Tracing Earth's past in prehistoric rock deposits

April 17 2023, by Shrivallabh Deshpande

Palaeoproterozoic (around 2 billion years-old) stromatolite fossils studied in this project. Credit: Yogaraj Banerjee

What did the Earth look like about 2 billion years ago, when the planet's atmosphere was being oxygenated?

By analyzing ancient dolomite (carbonate) deposits found in Vempalle, in the Cuddapah district of Andhra Pradesh, researchers at the Indian Institute of Science (IISc) and the University of Tennessee have estimated the temperature and composition of a shallow, inland sea that most likely existed at that time, called the Palaeoproterozoic era.

Their findings provide insight into how the conditions during that time provided just the right ambience for the emergence and bloom of photosynthetic algae. It also shows how a wealth of data about our planet's past remains hidden inside ancient rocks.

"The story of our planet is written in the different strata of rocks," explains Prosenjit Ghosh, Professor at the Center for Earth Science (CEaS), IISc, and corresponding author of the study published in *Chemical Geology*.

Planet Earth hasn't always been this hospitable for life. It has been through different phases of climatic extremes, including periods when carbon dioxide levels were almost too toxic for living creatures, just like our neighbor, Venus. However, various studies of fossils from the Palaeoproterozoic era have shown that some life might have existed even under these harsh conditions.

The large amounts of CO_2 in the atmosphere were absorbed by the sea and trapped as carbonates in dolomites, says Yogaraj Banerjee, a former Ph.D. student from CEaS and one of the authors.

Outcrop of the Palaeoproterozoic section in the Cuddapah basin. Credit: Yogaraj Banerjee

"[Dolomite] is a direct precipitate from seawater. It provides a signal not only of seawater chemistry but also of seawater temperature," explains Robert Riding, Research Professor at the Department of Earth and Planetary Sciences, University of Tennessee, and another author of the study.

The team of researchers collected dolomite samples from chert—hard rocks formed by the interaction of microbes with seawater—as well as deposits underneath them called dolomitic lime-mud. Having first identified the strata of rock where the dolomitic mud could be found, the researchers extracted and transported them back to the lab. Then, they used a state-of-the-art technique known as clumped isotope thermometry to analyze them. The technique allows scientists to narrow down the temperature and composition of the deposits by looking at the arrangement of the carbon and oxygen bonds.

After two years of intense analysis, the team was able to figure out from the dolomitic mud that the temperature of the seawater during its original time period was about 20°C. This is in contrast to previous studies that analyzed only chert samples from around the same period, and had estimated that the temperature was higher, around 50°C. The lower temperature estimate from the current study agrees more closely with the theory that the conditions were ideal for supporting lifeforms.

During the Palaeoproterozoic era, the type of water present was earlier believed to be only heavy water, containing a specific set of isotopes or forms of hydrogen. However, in the current study, the team showed that light water—the regular form of water found even today—was also present back then.

Taken together, these insights—the lower seawater temperature and the presence of light water—strongly support the hypothesis that the conditions around two billion years ago were just right for photosynthetic algae to emerge. These algae were mainly responsible for pumping oxygen into the atmosphere, and making way for other lifeforms to evolve and populate the planet.

The team now plans to search for similar lime-mud deposits in other places around the world to gather additional insights about the Palaeoproterozoic era.

More information: Sanchita Banerjee et al, Oxygen isotopic composition of Paleoproterozoic seawater revealed by clumped isotope analysis of dolomite, Vempalle Formation, Cuddapah, India, *Chemical Geology* (2023). DOI: 10.1016/j.chemgeo.2023.121356

Provided by Indian Institute of Science