Piecing together the climate puzzle through geologic record

Jeremy Owens, Guest columnist Published 8:47 a.m. ET May 18, 2020

Collecting core samples to investigate whether ocean oxygen conditions occurring 15 million years ago played a roll in the deposition of Central Florida's large phosphorite deposits. *(Photo: Special to the Democrat)*

As an undergraduate in environmental science, I became interested in comparing the climate effects of modern anthropocentric or human-induced activities with natural processes found in the ancient geologic record. This started me down a path of uncovering clues in the geologic record to understand these processes.

Today, I study the variation and evolution in the amount of marine oxygen during ancient climate events to have a better understanding of the anticipated consequences of reduced ocean oxygen resulting from today's global warming.

Understanding the causes, consequences, and rate of change for ancient climate is important for predicting future globally integrated consequences based on similar causative factors. The Earth has experienced many climatic perturbations in its 4.6 billion year history, although an examination of the historical record indicates that current climate changes are occurring much more rapidly than in the past.

Today scientists have direct measurements of temperature, atmospheric gases, sea-level, marine chemistry, and others. The ancient record, however, is reconstructed using proxies that archive environmental signatures much like fingerprints or DNA signatures.

Going back a few million years at best, climate scientists use a range of records to reconstruct local to global conditions such as tree rings, soils, ice cores, coral reefs, and many others. Each of these proxies provide almost yearly information for one or more pieces of the climate puzzle, but none provide the entire record.

Going further back, marine sediments and micro-fossils that form sedimentary rocks provide extensive global coverage across nearly all of Earth's history but ... omposition of sedimentary rock samples that were deposited under ancient oceans. Thu ... robust picture of the Earth's climate history.

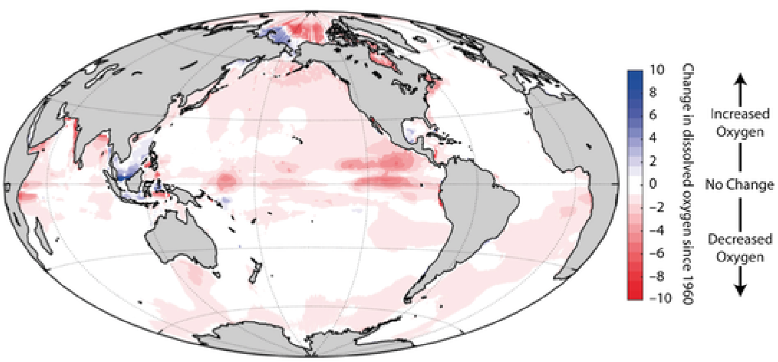
The burning of fossil fuels is a chemical process that converts ancient organic matter, such as oil and coal, which was mostly buried over 100 million years ago, to produce energy. This process releases $CO_2 + H_2O$, and is the same reaction as cellular respiration and the reverse of photosynthesis, which captured the sun's energy and converted ancient carbon dioxide to organic matter.

Conducting field research in the Wrangell Mountains, Alaska, on the Triassic–Jurassic extinction event, one of the 5 major extinction events of the Phanerozoic eon. *(Photo: Special to the Democrat)*

Atmospheric water and carbon dioxide are efficient at trapping reflected energy from the earth in the form of heat (infrared wavelengths), which is different from, and additional to, the energy coming from the sun. The more water and carbon dioxide in the atmosphere, the more heat trapped. We know from studying ancient earth and the atmospheres of other planets that a certain amount of 'greenhouse' gases, such as carbon dioxide, are important for earth's habitability but there is a 'healthy' natural balance.

Ironically, we are now consuming fossil fuels that are the consequence of ancient climate events similar to those contributing to today's global warming. A large portion of the oil we consume is from the Mesozoic Era (252 to 65 million years ago). During this time the climate was much warmer with no polar ice sheets, lily pads in the arctic circle, and fossil records of cold-blooded reptiles in the United Kingdom.

This was due to major volcanism resulting from the breakup of the super continent, which released massive quantities of carbon dioxide and which, like today, trapped heat. For those that agree that the climate is changing and that carbon levels in the atmosphere are increasing, but are doubtful that it is resulting from man-made events, the carbon isotopic signature from volcanic activity is qualitatively different from the burning of fossil fuels.



Reduction in ocean oxygen since 1960. *(Photo: Special to the Democrat)*

Warmer temperatures have a dramatic effect on the amount of oxygen in the ocean as warmer waters hold less gas such as oxygen. The Mesozoic is also known for having numerous de-oxygenation events that allow for more organic carbon burial, thereby reducing the amount of CO_2 in the ancient atmosphere, and resulting in the significant oil reservoirs we extract today. As we burn those oil reserves we release that ancient trapped CO_2 into today's atmosphere.

There is also evidence in the geologic record that de-oxygenation led to significant biological effects and at times global extinctions, such as the Toarcian Oceanic Anoxic Event. While the source of atmospheric carbon dioxide is different, the impact of de-oxygenation occurring in our modern oceans could have similar long-term ecological effects and consequences to those occurring in the Mesozoic era. Understanding the link between ocean oxygen levels and species extinction could help predict future climate scenarios and provide mitigations to reduce these outcomes.

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