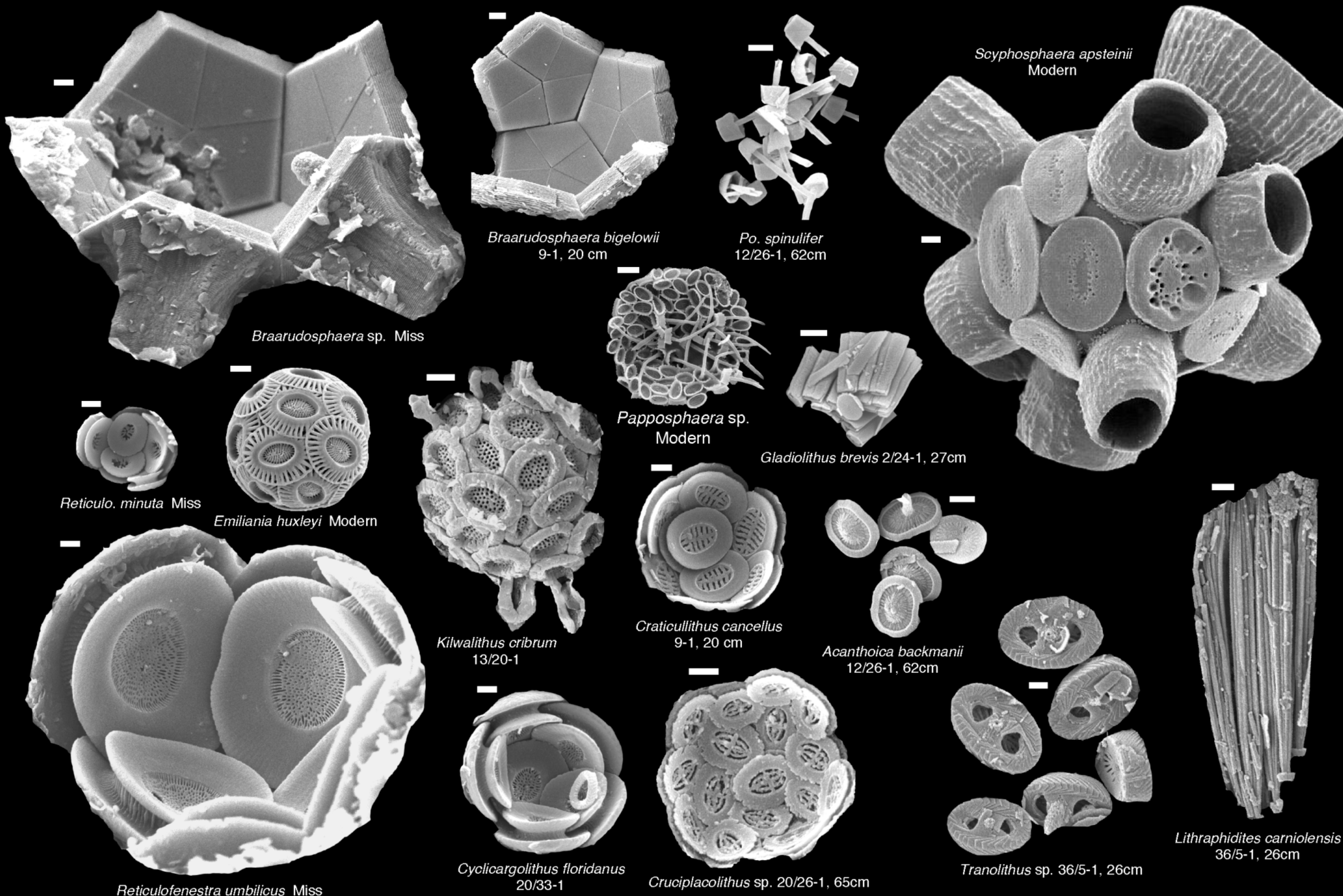
UCL

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

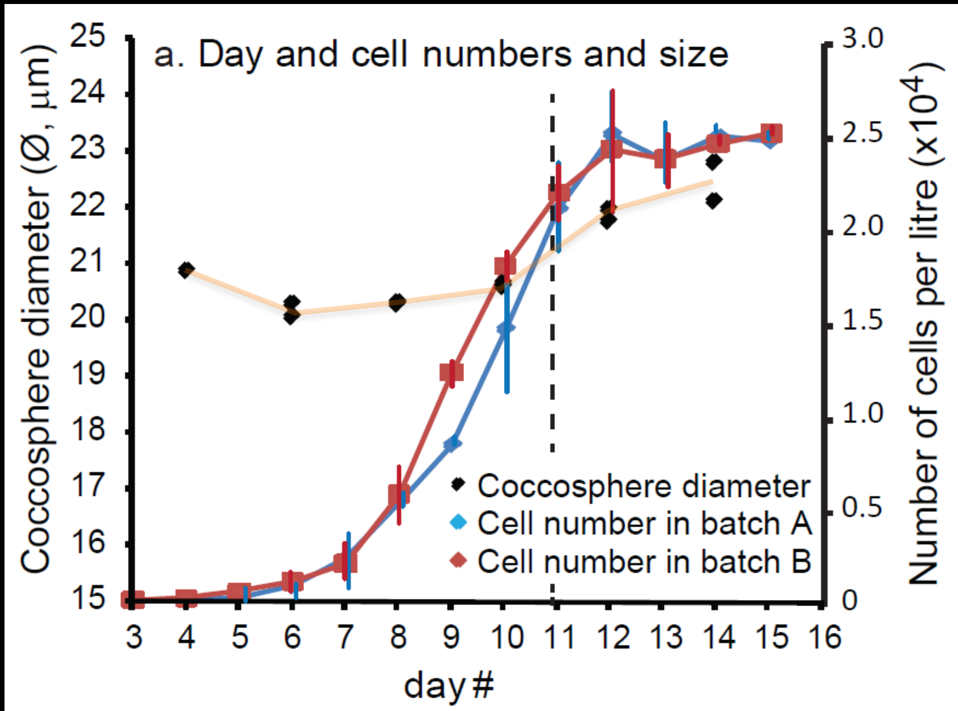
THE ROYAL SOCIETY
CELEBRATING 350 YEARS

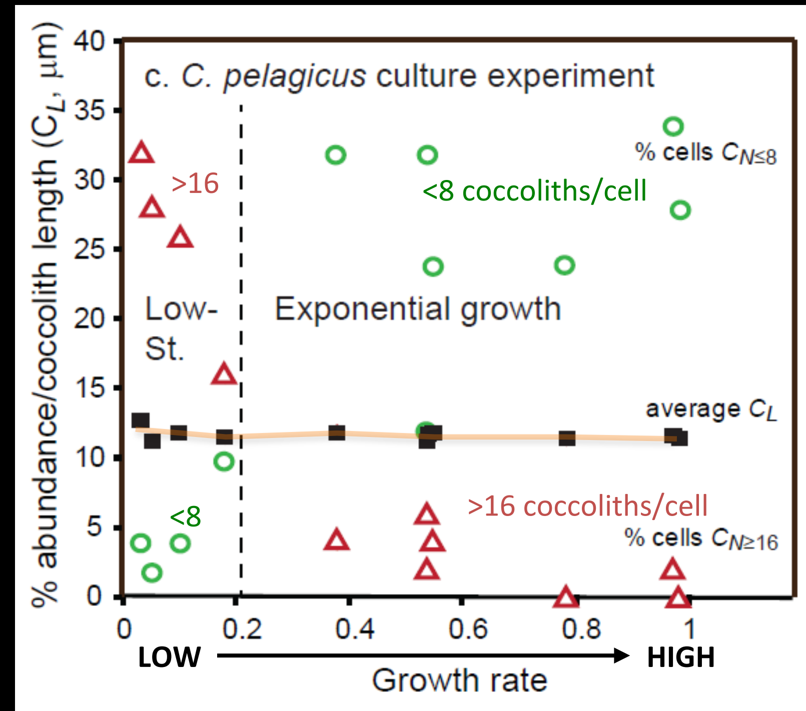
NATURAL ENVIRONMENT RESEARCH COUNCIL

UK Ocean Acidification Research Programme


Braarudosphaera sp. Miss
Braarudosphaera bigelowii
9-1, 20 cm
Po. spinulifer
12/26-1, 62cm
Scyphosphaera apsteinii
Modern
Papposphaera sp.
Modern
Gladiolithus brevis 2/24-1, 27cm
Reticulo. minuta Miss
Emiliania huxleyi Modern
Kilwalithus cribrum
13/20-1
Craticullithus cancellus
9-1, 20 cm
Acanthoica backmanii
12/26-1, 62cm
Lithraphidites carniolensis
36/5-1, 26cm
Reticulofenestra umbilicus Miss
Cyclicargolithus floridanus
20/33-1
Cruciplacolithus sp. 20/26-1, 65cm
Tranolithus sp. 36/5-1, 26cm

Coccosphere geometry from living cells

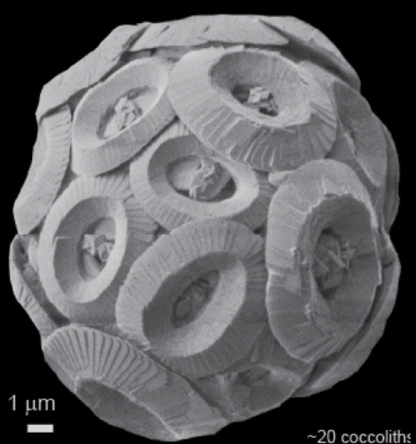




non-dividing

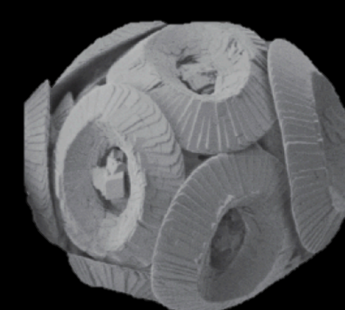
Batch culture *C. pel. braarudii*

recently divided

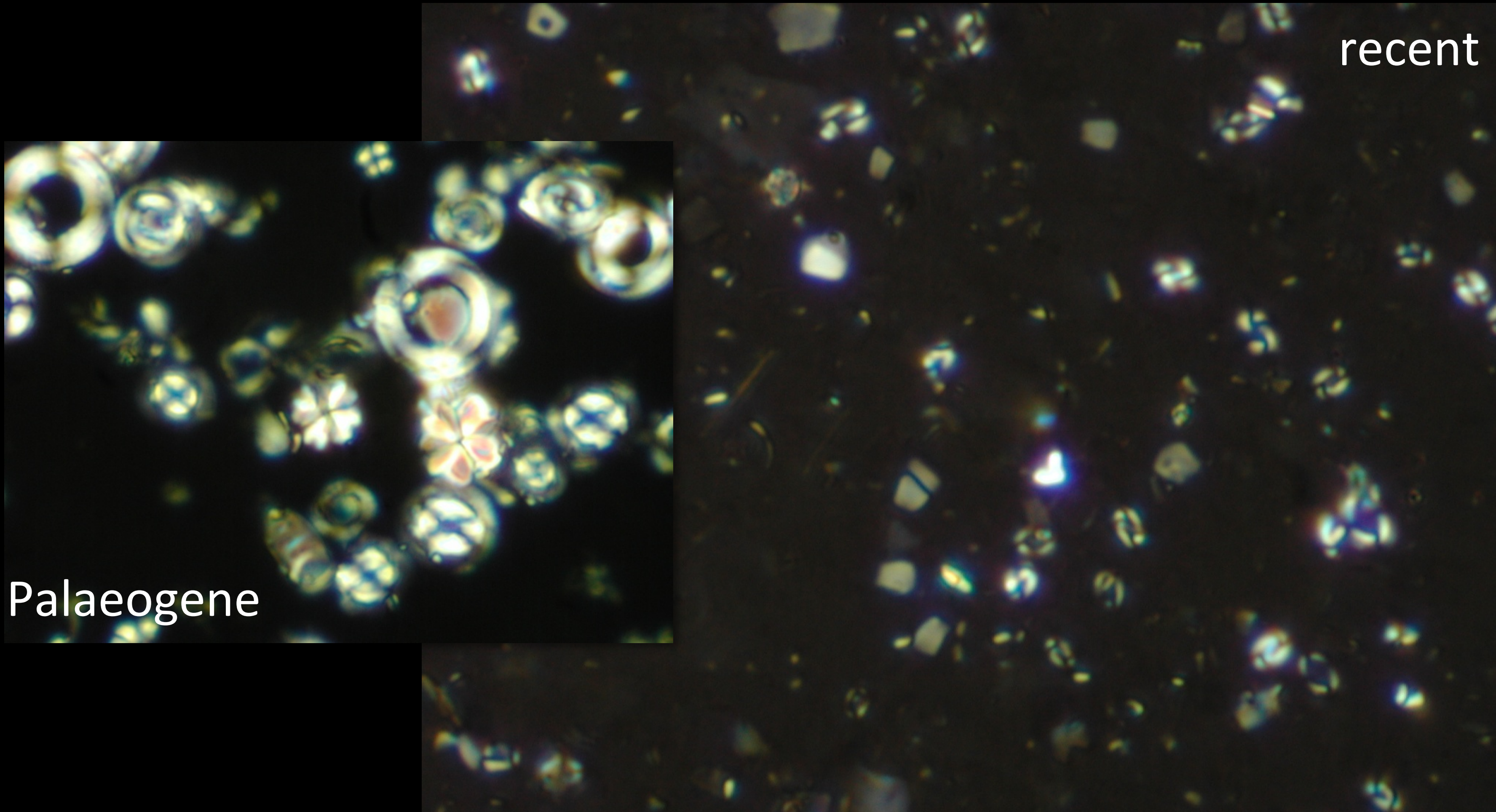


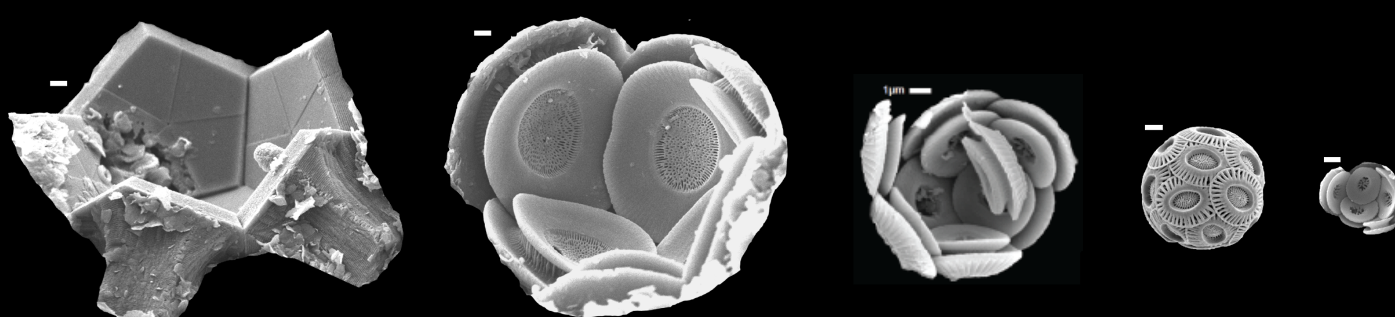
~20 coccoliths

~12 coccoliths



8-9 coccoliths


recent
Palaeogene


1µm