CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

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Project Number

S0806

Project Title

Evidence for Oxygenic Photosynthesis 2.75 Billion Years Ago

Abstract

Objectives/Goals

If oxygenic photosynthesis had evolved in the Archean (>2.5 bya) then Archean sedimentary rocks should be rich in organic carbon regardless of their proximity to hydrothermal systems.

Methods/Materials

Shale from a sedimentary succession were collected from drill cores with varying distances from known hydrothermal centers. Shale is placed into the mini jaw crusher to break down the rock. We place the pieces into a carbide mill in a shatterbox and powdered the samples. The powder was placed through a mesh plate to ensure fine powder. The total organic carbon contents of the rock were determined using an Eltra CS200 carbon-sulfur determinator based on the difference between total carbon combustible at 1400C and total inorganic carbon determined by volatilization with HCl addition. It is calibrated and the accuracy and precision are checked using external Geostandards. Blanks were continuously monitored throughout.

Results

We found very high and variable organic carbon concentrations in shales which are 2.7 byo. Organic carbon concentrations varied from 3.2%- 32.8% in the 5 drill cores. These are higher organic carbon concentrations in Archean rocks than what we were able to find. Drill core KL0039 had the highest organic carbon concentrations; from 22.3%- 32.8%. There was no correlation between total organic carbon concentrations and proximity to known hydrothermal centers(R2.<<0.5).

Conclusions/Discussion

Evidence shows the presence of oxygenic photosynthesis in the Archean (>2.5 bya), proving our hypothesis. There are 3 metabolisms that could result in shale with good amounts of organic carbon. They are oxygenic photosynthesis, photosynthetic sulfide oxidation, and methanogenesis. Iron based metabolisms can also produce organic matter but produce particulate iron oxides that can be used to respire it. 2 of the 3 are tied to hydrothermal systems#requiring sulfide and hydrogen. There is no correlation between distance from the known system and the organic carbon. Also, the organic carbon is too great to be produced by the systems. Thus, the organic matter is likely to be linked to oxygenic photosynthesis, proving that the organic carbon in the shale is the first evidence of oxygenic photosynthesis. It provides a minimum age constraint for the evolution of this metabolism at 2.7 bya. This shows that oxygenic photosynthesis was present before the rise of atmospheric oxygen at 2.4 bya.

Summary Statement

We are helping to constrain the origin of oxygenic photosynthesis on Earth by examining the organic carbon distribution in an Archean sedimentary rock succession.

Help Received

Michele Hampton helped organize our project and guide us, Noah Planavsky was our science fair mentor (grad student at UCR) who assisted us with the project and supervised us during the procedures, NASA funded our project, used the lab equipment at UCR biogeochemistry