Paleoproterozoic stromatolite microbial communities of the Belchers Group, Nunavut, Canada

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International Stromatolite Symposium – January 16th 2011

Archean Stromatolites: oldest forms of life on Earth

Domal stromatolites in the ~3.49 Ga Dresser Fm., Western Australia



Conical stromatolites in the ~3.35 Ga Strelley Pool Fm., Western Australia



Conical stromatolites in the ~3.35 Ga Strelley Pool Fm., Western Australia



Domal stromatolites in the ~2.7 Ga Tumbiana Fm., Western Australia



Microbial composition of some modern stromatolites



Papineau et al. (2005) AEM



Domal

Irregular bulbous



Phototrophy in modern stromatolites

A. Cyanobacteria



B. α-Proteobacteria





Papineau et al. (2005) AEM

Main conclusions:

- Modern stromatolites contain minor proportions of cyanobacteria, but also of anoxygenic phototrophsic bacteria.

- Phototrophic bacteria occur near the surface of stromatolites.

Paleoproterozoic stromatolites and the Great Oxidation Event



Observation:

- The accumulation of oxygen in the Paleoproterozoic atmosphere occurred in a step-wise fashion in the Paleo- and Neoproterozoic

- Stromatolite diversity and abundance significantly increased at the time of the GOE.

Questions:

- What was the trigger of the GOE?
- Which microorganisms lived in these stromatolites?

Melezhik et al. (1997)

The Belcher Islands, Nastapoka Arc, and Richmond Gulf

- Age constraints: Max -> 1.96 Ga (²⁰⁷Pb/²⁰⁶Pb)_{WR} (Todt et al., 1984) (Belcher Group) Min -> 1.80 Ga (²⁰⁷Pb/²⁰⁶Pb)_{WR} (Fryer et al., 1972)
- Age constraints: Min -> 2.025 Ga (²⁰⁷Pb/²⁰⁶Pb)_{monazite} (Chandler and Parrish, 1989) (Richmond Gulf Group)
- Metamorphic grade: zeolite to prehnite-pumpellyite facies



Expeditionary field cruise in the Hudson Bay



Geology of the Hudson Bay – Belcher Islands



*****Stromatolite occurrences

PHASES

SUBMARINE

PLATFORM

PHASE

CARBONATE PLATFORM

Jackson (1969)

Expeditionary field cruise in the Hudson Bay





<image>

Our combined expertise:

- Precambrian geology
- Biogeochemistry
- Stable isotope geochemistry
- Micropaleontology
- Structural geology
- Organic geochemistry
- Sedimentary petrology
- Astrobiology

Late Paleoproterozoic sequence stratigraphy, Hudson Bay



Megacycle 1: The Kasegalik Fm. on the West limb



Megacycle 1: Kasegalik stromatolites

(contact with Archean basement is never seen – needs scientific drilling)

Non-columnar undulatory lamina Columnar cylindrical and branching bifurcate/anastomosed

Domed nodular/hemispherical



Diversity of Kasegalik stromatolite reefs

Domed nodular/hemispherical





Gray dolomite

Columnar branching bifurcate/dendroid





Pink-gray dolomite

Increased redox states in Kasegalik Fm.

Ferruginous mudstone (red bed)



Clay-chert nodules



Chemostratigraphy of the Kasegalik Fm



The Eskimo volcanics and the Fairweather argillite



Top of the Kasegalik carbonates

Gray-green rippled argillite of the Fairweather Fm.

Bottom of the

Eskimo pillow basalt

Gradational contact between Fairweather and McLeary Fms.





Megacycle 2: The McLeary Fm. near Sanikiluaq



The McLeary Fm. near Sanikiluaq, local transgression

Lateral-branching columnar layered stromatolites Nodular, bulbous, multifurcate and anastomosed stromatolites

Bifurcate and multifurcate stromatolites



Dolomite + chert + ferric oxides + silt Dolomite + chert +/- ferric oxides + silt Dolomite + chert + silt

McLeary stromatolites near Sanikiluaq

Nodular, bulbous, oncolitic, columnar branching bifurcate and multifurcate stromatolites



McLeary stromatolites near Sanikiluaq

Nodular, bulbous, oncolitic, columnar branching bifurcate and multifurcate stromatolites







McLeary stromatolites near Sanikiluaq

Nodular, bulbous, oncolitic, columnar branching bifurcate and multifurcate stromatolites



Micropaleontology of the McLeary Fm. near Sanikiluaq

Cyanobacterial microfossils from black chert nodules



Hoffman (1976)

Chemostratigraphy of the McLeary Fm. near Sanikiluaq



Megacycle 2 - The McLeary Fm. on Tukarak Island



















Stromatolite beds with clumps of black chert





Turbinate and bulbous bioherms of multifurcate and bifurcate stromatolites



Turbinate and bulbous bioherms of multifurcate and bifurcate stromatolites



Tabuluar or bulbous bioherms of bifurcate and columnar stroms



Tabuluar or bulbous bioherms of bifurcate and columnar stroms



Cross-sectional top view of bulbous or tabular bioherm of multifurcate and bifurcate stroms



Tabuluar bioherms of multifurcate and columnar stroms

Tabular and turbinate bioherms of multifurcate and anastomosed stroms

Turbinate and bulbous bioherms of multifurcate and bifurcate stroms

Megacycle 3 - Geologic context: Tukarak Fm.





Geology of the Belcher Islands



Stromatolite occurrences

Mavor stromatolites and Costello Fms.

Mavor stromatolites



Costello dolomite concretions



Geology of the Hudson Bay – Richmond Gulf



Chandler (1988)

Nastapoka stromatolites



Nastapoka stromatolites – small details of large structures

Pseudocolumnar wavy stromatolites





Nasatapoka stromatolites form bioherms 10's m in size



Summary and discussion on Paleoproterozoic stromatolites

- There is wide variety of stromatolites in the Paleoproterozoic Belcher and Nastapoka Groups.
- There are more than 43 stromatolite morphotypes in the Belcher-Nastapoka Groups.
- The mineralogy of stromatolites (and the presence of ferric iron) is a factor related to morphology.

- The diversity of these stromatolites is likely due to variable microbial community composition.
- Variations in microbial community composition are related to the chemistry of the environment (mineralogy).

While these stromatolites are dolomitic, small differences in their mineralogies may correlate to differences in their microbial community composition.

Acknowledgments

NASA Exobiology and Evolutionary Biology Program

NASA Astrobiology Institute

Boston College

Carnegie Institution of Washington

Carnegie Institution of Canada

From the Proterozoic Biosphere book (1992)



From the Proterozoic Biosphere book (1992)



