Deep underground methanogenesis for recycling CO_2

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The dramatic increase of anthropogenic greenhouse gases concentrations in the atmosphere threatens the ecosystems equilibrium, including our way of life. The development of sustainable technologies in the frame of mitigation efforts to reduce anthropogenic CO_2 emissions remains an urgent need. A promising strategy consists in storing the CO_2 in deep geological formations, like deep saline aquifers, where it could be used as a raw material by endemic microbes. Far from being anecdotal, the transformation of part of the stored CO_2 into methane would lower the costs of capture and storage.
Deep saline aquifers are porous environments, with temperature ranging between 40°C to 100°C and hydrostatic pressure up to 150 bar. Methanogens, and more particularly hydrogenotrophic methanogens, which can transform CO_2 and H_2 into methane ($CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$), are part of the microbial population living in such environments. Using their metabolisms would allow considering deep saline aquifers as macro bioreactors for an upgrading process of CO_2 to methane (Fig. 1)[(1)]. However, little is known about their response to a high CO_2 injection [(2)]. Therefore, we are investigating in here methanogenesis reaction in these conditions, with a model strain, *Methanococcus thermolithotrophicus*[(3)],in order to determine the key parameters to improve the CO_2 recycling potential. We have developed multiscale high pressure approaches (microfluidics[(4)] and millifluidics) to investigate this biochemical reaction at lab scale, allowing to mimic deep environments.
The tools and approaches that we are developing and using will make it possible to simulate these deep ecosystems, to estimate the yields of such approaches and the possibility of testing exploitation scenarios.

Figure 1: Deep underground CO_2 bioconversion

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