Carbon isotopic compositions in culture brachiopod shells: what can we learn from them?

Claire Rollion-Bard

Hana Jurikova

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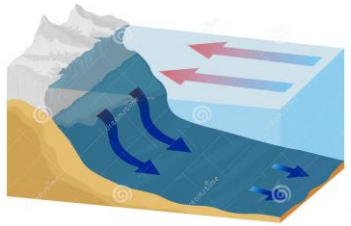
$$\delta^{13}C = \left(\frac{{}^{13}C / {}^{12}C_{sample}}{{}^{13}C / {}^{12}C_{std}} - 1 \right) \times 1000$$

$CaCO_3$

Mg/Ca
Sr/Ca
etc.



$\delta^{13}C$

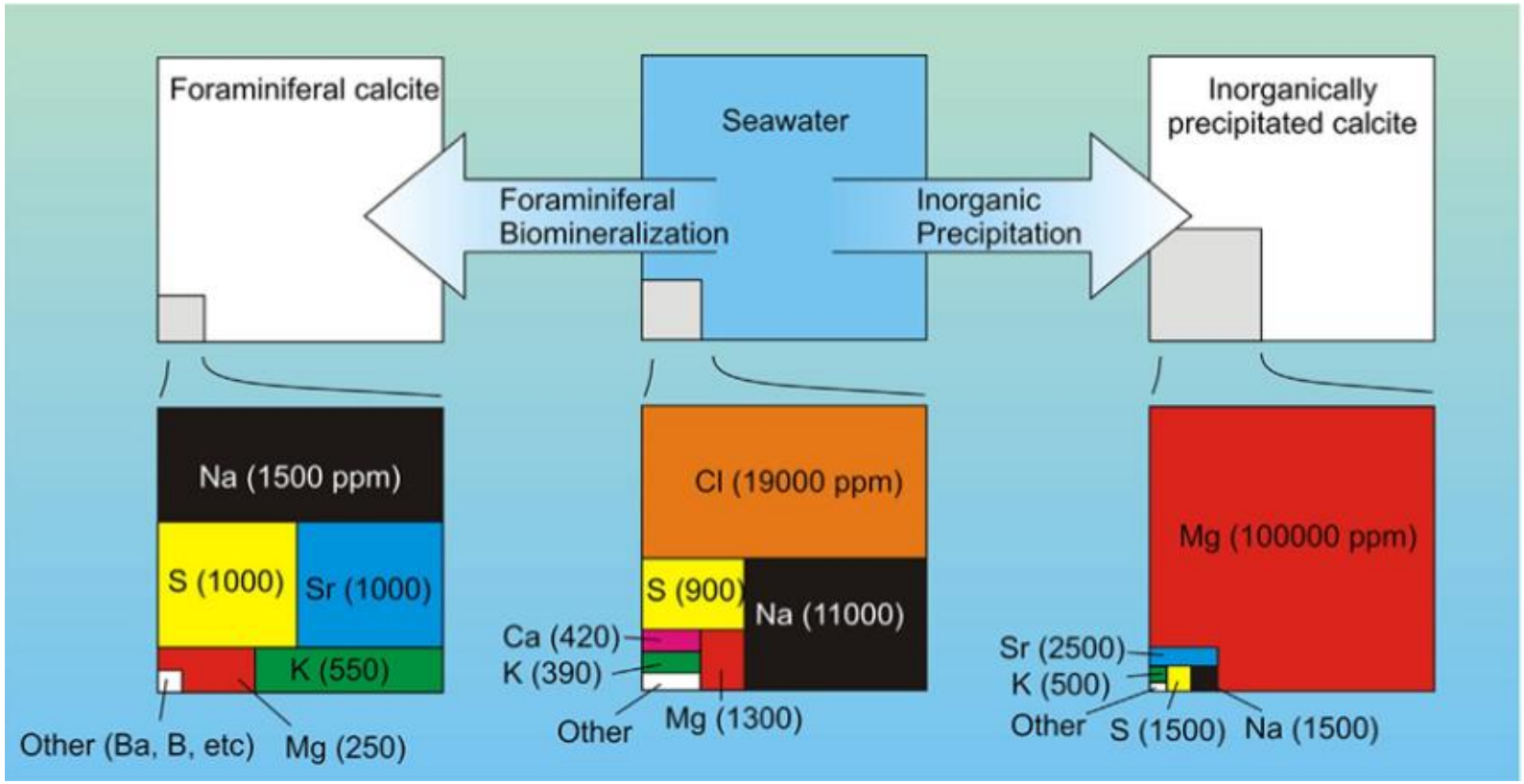
$\delta^{11}B$, $\delta^{7}Li$

$\delta^{18}O$

=> Record of various parameters (Temp., pH, salinity, elemental concentrations…) but some vital effects are present

Vital effect: modification of the record of environmental proxies by biological processes

Ex. foraminifera



De Nooijer et al (2014)

Vital effect: modification of the record of environmental proxies by biological processes

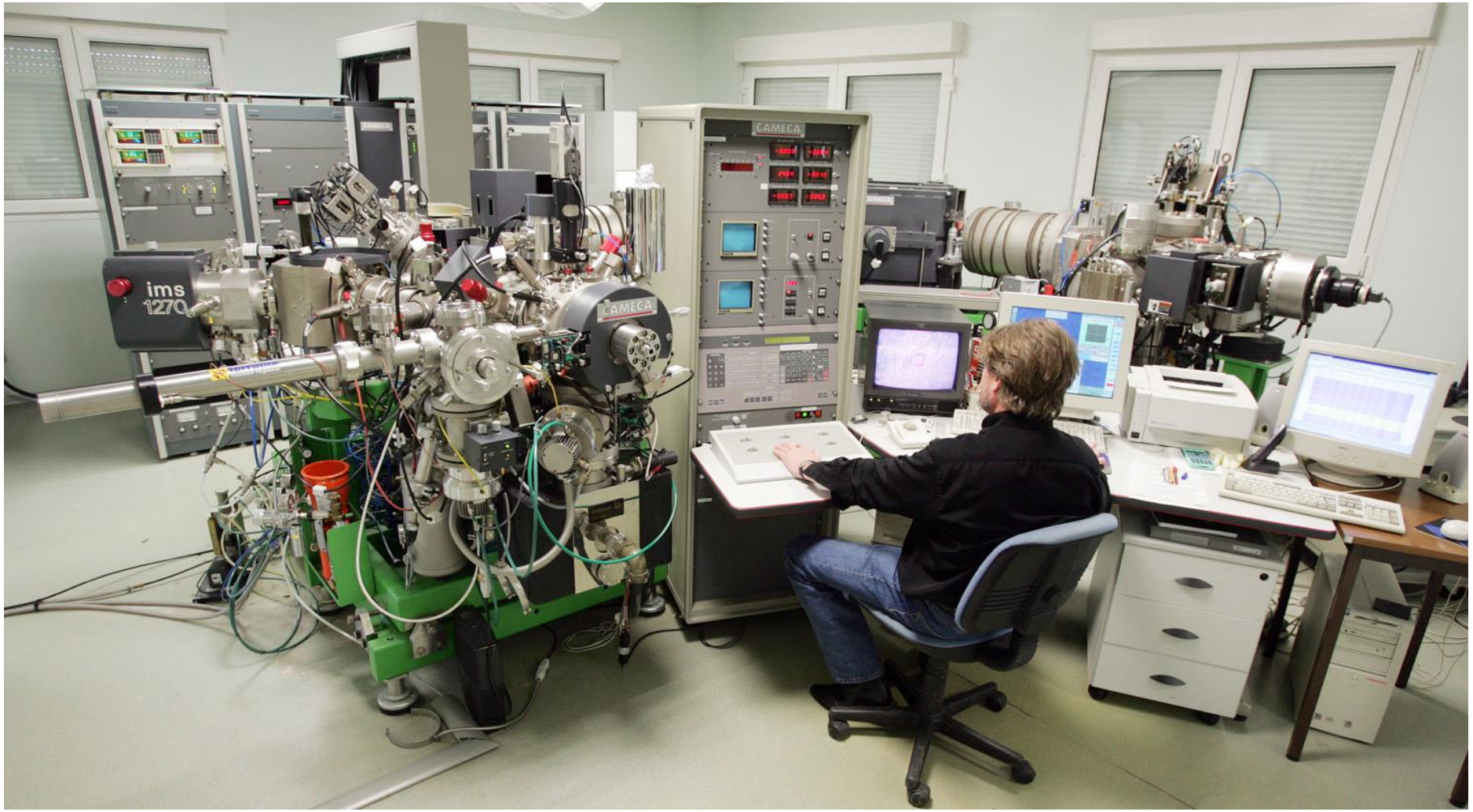
$\Rightarrow$ Difficulties for paleoclimatological reconstructions
(eg: which calibration for extinct species? Vital effect constant?)

What are the processes responsible of this vital effect?

=> Study of the biomineralisation processes via geochemical signature

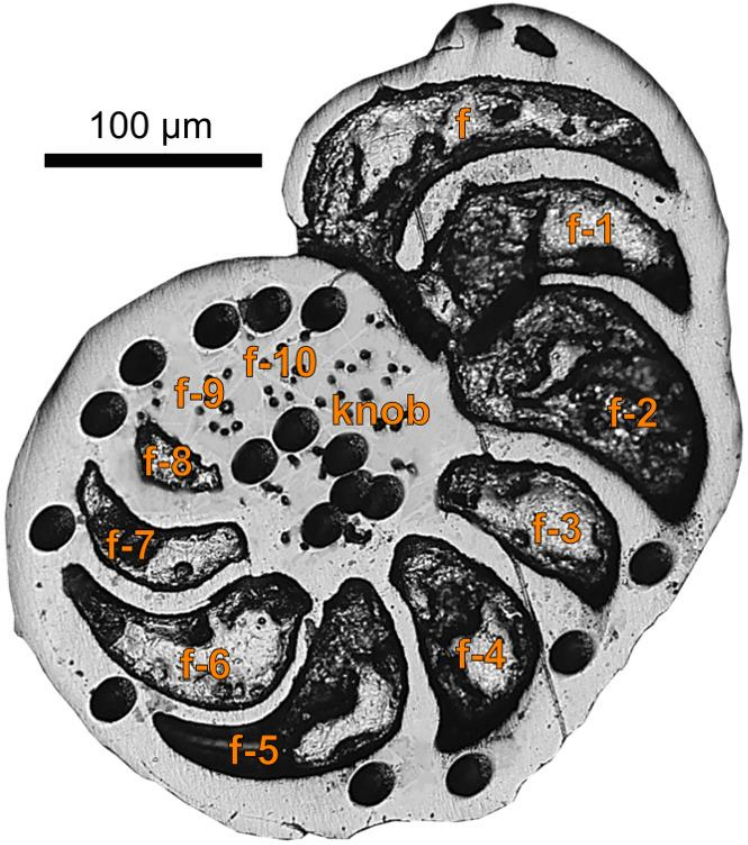
Use of in situ techniques (SIMS, laser ablation)

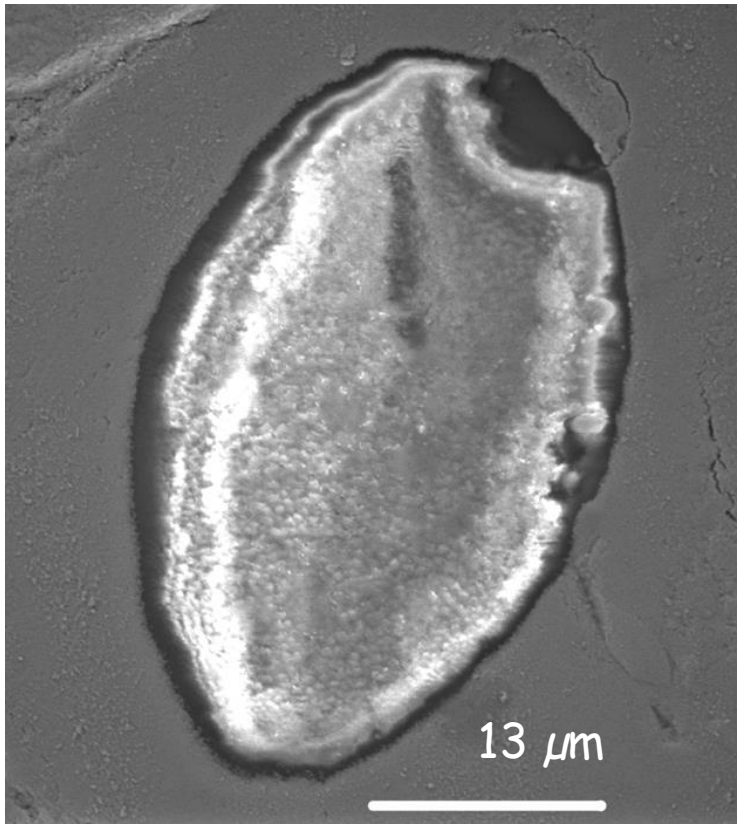
Ion microprobe (SIMS – Secondary Ion Mass Spectrometry)



Ims 1270 in CRPG, Nancy, France

Cibicidoides wuellerstorfi

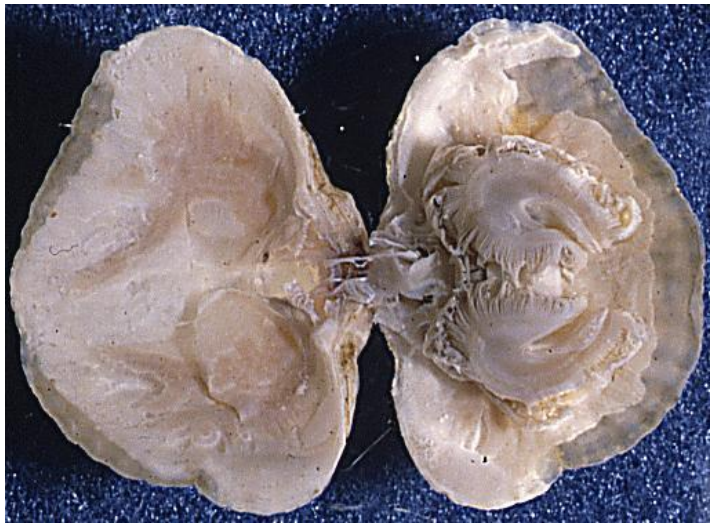


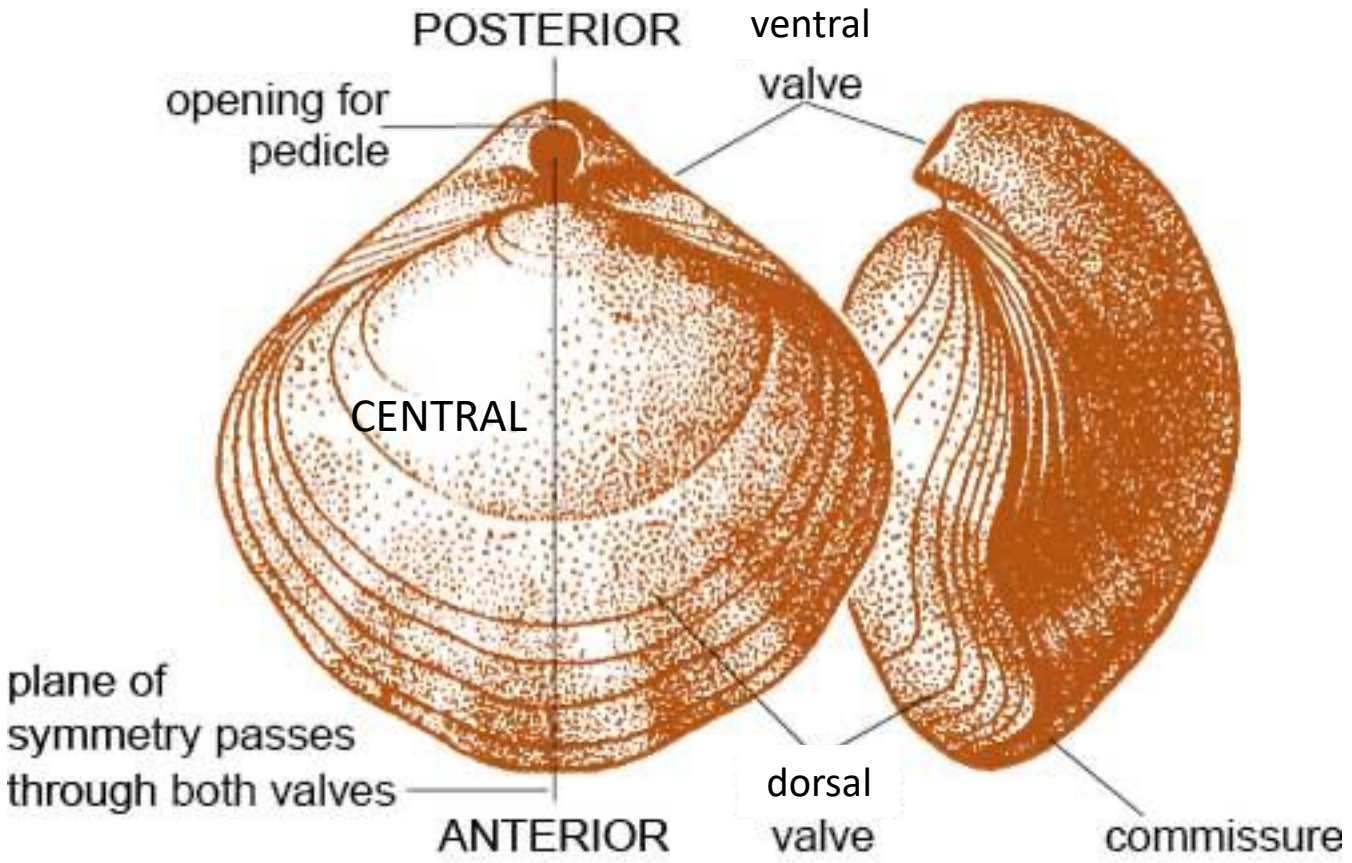


Raitzsch et al (2020)

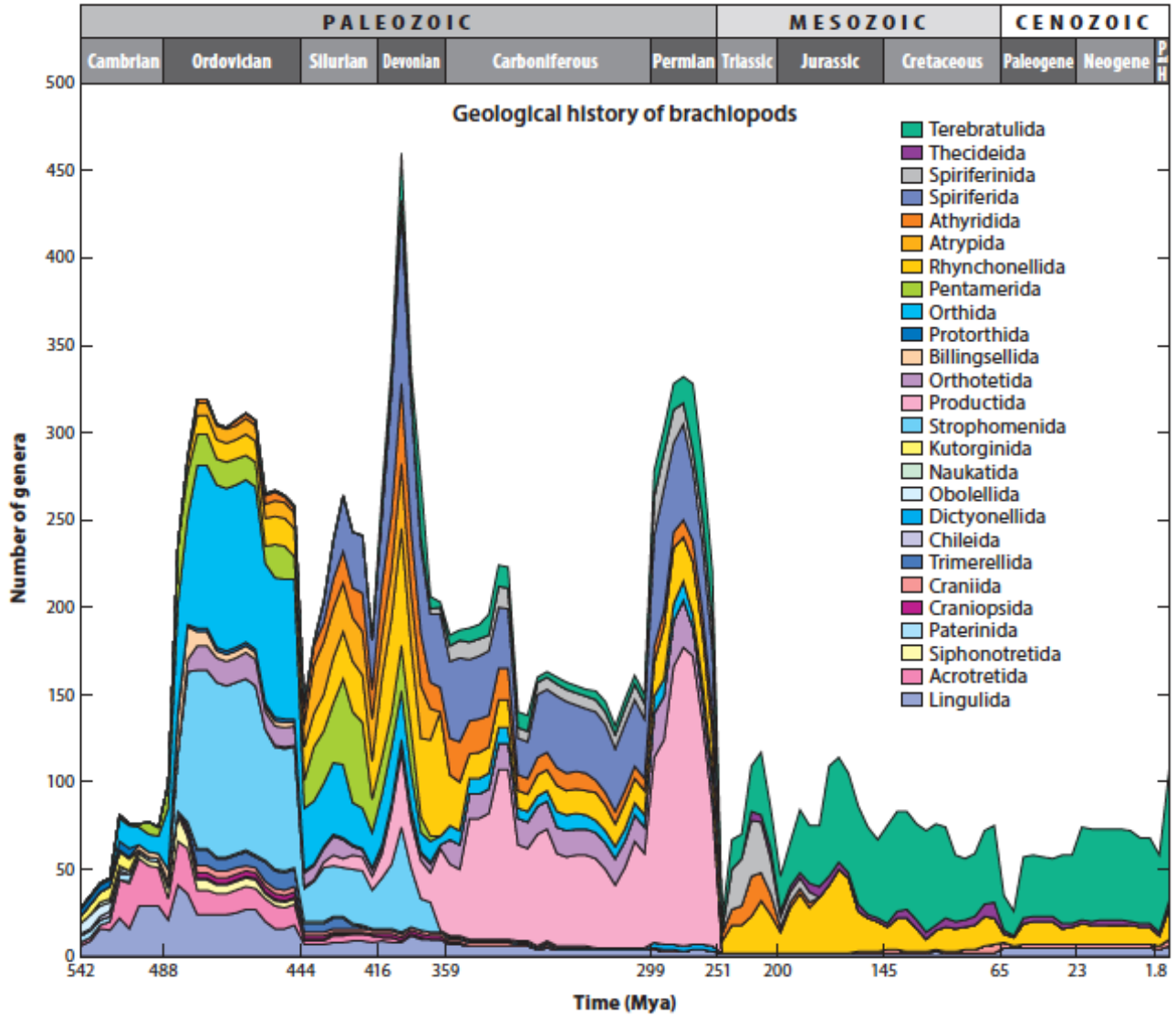
BRACHIOPODS

- They have 2 valves that totally enclose the soft parts.
- The average size is 20 - 70 mm but can range up to 370 mm (extinct species).



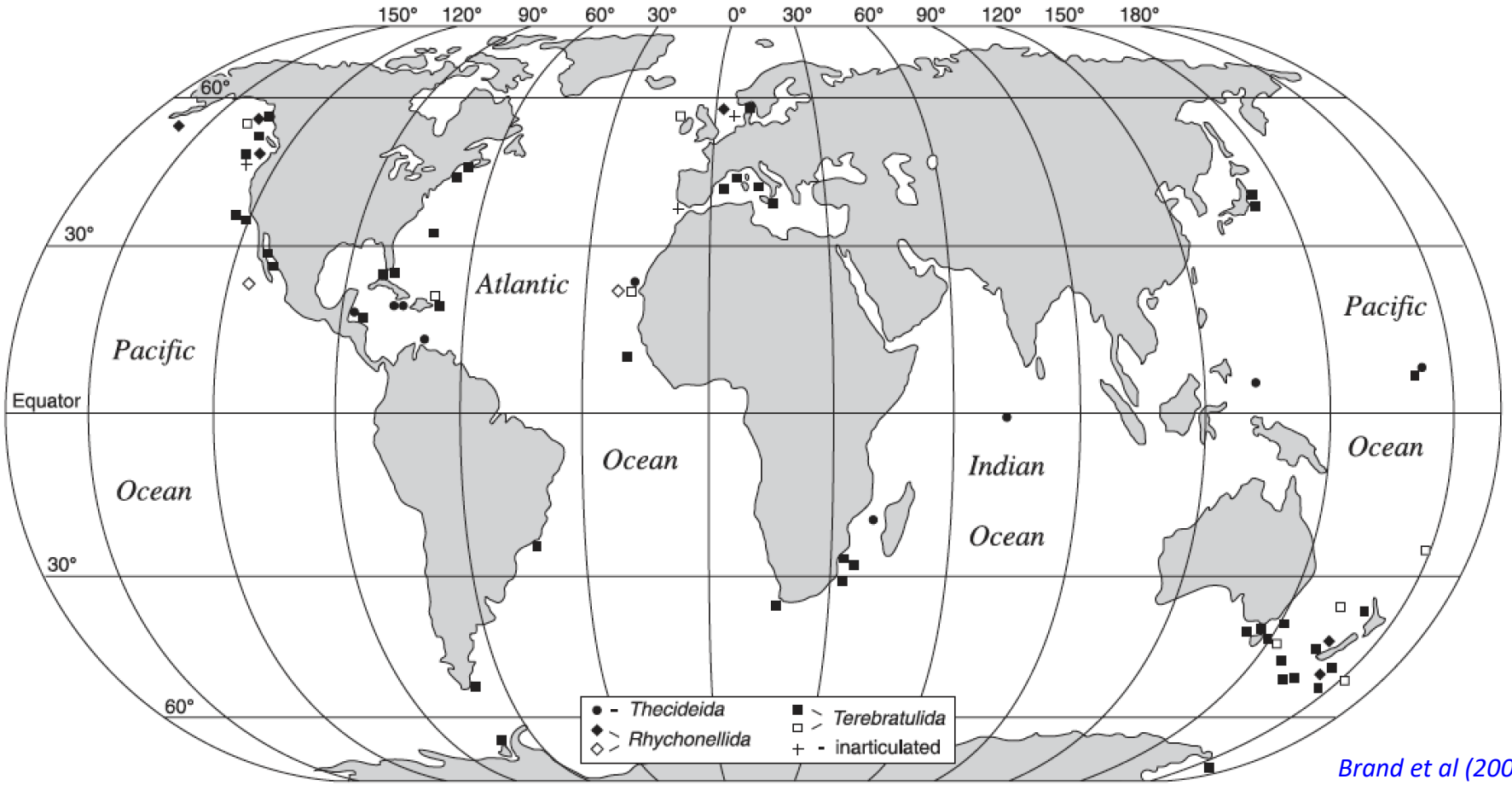


- Brachiopods are a long-lived Phylum ranging from the Cambrian to Present.
- In the Present not many forms are left with approximately 70 Genera.
- Over 2500 fossil Genera are known.
- The largest were found in the Cambrian (370 mm).



Calrson (2016)

Brachiopods are found throughout the world's marine environments.



Brand et al (2003)

Brachiopods usually attach to substrate using their pedicles, though some species burrow into sediments in shallow waters. They are found at all depths, most commonly on the continental shelf, and often in very cold waters.

Often used for paleoreconstructions

ELSEVIER

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CHEMICAL GEOLOGY
INCLUDING ISOTOPE GEOSCIENCE

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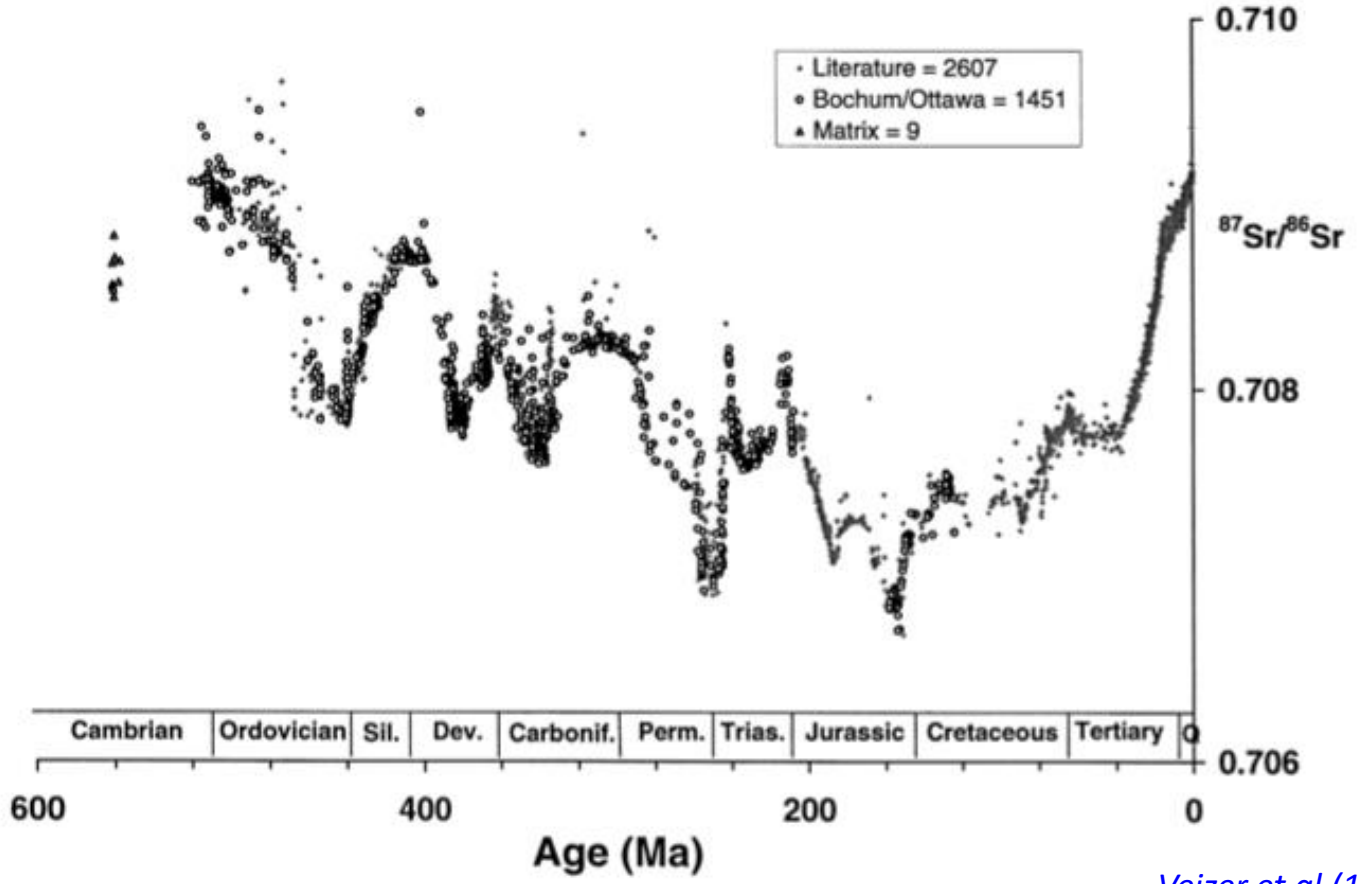
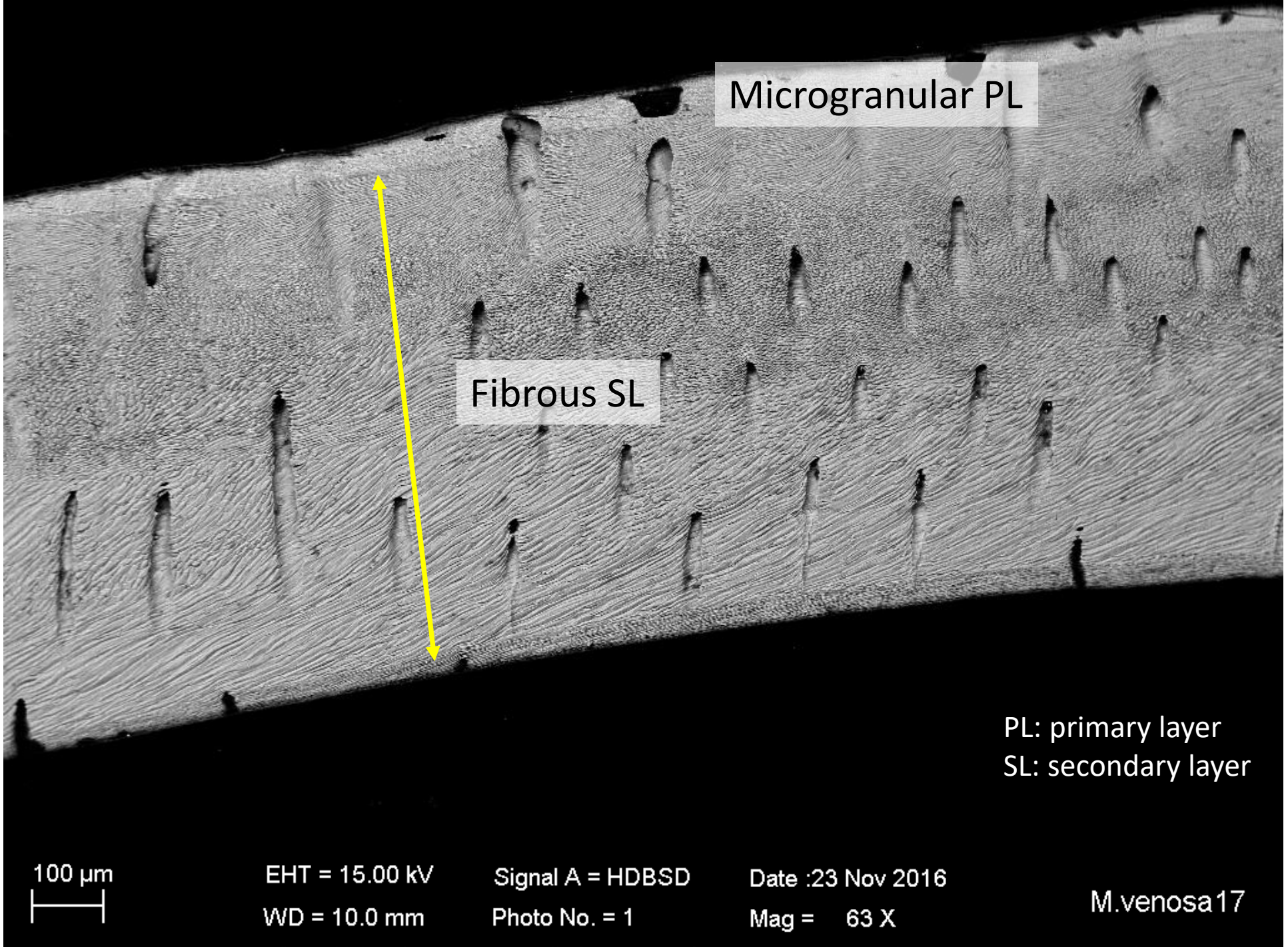
$^{87}Sr/^{86}Sr$, $\delta^{13}C$ and $\delta^{18}O$ evolution of Phanerozoic seawater

Ján Veizer [a,b,*], Davin Ala [b,c], Karem Azmy [b], Peter Bruckschen [a], Dieter Buhl [a], Frank Bruhn [a,d], Giles A.F. Carden [a,e], Andreas Diener [a,f], Stefan Ebneth [a,g], Yves Godderis [b,h], Torsten Jasper [a], Christoph Korte [a], Frank Pawellek [a], Olaf G. Podlaha [a,i], Harald Strauss [a,j]

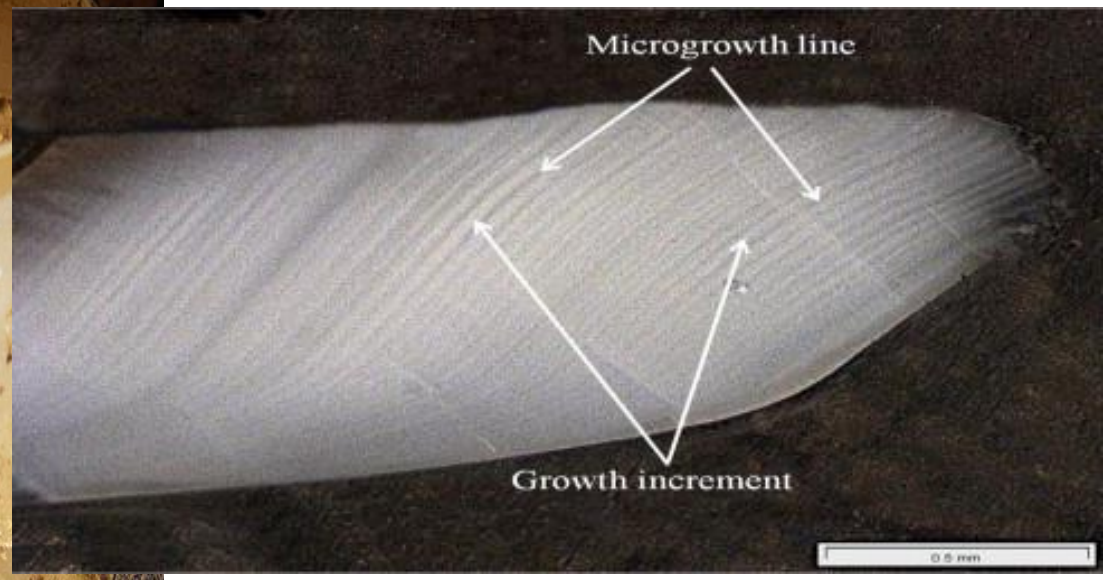


Based of 4055 samples of brachiopods, belemnites and conodonts

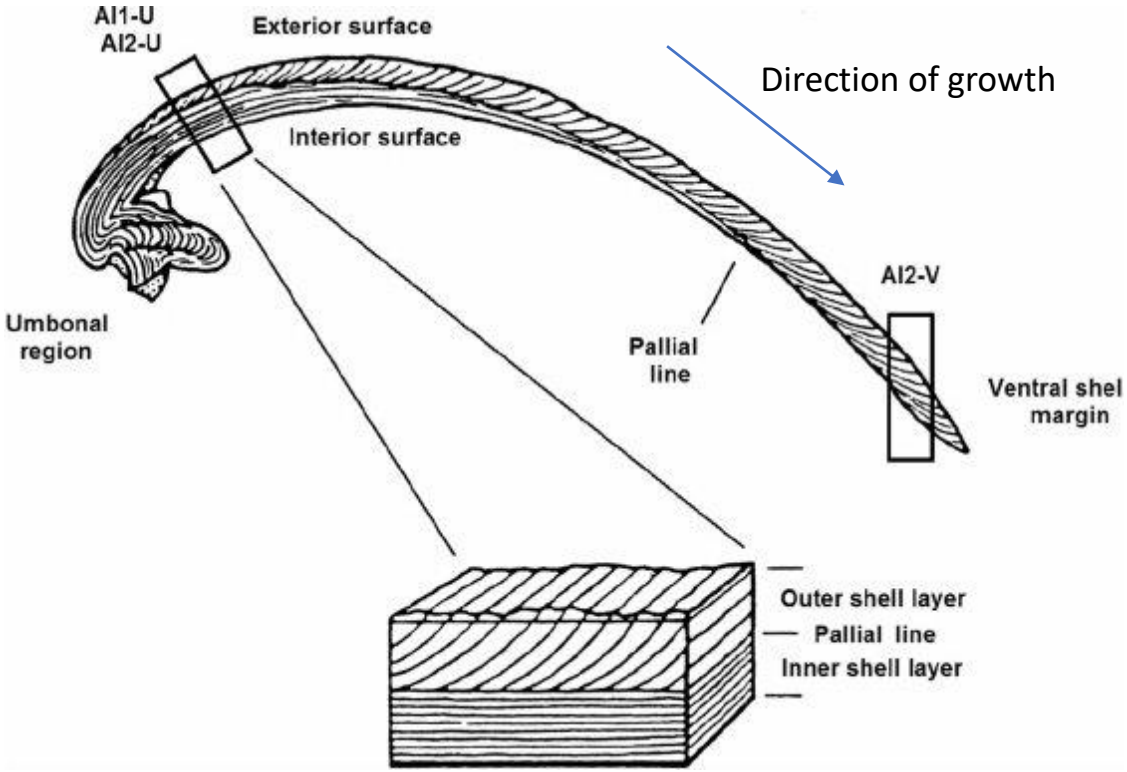
Veizer et al (1999)


Microgranular PL
Fibrous SL
PL: primary layer
SL: secondary layer
100 µm
EHT = 15.00 kV
WD = 10.0 mm
Signal A = HDBSD
Photo No. = 1
Date :23 Nov 2016
Mag = 63 X
M.venosa17

Model growth of brachiopods?



Mirzaei et al (2014)

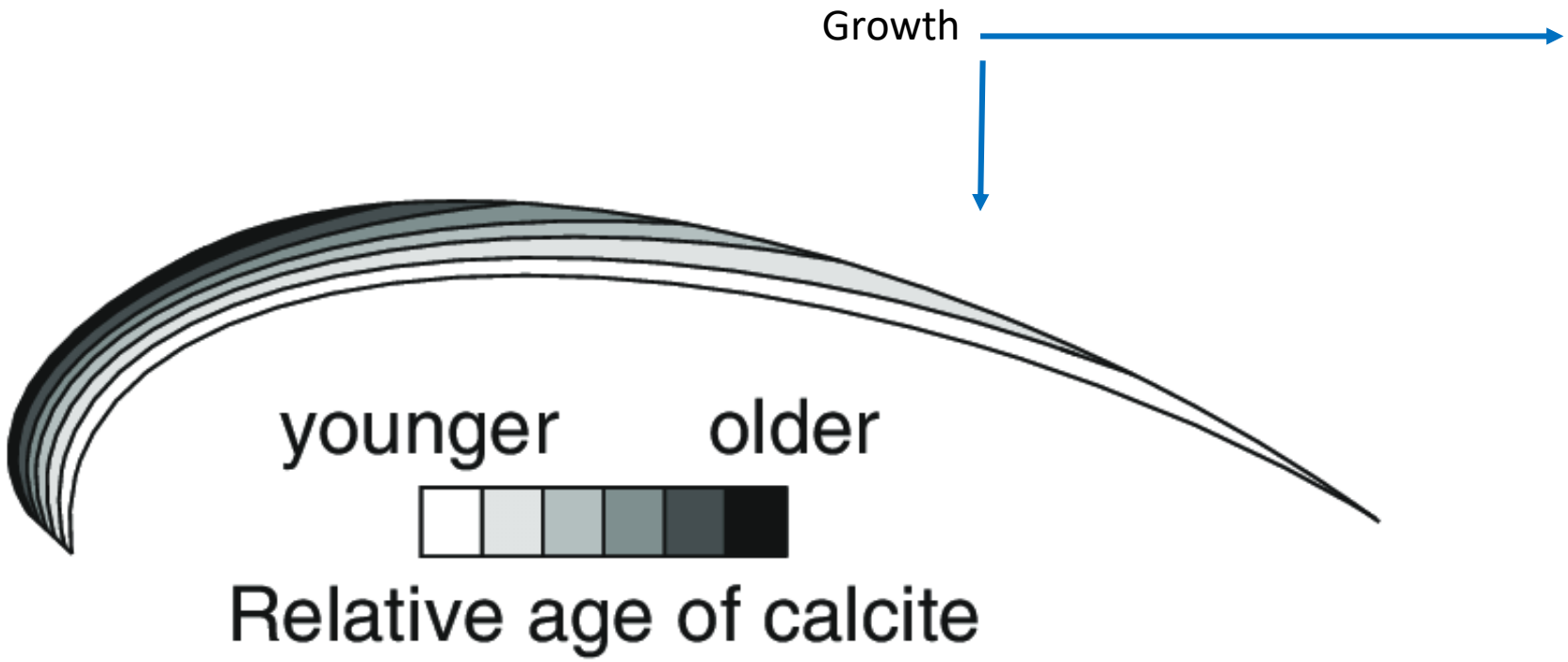


Helama et al (2015)

In bivalves, presence of growth lines

In brachiopods, no presence of growth lines

=> Mathematical model of growth



Penman et al (2013)
after Ackerly (1989)

- Cultured samples of *Magallenia venosa* (GEOMAR, Kiel)

CO_2 experiment

4th August 2016 – 18th April 2017

Sal	T(°C)	CO_2 (µatm)	pH	TA (mmol/mol)	DIC	omega	
30	10	2000	7.60	2.8		2.7	1.1

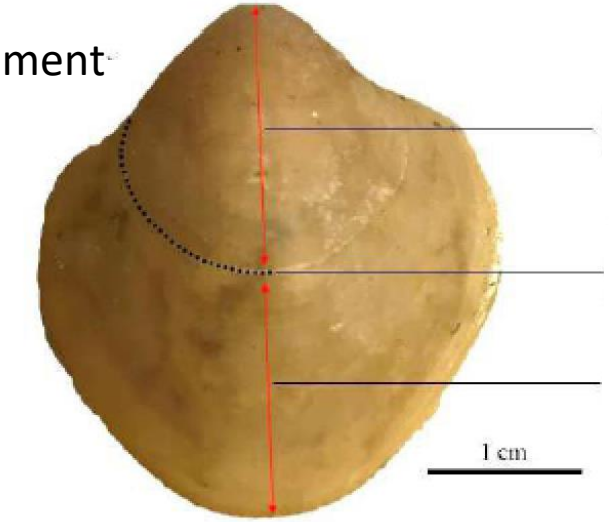
18th April 2017 –5th July 2017

Sal	T(°C)	CO_2 (µatm)	pH	TA (mmol/mol)	DIC	omega	
30	10	4000	7.35	3.1		3.5	0.6

$\delta^{13}C_{nature}$= -0.05 ‰ V-PDB

$\delta^{13}C_{culture}$=-23.63 ‰ V-PDB

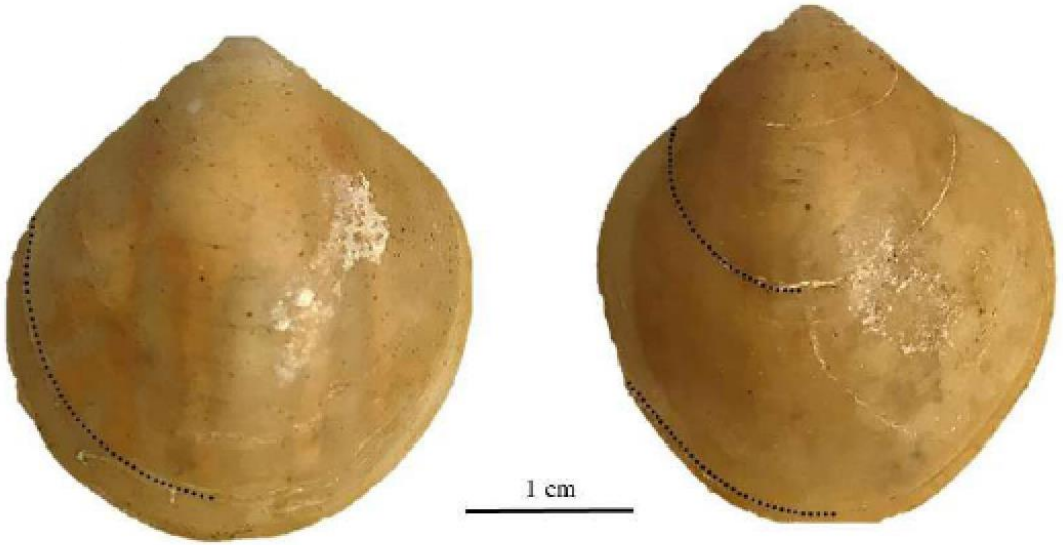
Control experiment



Natural conditions

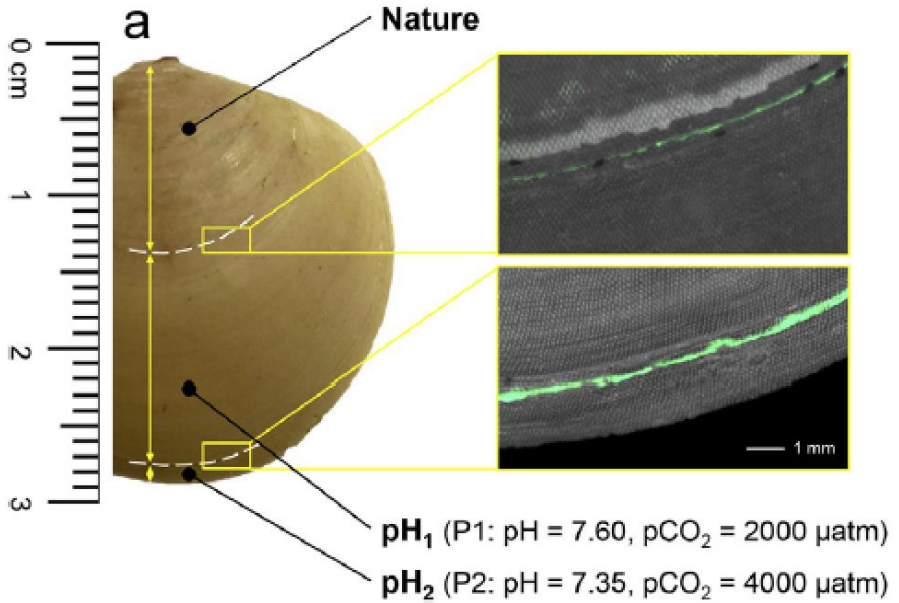
Growth line

Culture conditions



High T experiment

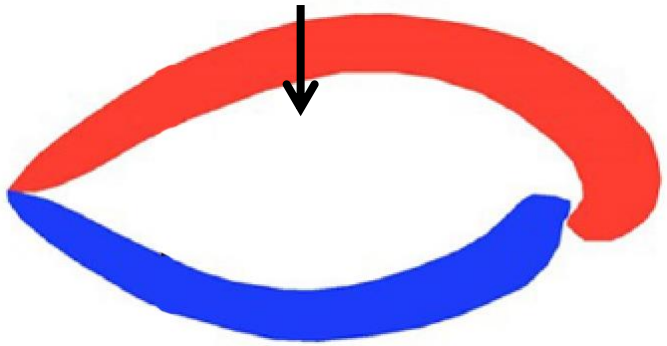
(Not presented here)

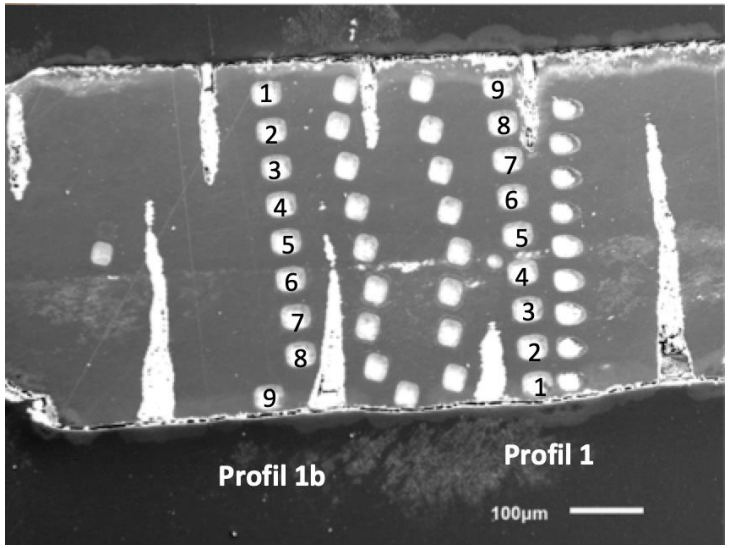


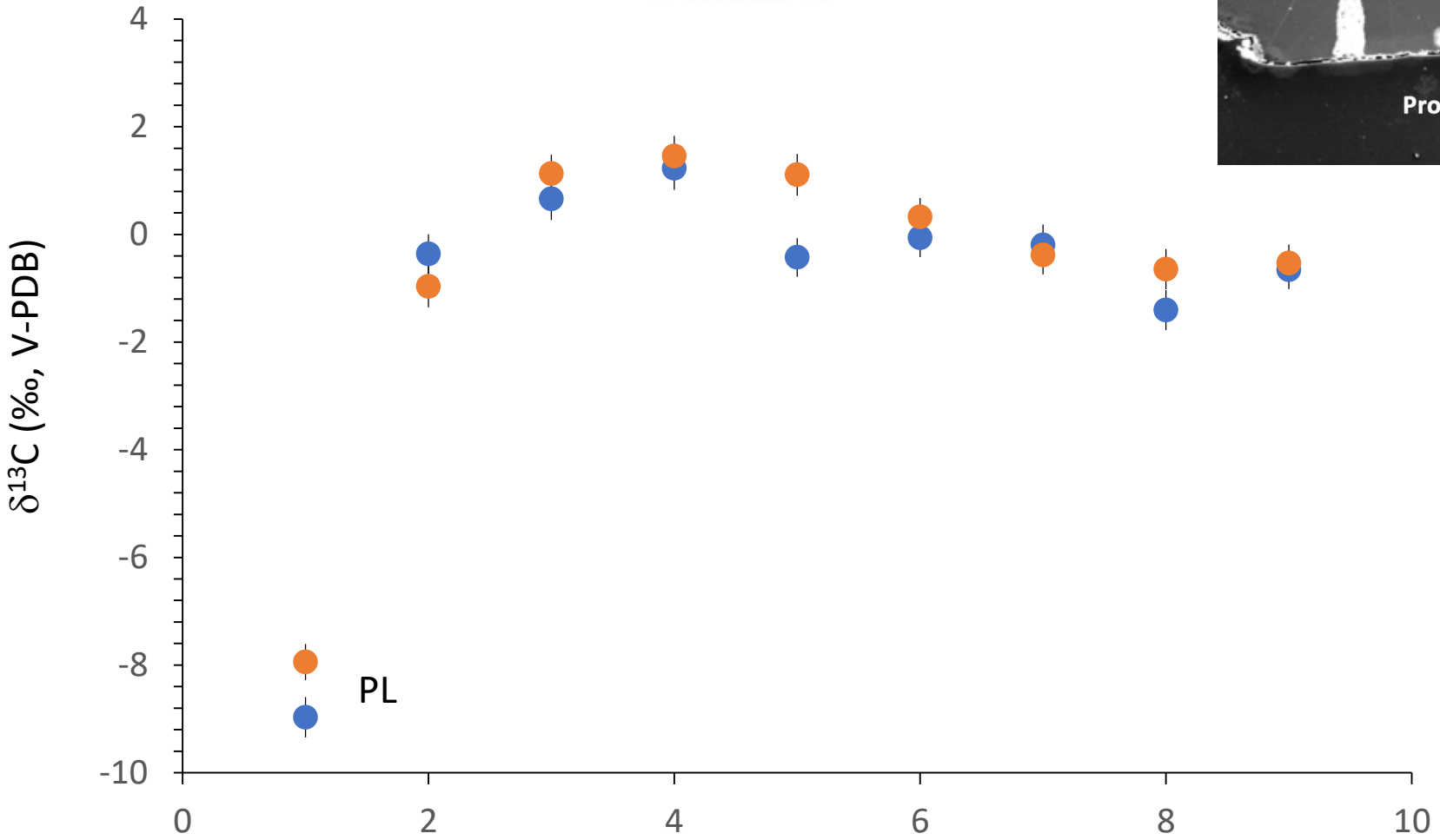
CO_2 experiment

Jurokova et al (2019)

Control experiment

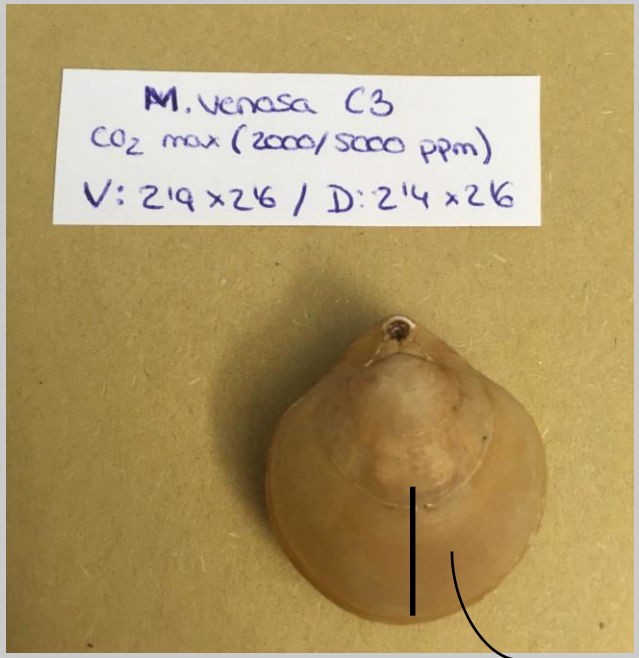






Rollion-Bard et al (subm)

CO_2 experiment



anterior

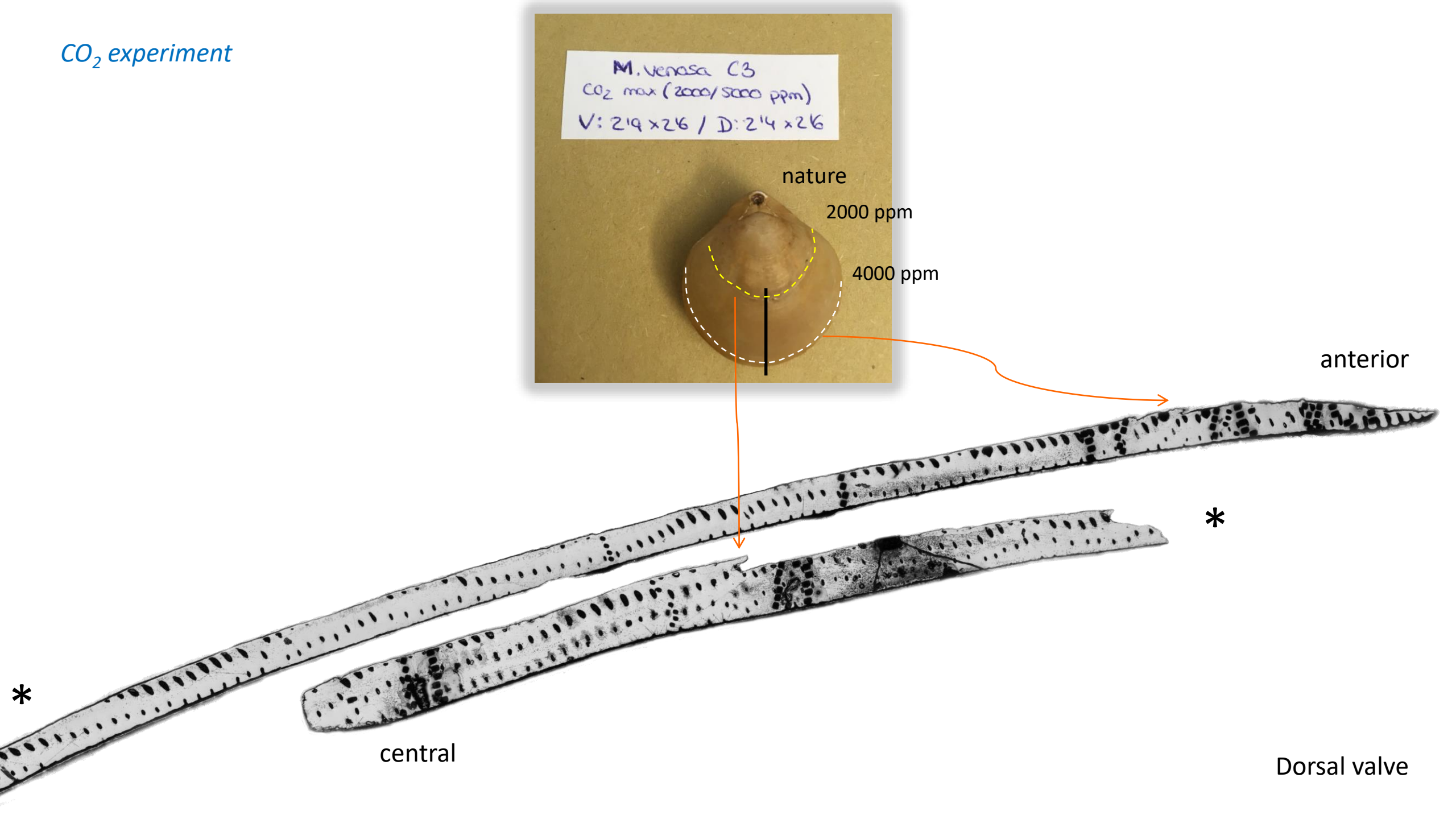
*

*

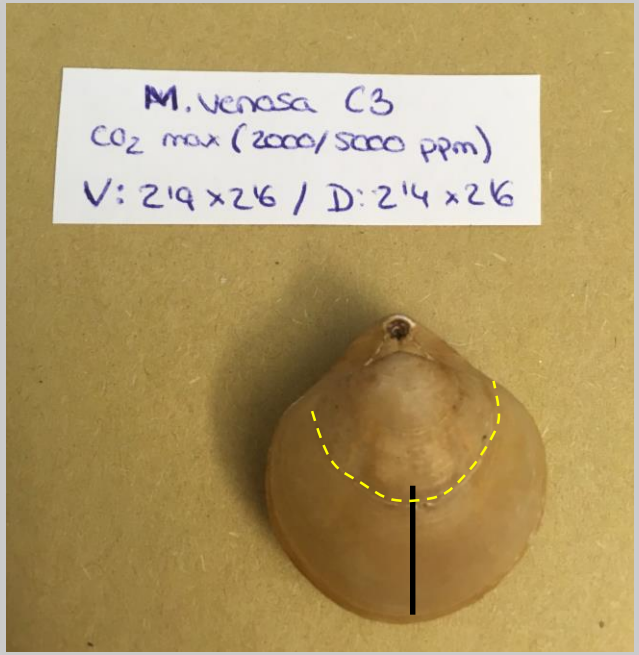
central

Dorsal valve

CO_2 experiment



CO_2 experiment



anterior

2

1

*

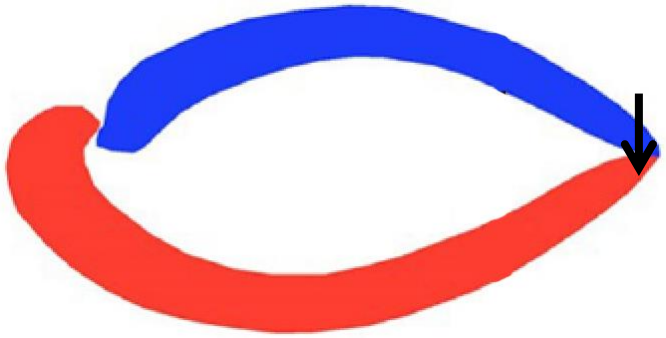
*

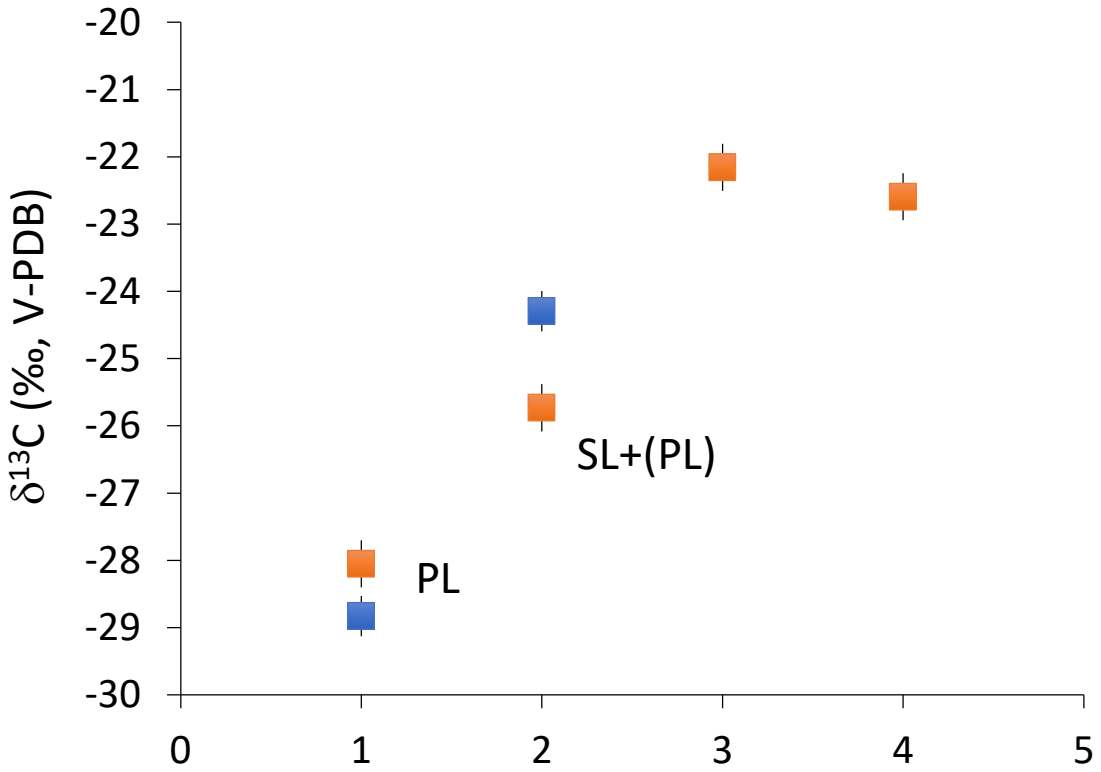
3

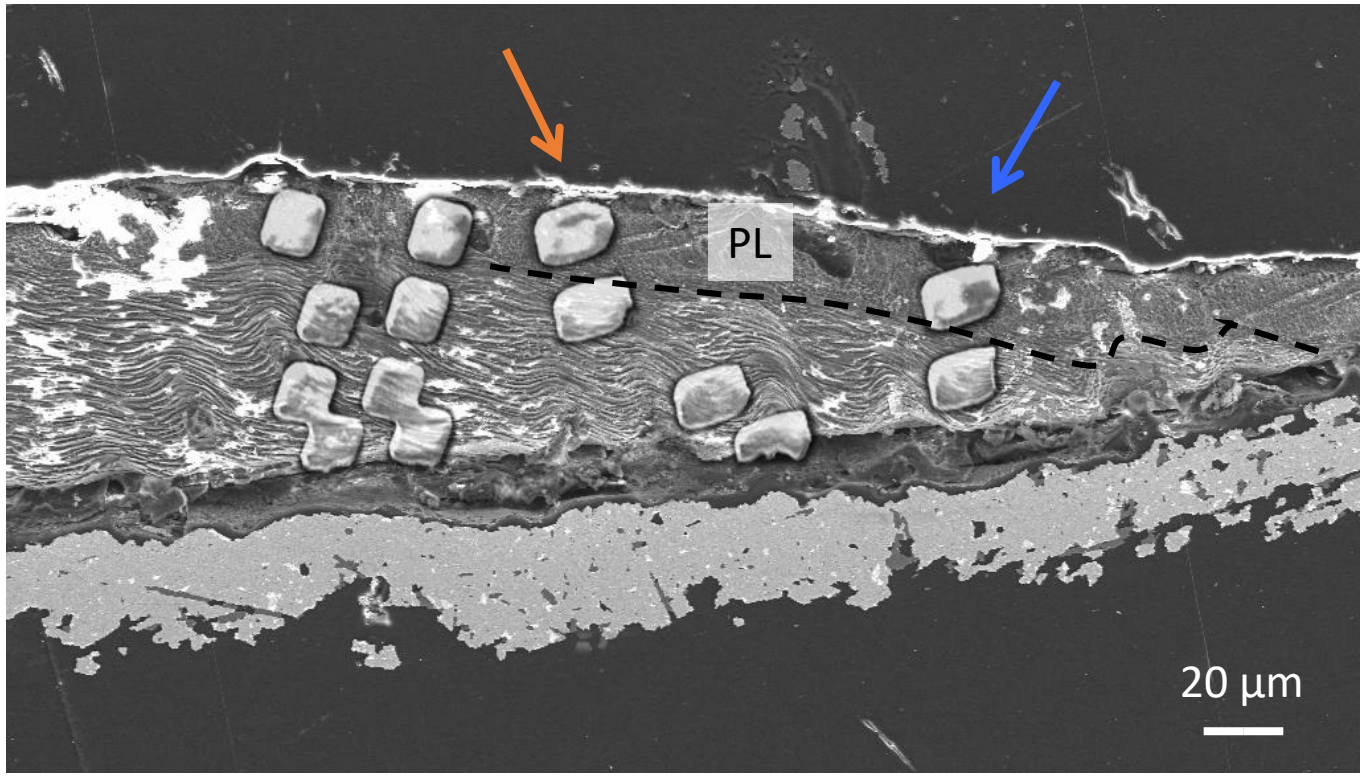
central

Dorsal valve

Zone 1

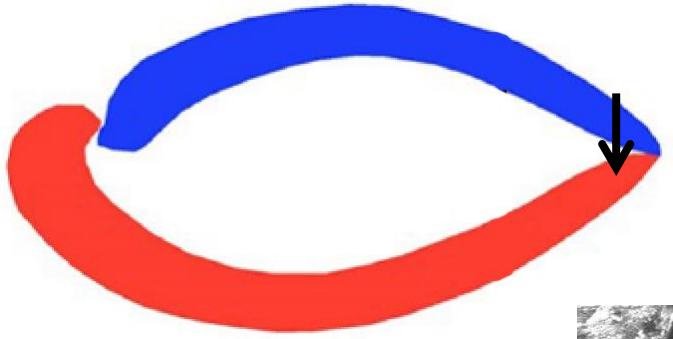


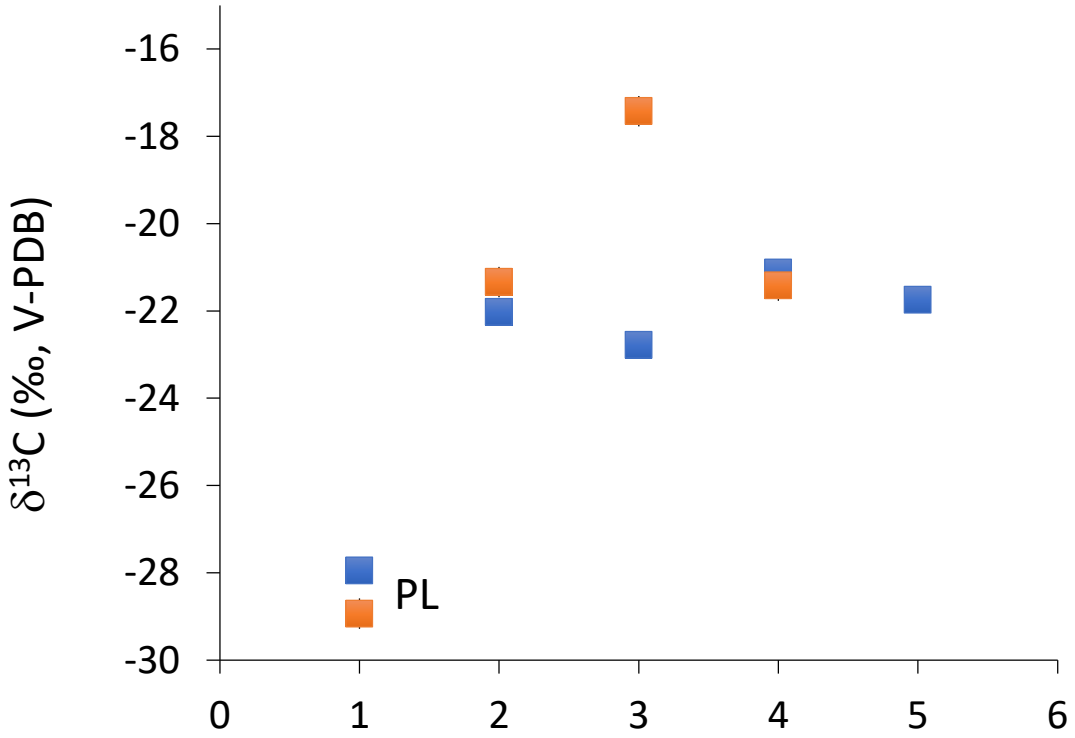


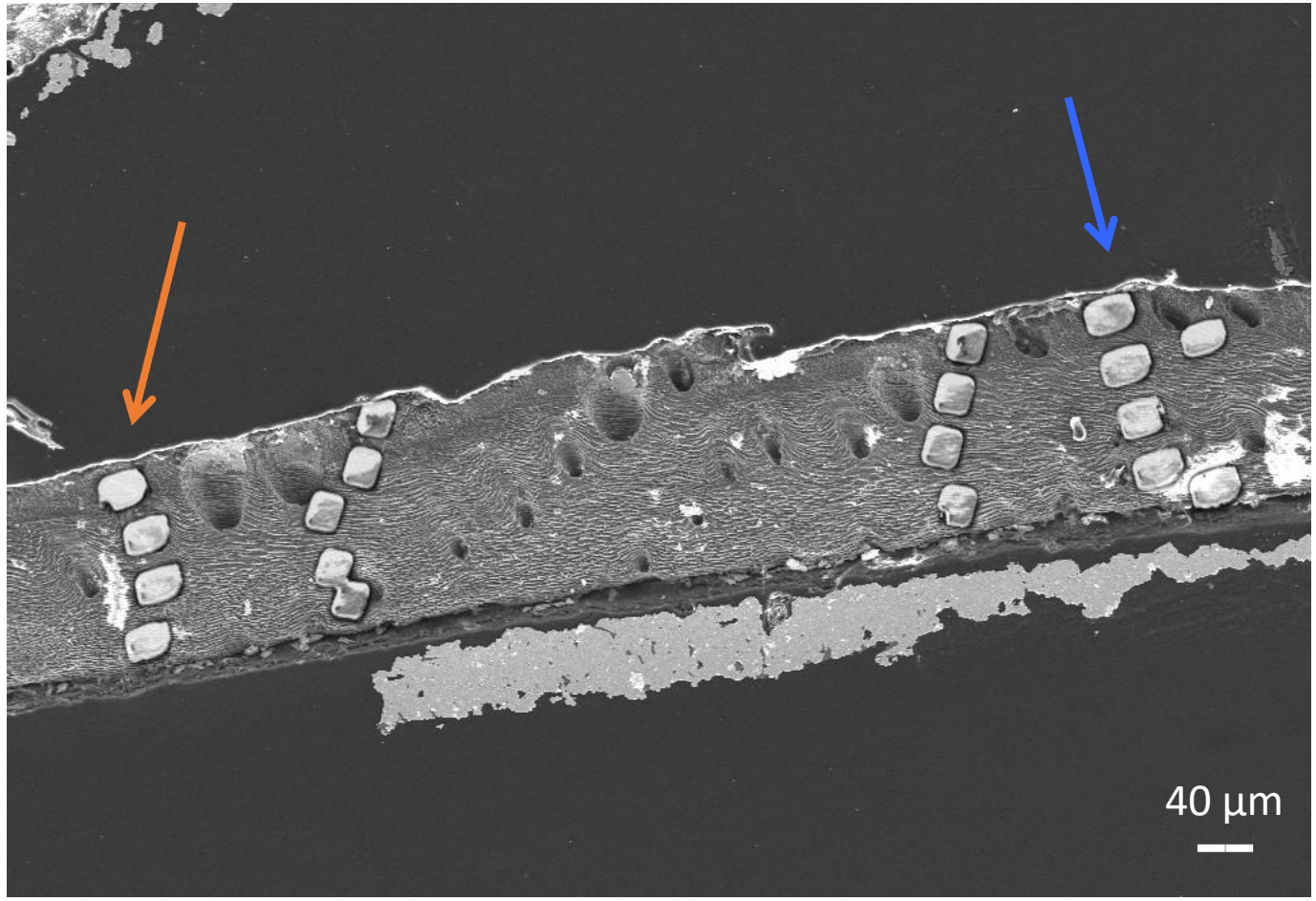


$\delta^{13}C_{culture}$=-23.63 ‰ V-PDB

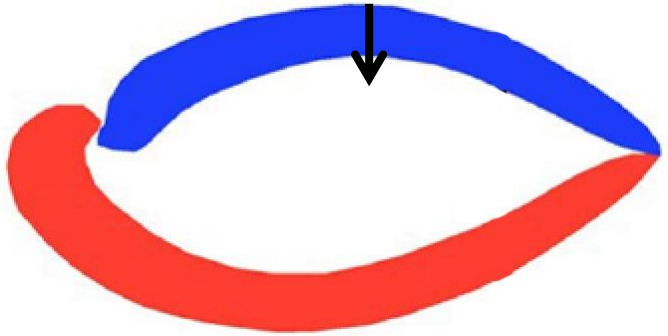
Zone 2

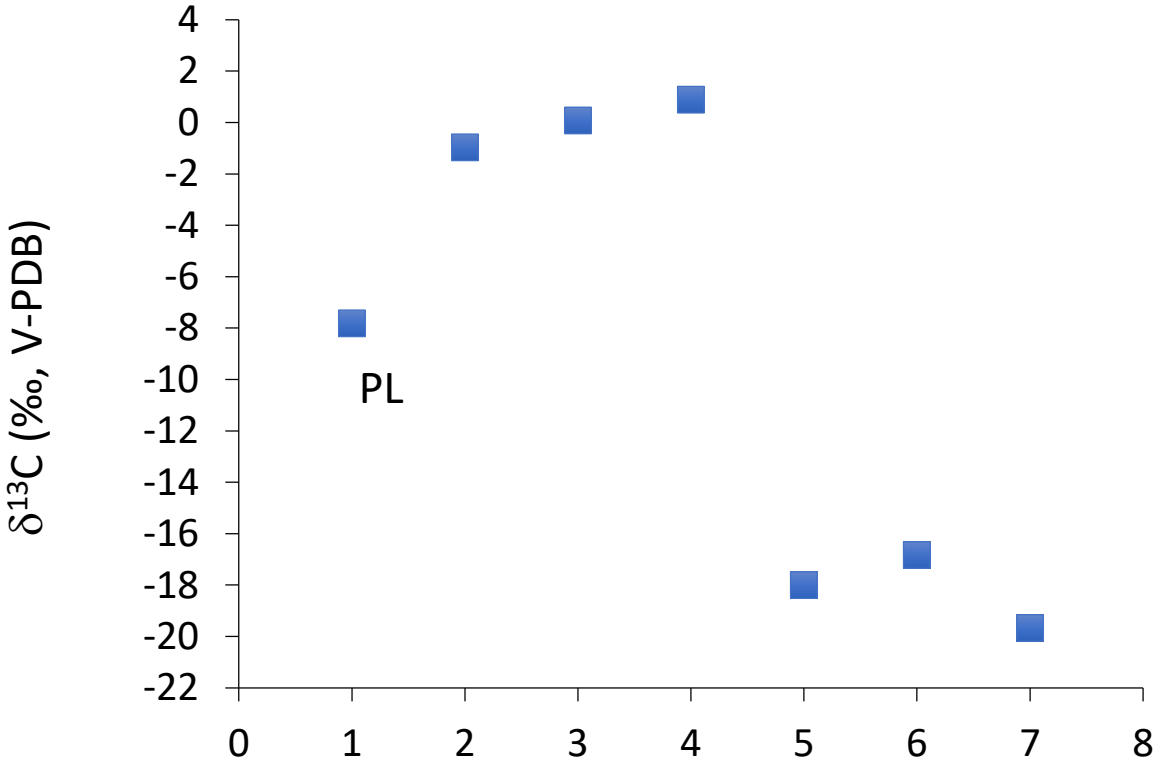


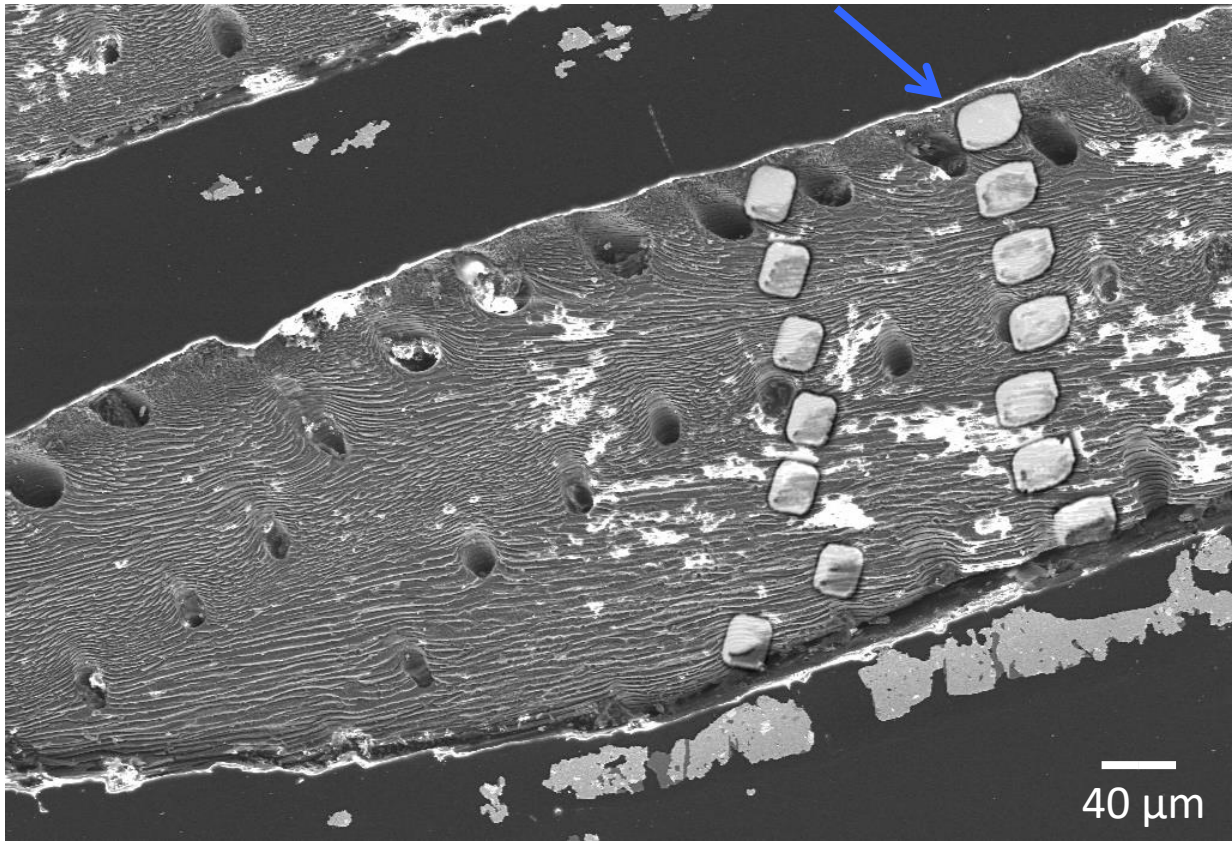




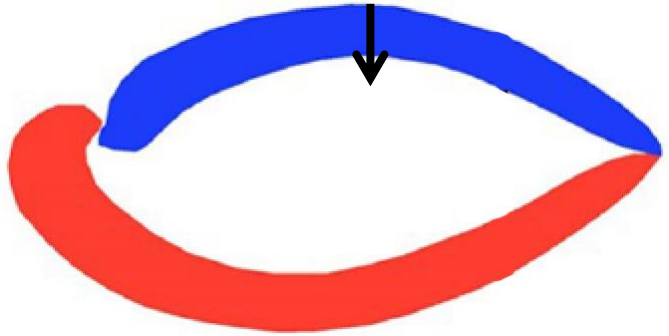
Zone 3

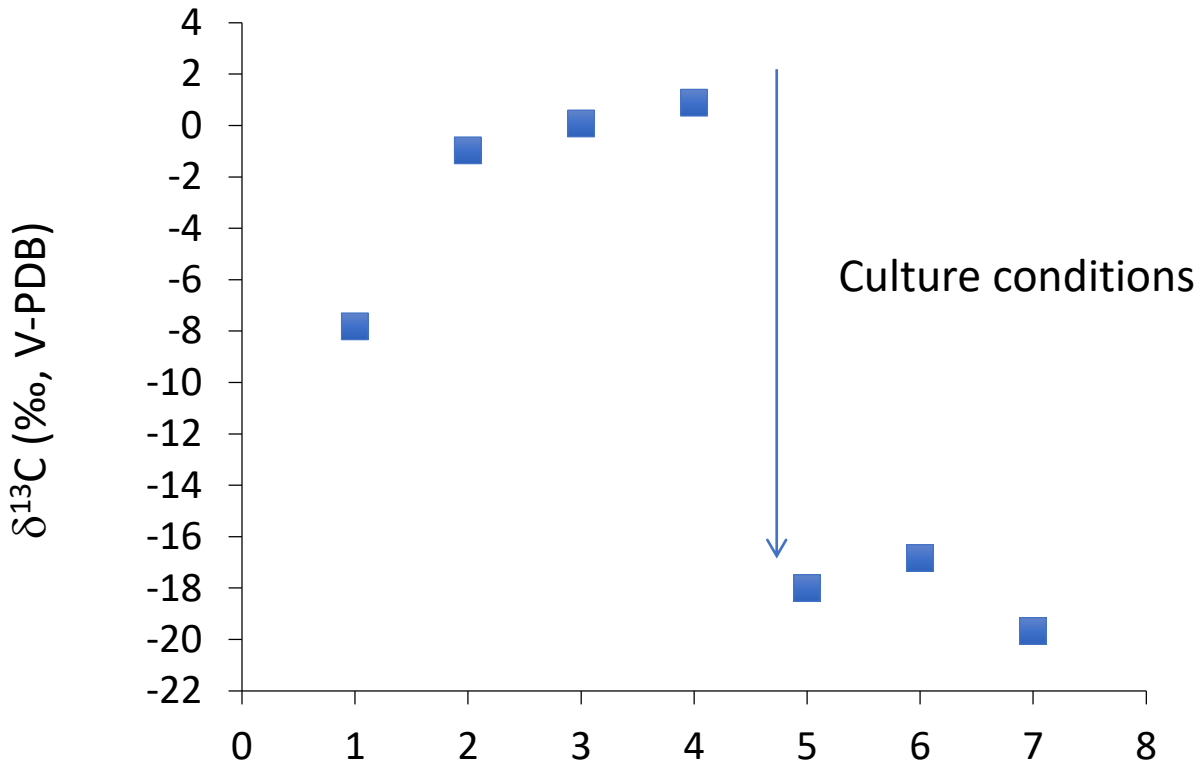






Zone 3

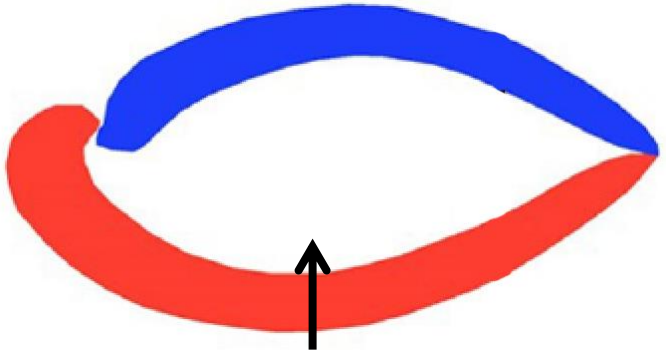


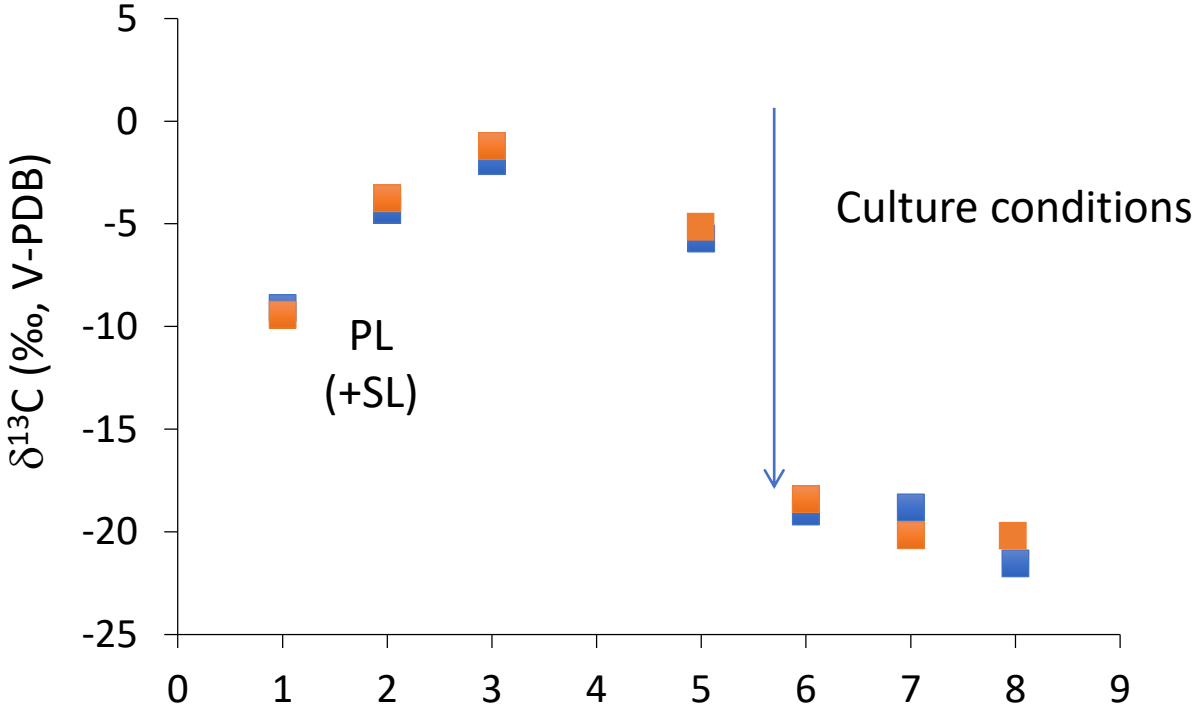


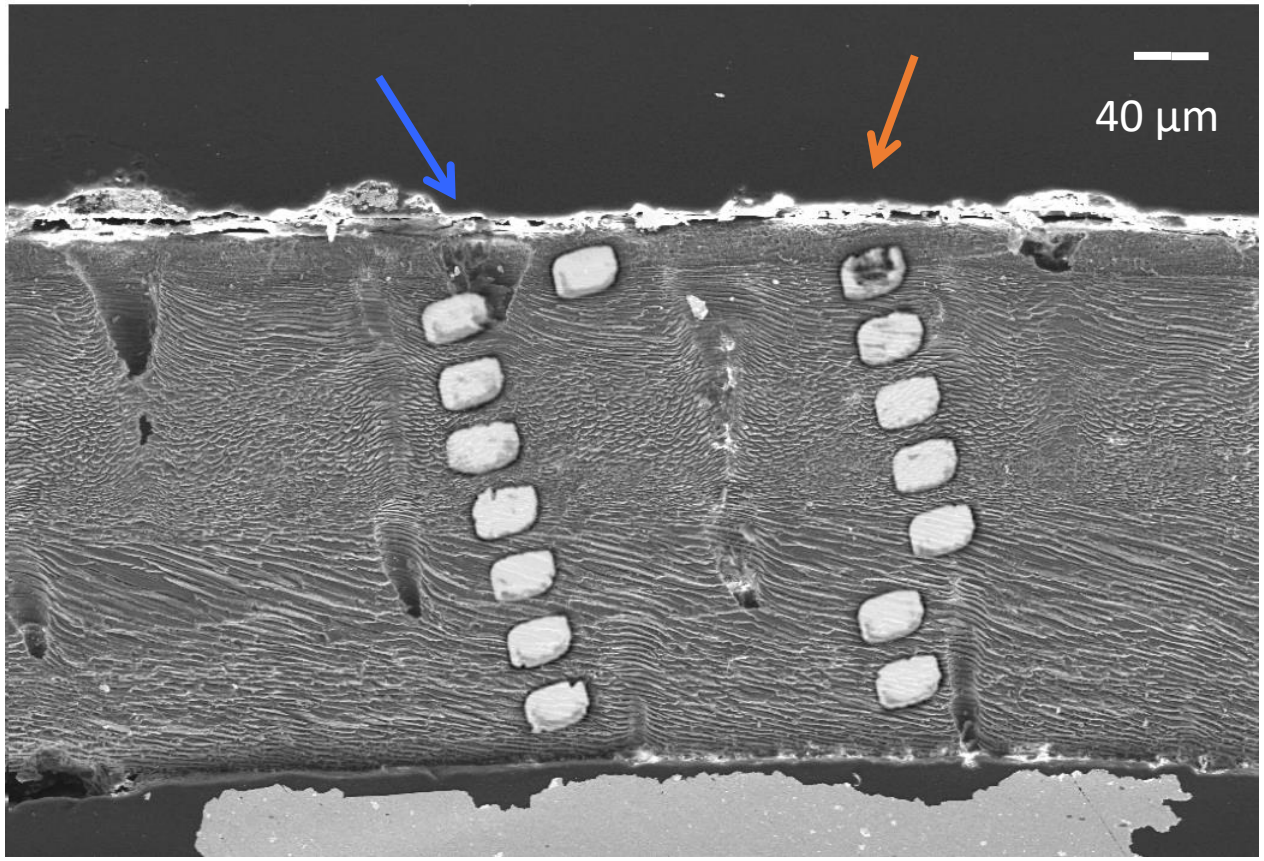
$\delta^{13}C_{nature}$= -0.05 ‰ V-PDB

$\delta^{13}C_{culture}$=-23.63 ‰ V-PDB

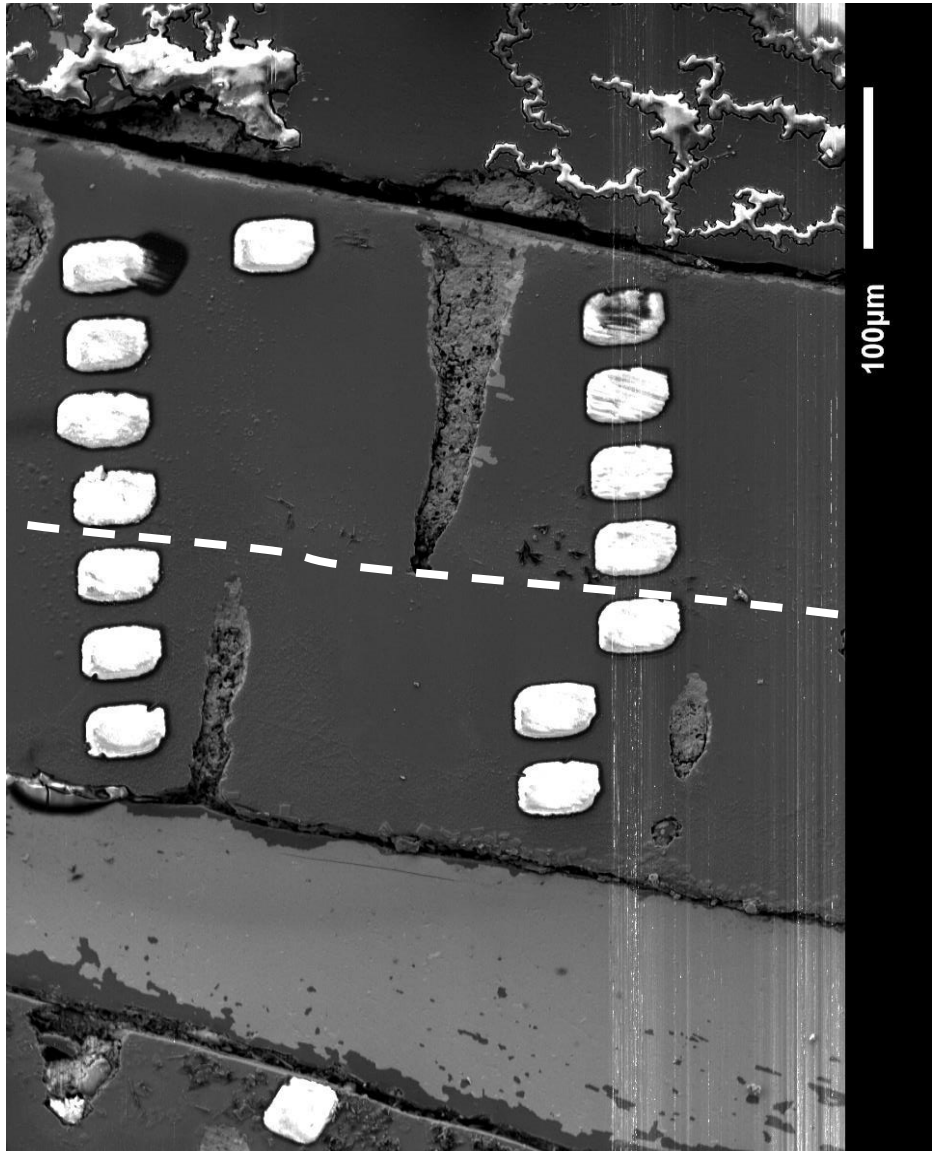
Ventral valve



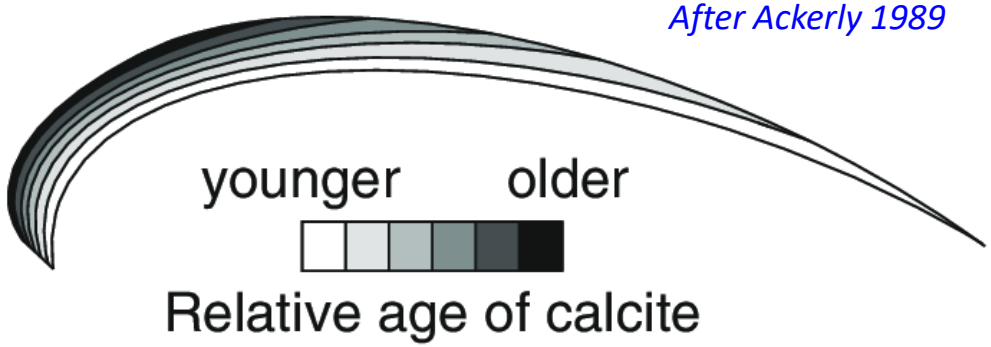




=> Addition of new layer on the parts already precipitated from natural conditions



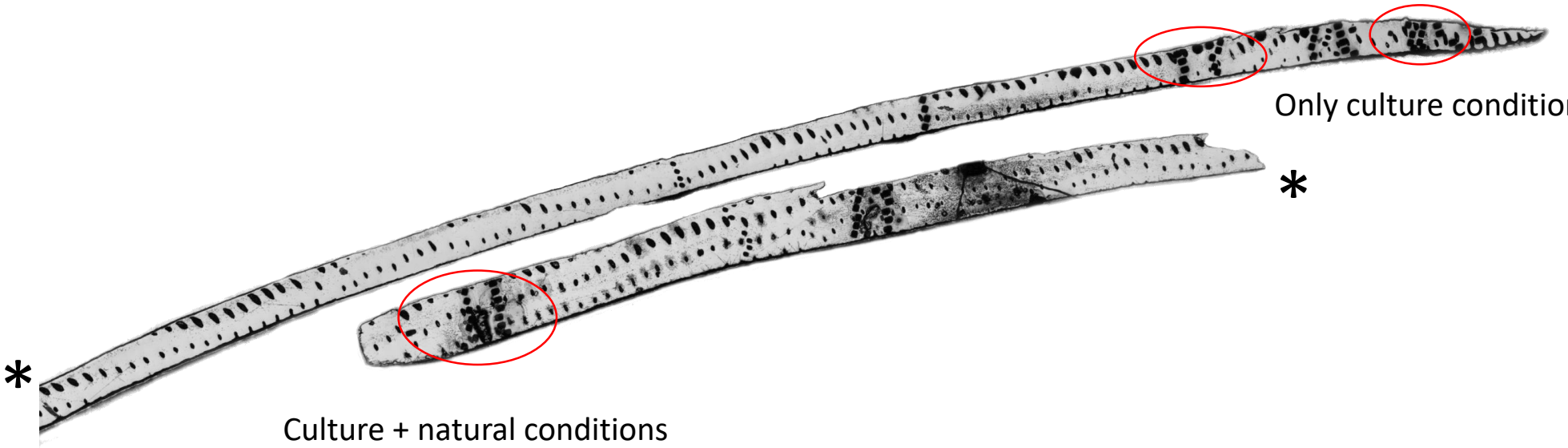
Penman et al 2013
After Ackerly 1989

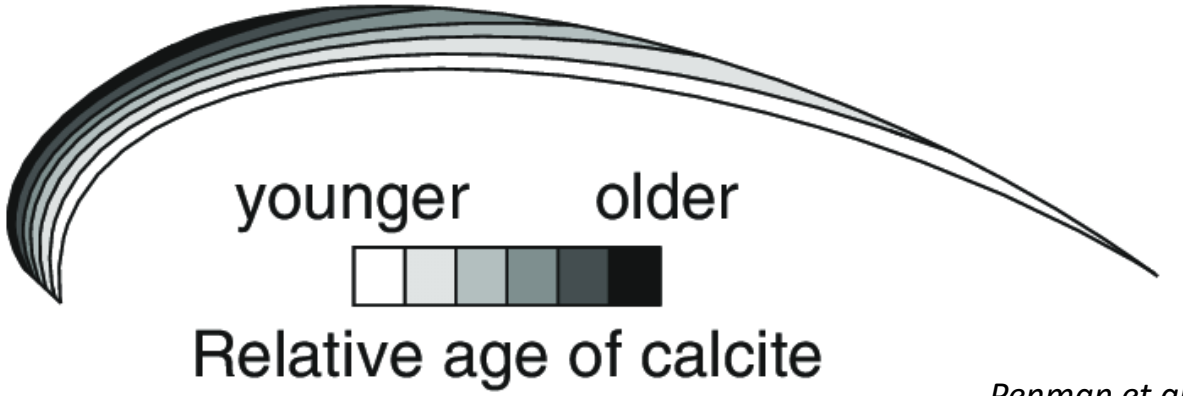


Natural conditions

Culture conditions

Central part
⇒ 2/3 Nature
1/3 Culture





Penman et al 2013
After Ackerly 1989

=> Validation of the growth model


THANKS