Nickel isotopes: a possible biomarker of early life?

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Transition metals such as iron, zinc, copper and nickel (Ni) play a major role in the metabolism of living organisms. It seems therefore possible to use these chemical elements as biomarkers, in particular for the early Earth when fossils were inexistent. Two types of procaryotes may have been present at that time: methanogenic archaea and phototrophic cyanobacteria. Nickel is potentially a good marker for methanogens as it is directly involved in methanogenesis (the F_{430} coenzyme, a tetrapyrolle with a Ni atom, is involved in the last step of methanogenesis as a component of the enzymatic methyl reductase complex) and, unlike iron, Ni is not significantly affected by redox reactions. Photosynthetic cyanobacteria associated with stromatolites also use Ni. As living organisms can fractionate isotopes when they incorporate chemical elements, Ni isotopes could potentially constrain the biological activity on the early Earth.

The aim of the present study is to (1) develop a new biomarker, particularly well suited to methanogenesis and resistant to metasomatism and redox processes; (2) study the preservation of the isotopic signal in rocks, and (3) look for traces of early life in archean samples – and identify the type of micro-organisms present at that time.

Following the pioneering work of Cameron et al. (2009), we performed cell growth experiments of *M. jannaschii,* a methanogenic archae, at various conditions of pH and temperatures to determine the influence of these parameters on the isotope fractionation, if any. Mass balance calculations show that *M. jannaschii* significantly assimilates Ni. Modifying the procedure of Cameron et al. (2009), we were able to get rid of the carbonate or sulfide precipitate that appears during the culture and potentially disturbs the isotopic mass balance. Both cells and media were analyzed for their isotope composition: the cells are depleted in heavy Ni isotopes relative to the starting and to the residual culture medium by more than 0.8‰. Effects apparently do not depend on the temperature, while pH is a more important parameter.

We now plan to study another strain to compare the results. At the same time, geological samples are investigated.

[1] Cameron *et al* (2009) *PNAS* **106**, 10944–10948