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# Geological Storage of Hydrogen in Deep Aquifers – an Experimental Multidisciplinary Study

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Green renewable resources appear to be main actors to reduce global warming and complete an efficient energy transition. Dihydrogen ($H_2$), one of the main actors, is a promising alternative for fossil fuels. The growing interest toward using $H_2$ as a green energy source involves the increase of its green production and the use of large capacity storage techniques. Deep aquifers are known for their large capacities and are frequently used for natural gas underground storage. However, $H_2$ has special properties that have to be taken into account before $H_2$ injection in the underground storage systems.

The experimental program conducted during this study permited to answer some of the pending questions about the effect of $H_2$ in the underground. Storage aquifers were reproduced experimentally in a reactor. Three main phases were considered: groundwater sampled from the deep aquifer and containing the autochtonous microorganisms, rock sampled from the reservoir and 85 bar gas phase representing the natural gas composed of 99 % methane and 1 % carbon dioxide. A fraction of 10 % $H_2$ was injected once the system attained the equilibrium. Throughout the experiment, thermodynamic studies mineral and microbial analyses were conducted.

During the first phase (21 days), sulfate was consumed from the liquid phase by microbial activity. Once $H_2$ injected, formate production was observed in parallel with continuous sulfate and $CO_2$ consumption from the liquid and the gas phase respectively. Once sulfate was completely depleted, $H_2$ and $CO_2$ were rapidly consumed until $CO_2$ depletion from the gas phase. Microbial diversity results confirmed the activity of methanogenic archea once sulfate was consumed from the gas phase. Moreover, microbial ecosystem switeched towards 'subsurface lithoautotrophic microbial ecosystems (SLiMEs), based on the consumption of $H_2$ and $CO_2$. Mineral analyses showed the decrease of calcite and the production of iron sulfide compounds. Results obtained by this multidisciplinary study helped to optimize the practice of $H_2$ storage and to take into account the interactions between liquid, solid, gas phases and microbial ecosystem present in the underground.