WASTELAND, BABY!: RECREATING THE BIRTH OF OXYGEN IN A TANK

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BACKGROUND

- During the Archean (an eon in Earth's history spanning 4-2.5 billion years ago) Earth's oceans and atmosphere were anoxic (lacking oxygen)
- Cyanobacteria are the first and only organisms to engage in oxygenic photosynthesis (using sunlight to make O_2 and organic carbon), and small areas of Earth during this time such as shallow lakes had micro oxygen cycles that gave off "whiffs" of O_2
- These whiffs never accumulated to atmospheric saturation due to reductants like sulfur-reducing bacteria (bacteria that reduces sulfur into hydrogen sulfide), which consumed O_2 during the reaction

Figure 1: Euxinic saltwater tank setup

- 2.4-2.1 billion years ago, oxygen levels began to rise enough to saturate the atmosphere and Earth's oceans, an event referred to as the GOE (Great Oxidation Event)
- One of the many hypothesized catalysts for this event is the decrease of O_2-loving gasses such as sulfur
- The evolution of metazoans (complex life) depends on O_2
- **Purpose: To model oxygen production from cyanobacteria in euxinic waters (high H_2S and low O_2) - a model for the GOE**
  - **Examine how primitive metazoans live in euxinic conditions (similar to environments they would have evolved in)**

METHODS

- Allow saltwater tank to become anoxic (seal the system and leave in darkness)
- Use a grow light to simulate sunlight for the euxinic saltwater tank by setting up apparatus as shown in Figure 1

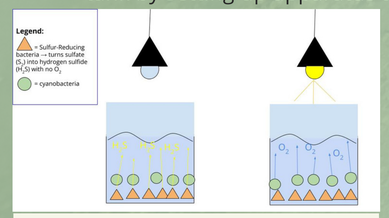

Figure 2: Tank schematics diagram

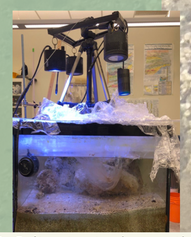

Figure 3: Saltwater tank growth light apparatus

- Use Clark-type Unisense microsensors to measure the hydrogen sulfide and oxygen concentrations before introducing light to the system and after allowing the system 12 days of light
- Measure from the surface to the bottom of the tank using a meter stick
- Attach the sensors to microsensor stand
- Using the microsensors, measure the oxygen and hydrogen sulfide levels every centimeter using the meter stick as a guide

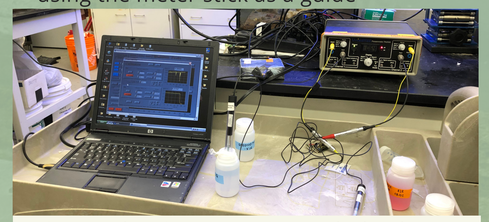

Figure 4: The microsensors are attached to the amp, converting the energy to picoamps and are recorded through the computer program

Figure 5: Unisense microsensors attached to the microsensor stand as tank depth is measured

RESULTS

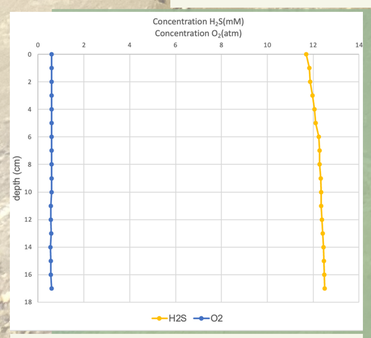

Figure 6: Concentrations of O_2 and H_2S During Darkness

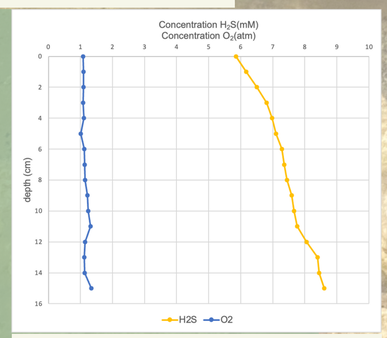

Figure 7: Concentrations of O_2 and H_2S During Light

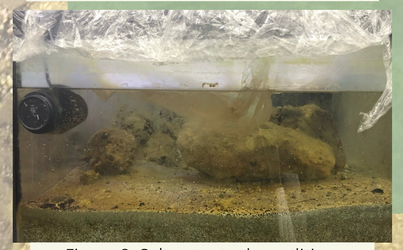

Figure 8: Saltwater tank conditions during darikness

Figure 9: Saltwater tank conditions during light

DISCUSSION

Figure 10: Worm burrows in saltwater tank

- Oxygen concentrations increase with the lights on because cyanobacteria are present and photosynthesizing
- Oxygen concentrations are highest at the bottom of the tank, where photosynthesis is occurring

Figure 11: Worms in the euxinic tank

- **Sulfide levels are decreasing as oxygen increases**
- Oxygen levels can increase in water even if sulfide is still being produced (the tank is not at equilibrium, both gasses are being produced at the same time)
- Early animals might have had a higher tolerance than previously believed for euxinia and could have lived in **"oxygen oases"** (areas in anoxic/euxinic environments with higher levels of oxygen)

Figure 12: Worms in the euxinic tank

Figure 13: An anemone (a cnidarian and animal from earlier in evolution) growing after 12 days of light and euxinic tank conditions

- Euxinic conditions are starting to lessen
- Further research: with time the sulfur signal might disappear
  - The model GOE can be examined as it reaches equilibrium to investigate how metazoans like an anemone continue to adapt to fluctuating levels of sulfide

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CITATIONS

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