

A Novel Approach to the Classification and Quantification of Microbial Images: Applications on Bahamian Stromatolites

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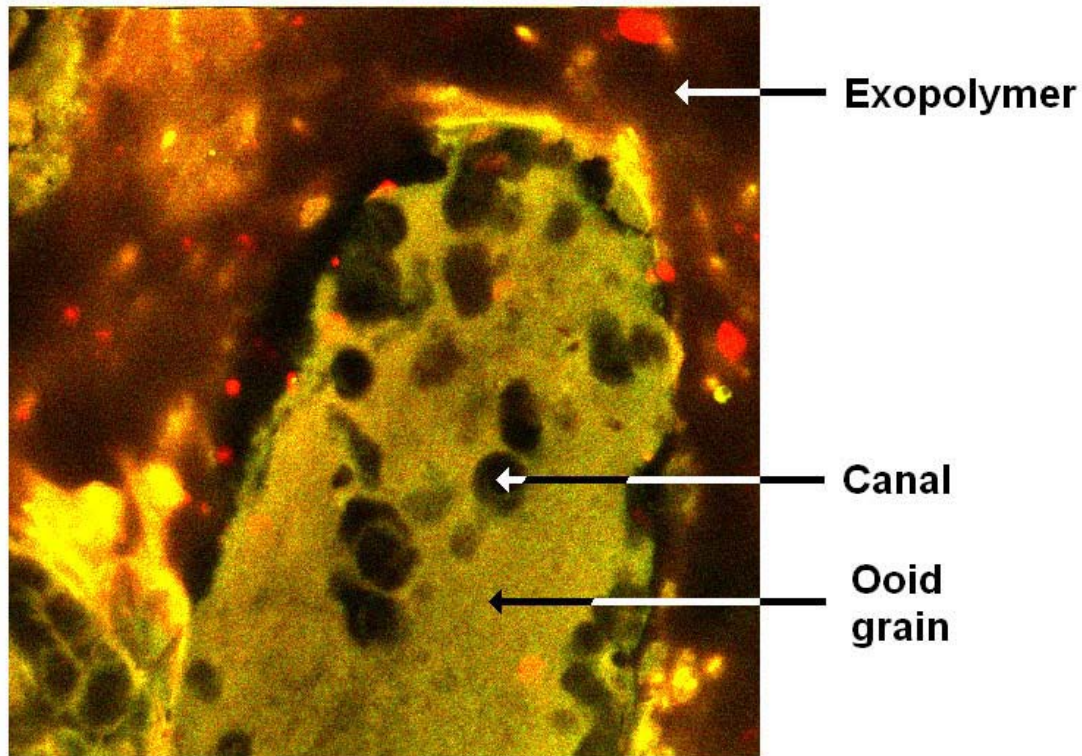
Stromatolites

Picture courtesy of OAR/National Undersea Research Program

- Oldest macrofossils on Earth (3 billion years)
- Still formed in the Bahamas
- Built through bacterial activities, mainly CaCO_3 precipitation and dissolution; influenced by environmental conditions such as pH, temperature etc.
- Laminated structure; there are three types of mat communities; two of which produce *micritic layers*
- Understanding their formation will facilitate understanding of prehistoric conditions



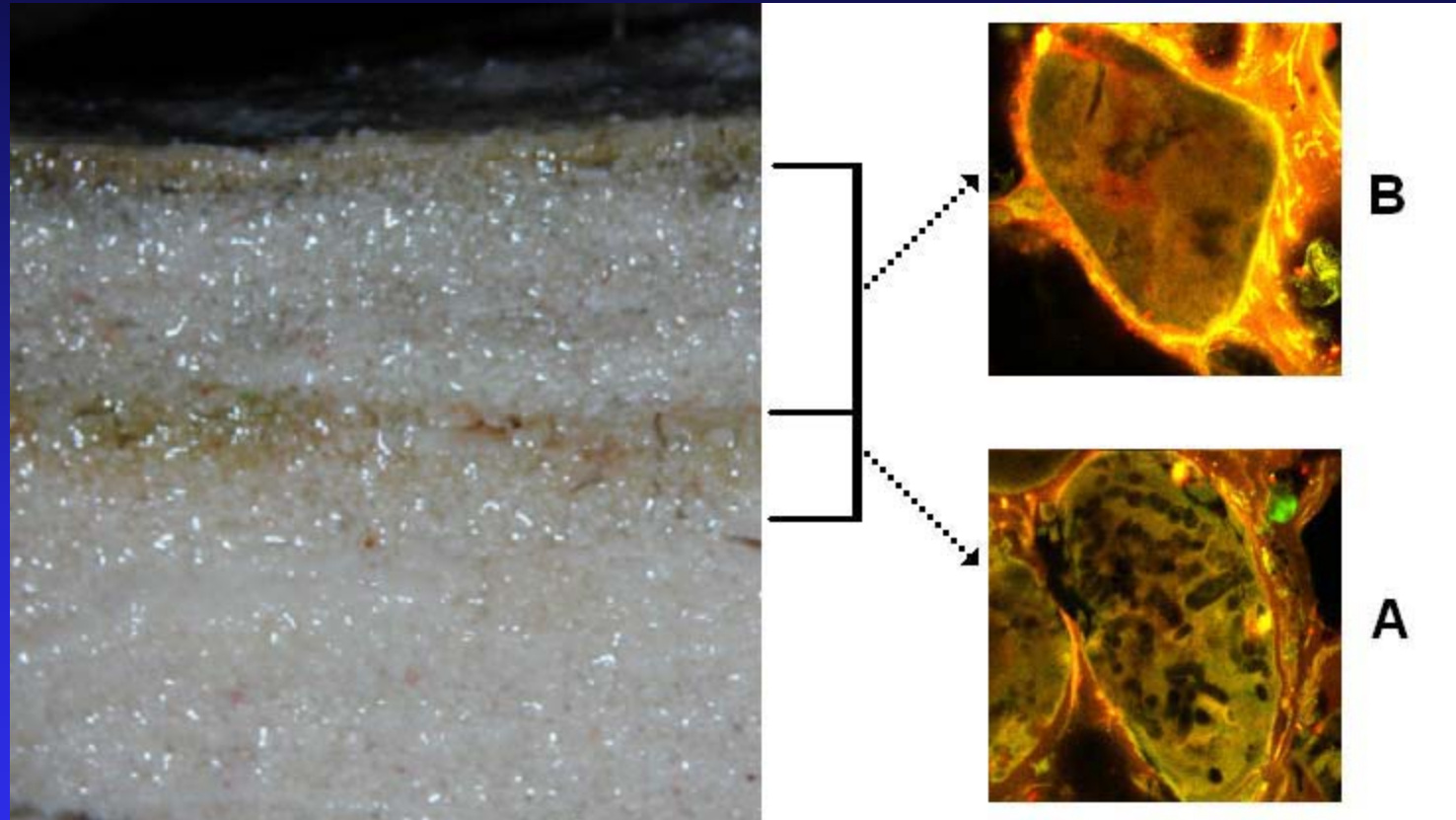
Research on boring processes



Boring processes, in ooid grains is due to endolithic species (*Solentia sp.*), and differentiates between "Type I" and "Type III" layers. Microbored "canals" are more abundant in Type III layers.

[A.I. Petrisor and A.W. Decho, Using geographical information techniques to quantify the spatial structure of endolithic boring processes within sediment grains of marine stromatolites, *Journal of Microbiological Methods*, *in press*]

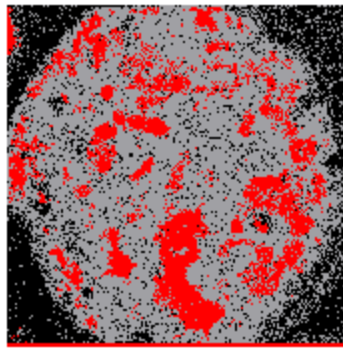
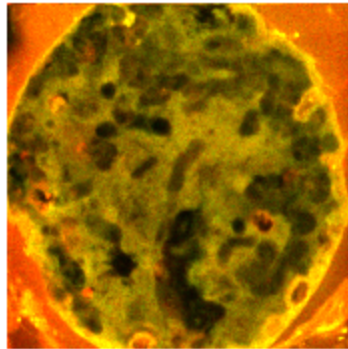
Can differences be seen?



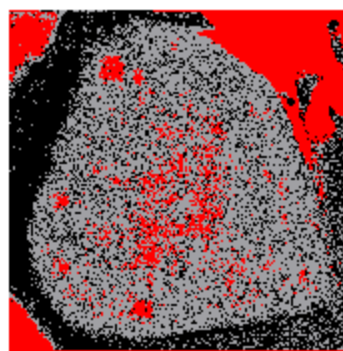
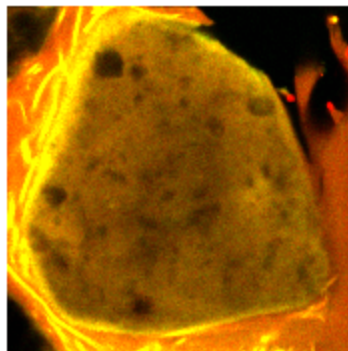
A- Type I mats; B- Type III mats

Classification and quantification

1



2



A

B

C

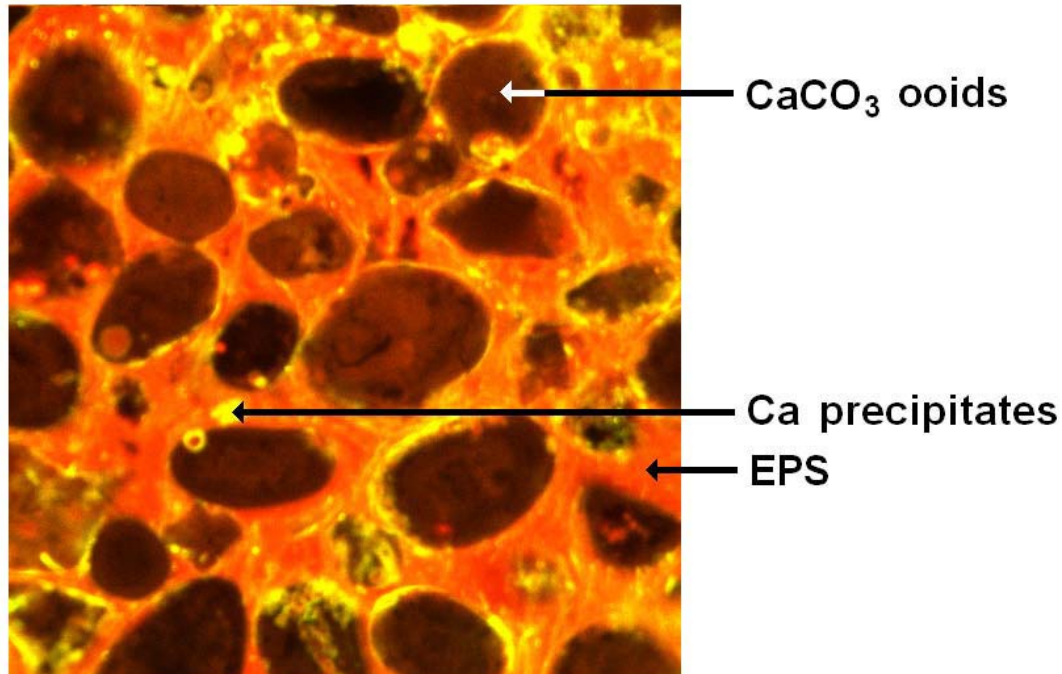
D

1- abundant canals; 2- fewer canals; A- initial images, B- classified images, C- filtered images, D- reclassified images with canals selected within the ooids

Results and significance

The results are consistent with what could be seen from sample images. Nevertheless, our approach provides a method to quantify differences: boring processes are significantly more abundant ($p < 0.001$) in Type III Mats. The conclusion is based on random samples of 30 images selected from within each type of mat.

Calcification in stromatolites

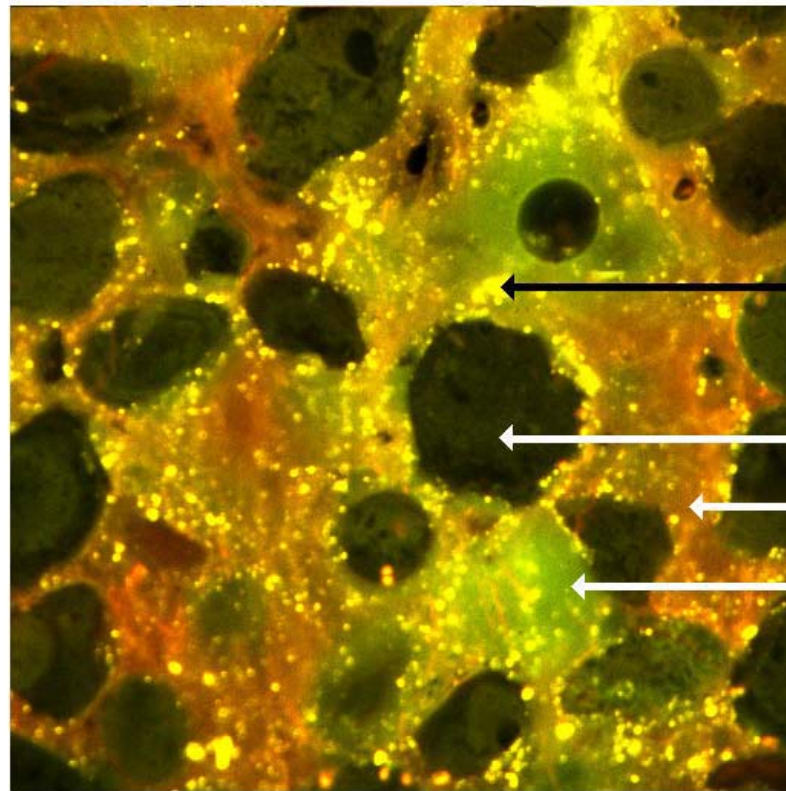


Typical image from Type I layers

This ongoing research is quantifying the amount of CaCO₃ precipitates in Type I and Type II layers. The results indicate significantly larger amounts in Type II layers. This is related to the activities of sulfate-reducing bacteria.

[A.I. Petrisor, T. Kawaguchi, and A.W. Decho, Manuscript in preparation]

Calcification in stromatolites (continued)



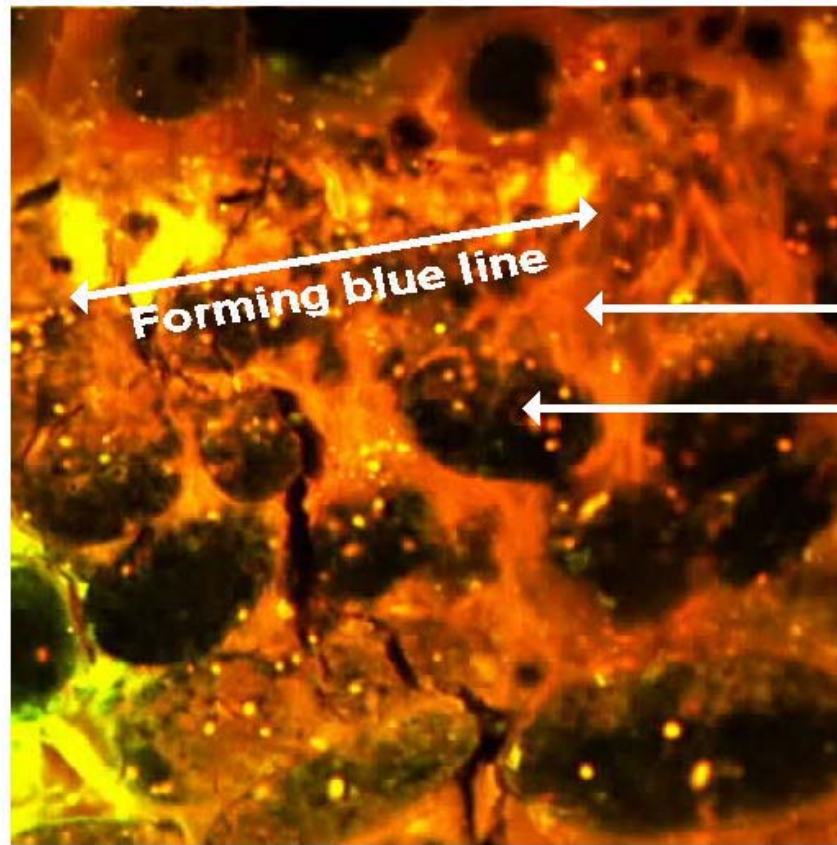
Ca precipitates

CaCO₃ ooids

EPS

Typical image from Type II layers

Natural break between the two types of mats: The Blue Line



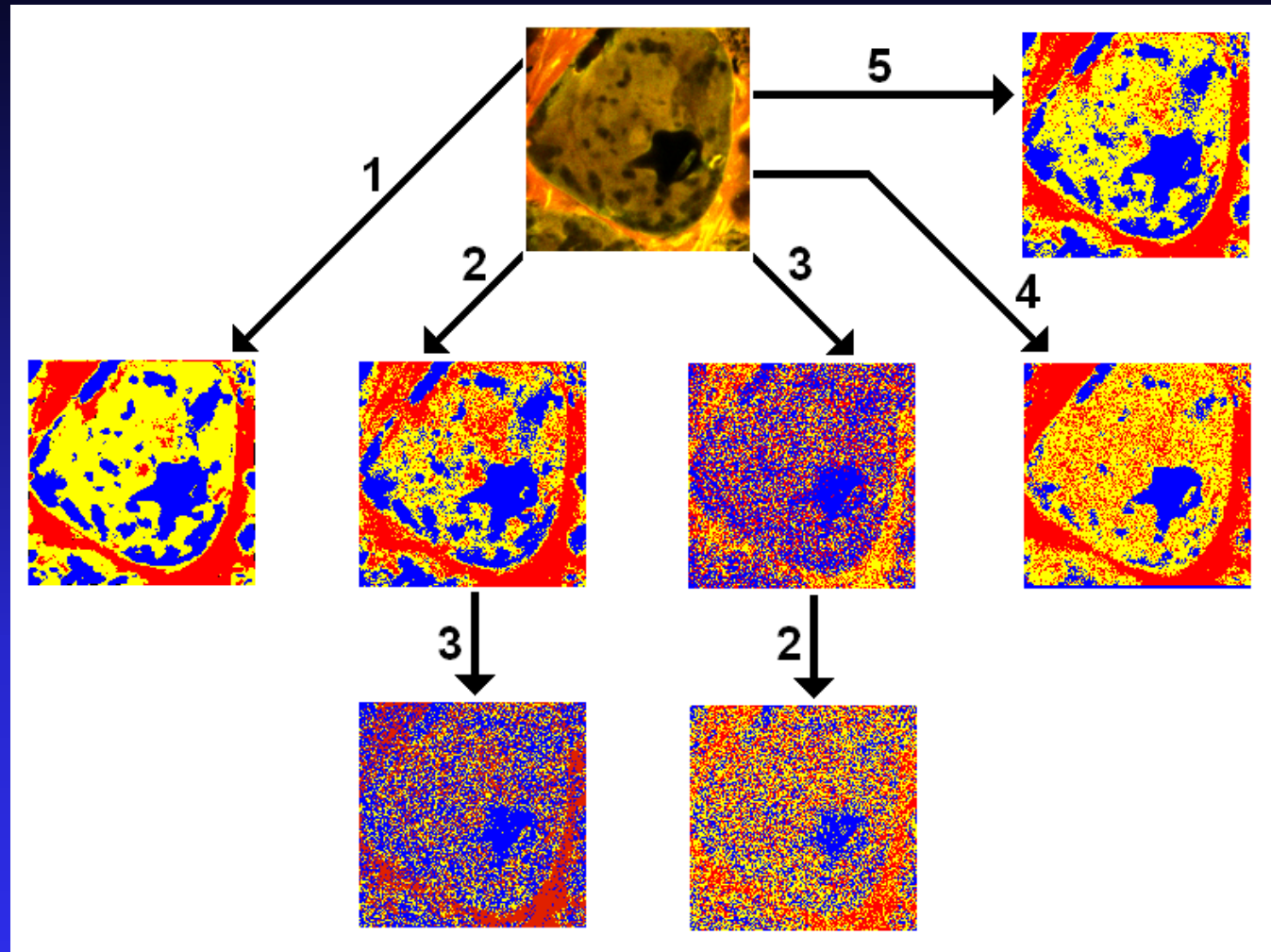
Exopolymer

Ooid grain

Results and significance

The results are consistent with what could be seen from sample images. Our approach provides a method to quantify differences: calcification is significantly predominant ($p < 0.001$) in Type II Mats. The conclusion is based on random samples of 30 images selected from Type II mats and 25 images selected from Type I mats.

Image enhancement: details



1- Unsupervised classification using Feature Analyst (includes enhancement); 2- contrast stretching; 3- filtration; 4- supervised classification; 5- unsupervised classification

Future directions

The new approach has been used to answer questions that have been answered using other qualitative or quantitative techniques. In the last case, the advantages of the new approach indicate its usefulness. In the future, fundamental research questions could be answered using the described method.