The Coevolution of Ancient Life and Climate

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Cloudina and Salterella: Introduction

- Project Overview
- Cloudina, earliest known skeletal metazoan.
- Cloudina became extinct near the Ediacaran-Cambrian boundary.
- Effect on Cambrian Explosion interpretation.

**Figure:** Cortijo et al. (2009).

- Salterella
Questions

When exactly did Cloudina live? Is there a more exact time frame?

What did Cloudina look like?

Can Cloudina’s lifestyle, feeding, growth and reproduction methods be inferred?

Is it possible to determine or approximate the phylogenetic affinity of Cloudina?

The exact same questions can be asked with regards to Salterella.

An Overall Question: What was the Cambrian Explosion?
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How to Answer these Questions

- **How to Constrain Absolute Time:**
  - Use Zircon U-Pb dating from Ashes.

- **Cloudinid Morphology:**
  - Sampled *Cloudina* fossils cannot be separated from the surrounding rock matrix.
  - Form complex conglomerations.
  - Use Grinding machine.
  - 3-D model statistical characterization.
  - Scanning Electron Microscope.
  - *Cloudina* fill, shell and matrix Carbon isotope plot.
How to Answer these Questions (2)

- Clouadinid Growth, Reproduction and Lifestyle:
  - Search for budding.
  - Search for bore holes.
  - *Cloudina* tube directionality.

- *Cloudina* Neighboring Environment Reconstruction:
  - Use spatial statistical analysis, Kriegering.

- Phylogenetic Affinity of *Cloudina*:
  - Compare growth curves to those of modern Serpulids.
Results and Analysis

There are two distinct groups of Cloudinids. Smaller radii group cannot be juveniles.

Potentially three distinct groups.
In figure measurements from same specimen, tubes randomly selected.

For the small radii case seems unimodal.
Within Large Radii Cloudinids, two subtypes: one with a thicker wall and one with a thinner wall.
Cloudina Isotope Plot

Shell and Matrix $\delta^{13}$ C vs. $\delta^{18}$ O

- $\delta^{13}$ Carbon
- $\delta^{18}$ Oxygen

01CT01DOL
07CT01FILL
07CT01MATRIX
07CT01SHELL
CPD
CPM
CPS
Budding Photographs, Cone in Cone photograph internal structure.

No boring holes found.
Results and Analysis (8)

- Growth curves.
- Evident problem with our methodology
Results and Analysis (9)

- Tube orientation

![Cloudina Tube Directions](image)

**Figure:** (right) Penny et al. (2014).

- Rayleigh test for uniformity of directionality
- Using R, p-value = 0.1660572.
Salterella

- Appear in the fossil record around the late Early Cambrian.
- Highly enigmatic, poorly understood.

**Figure:** Skovsted (2009).

**Future Work:**
- Grinding reconstructing.

Potential evolutionary link to *Cloudina*?
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- Grinding reconstructing.
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- Reconstruct *Salterella* environment.
I would like to thank my supervising professor Adam Maloof for granting me this opportunity, graduate student Akshay Mehra for letting me work on this project as well as for all the insight he provided, and to PEI for supporting the internship.

Questions
The End
Appendix
Results and Analysis

- Two sample t-test between Small with Cavity and Large with Cavity: p-value = 1.5294e-46. Reject null hypothesis of both data samples coming from populations with equal means, i.e. that both groups are identical.

- Two sample t-test between Small no Cavity and Large with Cavity: p-value = 9.8410e-51. Same conclusion.

- Two sample t-test between Small no Cavity and Small with Cavity: p-value = 0.8247. On radii size alone we cannot differentiate between these two groups.

- Two sample t-test between Large Radii thin wall and Large Radii thin wall: p-value = 3.8029e-17. Reject null hypothesis of both data samples coming from populations with equal means, i.e. that both groups are identical.
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