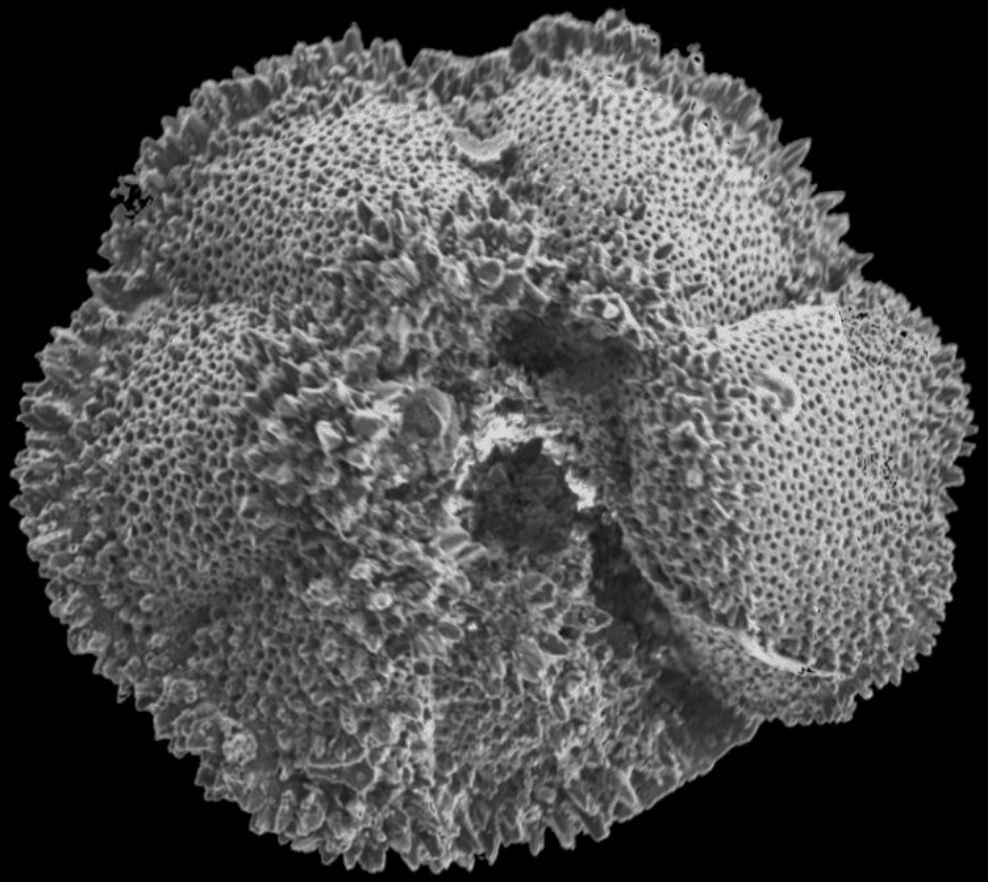
Seafloor Diagenesis Attenuates the Carbon Isotope Excursion Marking the PETM



Reinhard Kozdon

D. Clay Kelly John W. Valley

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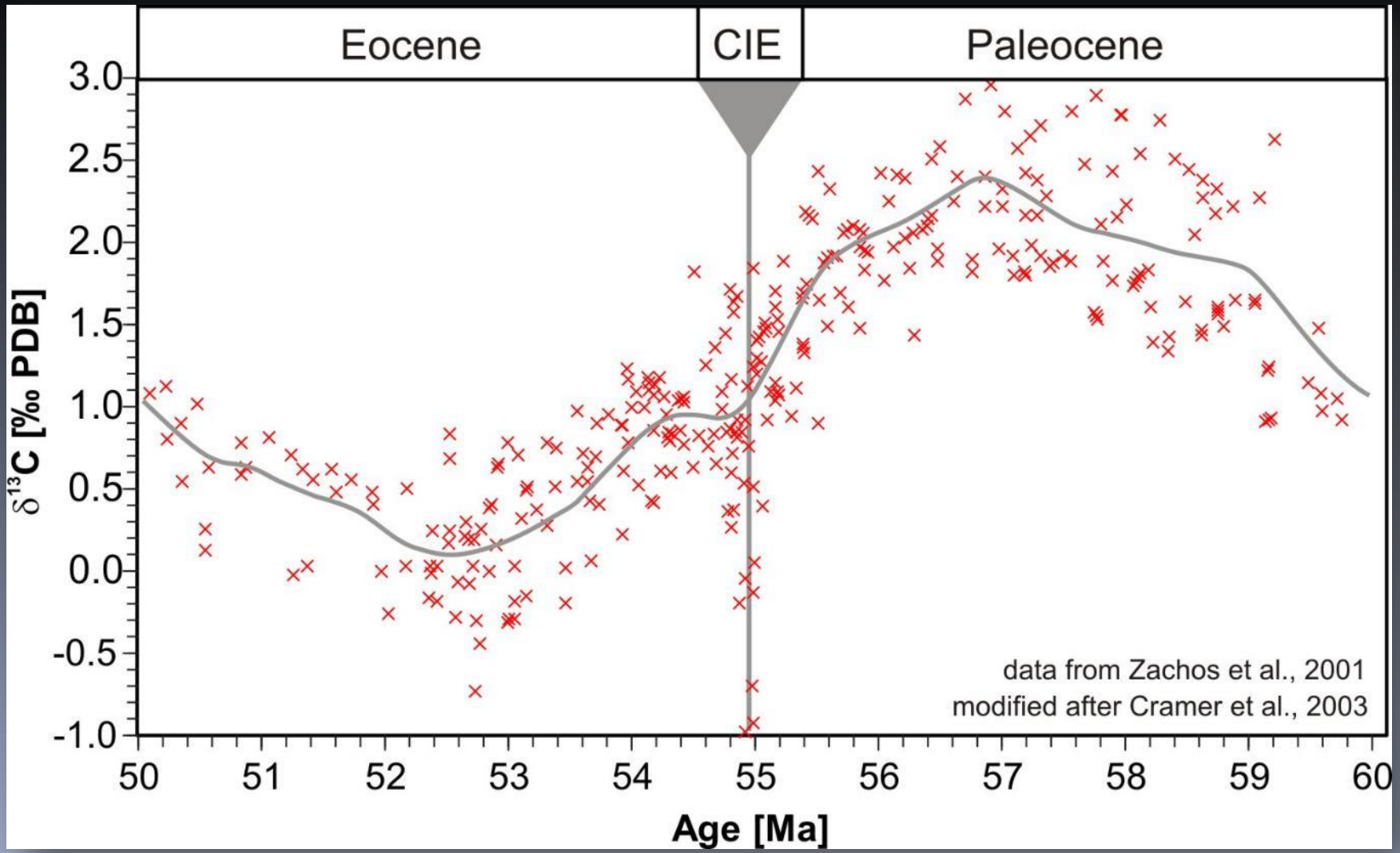
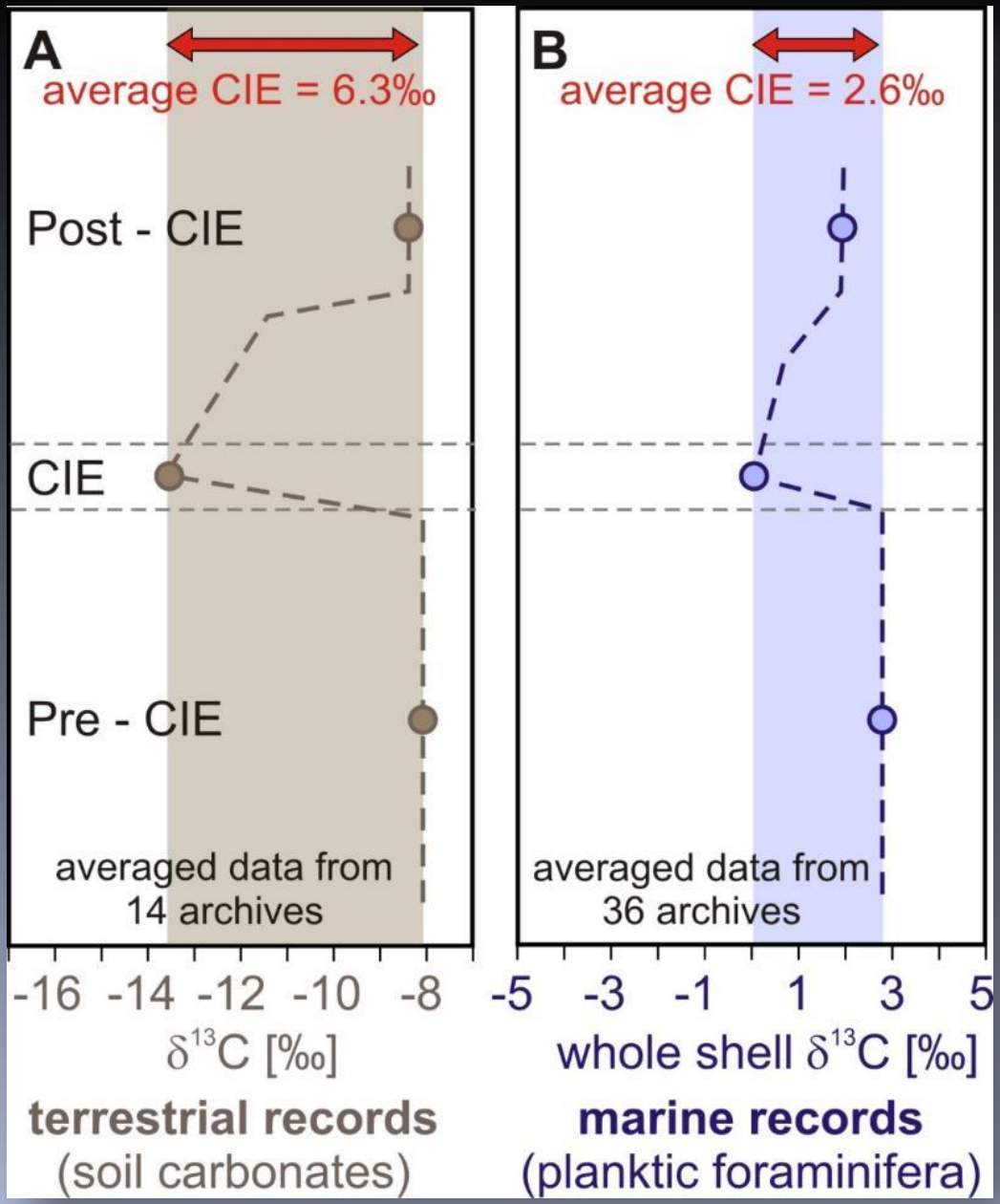
R. Kozdon, Workshop on High Resolution Proxies of Paleoclimate, Madison, Wisconsin, June 23-26, 2013

The Carbon Isotope Excursion (CIE). Massive release of carbon with low $\delta^{13}C$



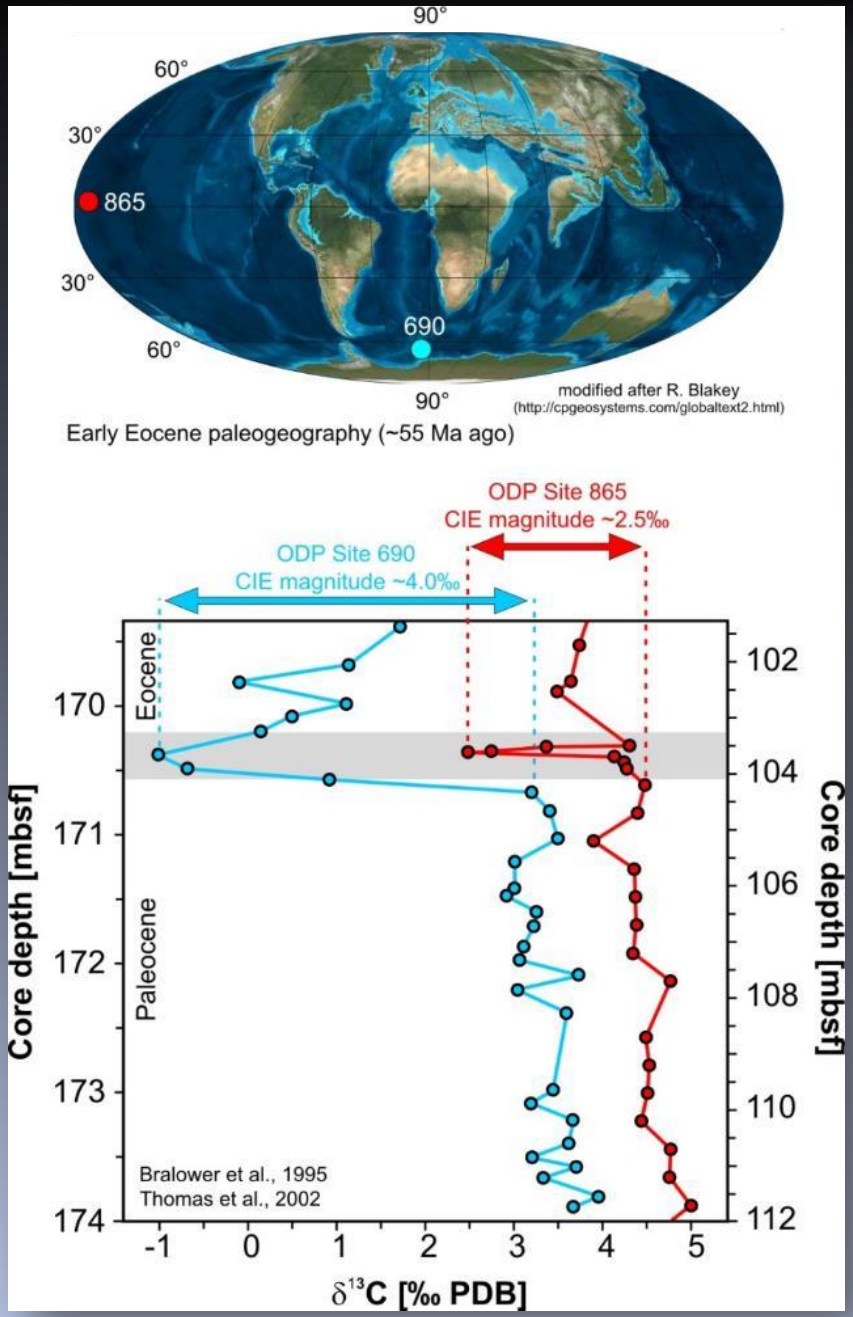
The magnitude of the CIE is a critical constraint for estimating the mass of C emitted during the PETM

Substrate - specific differences in the CIE magnitude

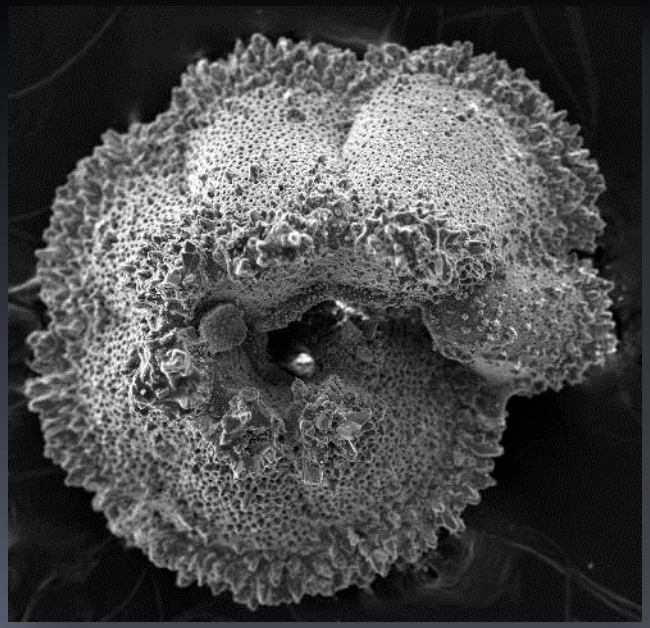


Modified from McInerney and Wing, 2011

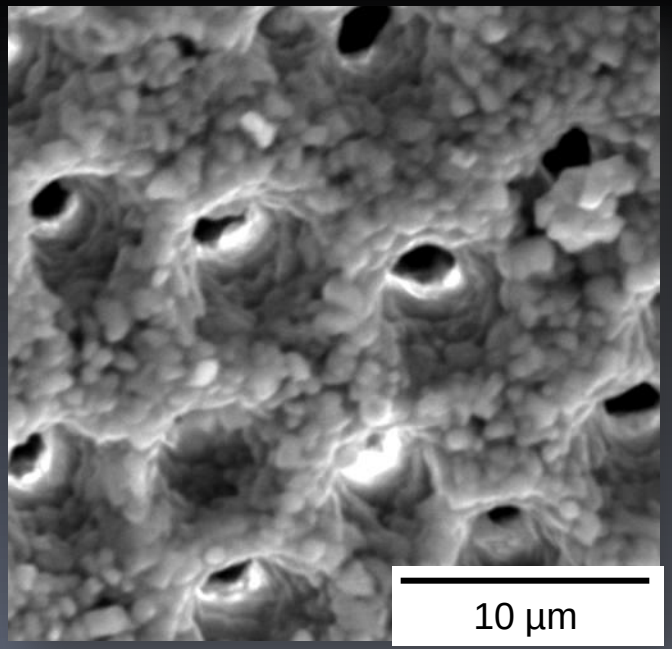
Core locations selected for this study



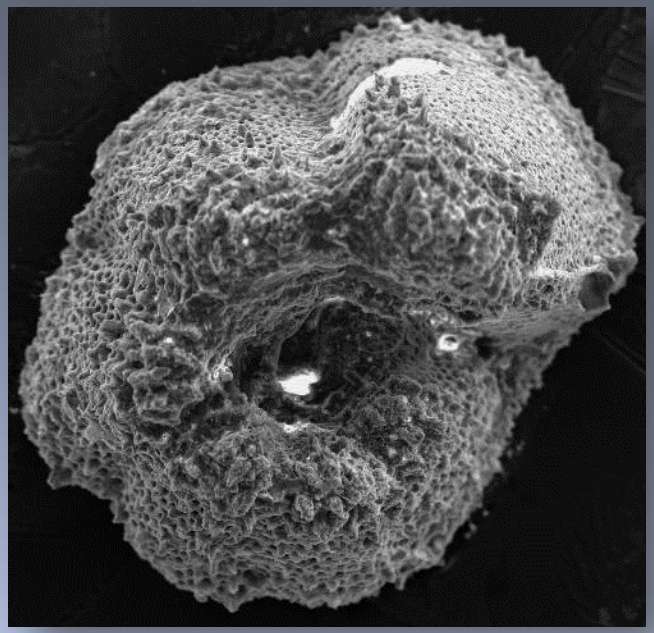
“Frosty” texture



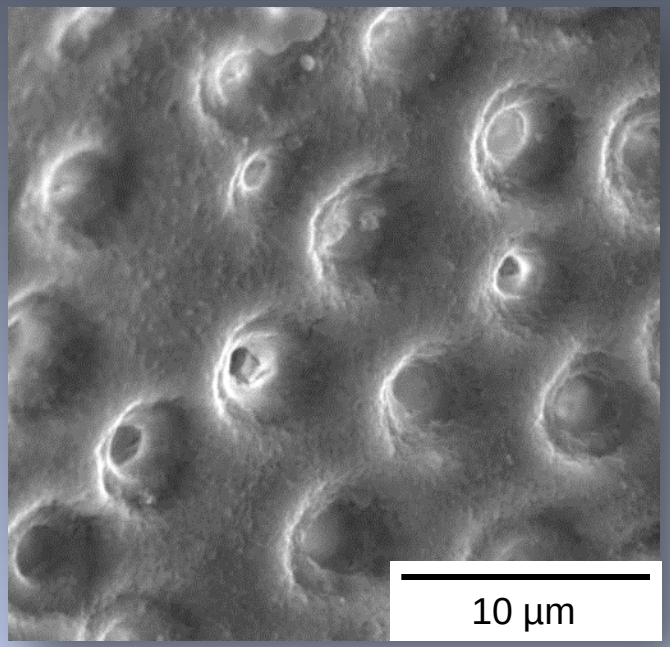
- ubiquitous
- open ocean environments



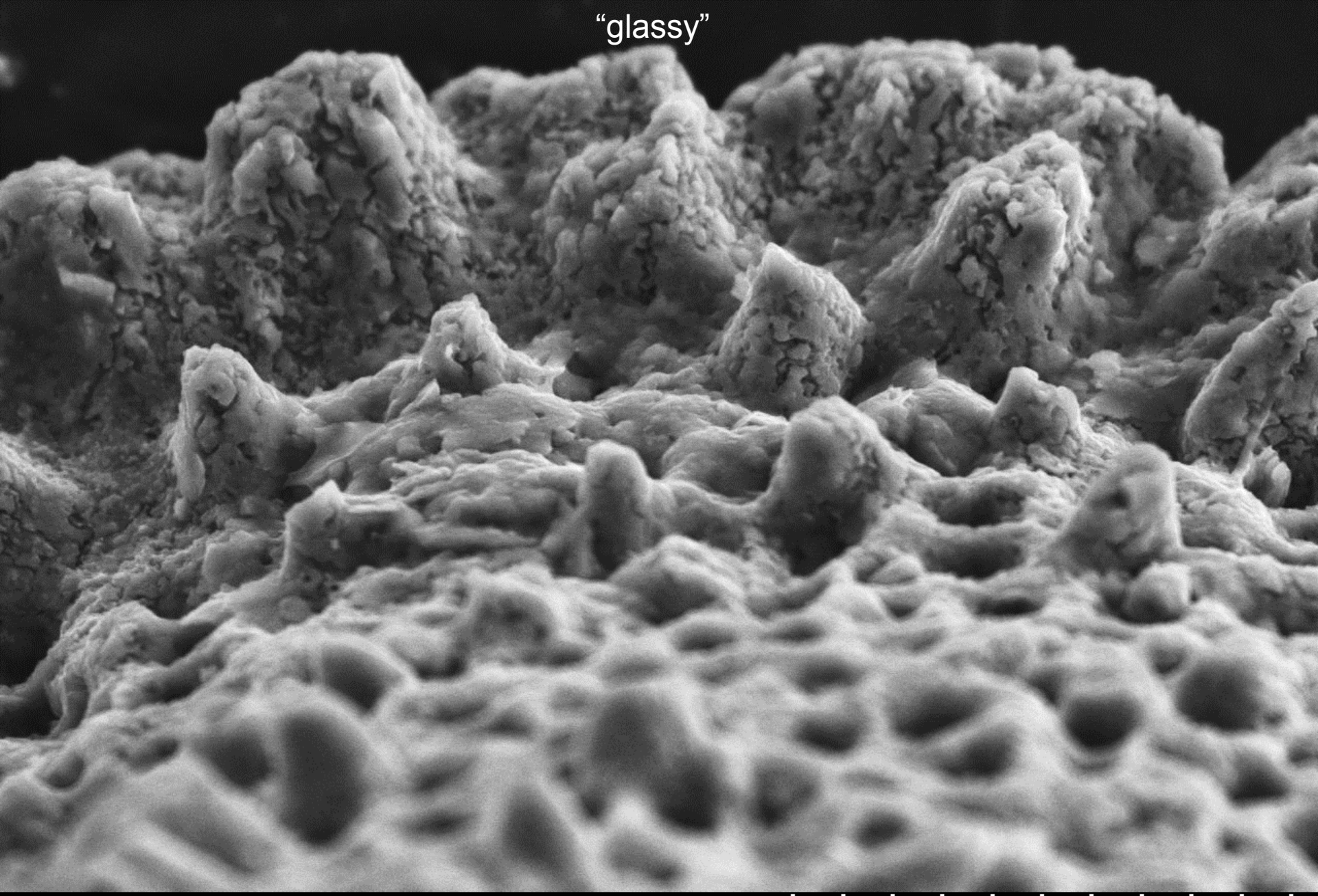
“Glassy” texture

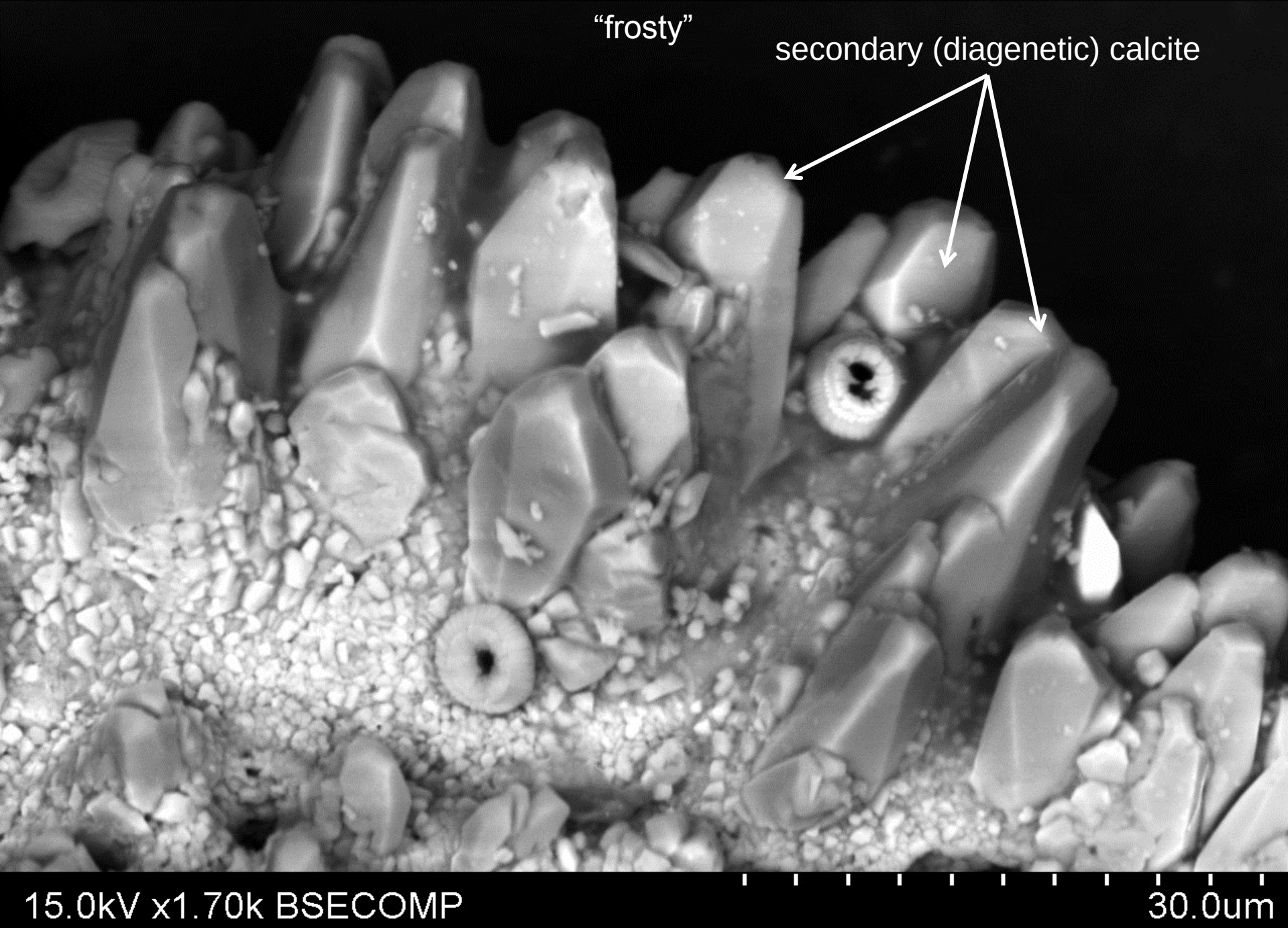


- shielded by clay-rich sediments
- limited number of sample locations (near-shore)

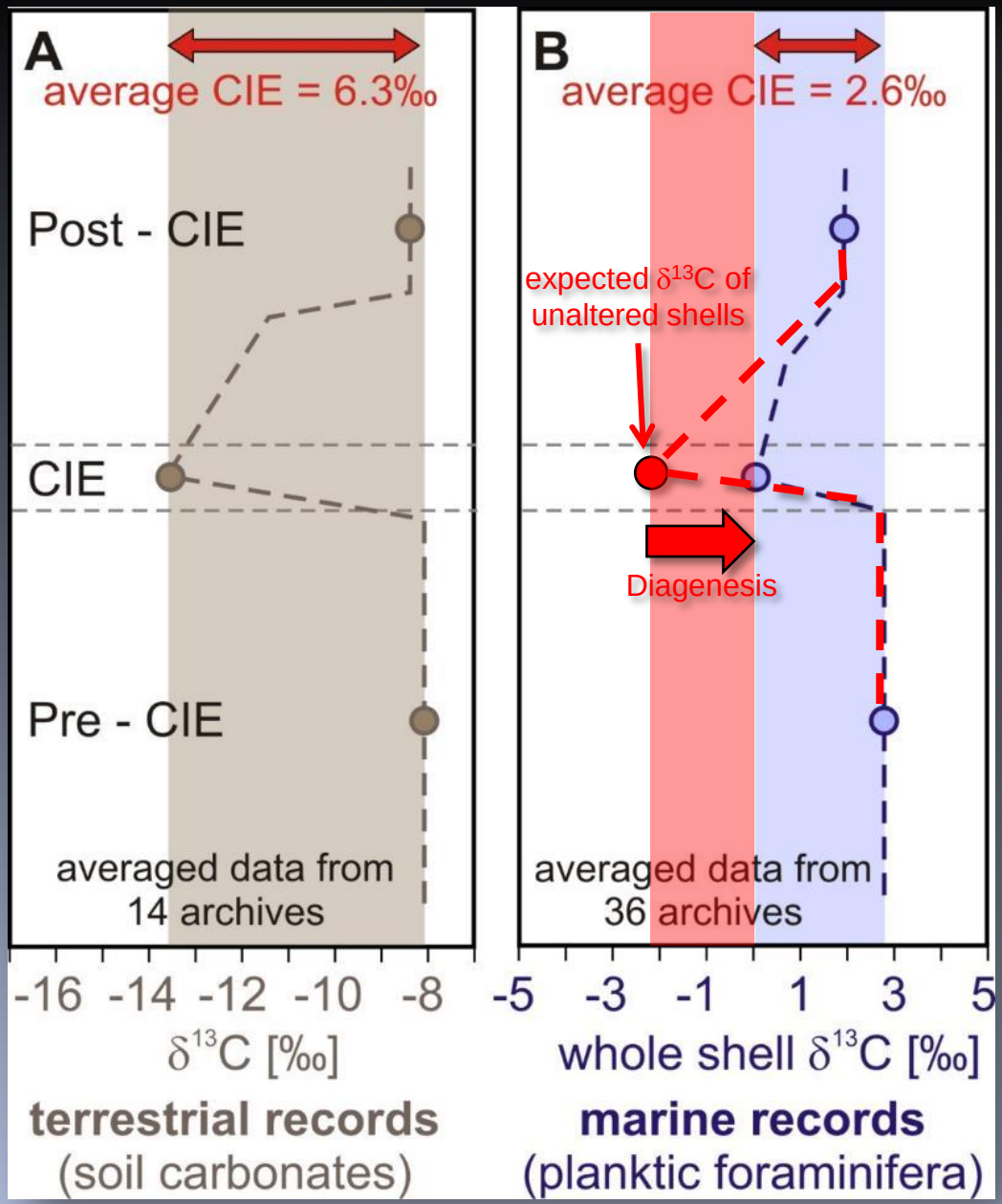


Glassy samples provided by J. Zachos


“glassy”
15.0kV x1.60k SE 5/12/2009
30.0um

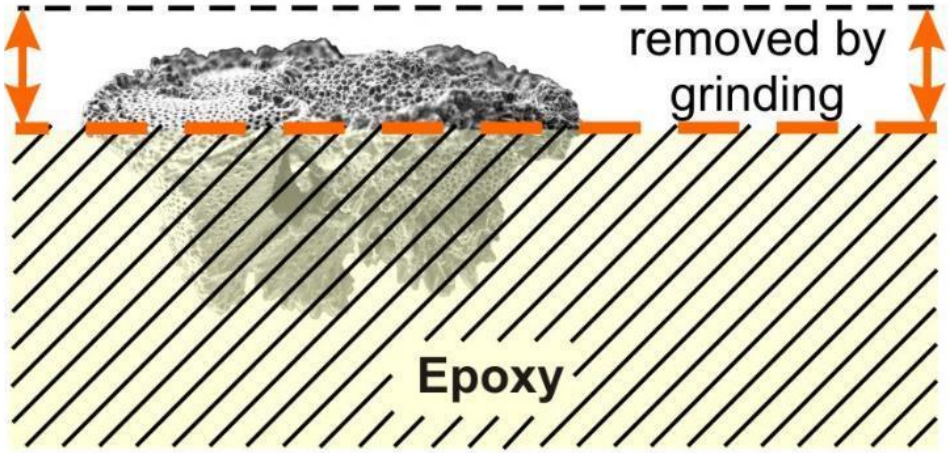

"frosty"
secondary (diagenetic) calcite
15.0kV x1.70k BSECOMP
30.0um

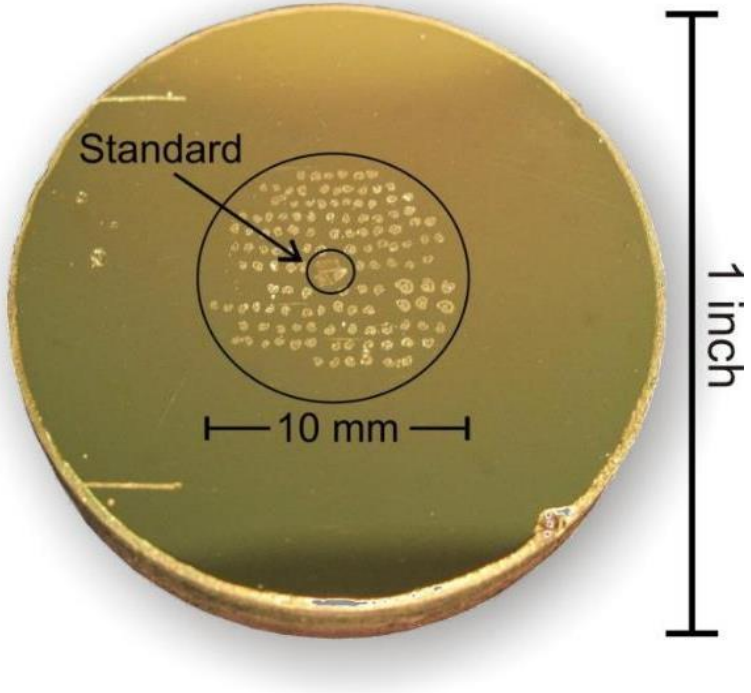
Hypothesis: Diagenetic overprinting causes discrepant CIE magnitudes



Modified from McInerney and Wing, 2011

Sample preparation





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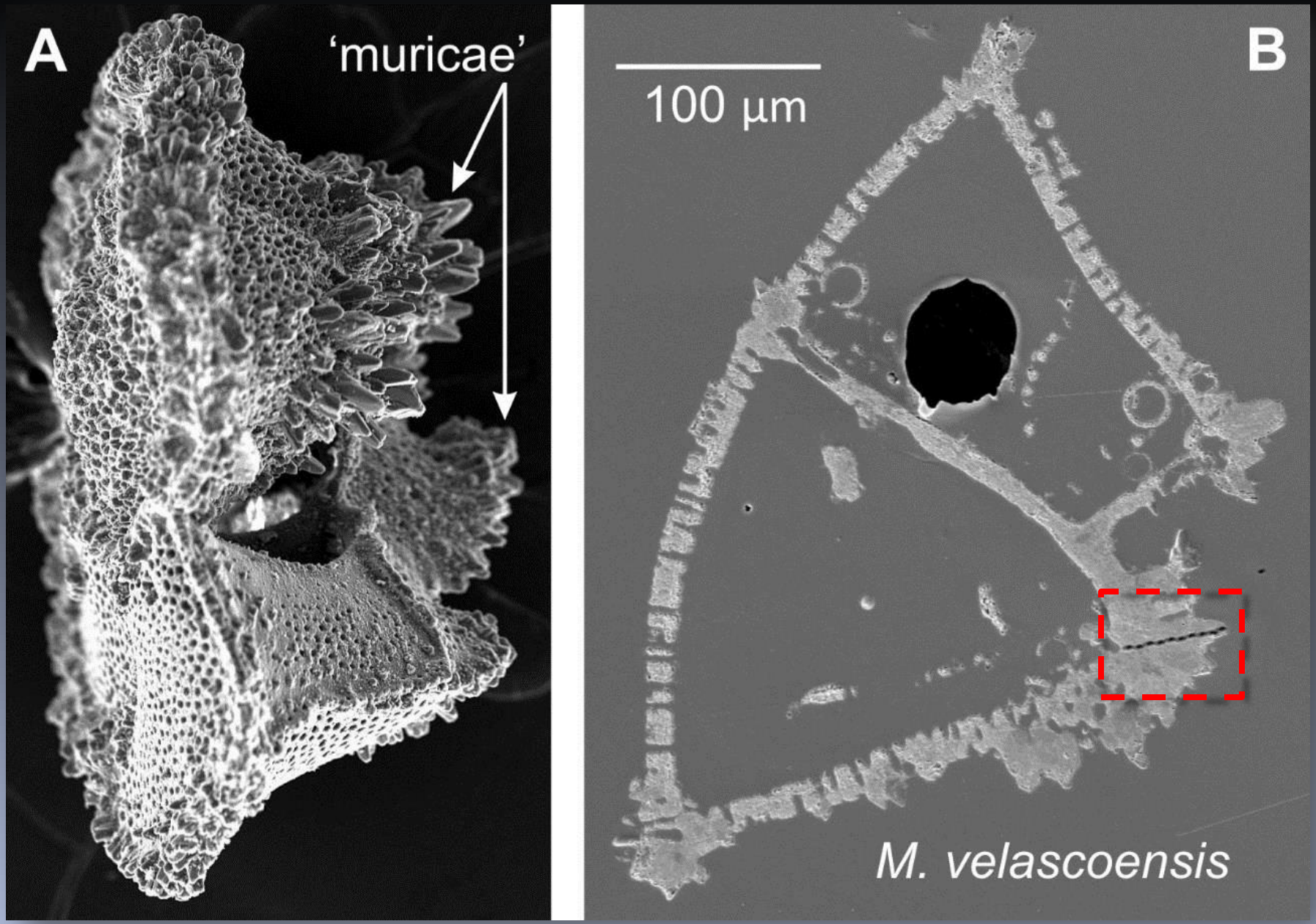
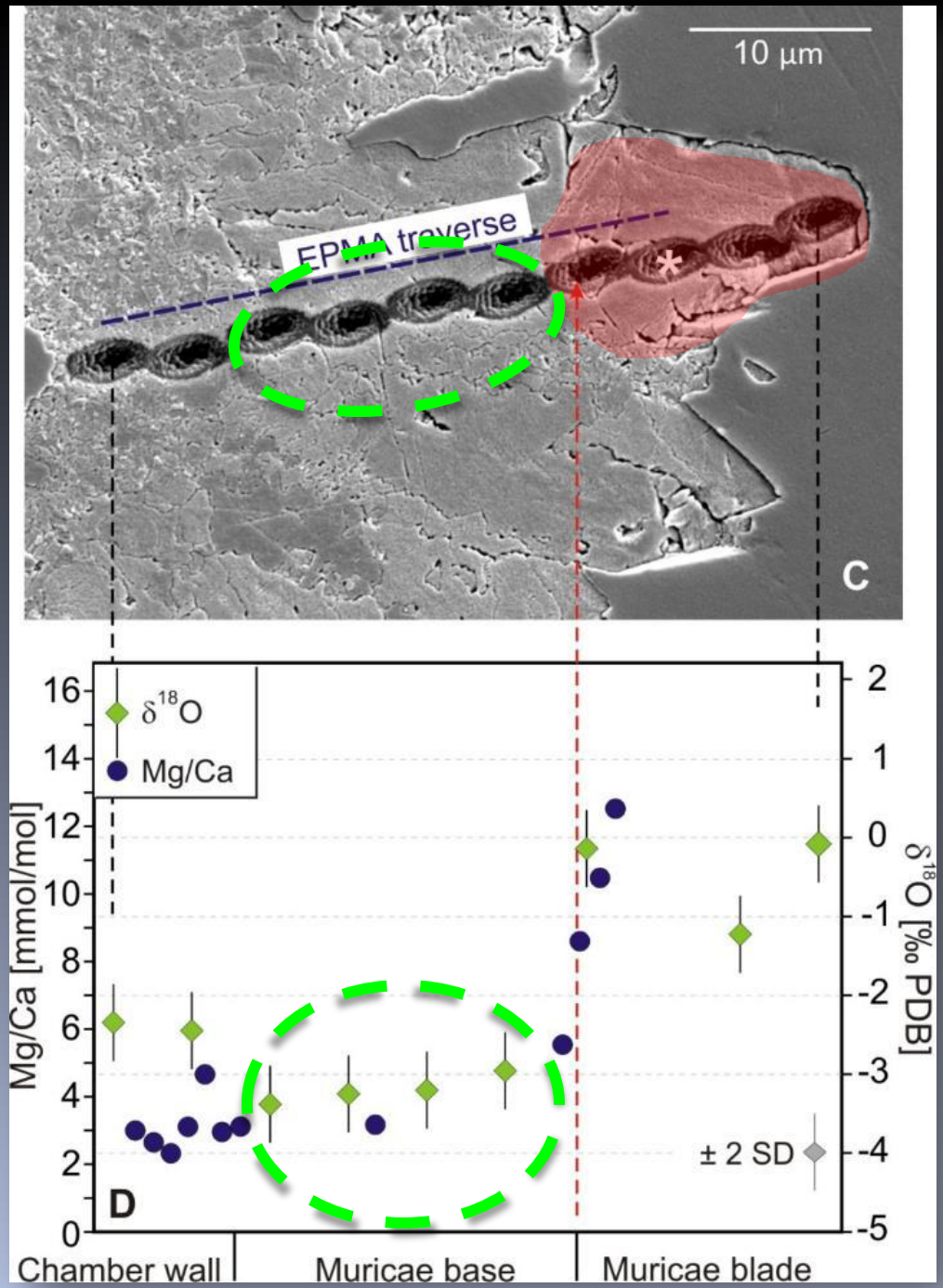
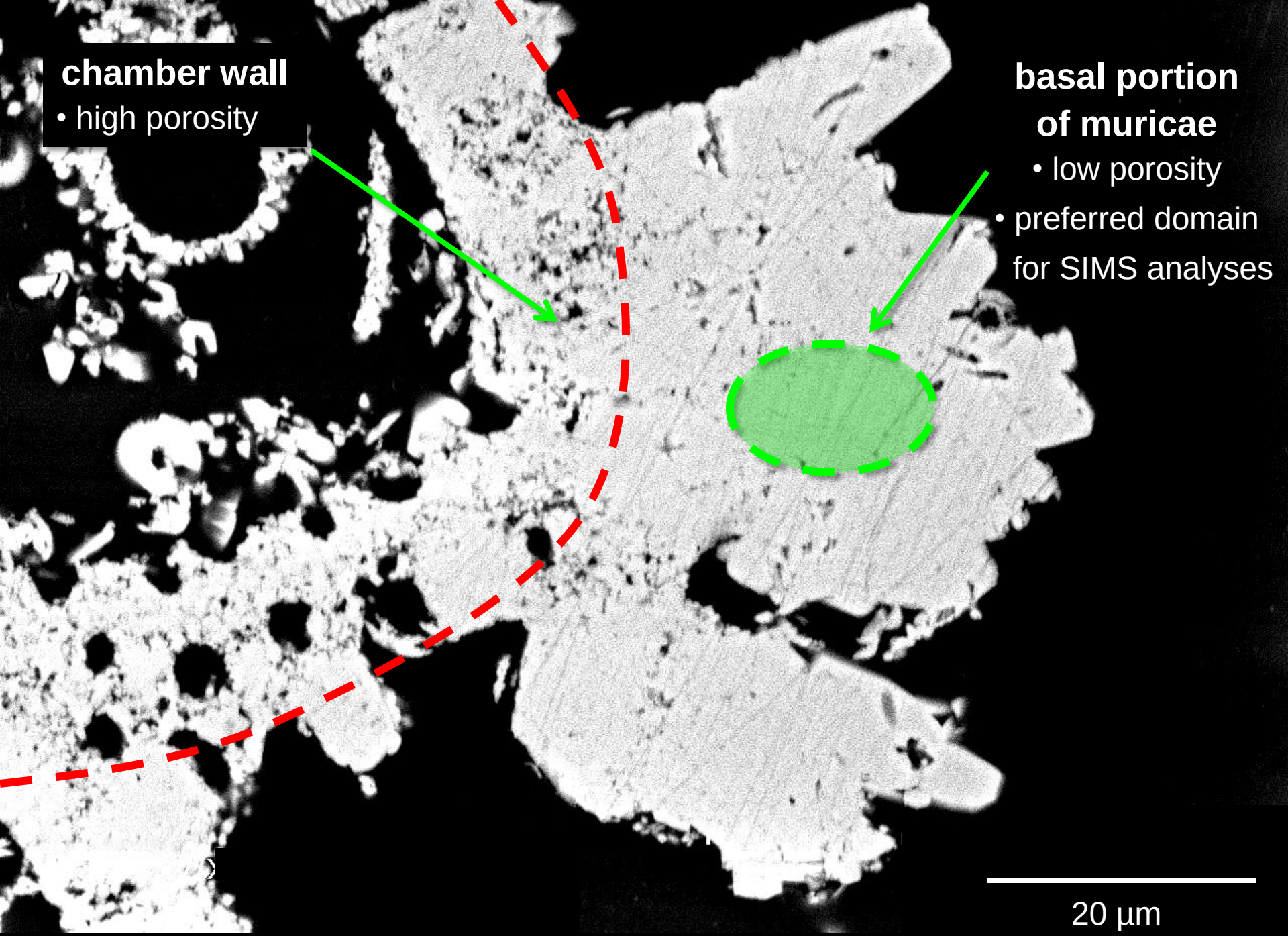
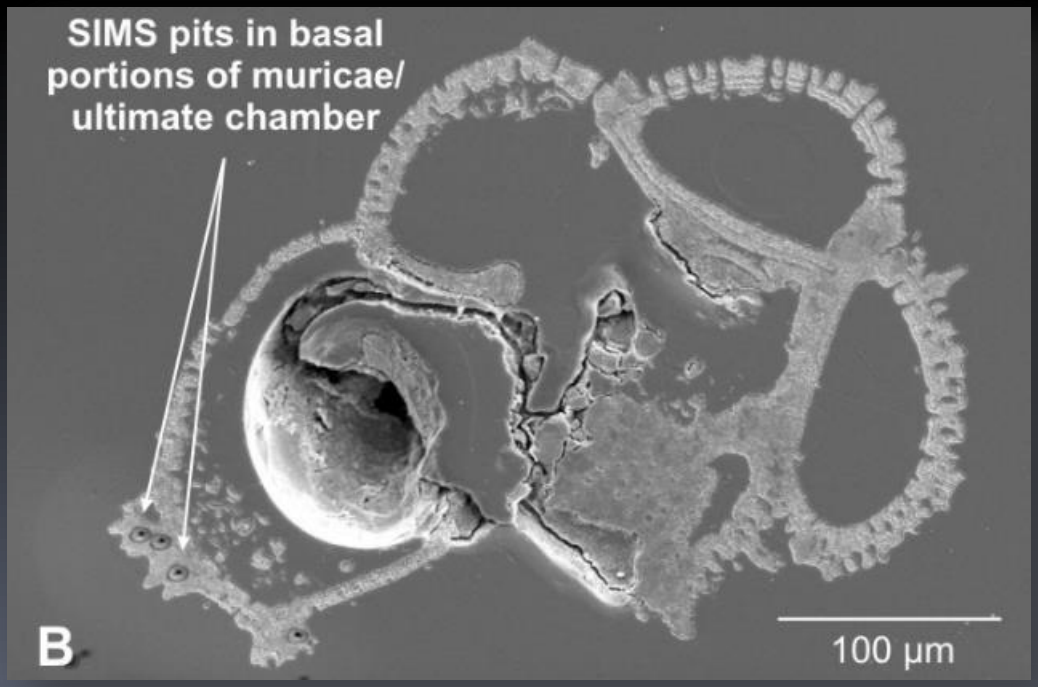
ODP Site 865, PETM

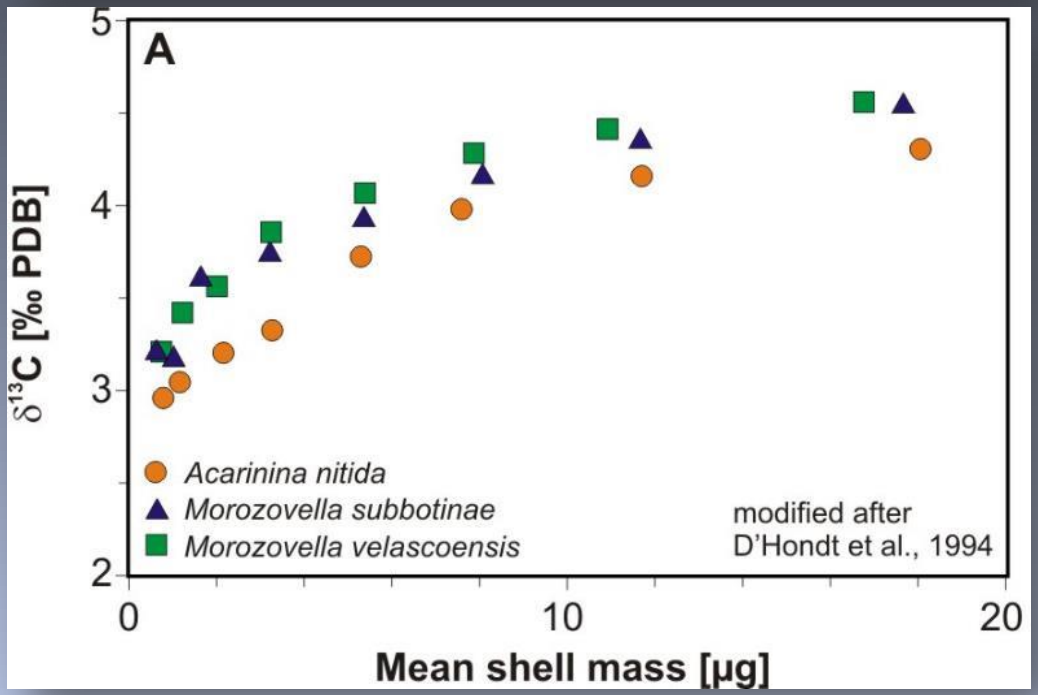


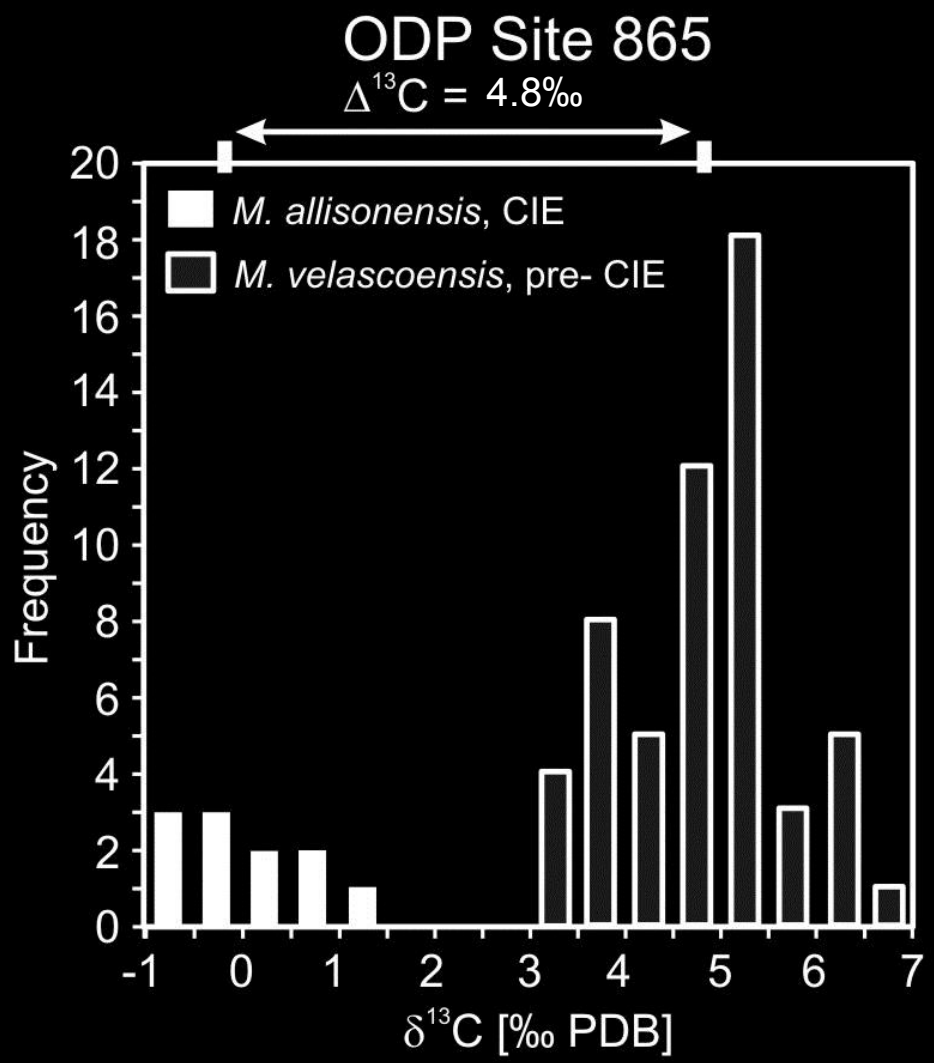
Kozdon et al., submitted

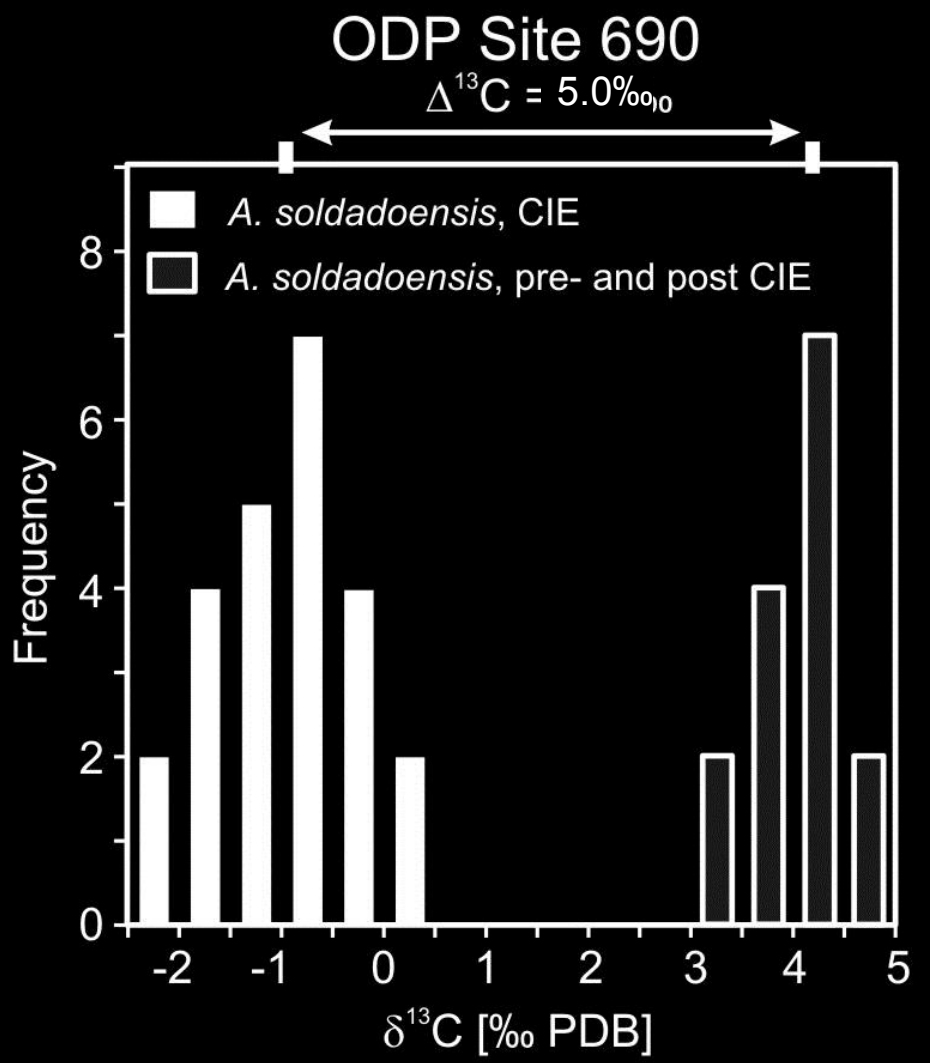

10 µm
EPMA traverse
C
δ18O
Mg/Ca
Mg/Ca [mmol/mol]
δ18O [‰ PDB]
± 2 SD
D
Chamber wall
Muricae base
Muricae blade


chamber wall
• high porosity
basal portion of muricae
• low porosity
• preferred domain for SIMS analyses
20 µm


SIMS pits in basal portions of muricae/ ultimate chamber
B
100 µm

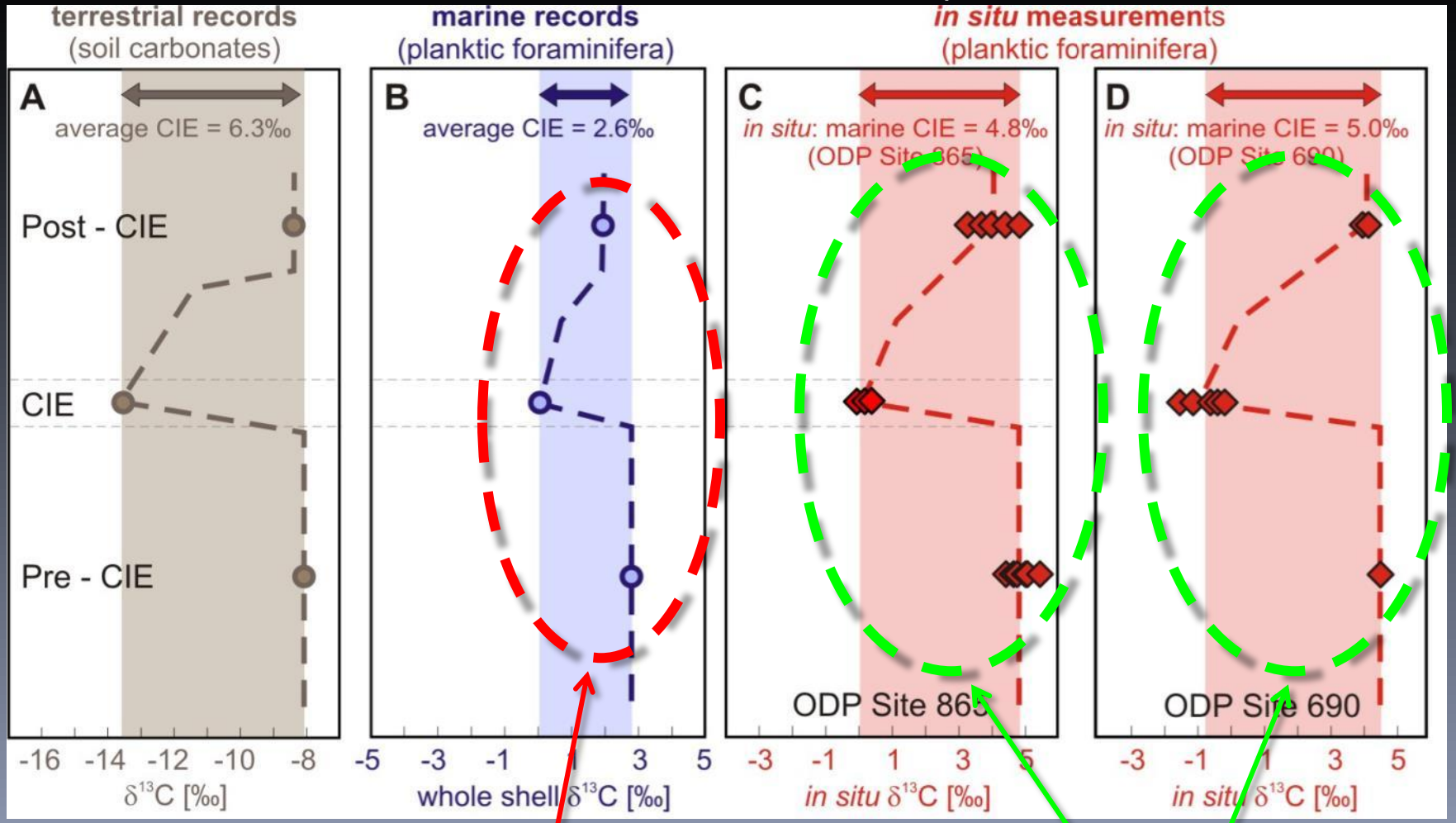

A
δ13C [‰ PDB]
5
4
3
2
0
10
20
Mean shell mass [µg]
Acarinina nitida
Morozovella subbotinae
Morozovella velascoensis
modified after
D'Hondt et al., 1994


ODP Site 865
$\Delta^{13}C$ = 4.8‰
M. allisonensis, CIE
M. velascoensis, pre- CIE
Frequency
$\delta^{13}C$ [‰ PDB]


ODP Site 690
$\Delta^{13}C$ = 5.0‰
A. soldadoensis, CIE
A. soldadoensis, pre- and post CIE
Frequency
$\delta^{13}C$ [‰ PDB]

Site 865, tropics

Site 690, high latitudes



averaged data from 14 archives

averaged data from 36 archives

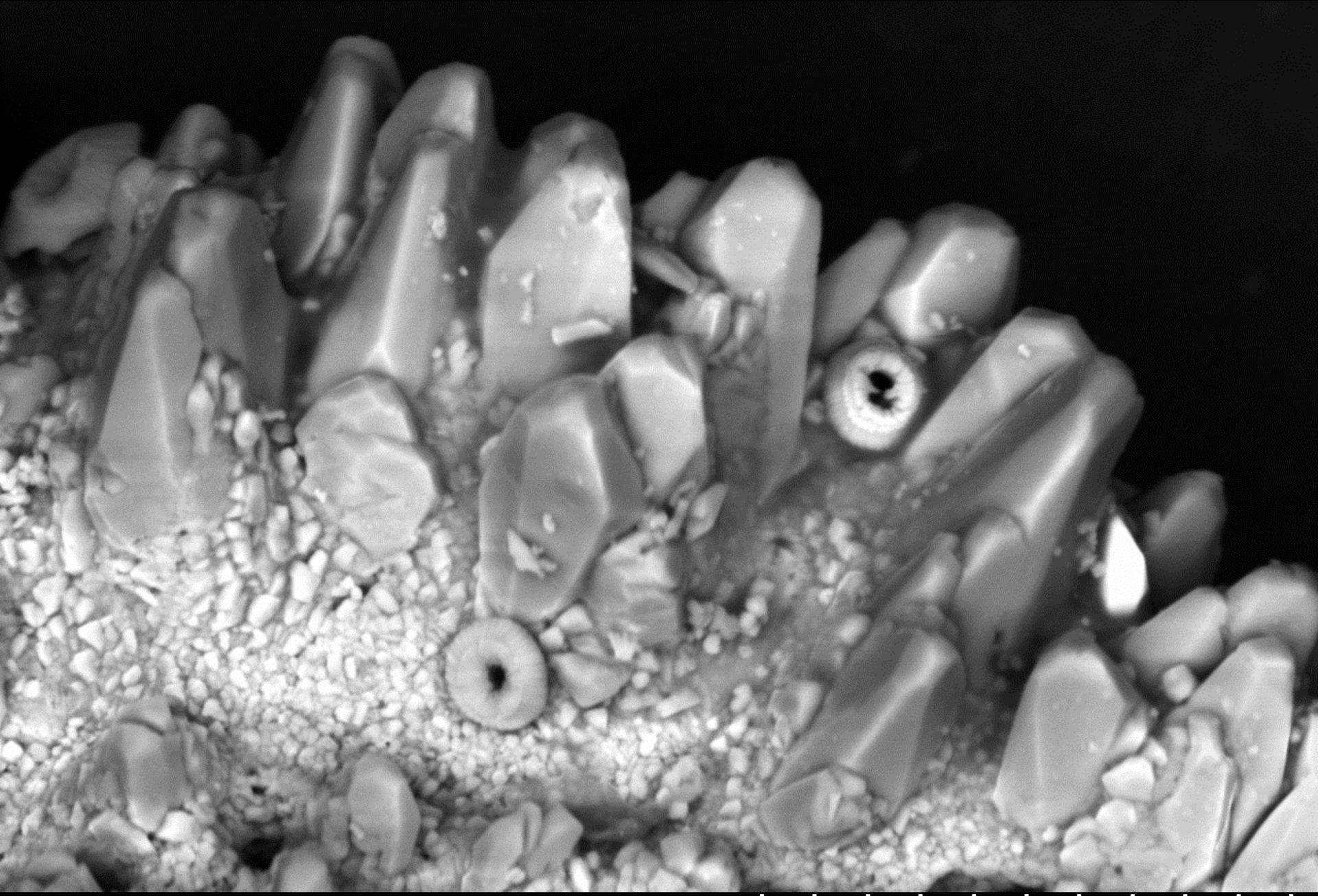
Modified from McInerney and Wing, 2011

"whole-shell analyses", comprises biogenic and diagenetic calcite

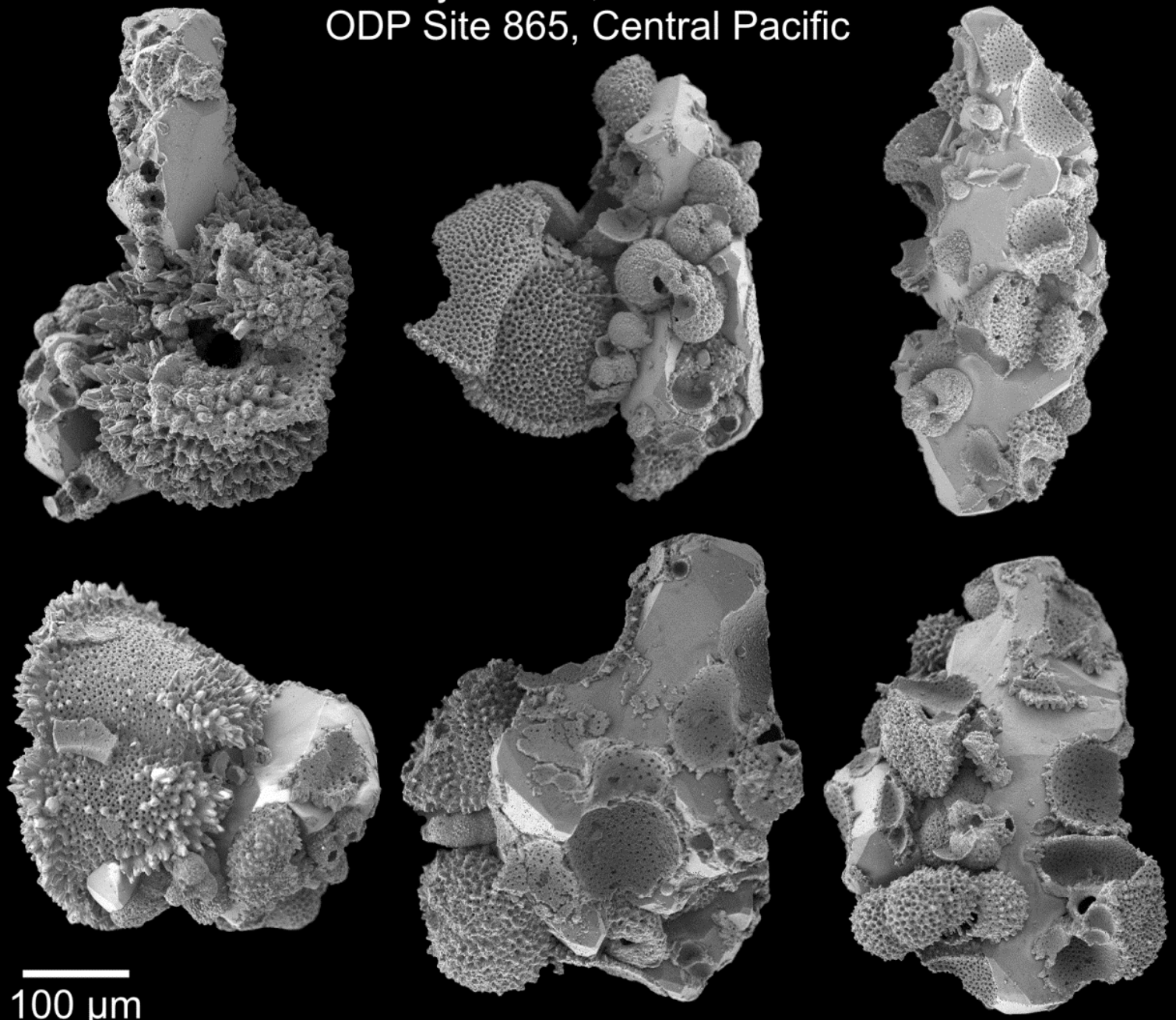
"*in situ*" analyses, placed in preserved biogenic calcite

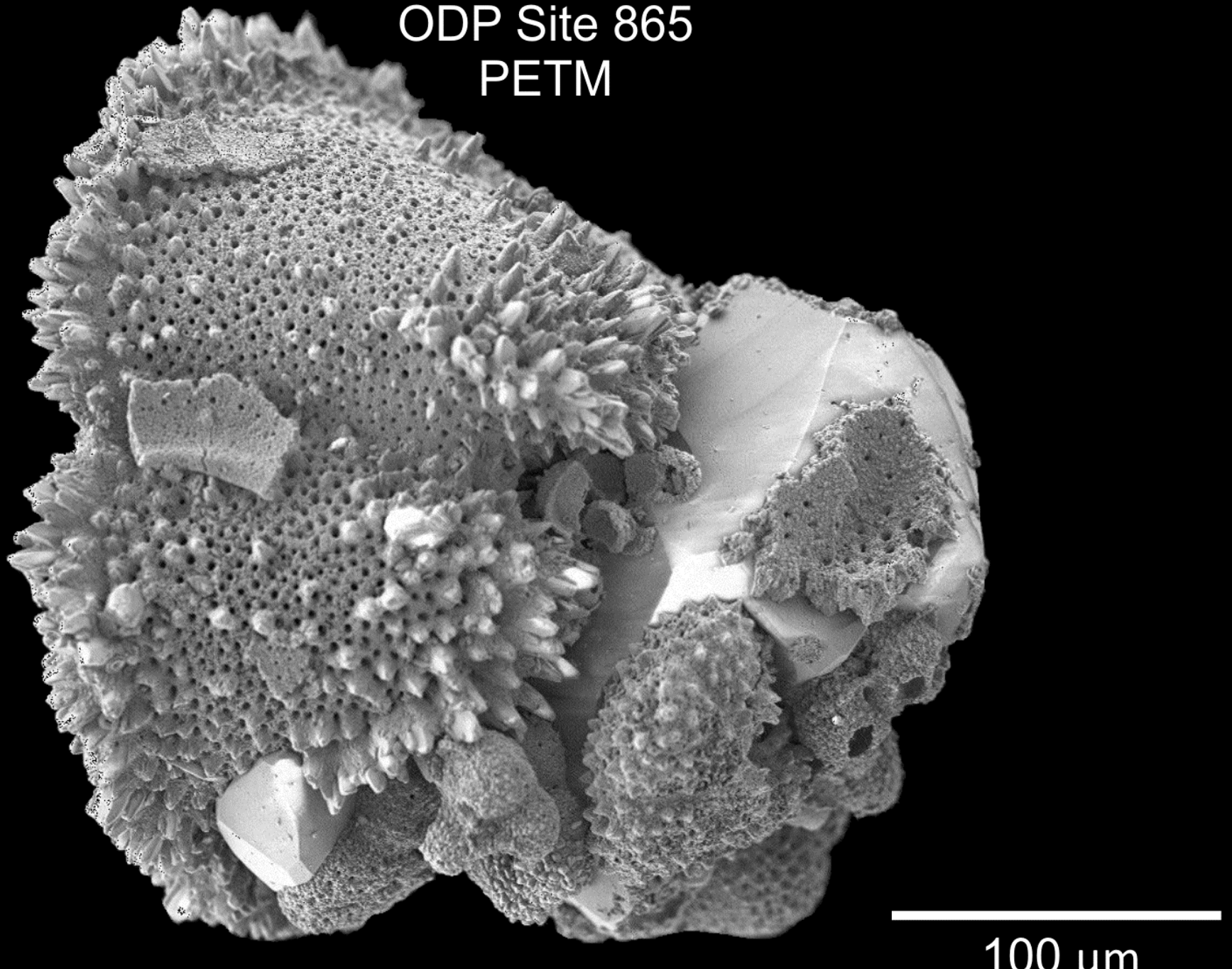
Identification of Diagenesis

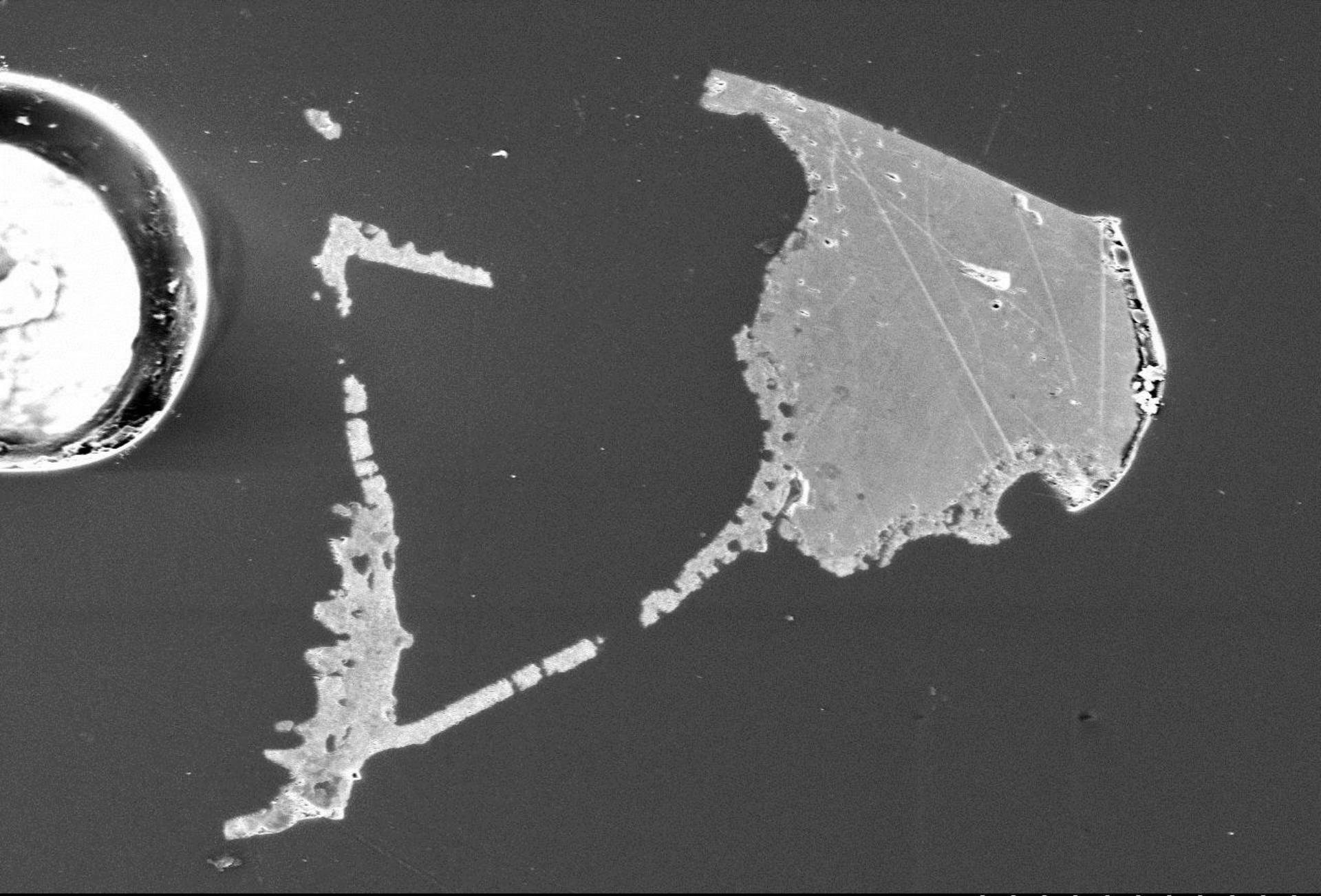
Quantification of Diagenesis

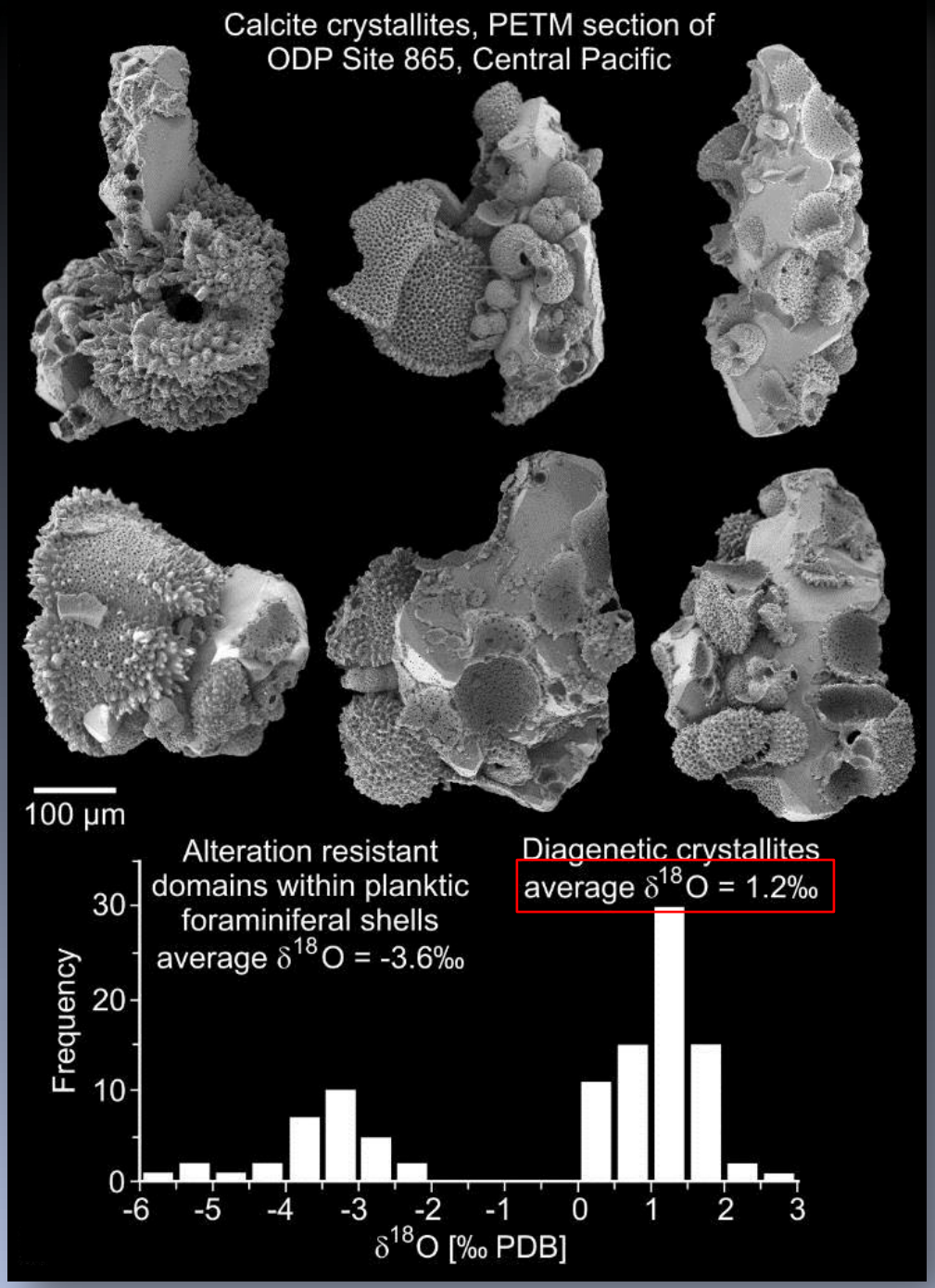

15.0kV x1.70k BSECOMP
30.0um

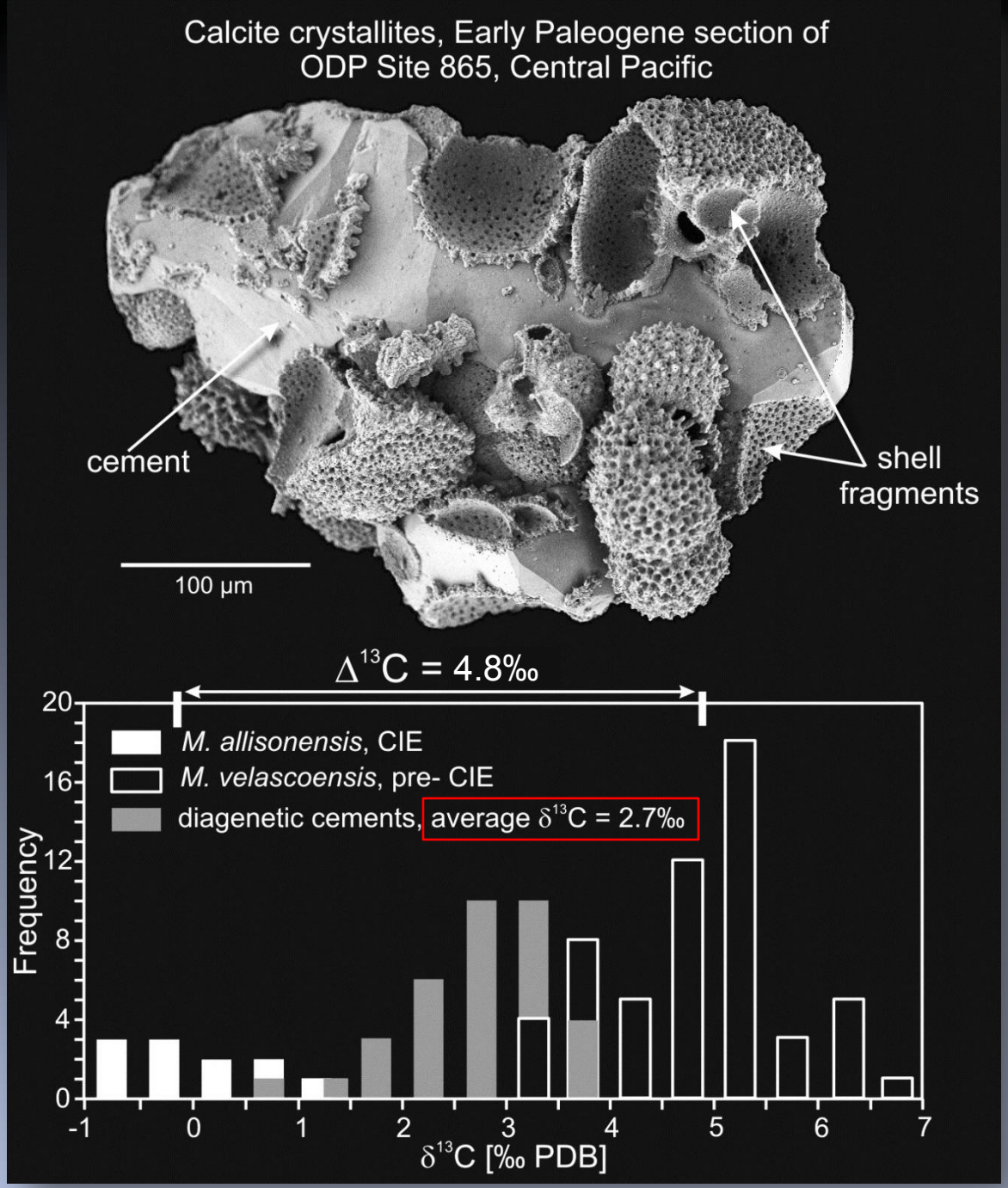
Calcite crystallites, PETM section of ODP Site 865, Central Pacific



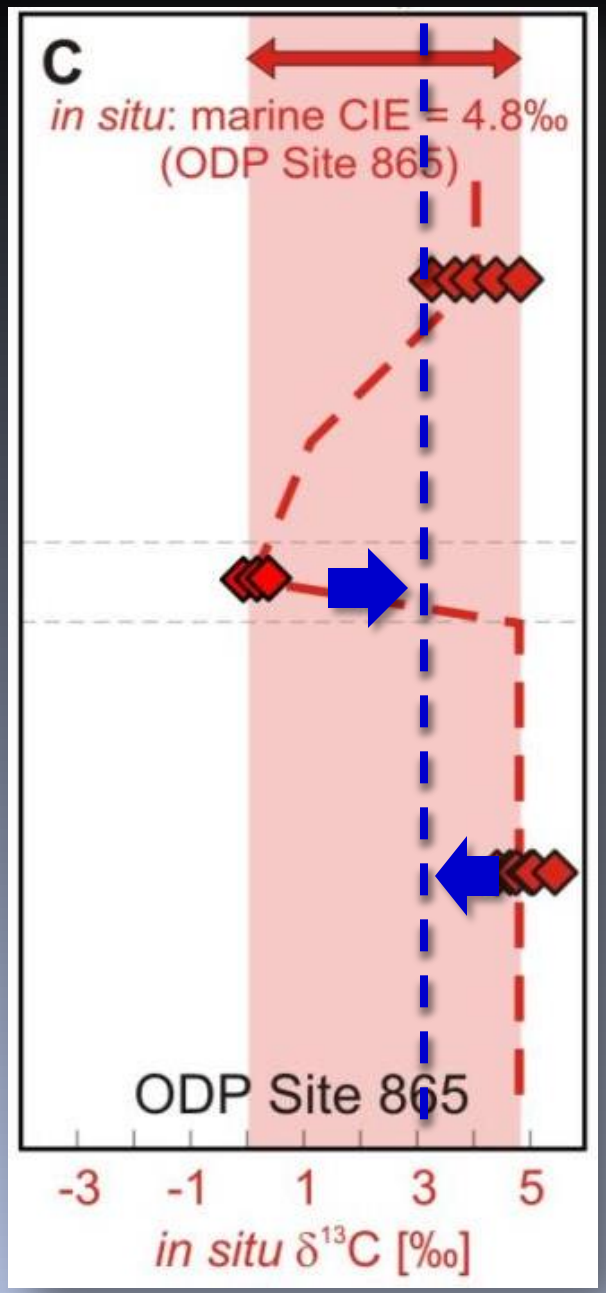

ODP Site 865
PETM
100 µm


15.0kV x300 SE
100um

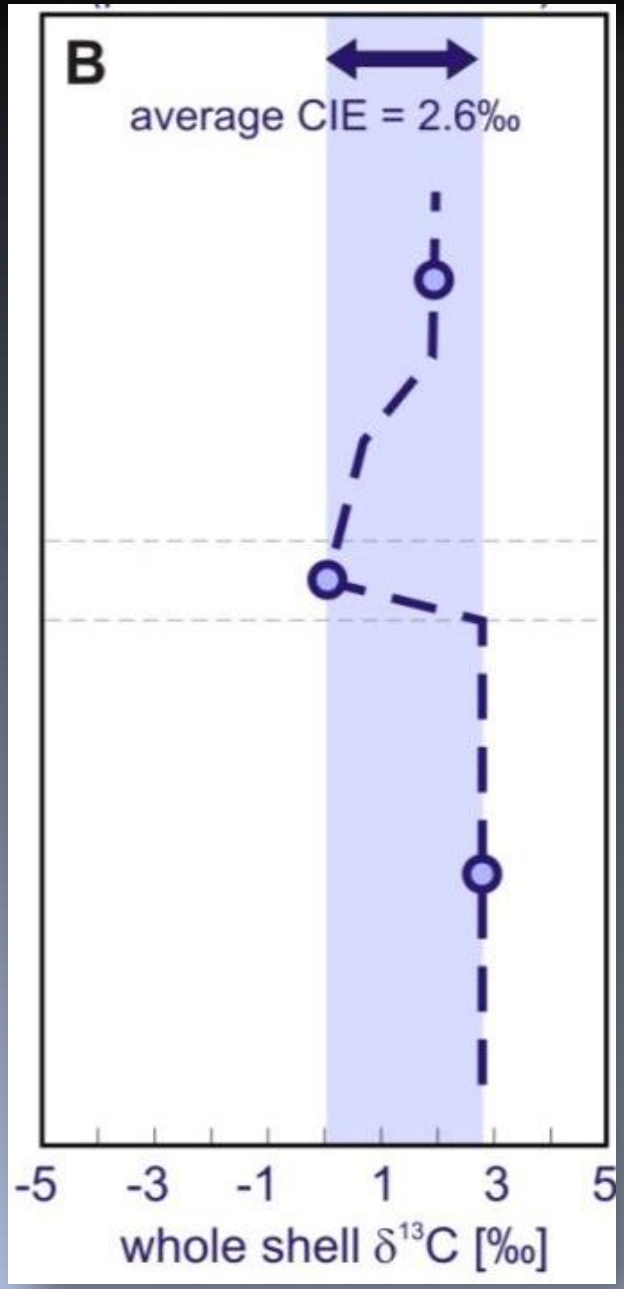

Calcite crystallites, PETM section of
ODP Site 865, Central Pacific
100 µm
Alteration resistant
domains within planktic
foraminiferal shells
average δ18O = -3.6‰
Diagenetic crystallites
average δ18O = 1.2‰
Frequency
30
20
10
0
-6
-5
-4
-3
-2
-1
0
1
2
3
δ18O [‰ PDB]

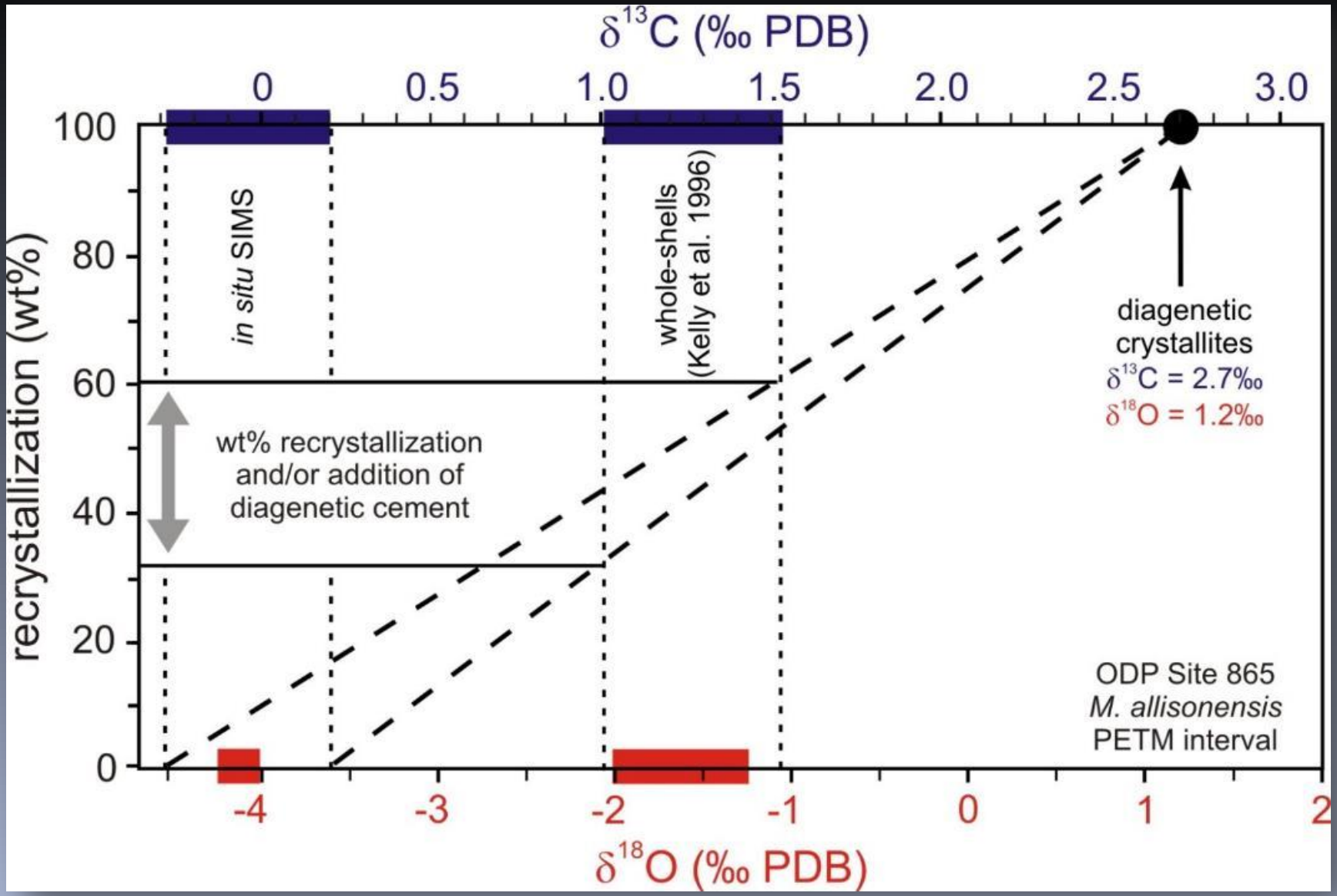

Calcite crystallites, Early Paleogene section of
ODP Site 865, Central Pacific
cement
shell
fragments
100 µm
Δ13C = 4.8‰
M. allisonensis, CIE
M. velascoensis, pre- CIE
diagenetic cements, average δ13C = 2.7‰
Frequency
δ13C [‰ PDB]

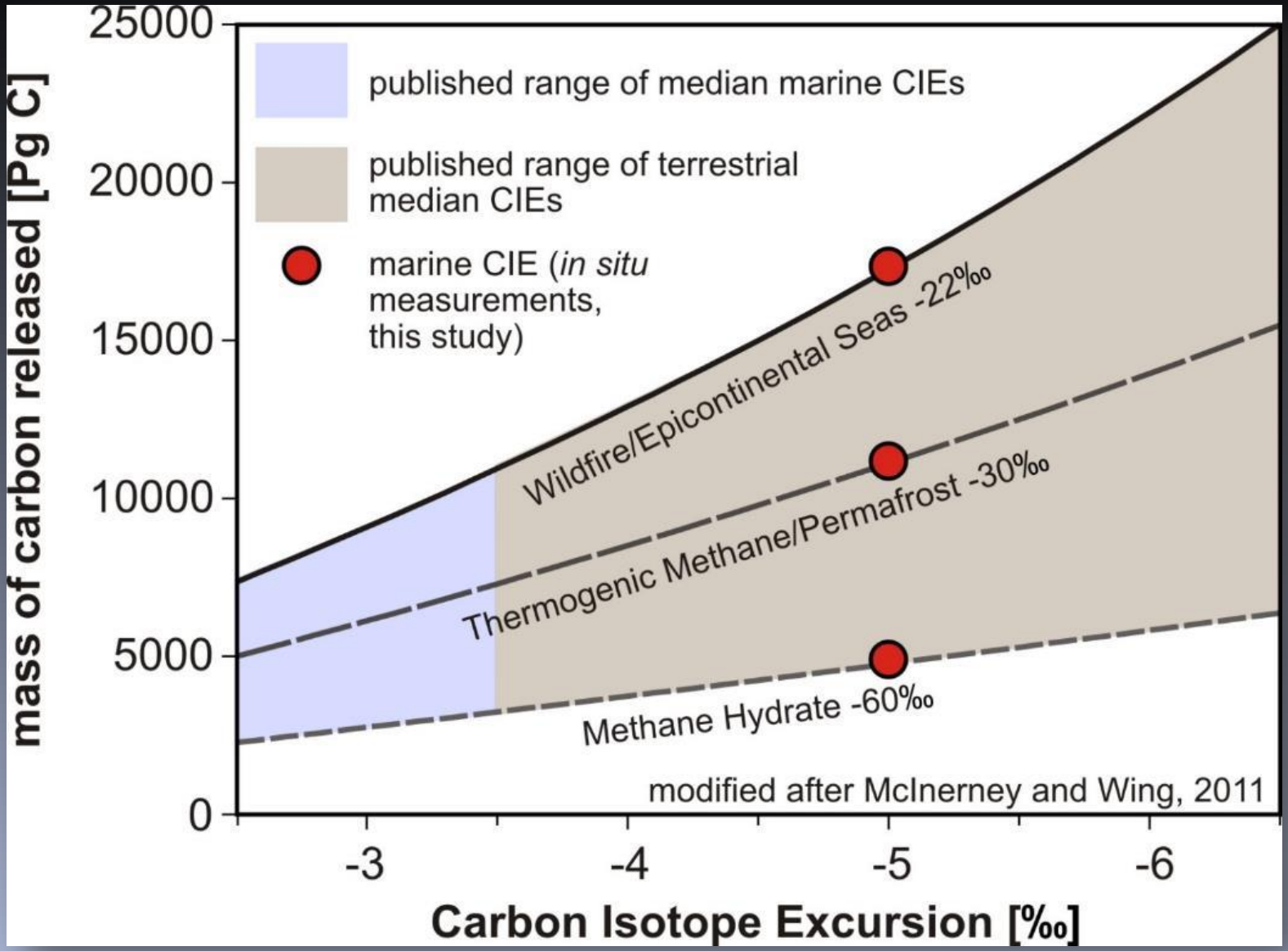
in situ $\delta^{13}C$



whole-shell measurements




δ13C (‰ PDB)
0
0.5
1.0
1.5
2.0
2.5
3.0
100
80
60
40
20
0
recrystallization (wt%)
in situ SIMS
whole-shells
(Kelly et al. 1996)
diagenetic
crystallites
δ13C = 2.7‰
δ18O = 1.2‰
wt% recrystallization
and/or addition of
diagenetic cement
ODP Site 865
M. allisonensis
PETM interval
-4
-3
-2
-1
0
1
2
δ18O (‰ PDB)


mass of carbon released [Pg C]
25000
20000
15000
10000
5000
0
published range of median marine CIEs
published range of terrestrial median CIEs
marine CIE (in situ measurements, this study)
Wildfire/Epicontinental Seas -22‰
Thermogenic Methane/Permafrost -30‰
Methane Hydrate -60‰
modified after McInerney and Wing, 2011
-3
-4
-5
-6
Carbon Isotope Excursion [‰]

Conclusions

- diagenesis in planktic foraminiferal shells attenuates the magnitude of the CIE
- a CIE of ~5‰ is preserved in biogenic domains of foraminiferal shells from both ODP Sites 865 and 690; these new data are highly congruous with the terrestrial record
- diagenetic cements from the PETM section of Site 865 have a mean $\delta^{13}C$ value of 2.7‰, pre-CIE biogenic calcite has a mean $\delta^{13}C$ of 4.7‰, and CIE biogenic calcite yielded a mean $\delta^{13}C$ value of 0.0‰
- mass balance estimates show that 30 - 60 wt.% of the shells investigated in this study is secondary diagenetic calcite
- a CIE magnitude of ~5‰ corresponds to the release of ~5000 Pg C (if methane with a $\delta^{13}C$ = -60‰ is the main source)