Conversion of H2 and CO2 into CH4 by Methanogens as a Potential Way of Energy Storage

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Summary
Methanogenic archaea are able to convert CO_2 and H_2 into CH_4. This metabolic activity is of uttermost importance to understand the feasibility to store green hydrogen in gas reservoir by transforming it into more stable methane. The goal of this work was to study the impact of several reservoir conditions on the rate of conversion: temperature, pressure, gas/water/rock composition. In the best cases, high degrees of conversion were achieved after only few days. However, other sources of methane were noticed during the experiment probably due to the stimulation of other metabolic processes. Moreover, a strong rock/archaea interaction was underlined.

Introduction
Hydrogen is frequently considered as a solution to solve the environmental issues of hydrocarbon energy. However, hydrogen storage and transportation need specific infrastructure (Kruck *et al.*, 2013). These costs could be avoided by converting hydrogen to methane which is widely used in the world. This reaction is currently realized in anoxic environments by archaea (Thauer *et al.*, 2008).
Efficiency of methanogenesis depends on many experimental conditions which are still not clearly understood. The aim of this work was to study the sensibility of these micro-organisms on these parameters that are representative of the reservoir environment.

Materials and methods
A natural consortium of archaea coming from a gas/oil reservoir in the Argentine Patagonia was used. Cultures were realized both at low pressures in glass recipients and in a high-pressure device to reach realistic conditions regarding the reservoir.
The experimental conditions which were tested were the pH (with or without buffer), the salinity (10 and 5 g/l), the temperature (55°C and 60°C), the partial pressure of CO_2 (0.3 to 4 bars) and H_2 (1.6 to 20 bars) and the kind of rock (clay, calcite, sandstone). Formation rate of methane was characterized by analyzing the gas composition (partial pressure, total pressure and isotopic ratio $\delta^{13}C$ and $\delta^{2}H$ of CH_4 and CO_2). Archaea activity was characterized according to their quantity, their diversity (analyses of the 16S rRNA gene) and by the evolution of the water/rock composition.

Results/Discussion
CO_2 and H_2 are quickly converted into CH_4. In the best case, a degree of conversion reaching 100% was measured after only few days. However the Methanogens was demonstrated as being strongly dependent of the rock. Only the presence of carbonaceous rocks allowed the production of methane. Even if the buffering effect of such rocks was mainly responsible of this dependency (Sinha *et al.*,2017), surface specific interactions were also identified between microbes and minerals. It was also noticed that methane was overproduced during the experiment regarding the initial content of hydrogen. The main proposed hypothesis was targeting the possible stimulation of remanent crude oil biological degradation by the combined injection of H_2 and CO_2 gas (Thauer *et al.*, 2008).

References
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