# Uranium isotopes carry the fingerprint of ancient bacterial activity

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Credit: NASA

The oceans and other water bodies contain billions of tons of dissolved uranium. Over the planet's history, some of this uranium was transformed into an insoluble form, causing it to precipitate and accumulate in sediments. There are two ways that uranium can go from a soluble to an insoluble form: either through the action of live organisms - bacteria - or by interacting chemically with certain minerals. Knowing which pathway was taken can provide valuable insight into the evolution and activity of microbial biology over Earth's history.

Publishing in the journal *PNAS*, an international team of researchers led by the Ecole Polytechnique Fédérale de Lausanne in Switzerland describes a new method that uses the isotopic composition of uranium to distinguish between these alternative pathways.

The link between bacteria and the rock record is not new. Under certain conditions, bacteria interact biochemically with dissolved ions such as sulfur, or uranium, causing them to become insoluble and precipitate, contributing to their accumulation in oceanic sediments. But for the first time, scientists can determine whether bacteria were active at the time and place the sediments were formed by analyzing tiny amounts of uranium present in sediments.

## Picky electron donors

The fact that bacteria and uranium interact at all may sound somewhat surprising. But as Rizlan Bernier-Latmani, the study's principal investigator explains, to complete certain metabolic processes, the bacteria need to get rid of electrons, and dissolved uranium just happens to be capable of taking them up. Uranium is far from being the only metal to which bacteria donate extra electrons. But once it precipitates in its insoluble form, uranium is the only metal known to date that preserves a signal that scientists can analyze to detect whether bacteria were involved in its transformation.

What makes uranium unique is that bacteria are picky when it comes to the atomic weight of the uranium to which they donate electrons. Of the two most abundant uranium isotopes found on earth - uranium-238 and uranium-235 - bacteria seem to prefer the heavier uranium-238. The chemical transformation pathway, by contrast, treats both forms of uranium equally. As a result, a slightly higher ratio between heavy and light isotopes in solid uranium extracted from the ground points at a bacterial transformation process.

## The evolution of life

Being able to discriminate between both pathways gives researchers a unique tool to probe into environmental niches occupied by bacteria billions of years ago. Applying their methodology to existing data of Archean sediments from Western Australia, the authors argue that uranium found in oxygen-depleted sediments there was immobilized biologically. Bacteria, they argue, were active there already 2.5 billion years ago when the sediments were formed.

To an environmental biogeochemist like Bernier-Latmani, knowing whether or not bacteria were active at that time and place is exciting, as it could provide new insight into the planet's chemical evolution, for example on the abundance free oxygen in the oceans and the atmosphere.

"We have some understanding of how oxygen concentrations in the atmosphere and oceans evolved over time. There is increasing evidence that traces of oxygen were available already billions of years ago in an overall anoxic world - and bacteria existed that indirectly used it. These changes have a direct bearing on the evolution of life and on mass extinctions," she says. In the complex puzzle of the planet's early history, uranium could be holding some of the missing pieces.

**More information:** Uranium isotopes fingerprint biotic reduction, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1421841112

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