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Experimental silicification of extremophilic Archaea, *Methanococcus jannaschii*. Applications for the search of evidence of life in early Earth and extraterrestrial rocks.

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Early life forms on Earth included chemolithotrophic organisms and such organisms would probably have existed on Mars, if life was present on that planet. Since the earliest life forms known to date ($>$ 3 Gyr) were preserved due to the precipitation of dissolved silica on cellular structures (silicification), we undertook an experiment to silicify a type of microorganism that could have existed in the environmental conditions of early Earth and early Mars, given the different environmental conditions. We chose the thermophilic species *Methanococcus jannaschii* (methanogenic Archaea) as a representative of an anaerobic, autotrophic, thermophilic microorganism. This is the first time that an Archaea has been used in a simulated fossilisation experiment and one of the very first fossilisations of an hyperthermophile microorganism. Given the tentative identifications of CH_4 gas in the atmosphere of Mars, this experiment is of high relevance to analogue martian studies.

After having been cultured under Early Achaean conditions (autotrophic and anaerobic medium, T$^{\circ}$C $>$ 60 $^{\circ}$C, CO_2 + H_2 atmosphere), the microorganisms were placed in a silica-saturated medium in order to study the evolution of both cells and biofilms exposed to silica. SEM observations showed that only extracellular polymeric substances (EPS) were preserved by fossilisation and that they were well-preserved. However, it appears that the microorganism cells themselves are not silicified : in different experiments they were either not preserved at all or they formed simply a degraded structure

that was not silicified . This may imply that the *M. jannaschii* cell wall may not be able to bind dissolved silica.

Previous studies on experimental fossilisation showed that several microorganisms (such as cyanobacteria, Bacteria) can be successfully preserved and fossilised in silica. The implication may be that certain types of microorganisms are more readily preserved in the rock record than others.

This experiment provides valuable insight into the silicification and preservation processes of the kind of microorganisms that could have existed on the early Earth. Knowledge of these mechanisms can be helpful for the search and the identification of microfossils in both terrestrial and extraterrestrials rocks, and in the particular case of Mars.