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Experimental silicification of microorganisms. Applications in the search for evidence of life in early Earth and extraterrestrial rocks

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Early life on Earth was anaerobic and apparently thermophilic. It included chemolithotrophs organisms that could have existed on early Mars, as well as photosynthesisers. 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 the types of microorganism that could have existed in the environmental conditions of early Earth and early Mars, given the different environmental conditions at that time. We chose for this study several microbial strains, representative of anaerobic, autotrophic and thermophilic microorganisms., such as the deep-sea Archaea *Methanococaldococcus jannaschii* and *Pyrococcus abyssi*, or the hot-springs photosynthetic Bacteria *Chloroflexus aurantiacus*. This is the first time that Archaea have been used in a simulated fossilisation experiment and one of the very first fossilisations of hyperthermophilic microorganisms.

This experiment demonstrated that not all organisms silicify. *M. jannaschii* for instance first increase their production of EPS to protect themselves but lysed within a week compared to *P. abyssi* that continued to survive for some months in the silica solution. Extracellular polymeric substances (EPS) played a key role in the silicification process. Chemical analysis were used to monitor the preservation or degradation

of organic matter during silicification. These results suggest that differences between species have a strong influence on the potential for different microorganisms to be preserved by fossilisation.

This study 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.