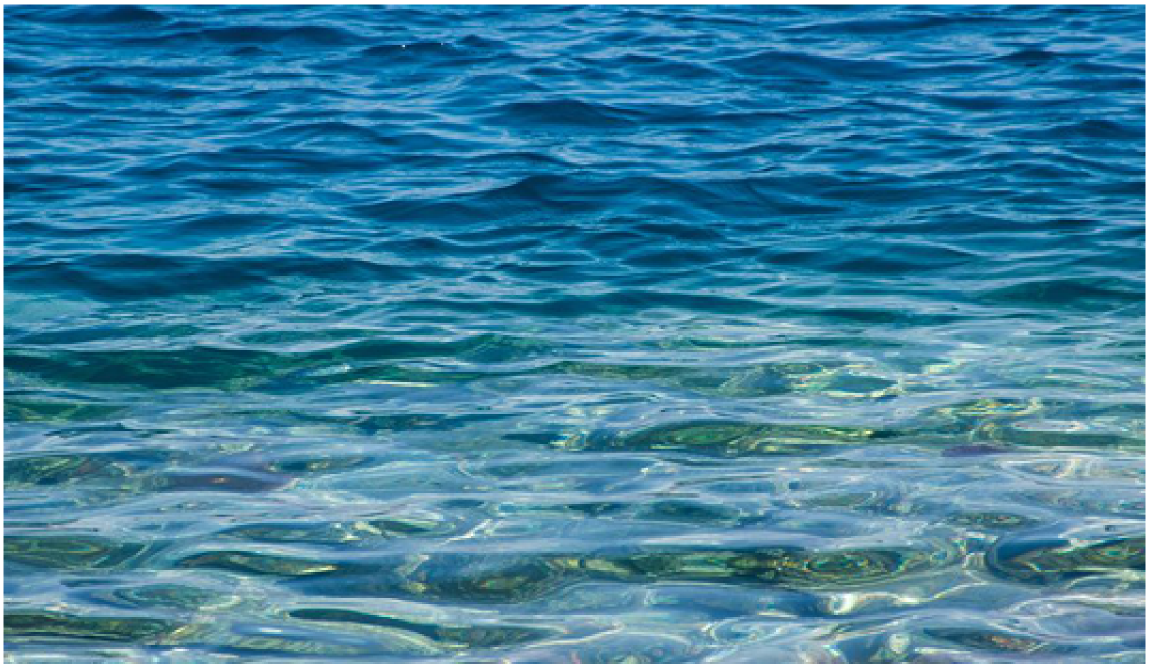
Hidden witnesses to climate history

August 4 2017



Sediments below the bottom of the Arabian Sea harbour microbiol communities that reflect the history of climate in this region. Credit: 500cx / fotolia.com

They once inhabited the seafloor and have been steadily buried: Microorganisms in the sub-surface sediments at the bottom of the Arabian Sea reveal details of fluctuations in climate and environmental conditions over the past 52,000 years.

The sediments below the sea-bottom harbor microbial communities that survive there in spite of the lack of both light and oxygen. Many of the microbes belong to genera that once lived directly on the seafloor, and were progressively buried by accumulating sediments. But their metabolic pathways have adapted to the changing conditions. However, these cells now grow and divide very slowly, and are consequently under weak selection. Professor William Orsi of the Department of Earth and Environmental Sciences at LMU, in collaboration with an international team of researchers, has now taken a closer look at the microbial life in sedimentary cores from the Arabian Sea. The investigation reveals that the metabolisms of a subset of these microorganisms reflect the history of the climate in this region. The new findings, which appear in the online journal *Nature Scientific Reports*, also suggest how microbial communities in the oceans may react to global warming.

The Arabian Sea hosts the world's largest Oxygen Minimum Zone, in which levels of dissolved oxygen are extremely low. As a result, the rate of oxidation of organic matter in the OMZ is drastically reduced. Surprisingly, however, organic carbon is enriched only in specific sedimentary layers, which are separated by intervening strata that contain very little organic material. Earlier studies had shown that this distribution is correlated with repeated – and in geological terms very rapid – oscillations in the water temperature: Warm water contains less dissolved oxygen, which allows higher levels of organic substances to accumulate in the sediments. Indeed, sediments that contain large concentrations of organic material were laid down in periods in which the average water temperature rose by some 5°C within the space of a few decades.

To explore the effects of these temperature oscillations on the microbial communities within these sediments, the researchers recovered a 13-m core that covers the past 52,000 years of deposition, and analyzed the DNA present in different sections of the core. "This screen enabled us to characterize the sequence composition of the DNA at different levels in the sediments and date them with a precision of 100 years," Orsi explains. The sequence data in turn provide insights into the metabolic capacities of the microorganisms buried in the sediments. The analysis revealed that metabolic activities of 10 to 15% of the bacterial groups represented in their core sample reflect the climatic conditions prevailing at the time the sediments were deposited. This subset consists mainly of so-called denitrifying and sulfur-oxidizing groups. Denitrifiers obtain their metabolic energy from the conversion of nitrates into molecular nitrogen gas and nitric oxides. "Independently of depth and nitrate level, the denitrifiers among our indicator groups occur primarily in sediments that are rich in organic material, and were therefore deposited during the warmer periods. They apparently obtain most of their energy from fermentation reactions," Orsi explains. "They were obviously quite sensitive to temperature fluctuations, as they are absent from sediments that contain reduced amounts of organic carbon. So this tells us, for the first time, that rapid climatic oscillations clearly have an influence on the diversity of denitrifying bacteria."

The results also allow the researchers to infer how marine microorganisms are likely to react to future changes in the climate. Over the past 50 years, levels of dissolved oxygen in the oceans have shown a tendency to fall. Denitrifying bacteria in OMZs have been depleting nitrogen from the ecosystem and converting it into the greenhouse gas nitrous oxide (N2O), which contributes to global warming. "Our data demonstrate that, as the oxygen level in the water falls – which signals a warming trend – the relative prevalence of denitrifiers increases. Moreover, their species composition has changed completely since the last Ice Age," Orsi says. This could potentially contribute to a climatic feedback mechanism." He and his colleagues now plan to extend their studies to other regions of the oceans in order to test the robustness of their data from the Arabian Sea.

More information: William D. Orsi et al. Climate oscillations reflected within the microbiome of Arabian Sea sediments, *Scientific Reports* (2017). DOI: 10.1038/s41598-017-05590-9

Provided by Ludwig Maximilian University of Munich