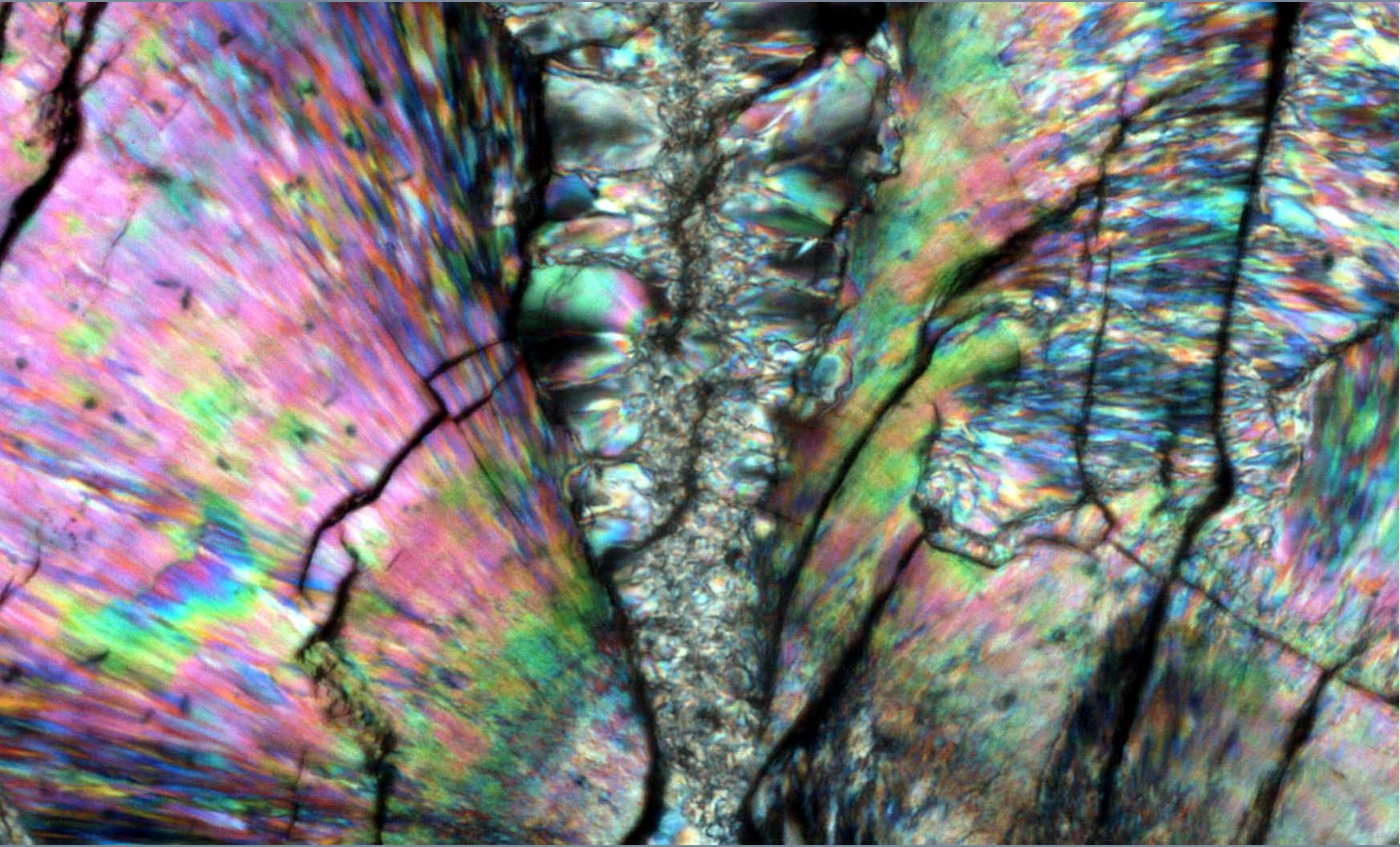
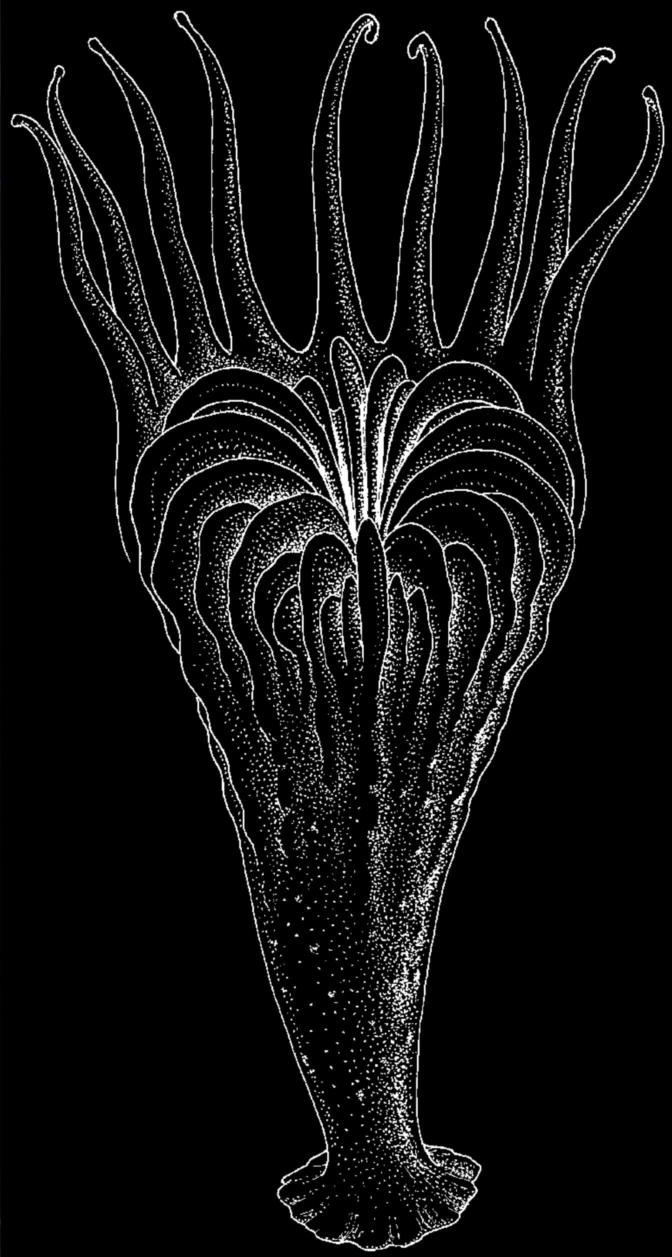
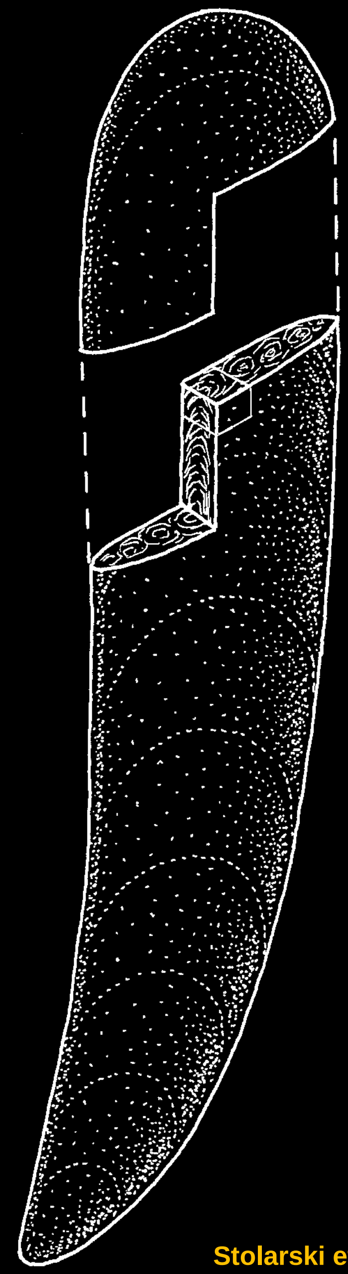
Szkielet koralowca
aragonitowy i kalcytowy w jednym



Jarosław Stolarski, Instytut Paleobiologii PAN

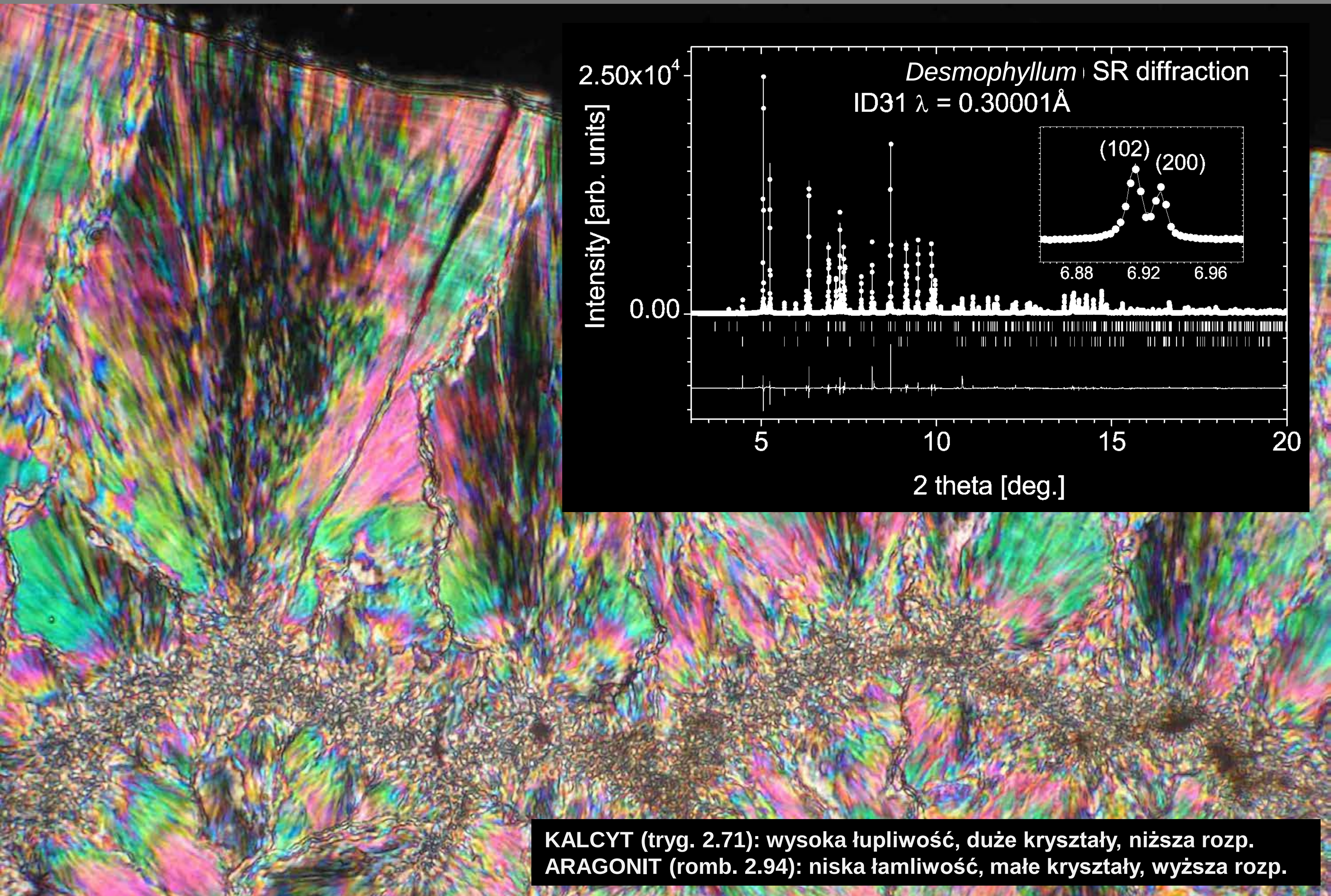
Polip vs. szkielet dzisiejszego koralowca (*Desmophyllum*)





Stolarski et al. in prep

Aragonitowa mineralogia szkieletu dzisiejszych Scleractinia



KALCYT (tryg. 2.71): wysoka łupliwość, duże kryształy, niższa rozp.
ARAGONIT (romb. 2.94): niska łamliwość, małe kryształy, wyższa rozp.

Fizykochemiczny model tworzenia szkieletu Scleractinia

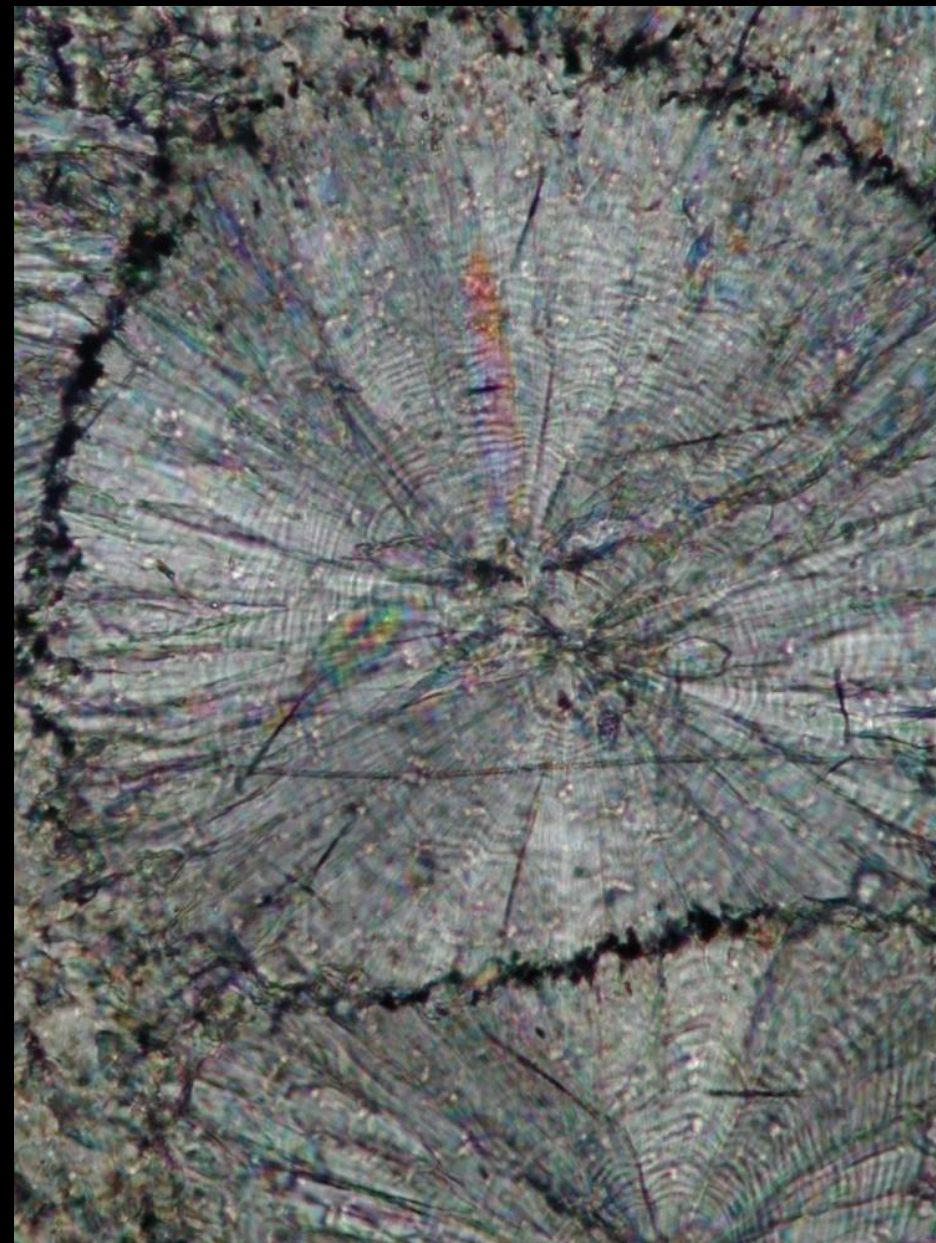
SPHERULITIC CRYSTALLIZATION AS A MECHANISM OF SKELETAL GROWTH IN THE HEXACORALS.

By W. H. Bryan, M.C., D.Sc., and Dorothy Hill, M.Sc., Ph.D.,
Department of Geology, University of Queensland.

(*Read before the Royal Society of Queensland, 25th November, 1940.*)

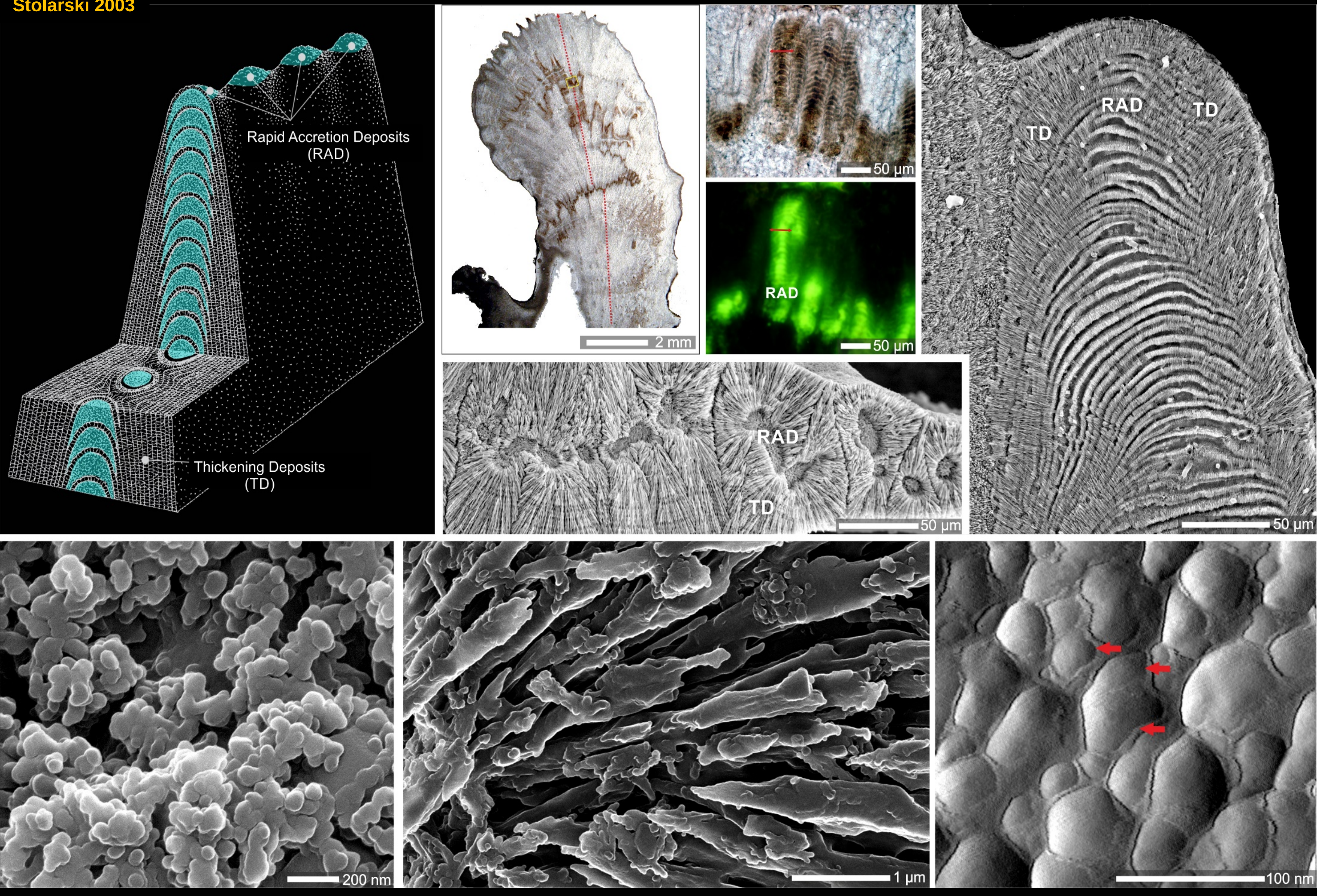
I. Introduction.

For some years the authors of this paper had been working independently on the structure of spherulites and of corals respectively. Certain similarities in structure were noted between these organic and inorganic materials which, even at first glance, appeared to be more than superficial. It was therefore decided to collaborate in making more detailed comparisons of coralline and spherulitic structures in order to determine the degree of similarity and its possible significance.



Biologiczne spojrzenie na szkielet koralowca Scleractinia: struktura

Stolarski 2003

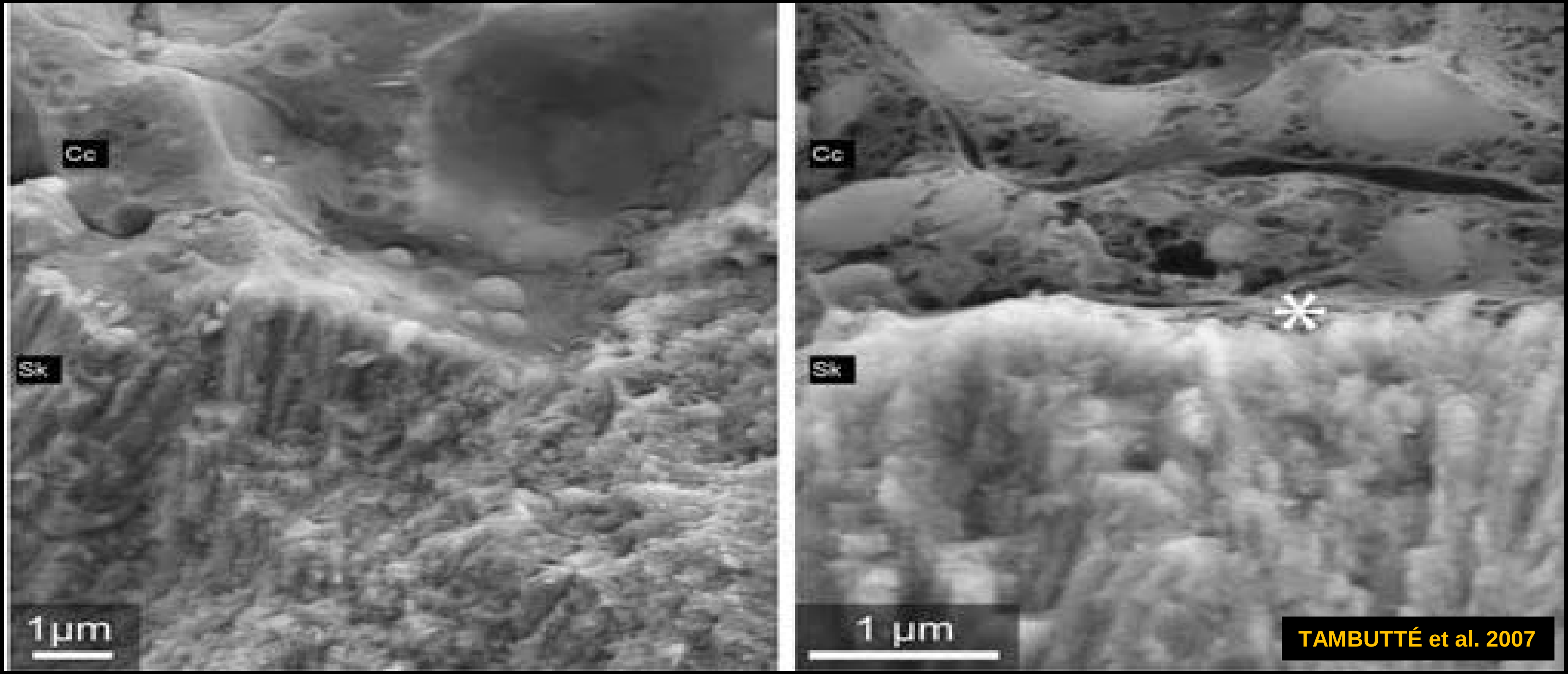


Biologiczne spojrzenie na szkielet koralowca Scleractinia: przestrzeń kalcyfikacji

Z value is "idealized thickness of the calcifying space" which is suggested to be "of 30 to 150 µm"

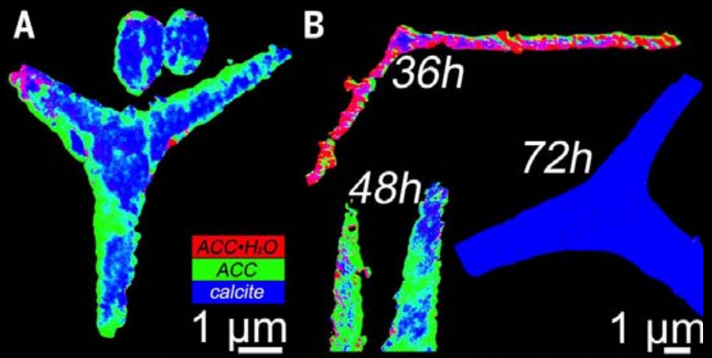
GAGNON et al. 2012

CLODE & MARSHALL 2003

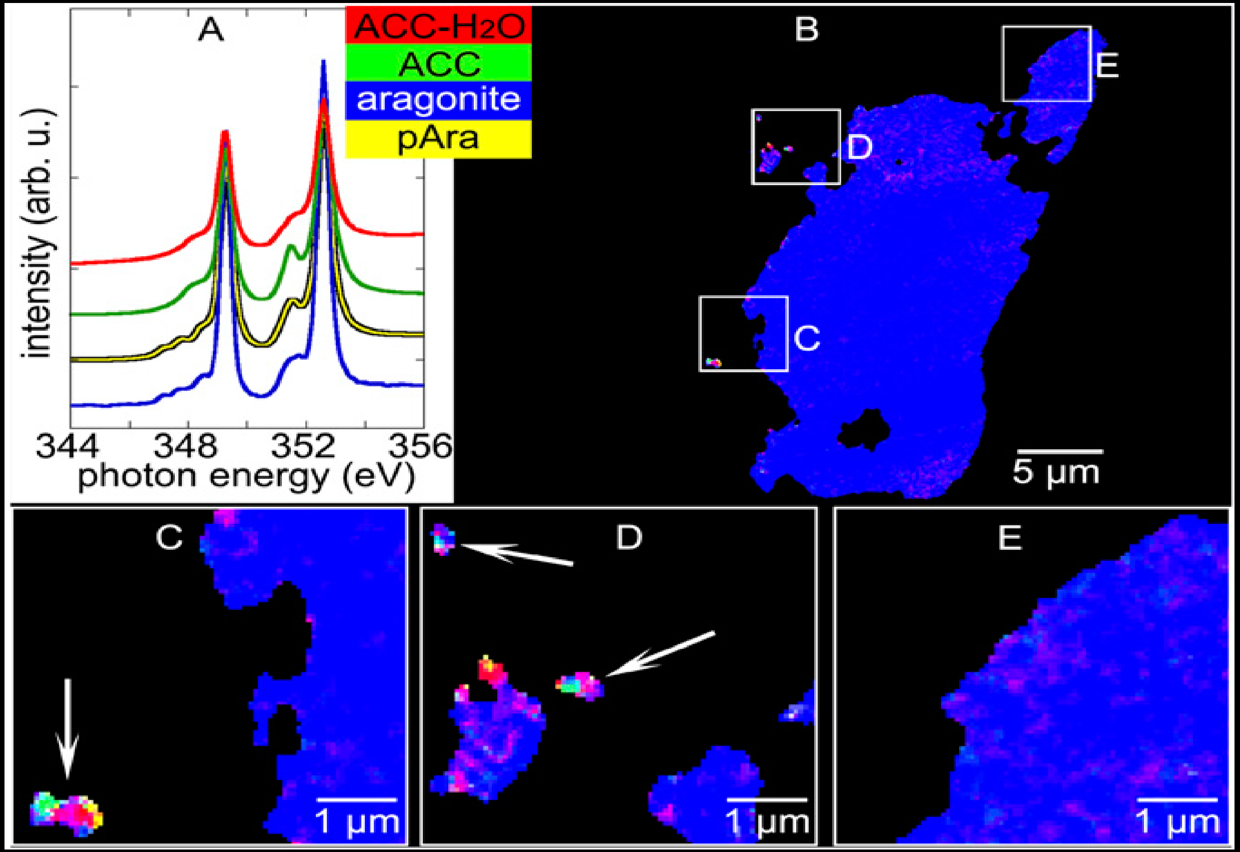


TAMBUTTÉ et al. 2007

Biologiczne spojrzenie na szkielet koralowca Scleractinia: amorficzne prekursory



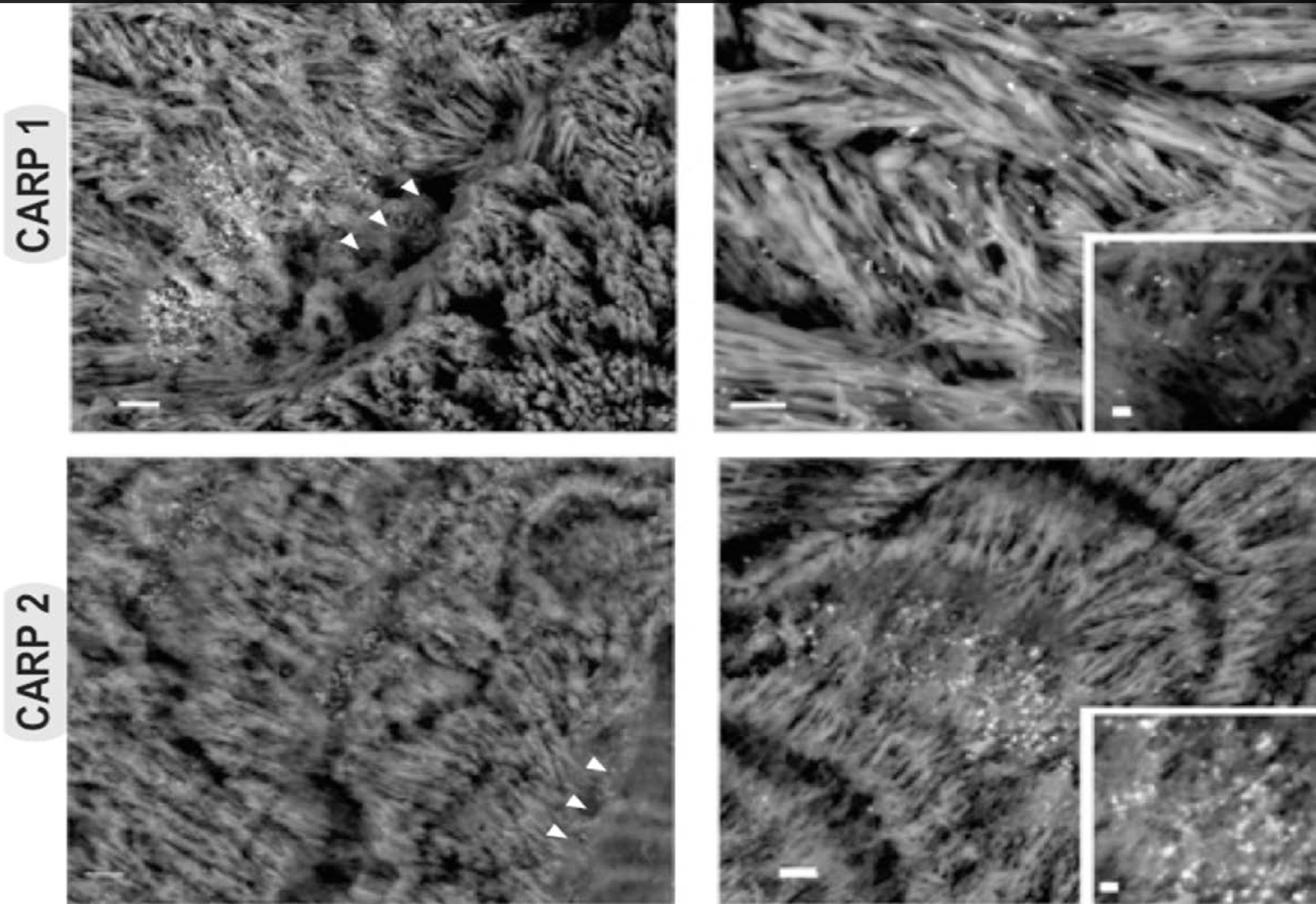
De Yoreo et al. 2015 Science (polarization-dependent imaging – PIC)



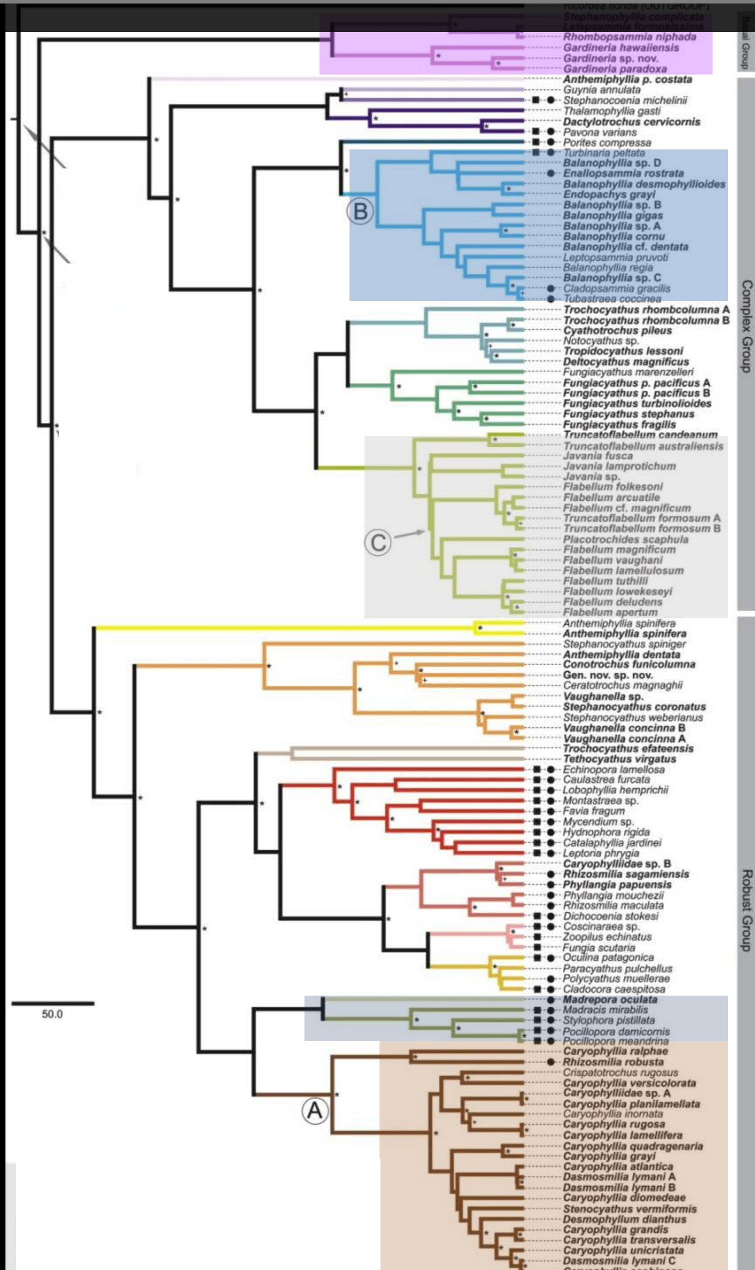
Mass, T. et al. 2017. Amorphous calcium carbonate particles form coral skeletons. PNAS E7670–E7678.

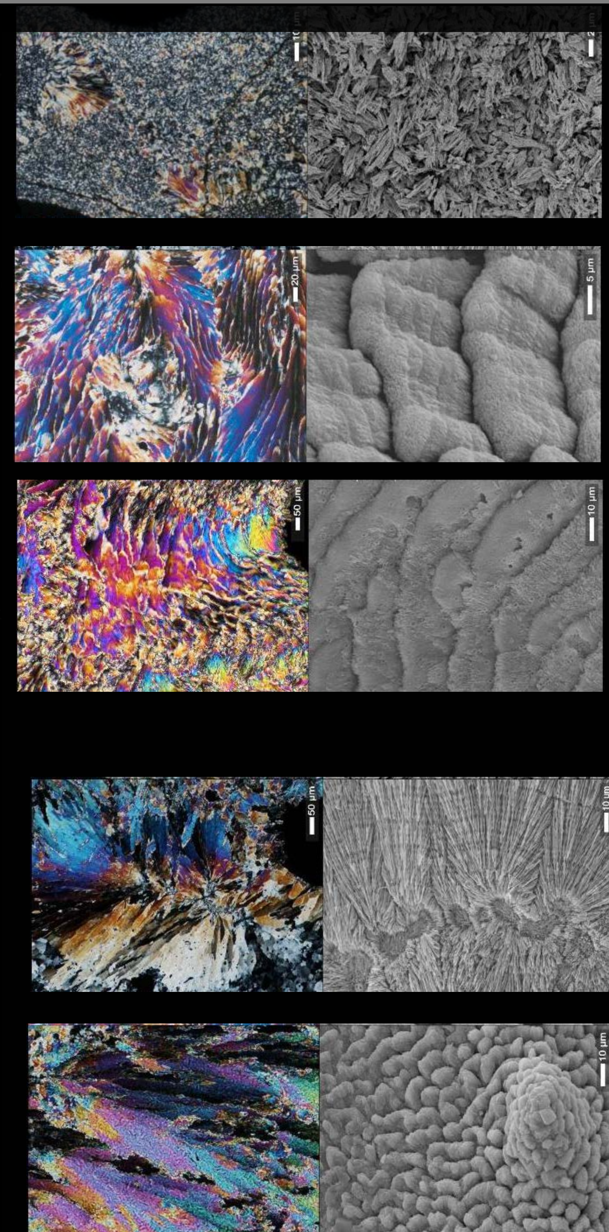
Białka biomineralizacyjne

Mass, T. et al. 2014. Immunolocalization of skeletal matrix proteins in tissue and mineral of the coral *Stylophora pistillata*. PNAS 111 (35) 12728-12733.



Organizacja mikrostrukturalna szkieletu vs. filogeneza





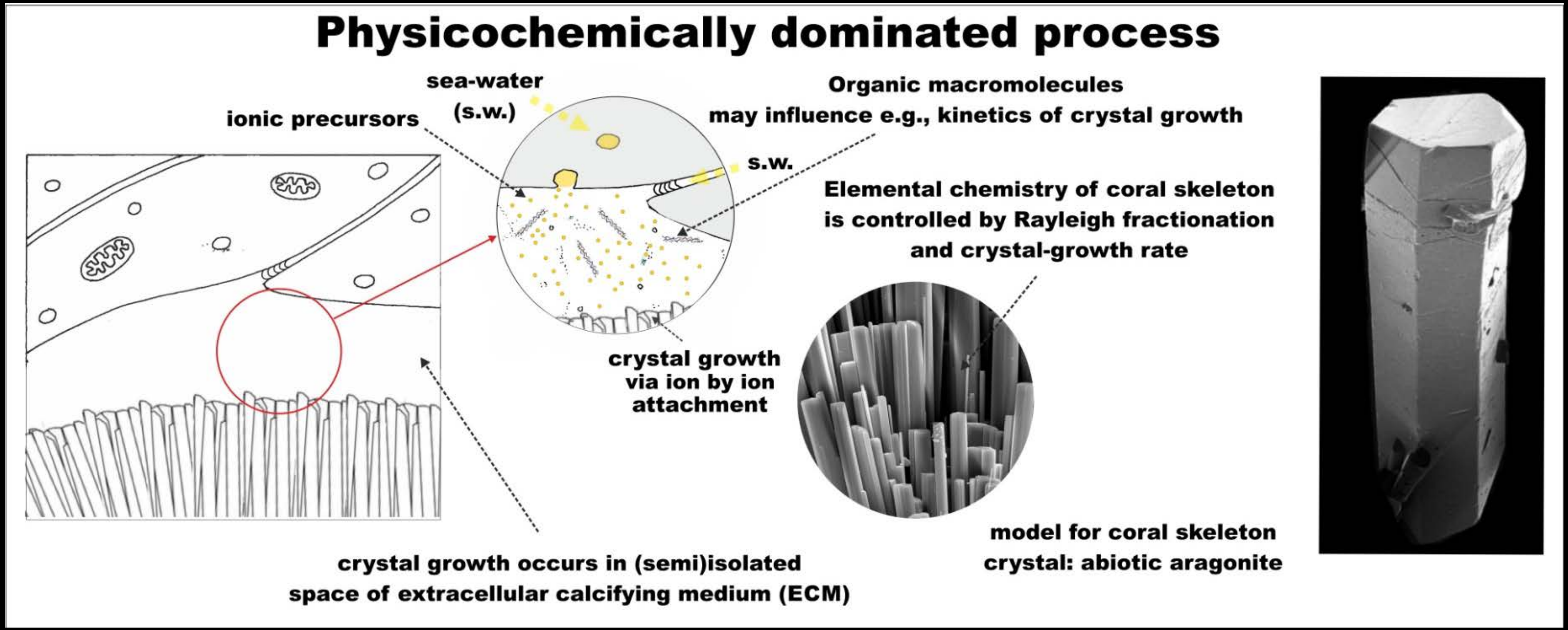
BASALIA
Micrabaciidae
Gardineriidae

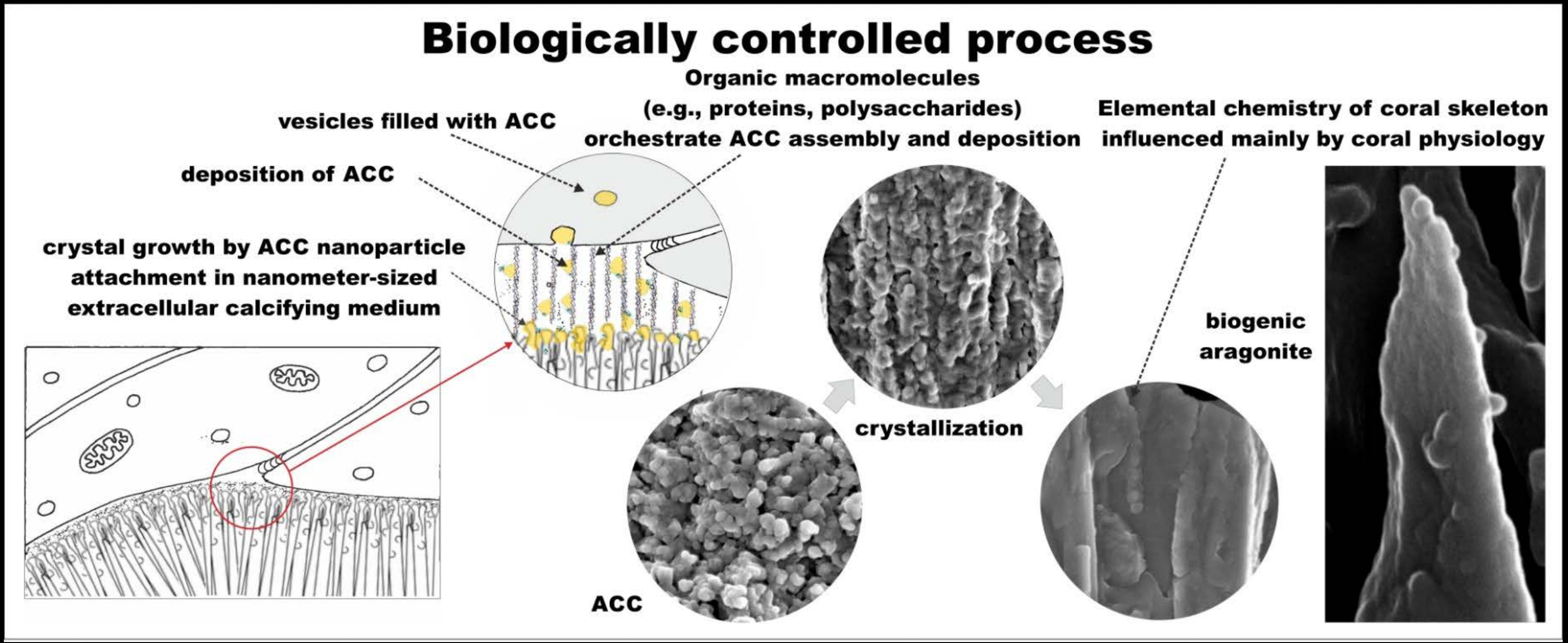
COMPLEXA
Acroporiidae
Flabellidae
Lobophyllidae

ROBUSTA
Anthemiphyllidae
Caryophyllidae s.s.
Pocilloporiidae

Stolarski, J. et al. 2011. The ancient evolutionary origins of Scleractinia revealed by azooxanthellate corals. BMC Evolutionary Biology 11:316

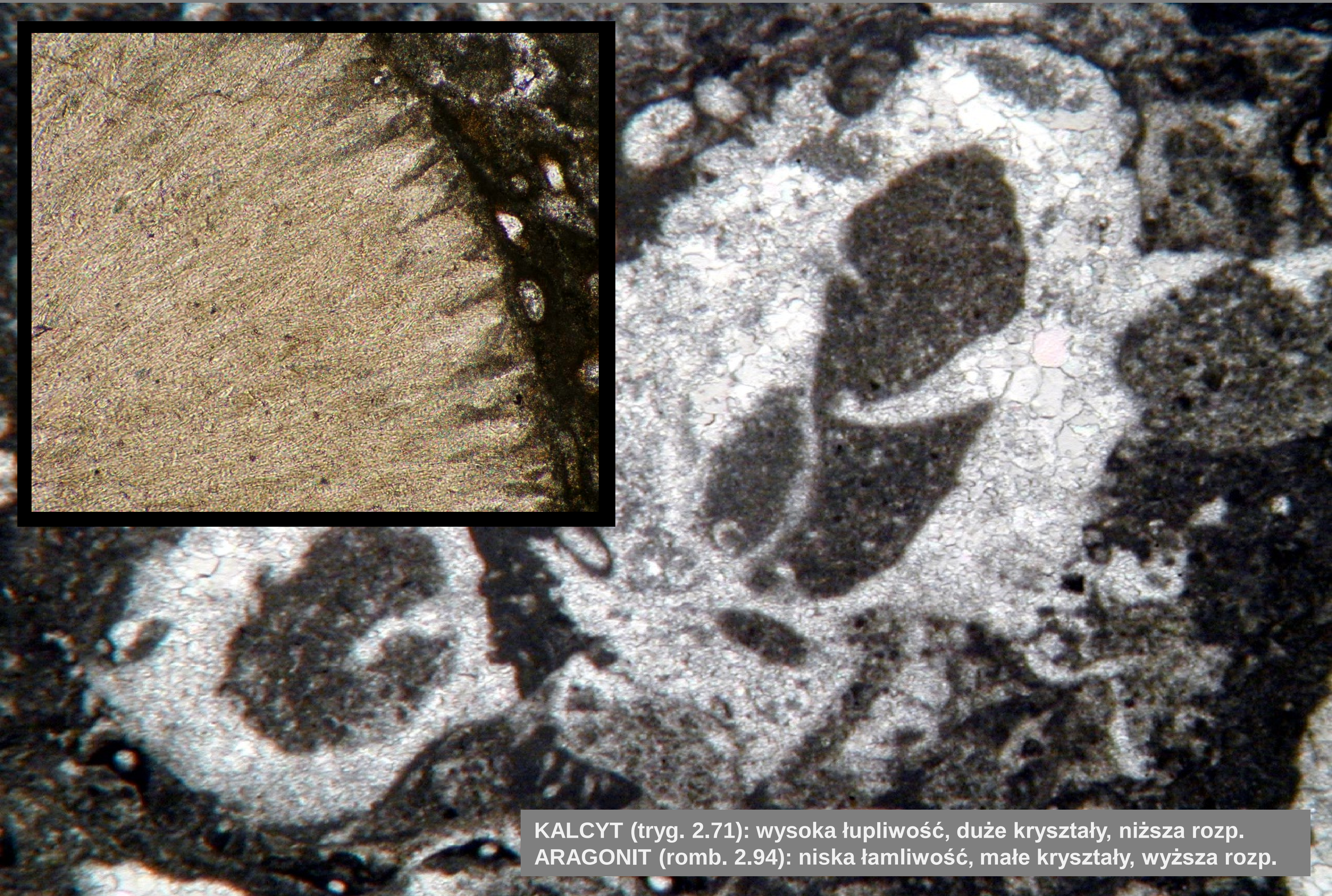
Modele kalcyfikacji: biologiczny vs. fizykochemiczny





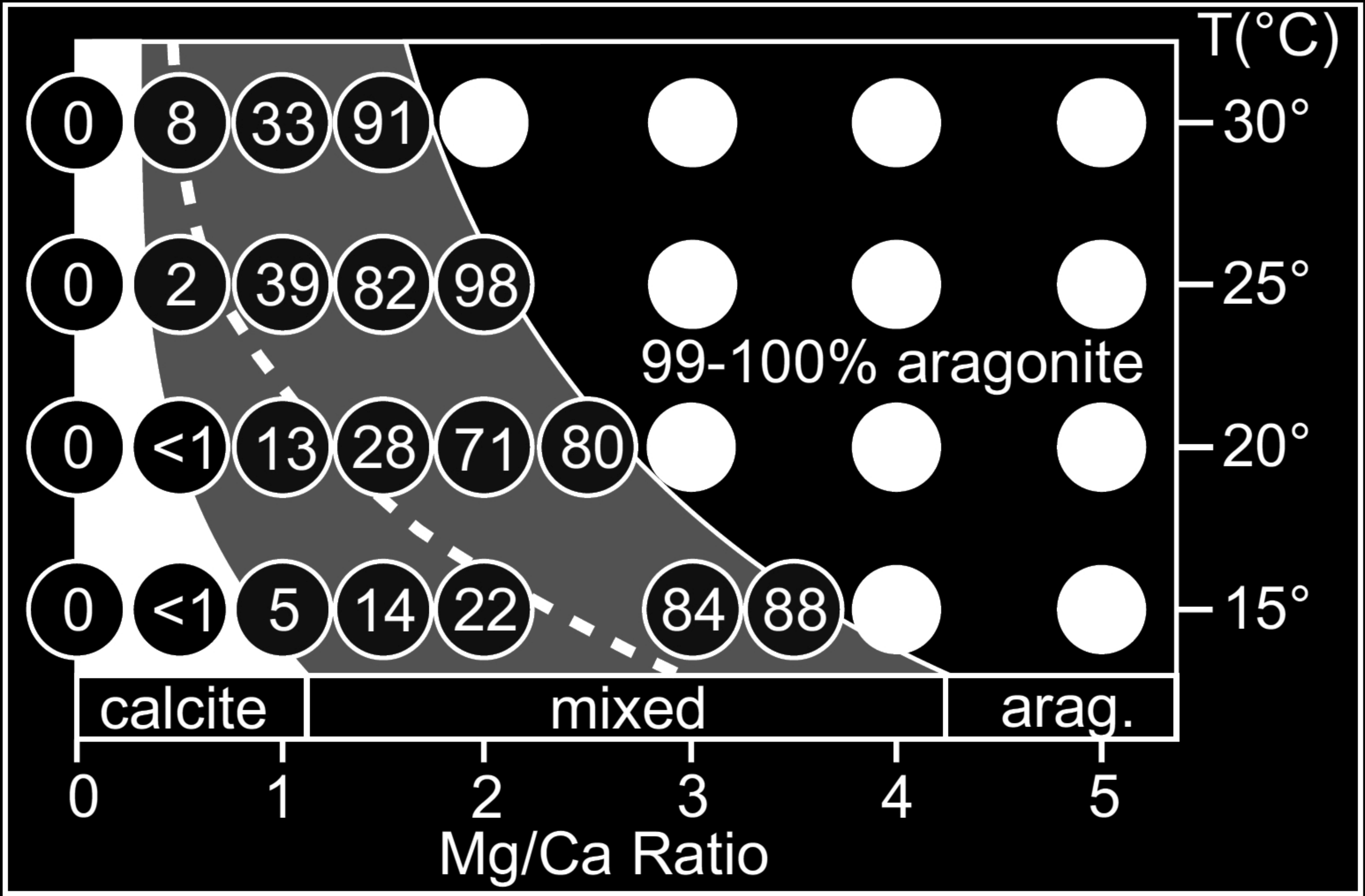
Drake et al. 2020

Diagenetyczne przejście fazowe aragonit -> kalcyt



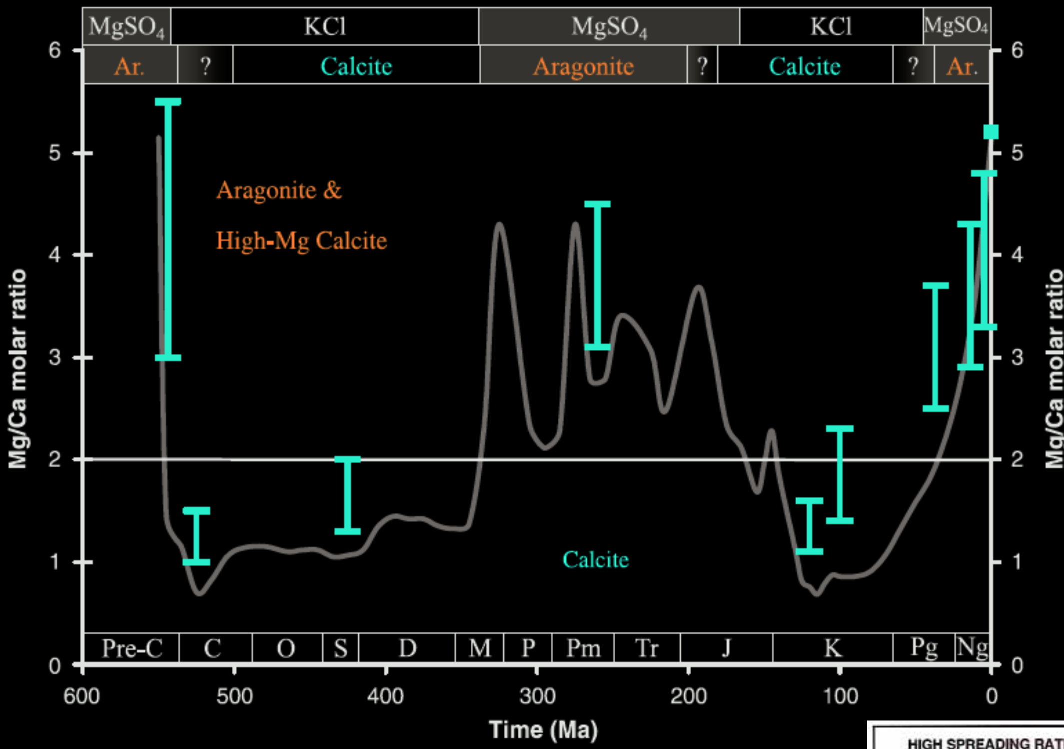
KALCYT (tryg. 2.71): wysoka łupliwość, duże kryształy, niższa rozp.
ARAGONIT (romb. 2.94): niska łamliwość, małe kryształy, wyższa rozp.

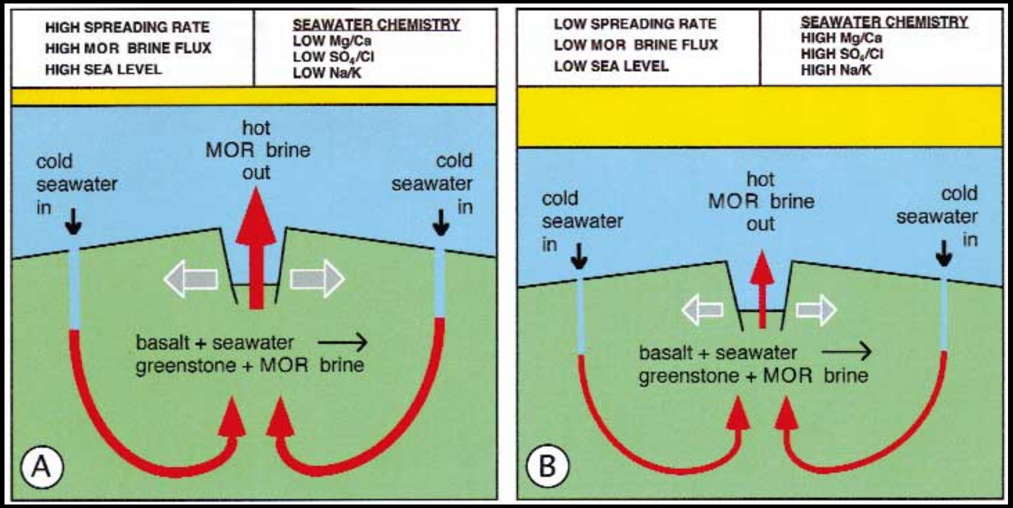
Wytrącanie węglanu wapnia: stosunek Mg/Ca



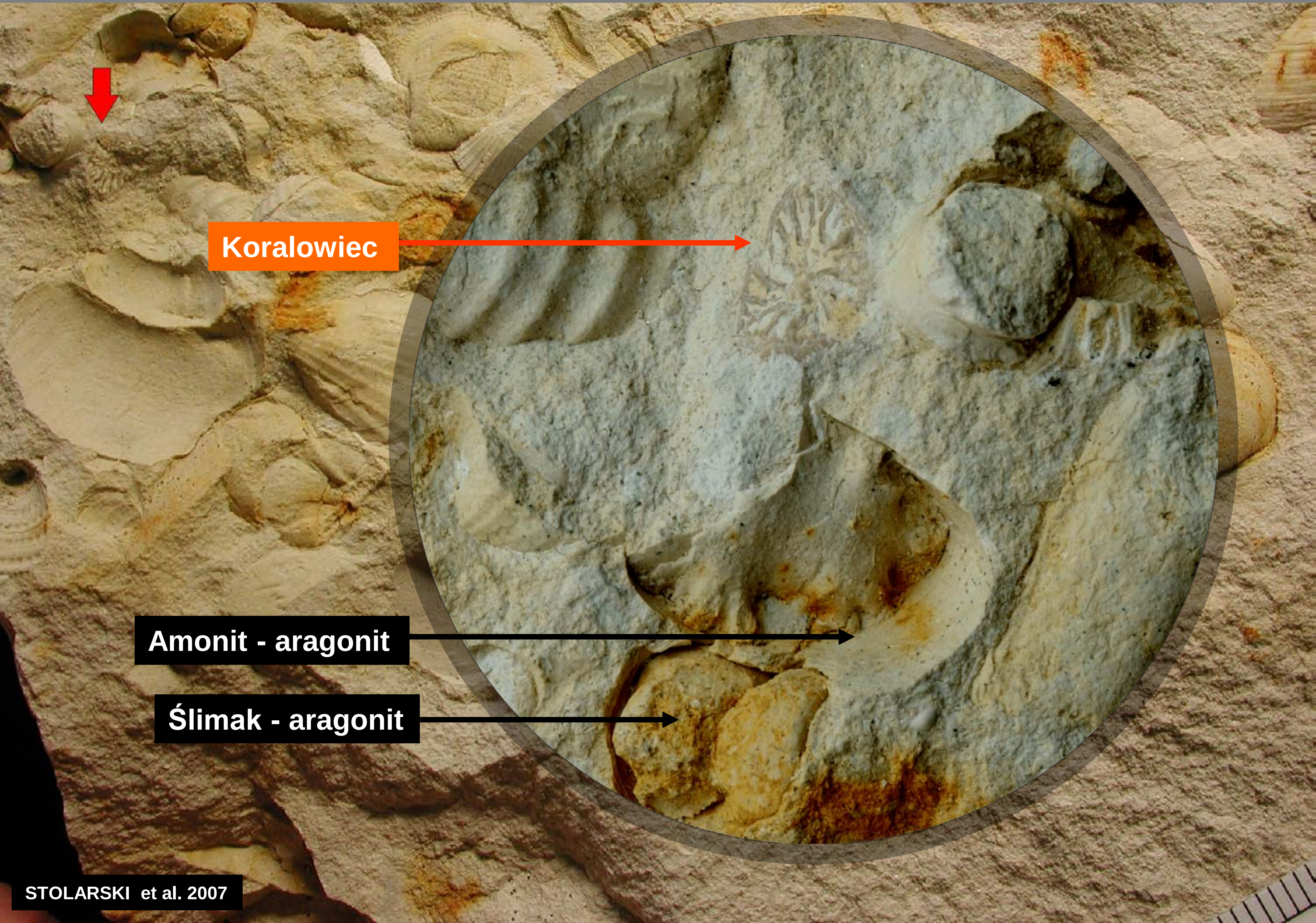
Balthasar & Cusack 2015 Geology 43:99-102

Morza kalcytowe i morza aragonitowe

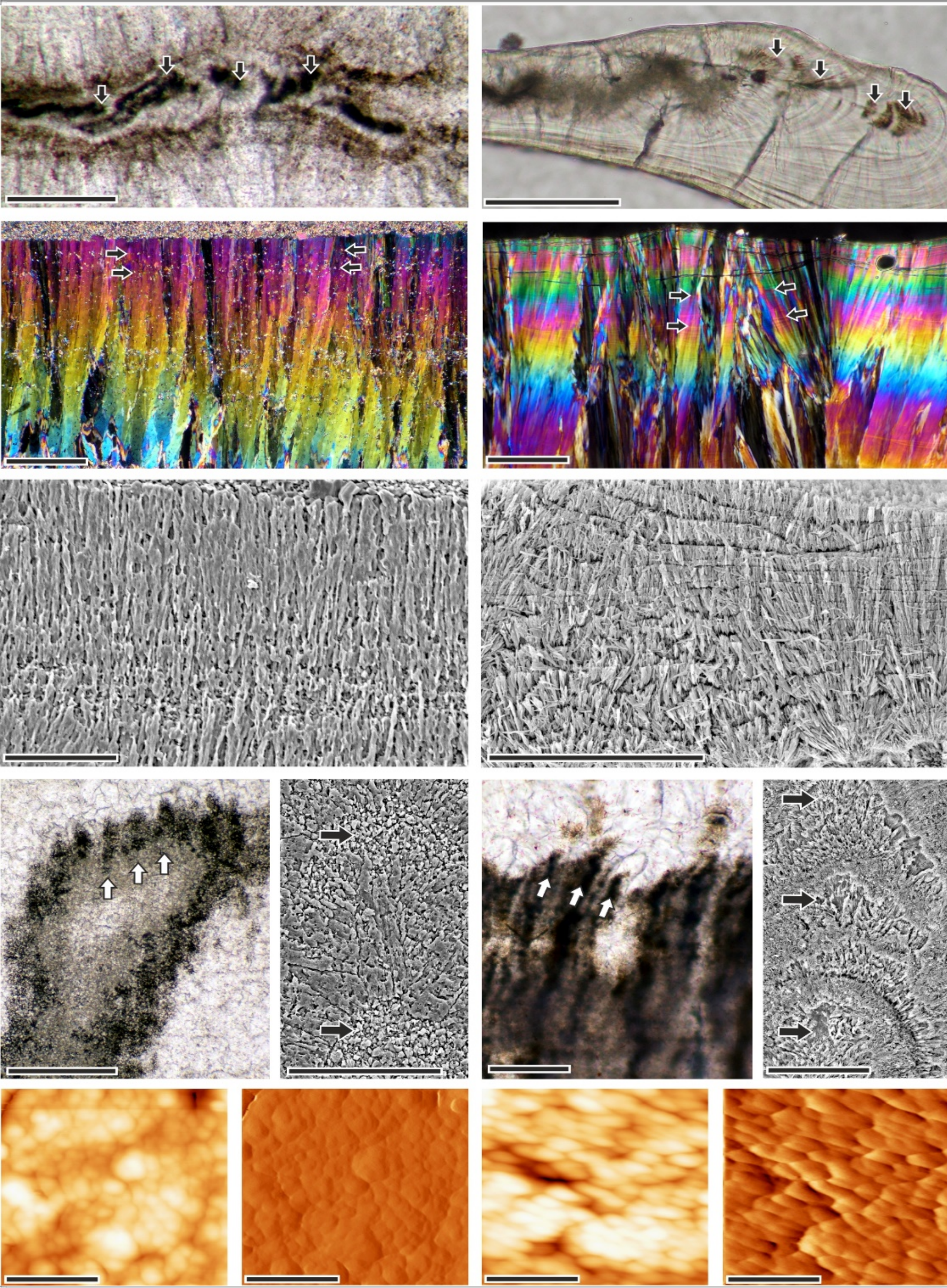




Pierwotnie kalcytowy koralowiec *Coelosmilia* : kreda



Pierwotnie kalcytowy koralowiec *Coelosmilia* : kreda



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16. Materials and methods are available as supporting material on *Science* Online.
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30. Financial support by The Academy of Finland and the UK Natural Environment Research Council is gratefully acknowledged.

Supporting Online Material
www.sciencemag.org/cgi/content/full/1144124/DC1
Materials and Methods
Figs. S1 to S10
Tables S1 to S3
References

23 April 2007; accepted 13 August 2007
Published online 30 August 2007;
10.1126/science.1144124
Include this information when citing this paper.

A Cretaceous Scleractinian Coral with a Calcitic Skeleton

Jarosław Stolarski, Anders Meibom, Radosław Przeniosło, Maciej Mazur

It has been generally thought that scleractinian corals form purely aragonitic skeletons. We show that a well-preserved fossil coral, Coelosmilia sp. from the Upper Cretaceous (about 70 million years ago), has preserved skeletal structural features identical to those observed in present-day scleractinians. However, the skeleton of Coelosmilia sp. is entirely calcitic. Its fine-scale structure and chemistry indicate that the calcite is primary and did not form from the diagenetic alteration of aragonite. This result implies that corals, like other groups of marine, calcium carbonate–producing organisms, can form skeletons of different carbonate polymorphs.

Scleractinian corals belong to the taxonomic class of anthozoans and are among the most prolific biomineralizing organisms in nature (*1*). Their calcium carbonate skeletons form shallow- and deep-water reefs and are prominent in the fossil record as far back as 240 million years ago (Ma) (*2*). Living scleractinians produce entirely aragonitic skeletons (*3*, *4*). An identification of calcite in calcification centers of the shallow-water scleractinian *Mussa* sp. (*5*) was not confirmed by subsequent analysis (*6*). Aragonite is metastable at ambient temperatures and pressures and is susceptible to diagenetic transformation to calcite, the stable form of calcium carbonate under ambient conditions. Most fossil scleractinians have therefore been dissolved or transformed to calcite, preserving only their macroscopic morphology. In these cases, the original mineralogy can be inferred on the basis of their Sr content and by analogy with living scleractinians (*7*). Although some studies have left open the possibility that the original mineralogy of some fossil Scleractinia was calcitic (*8*–*10*), it has been generally accepted that the aragonitic skeletal mineralogy of scleractinians was highly conserved throughout their evolution (*11*).

Here we show that a fossil scleractinian coral formed a calcitic skeleton. We studied a suite of fossil corals attributed to the caryophylliid genus *Coelosmilia*. Our specimens are from the Upper Cretaceous (Maastrichtian) deposits of Poland (fig. S1) and are similar, but not identical, to the fossils studied in (*12*) in which the calcite in the corals was inferred to have formed diagenetically. We have now used a variety of microanalytical methods to show that the calcite is instead primary. The overall skeletal architecture of *Coelosmilia* is similar to that of modern deep-sea corals, such as *Desmophyllum* (Fig. 1) and *Javania* (fig. S2). *Coelosmilia* sp. has a conical calice with septa arranged into five full cycles forming a hexameral pattern. Our specimens are complete skeletons and well preserved. External

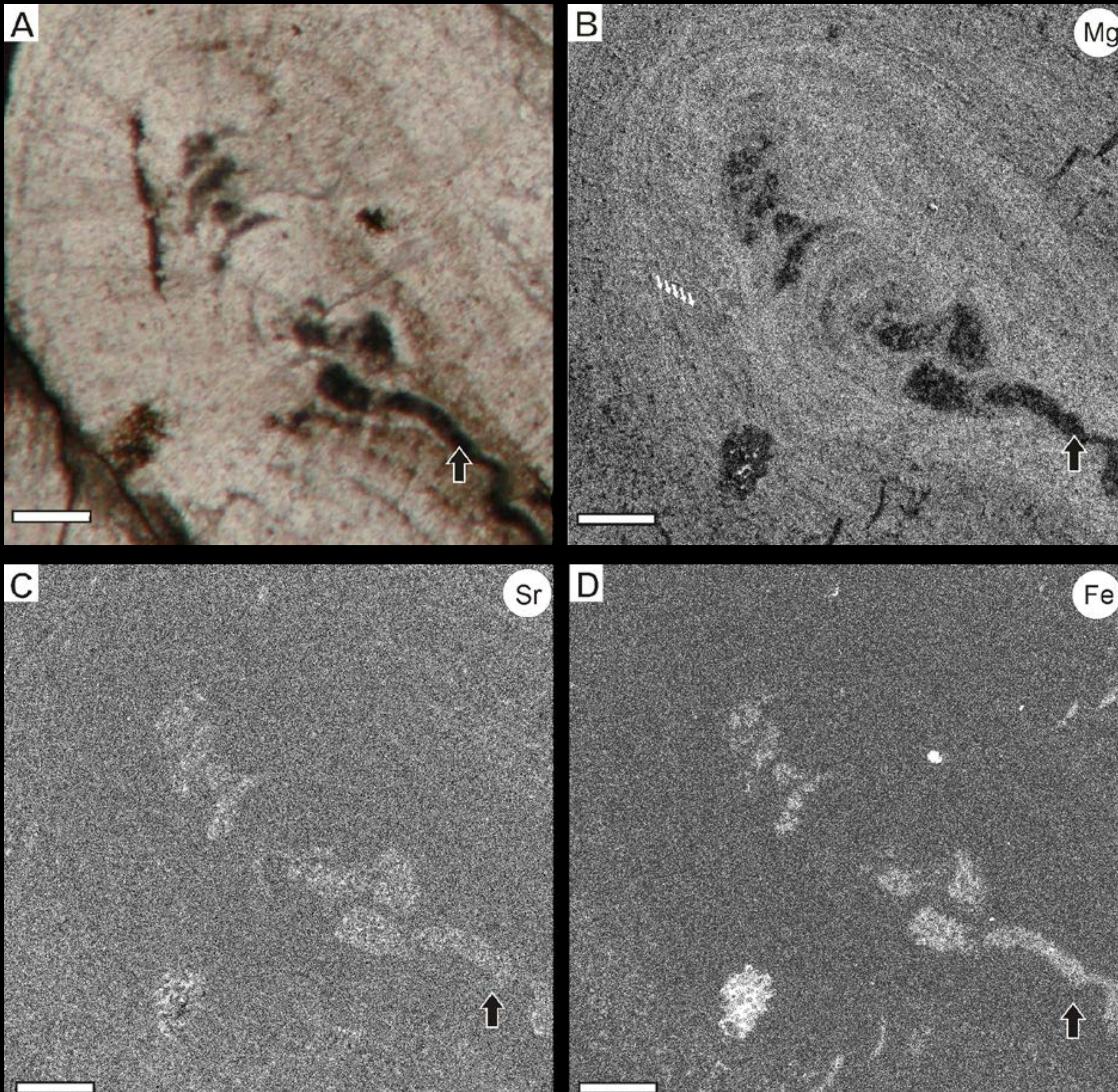
[1]Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, PL-00-818 Warsaw, Poland. [2]Muséum National d'Histoire Naturelle, Laboratoire d'Etude de la Matière Extraterrestre, USM 0205 (LEME), Case Postale 52, 61 rue Buffon, 75005 Paris, France. [3]Institute of Experimental Physics, University of Warsaw, Hoża 69, PL-00-681 Warsaw, Poland. [4]Department of Chemistry, Laboratory of Electrochemistry, University of Warsaw, Pasteura 1, PL-02-093 Warsaw, Poland.

*To whom correspondence should be addressed. E-mail: stolacy@twarda.pan.pl

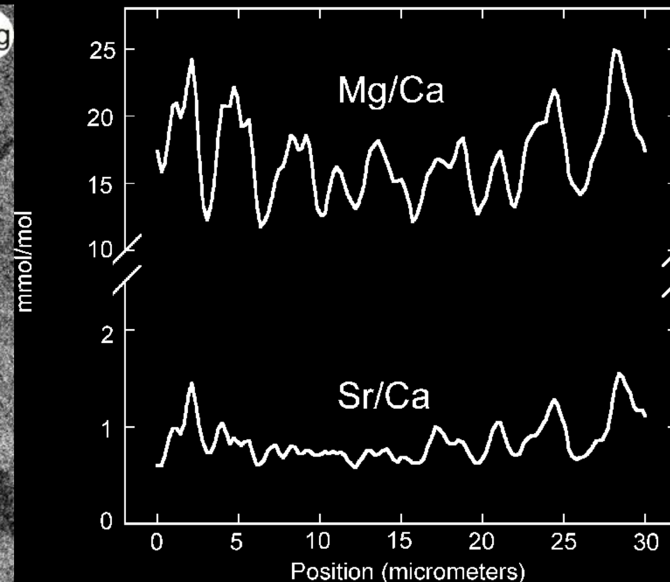
Fig. 1. Morphology of the Late Cretaceous calcitic *Coelosmilia* sp. Relatively smooth septa, a thick septothecal wall, and a lack of pali are typical features of this solitary, azooxanthellate scleractinian coral.

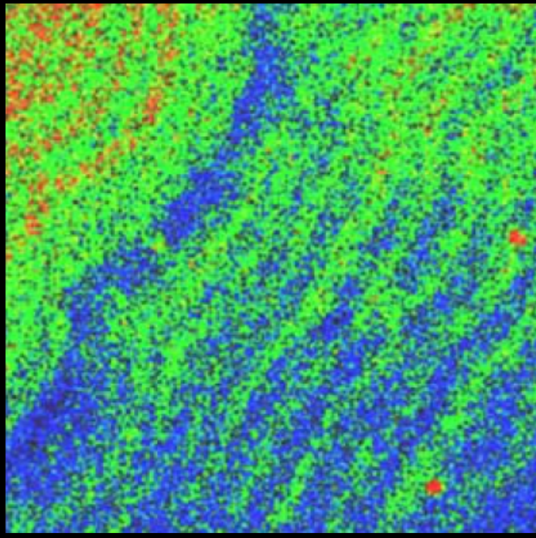
Stolarski et al. 2007 Science

Pierwotnie kalcytowy koralowiec *Coelosmilia* : mikrostruktura i geochemia



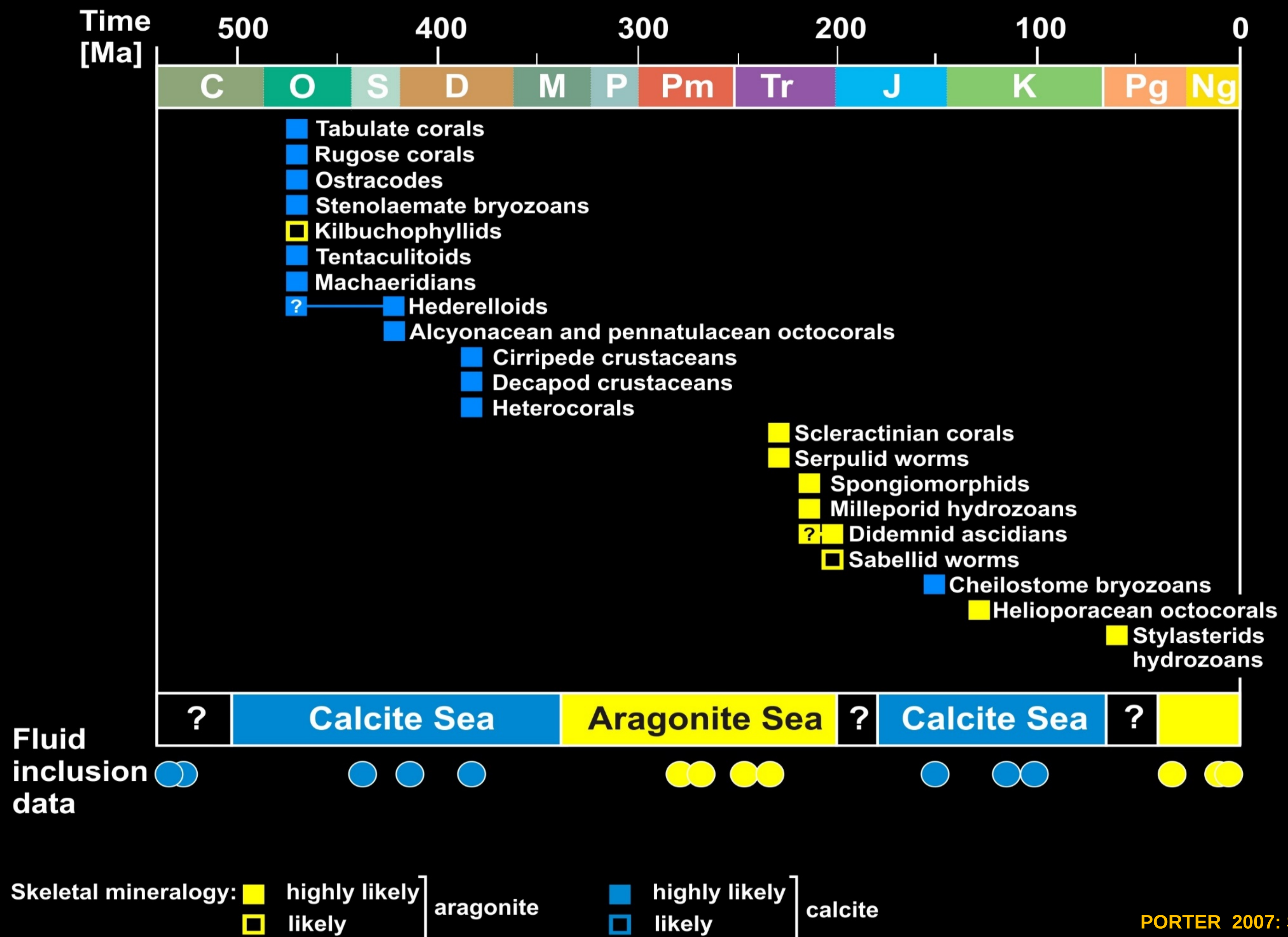
STOLARSKI et al. 2007





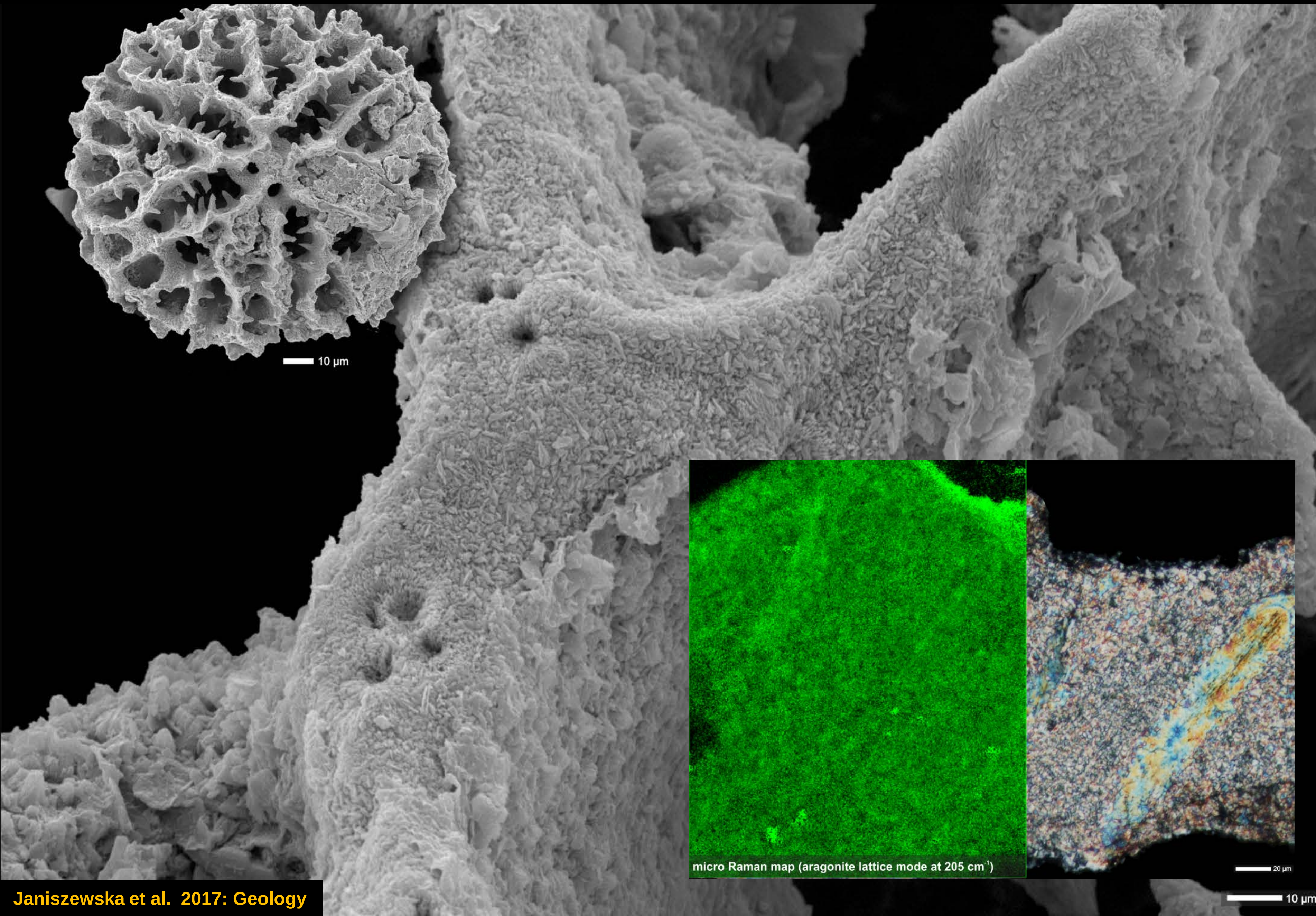
MEIBOM et al. 2004

Czas wyłonienia się kladu w stanie kopalnym vs. mineralogia szkieletu



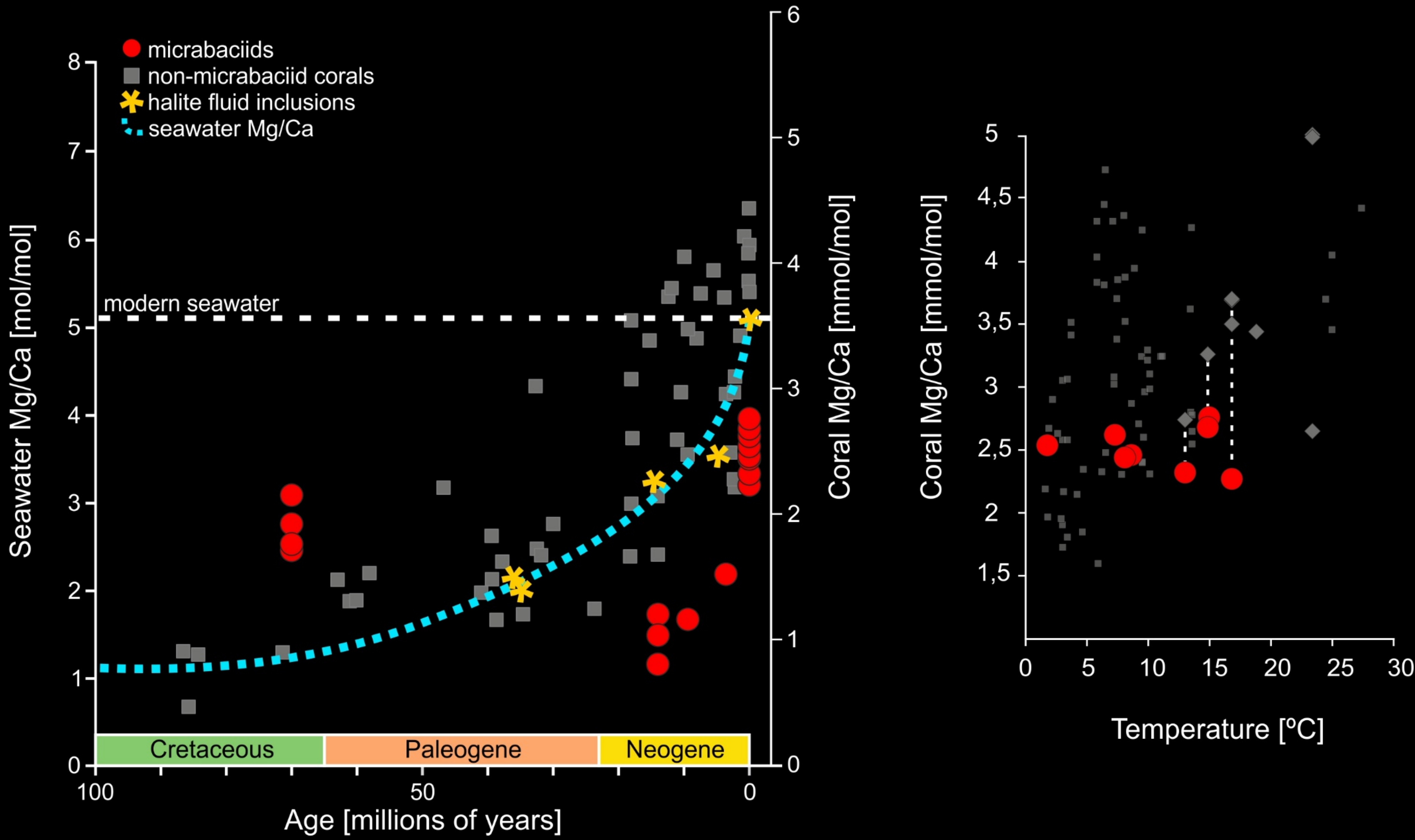
PORTER 2007: Science

Kredowe, aragonitowe mikrabacidy

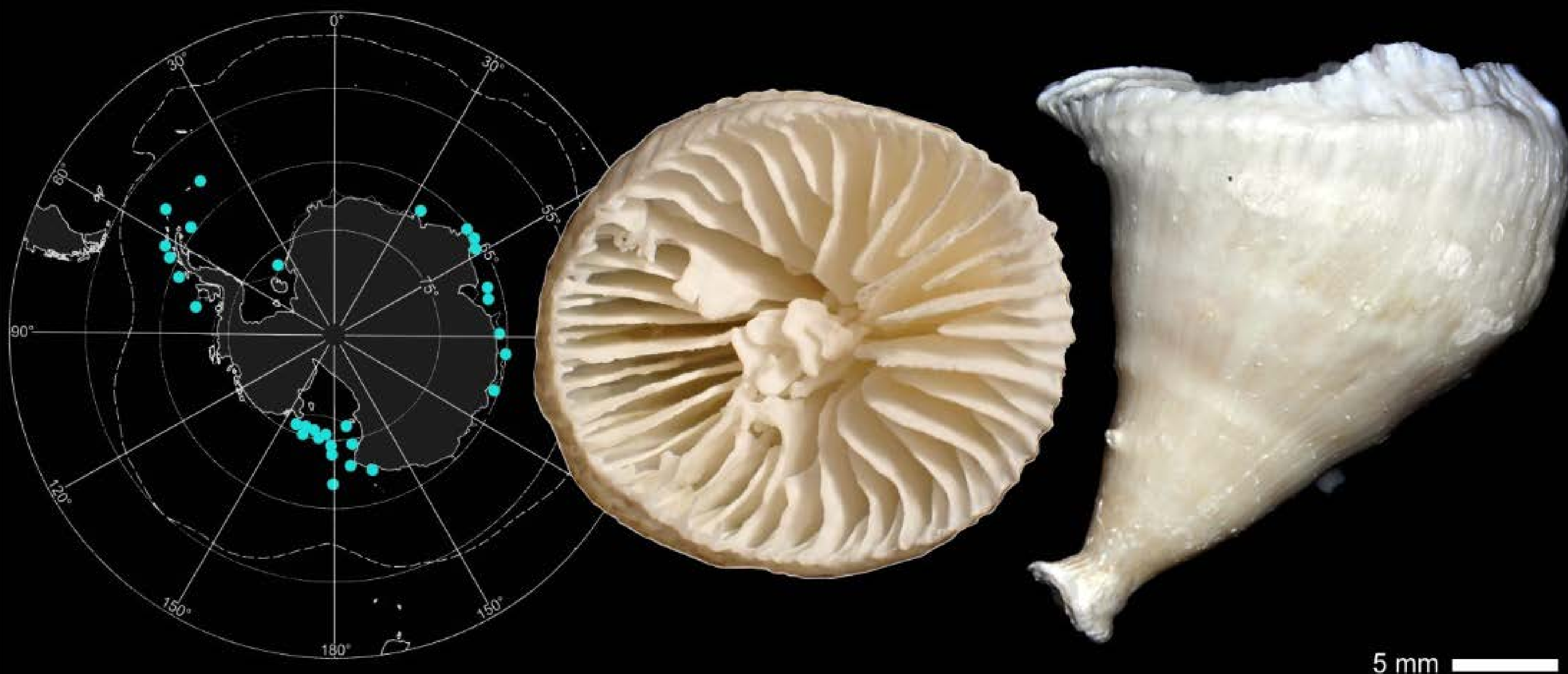


Janiszewska et al. 2017: Geology

Kopalne i dzisiejsze aragonitowe mikrabacidy: geochemia szkieletu reliktem fizjologii mórz kredowych?

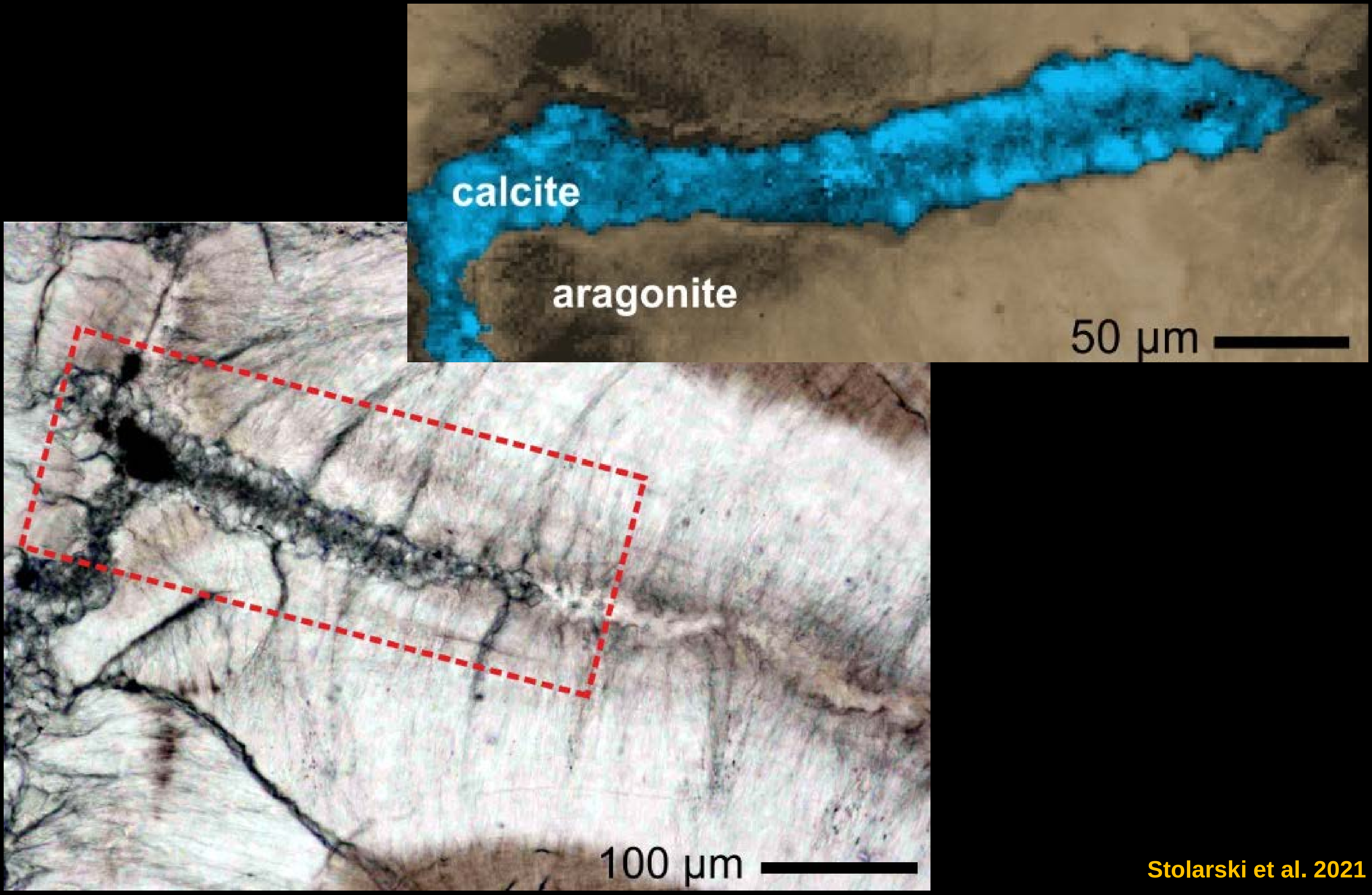


Paraconotrochus antarcticus z Oceanu Południowego (50-700 m)



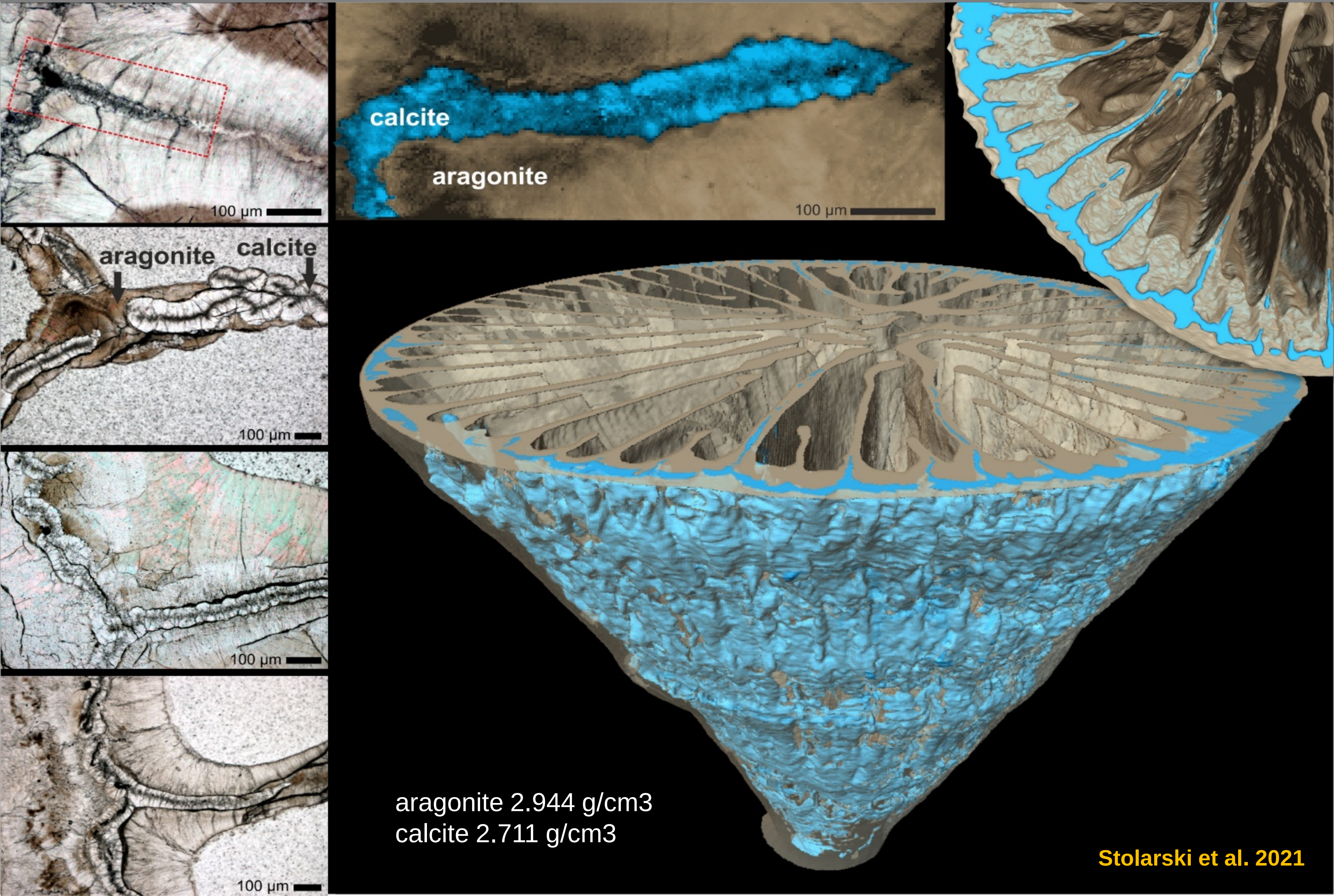
Stolarski et al. 2021

Paraconotrochus antarcticus z Oceanu Południowego: struktura i mineralogia szkieletu

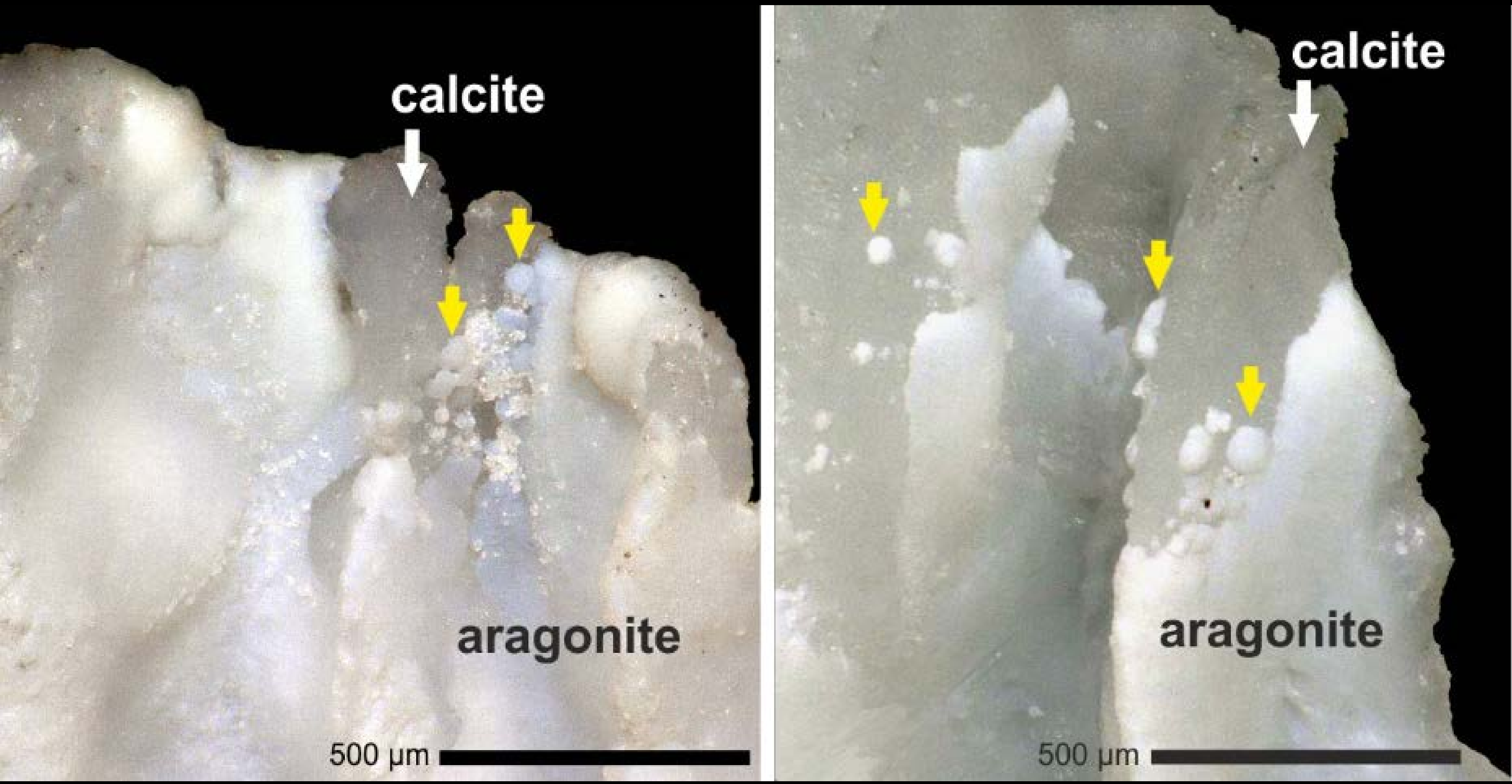


Stolarski et al. 2021

Paraconotrochus antarcticus z Oceanu Południowego: struktura i mineralogia szkieletu

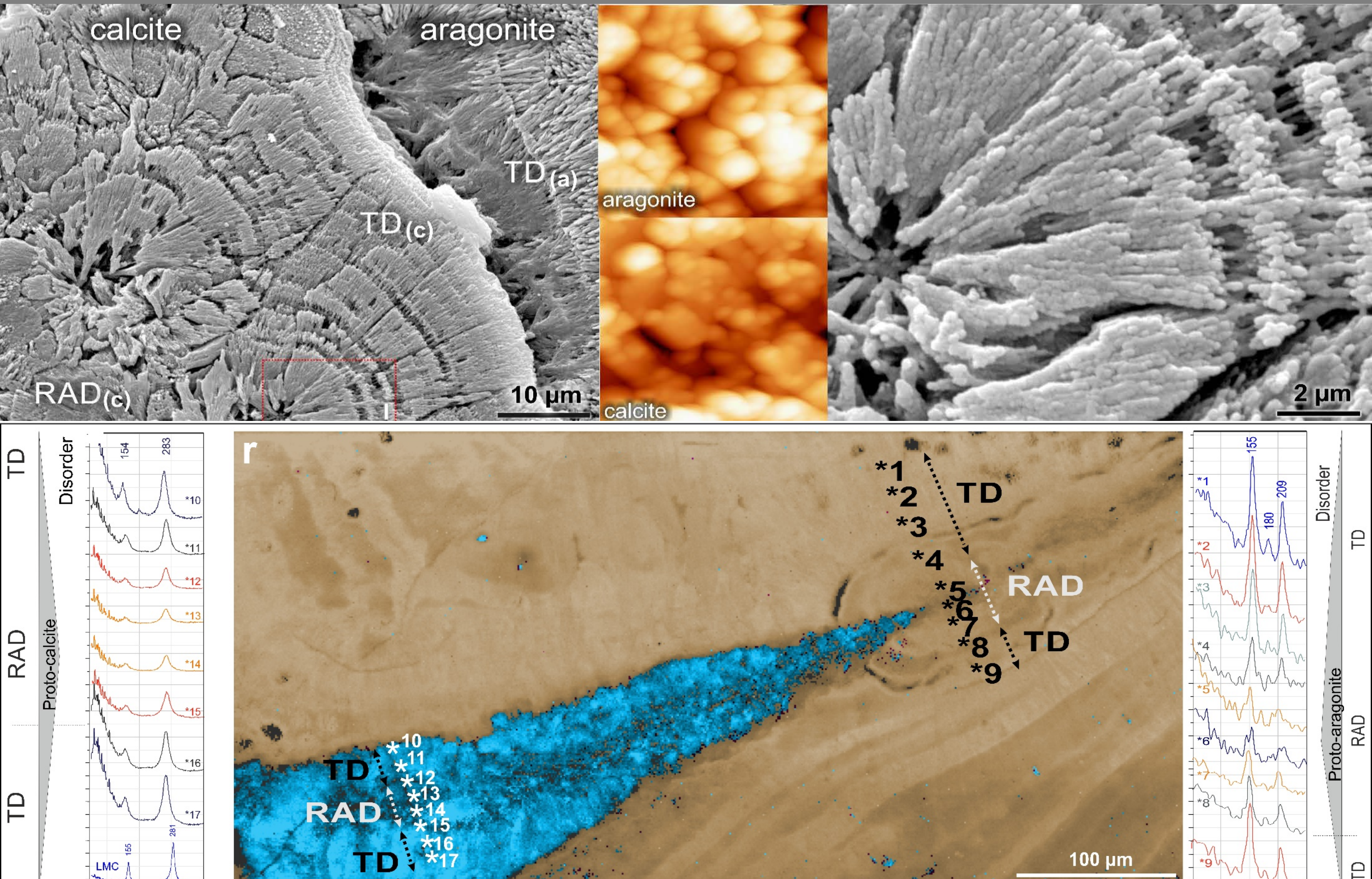


Paraconotrochus antarcticus z Oceanu Południowego: struktura i mineralogia szkieletu



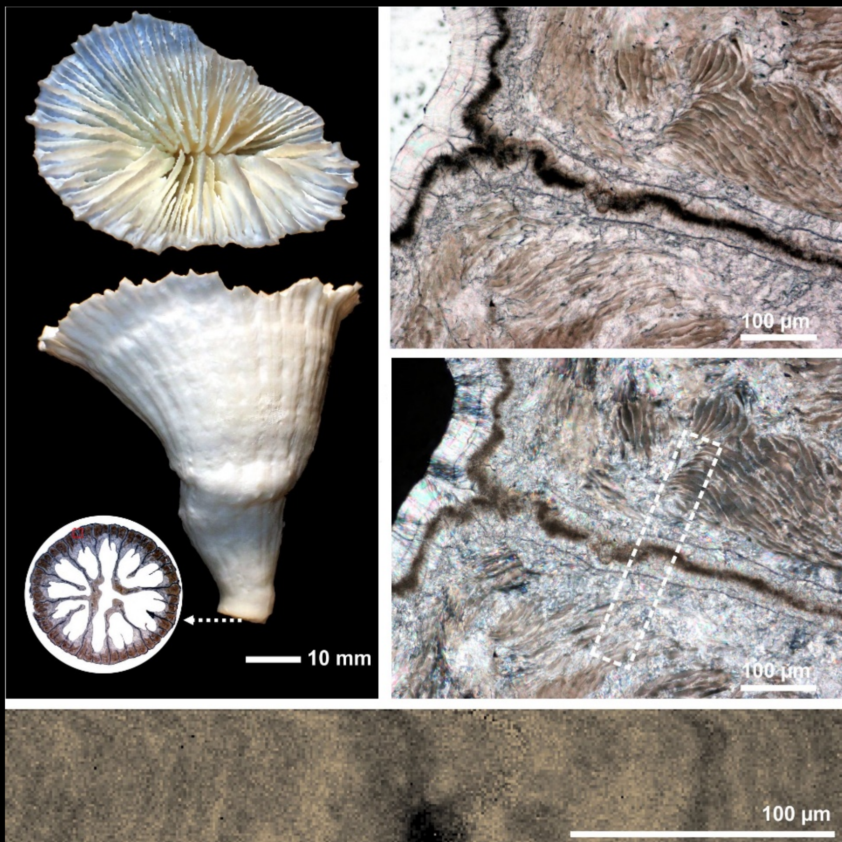
Stolarski et al. 2021

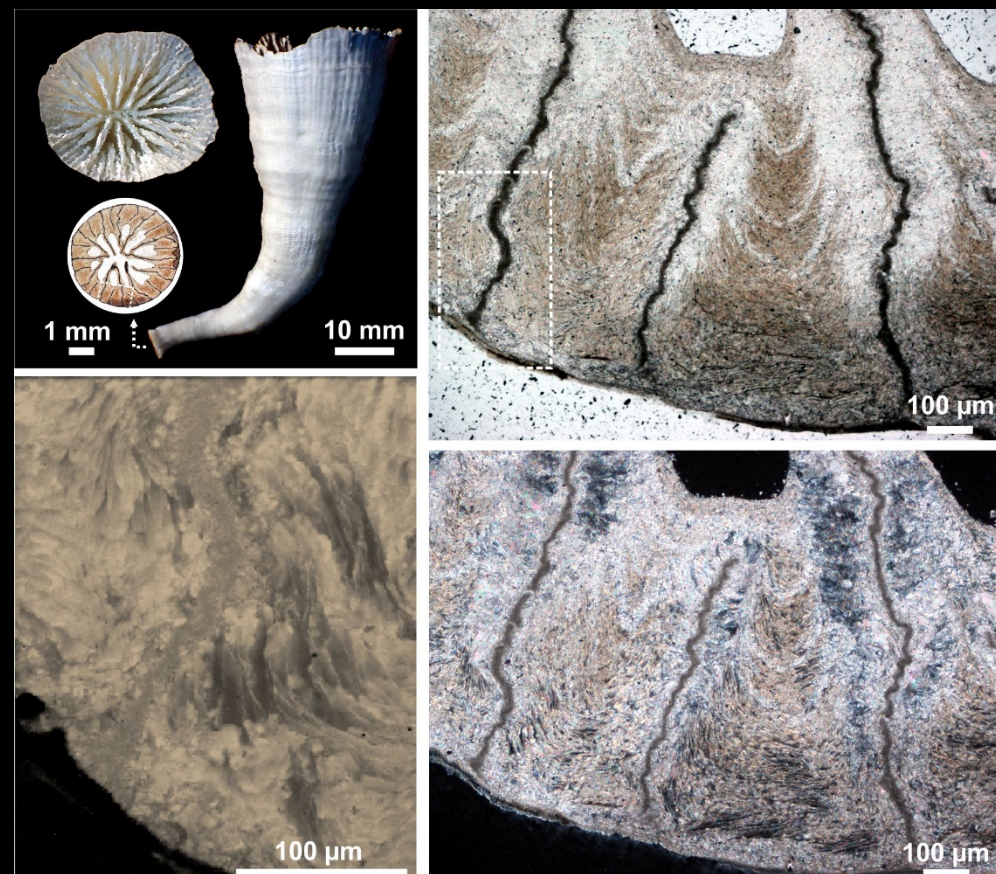
Paraconotrochus antarcticus z Oceanu Południowego: struktura i mineralogia szkieletu



Stolarski et al. 2021

Koralowce współwystępujące z *P. antarcticus* (Ocean Południowy)

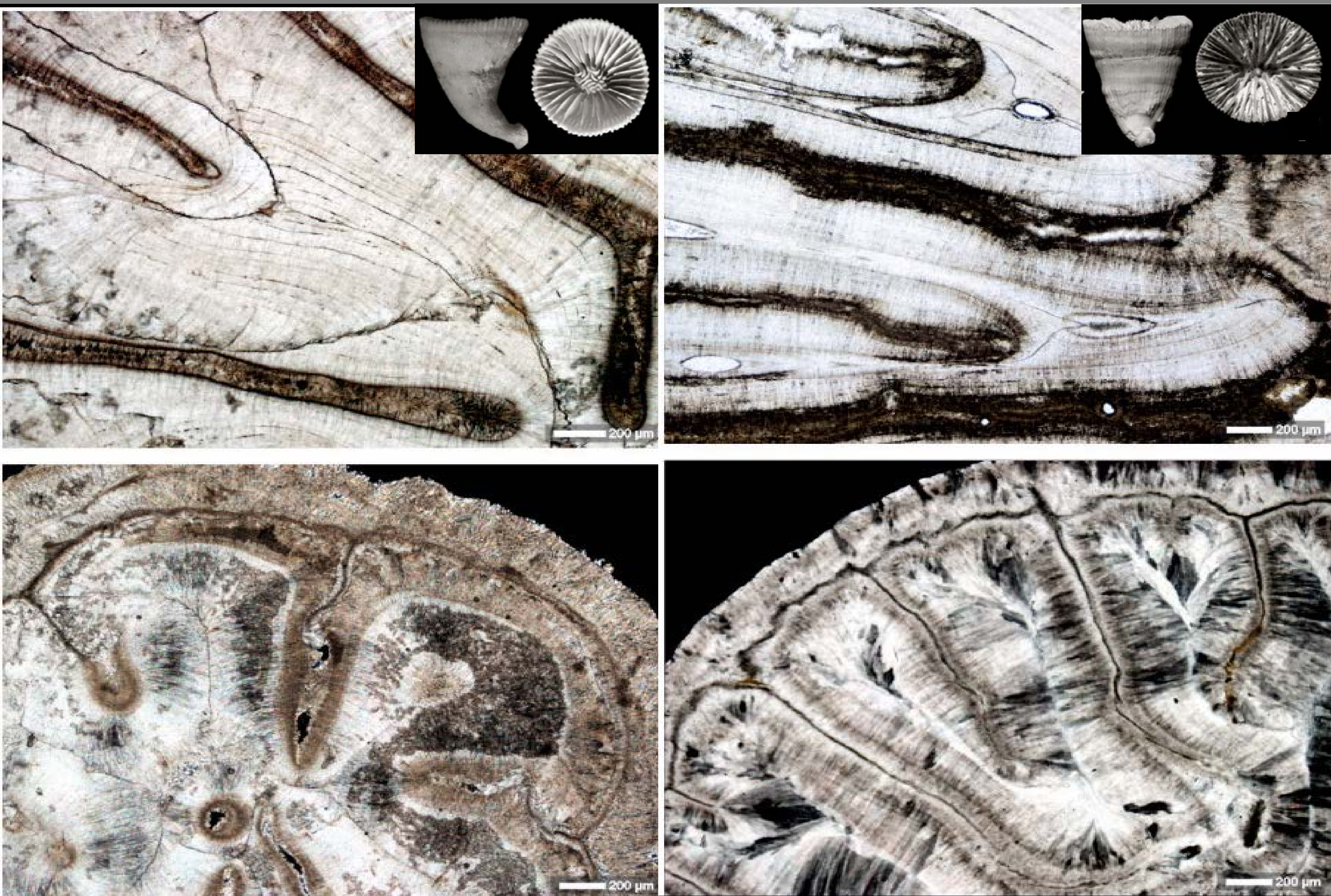




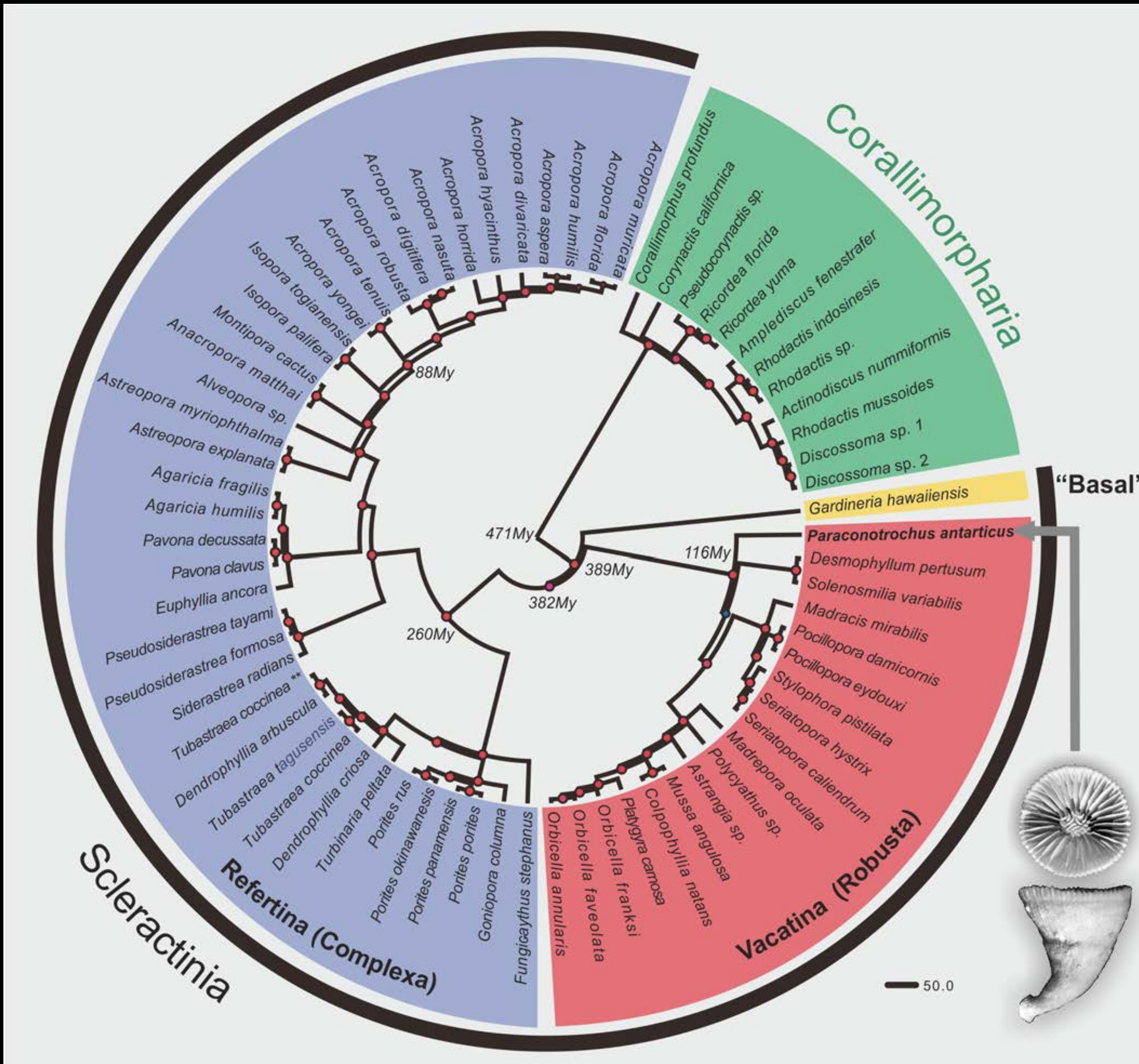
Stolarski et al. 2021

P. antarcticus vs. Coelosmilia

Stolarski et al. 2021

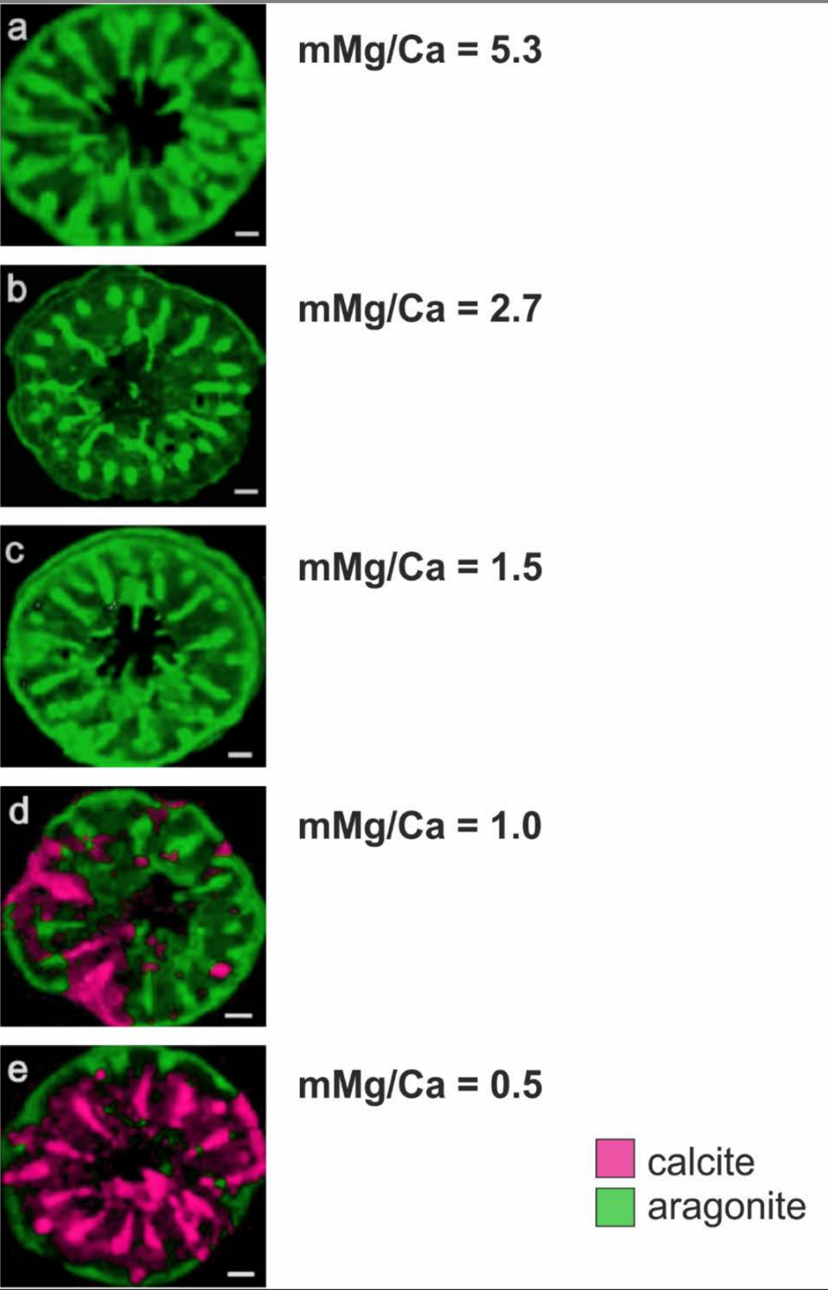


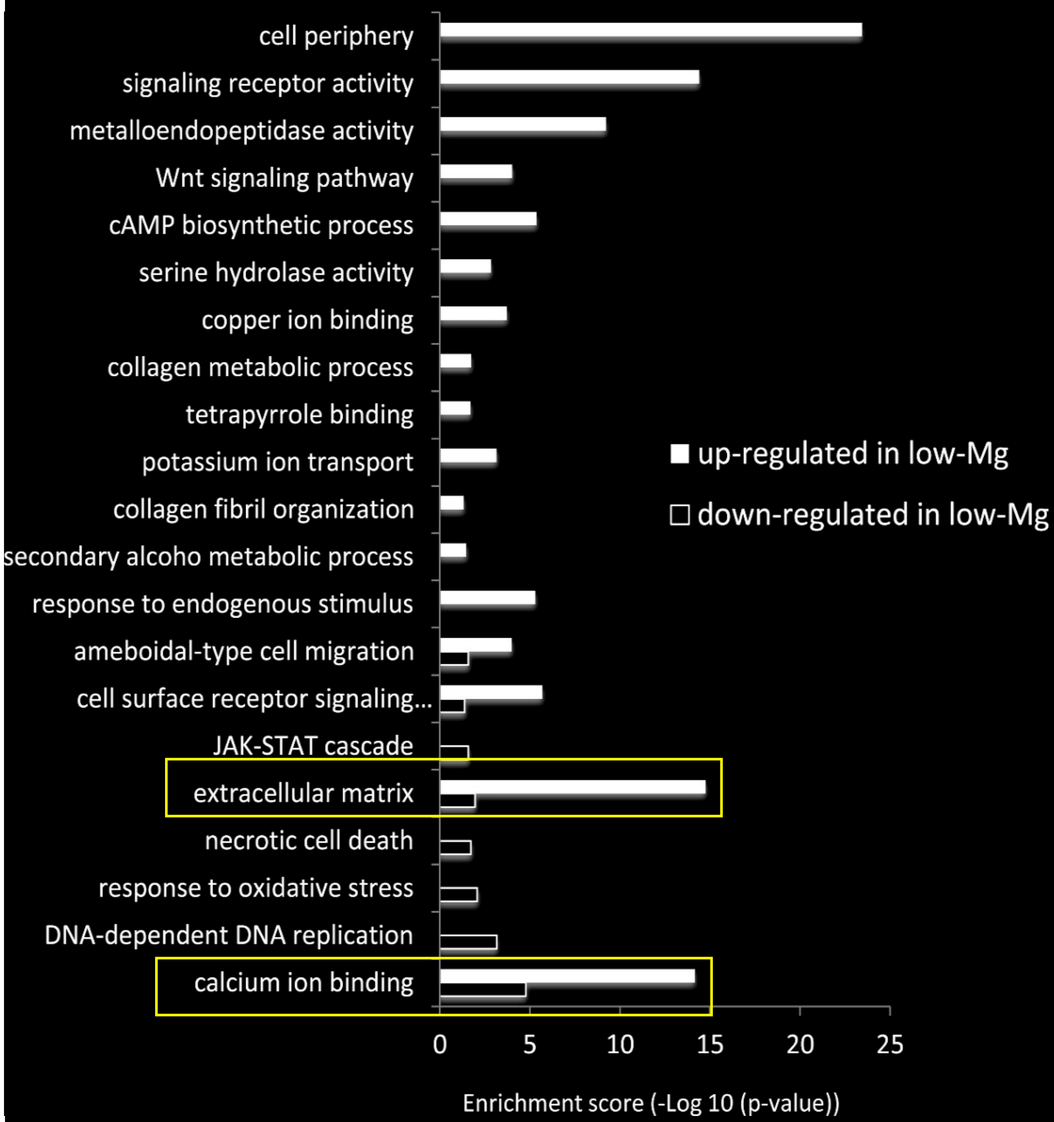
P. antarcticus vs filogeneza (kompletny genom mitochondrialny)



Stolarski et al. 2021

Eksperymenty: kalcytowy szkielet we wczesnej astogenezie *Acropora*

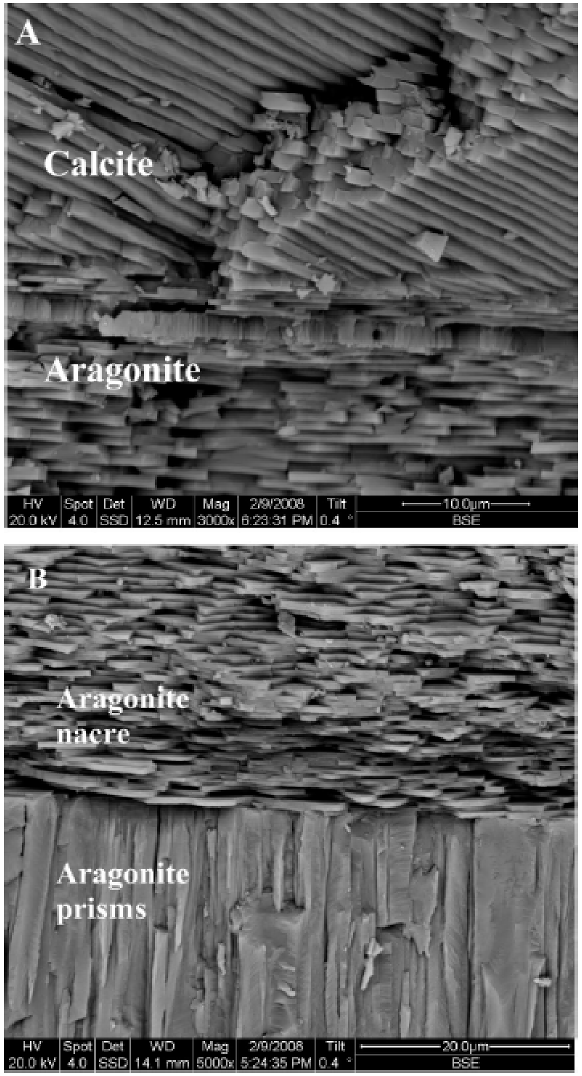




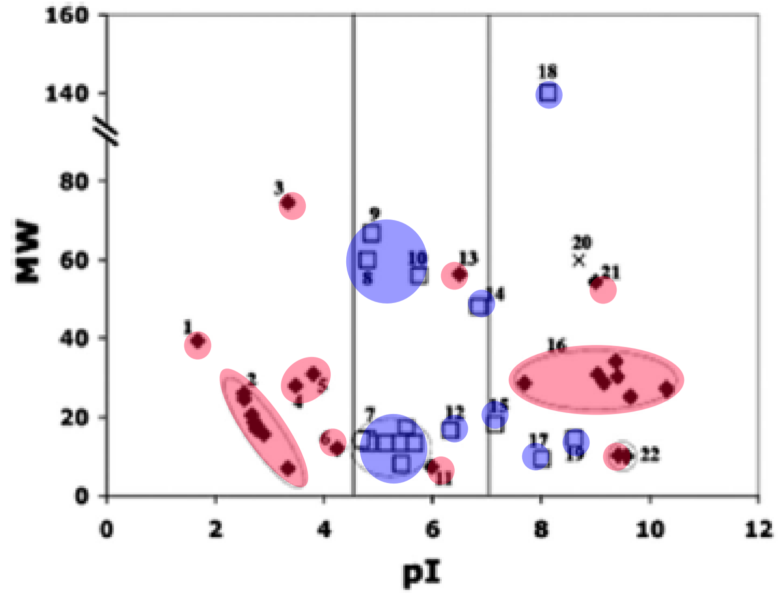
Higuchi et al. 2014: PLOS ONE

Yuyama & Higuchi et al. 2019: PeerJ

Mięczaki: aragonit vs kalcyt



Backscattered electron image of fracture section of two bivalves. (A) The bimineralic *Mytilus edulis* with calcite prisms to the exterior (top) and aragonite nacre to the interior (bottom). Scale bar = 10 μm. (B) Interface between aragonite nacre (top) and aragonite prisms (bottom) at the innermost shell of *Modiolus modiolus*. Scale bar = 20 μm.



KALCYT

ARAGONIT

Molluscan shell proteins according to their molecular weight and pI values. Open squares indicate those proteins associated with aragonite; filled diamonds indicate those associated with calcite; and crosses indicate proteins associated with both polymorphs. 1 = aspein; 2 = Asp-rich proteins; 3 = MSP-1; 4 = MSP-2; 5 = MS131; 6 = prismalin-14; 7 = N-14/N16/pearlin/perline proteins masking AP7 and AP24; 8 = MS160; 9 = mucoperlin; 10 = nacrein from *P. fucata*; 11 = MSI7; 12 = dermatopontin; 13 = tyrosinase-like1; 14 = nacrein from *T. marmoratus*; 15 = perlucin; 16 = shematrin proteins; 17 = perlustrin; 18 = lustrin A; 19 = perlwapin; 20 = N-66; 21 = tyrosine-like2; 22 = KRMPs. Reprinted with permission from ref 202. Copyright 2008 Elsevier B.V.

Makrocząsteczki zaangażowane w nukleację kalcytu są silnie wieloanionowe i silnie kwasowe w porównaniu do makrocząsteczek zaangażowanych w nukleację aragonitu.

Marin et al. 2007 Current Topics in Developmental Biology

Wpływ białka Stm (*starmaker*) na mineralogię otolitów *Danio*: Söllner et al. Science 2003 282- 286