Géosciences pour une Terre durable

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Conversion of H_2 and CO_2 into CH_4 by methanogens as a potential way of energy storage.

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Hydrogen is frequently considered as a solution to substitute fossil energies. However, hydrogen storage and transportation need dedicated infrastructures and materials that are expensive (Kruck *et al.*, 2013). These costs could be avoided by converting hydrogen to methane which is easier to store.

This reaction is naturally realized in anoxic environments by archaea (Thauer *et al.*, 2008) and could be harnessed into geological reservoirs. However, the efficiency of methanogenesis depends on many experimental conditions which are still not clearly understood.

Objectives

- **Study the archaea needs to growth and behaviors**
- **Determine the best conditions for methane production**

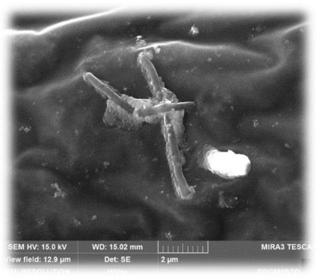
Standard experiments (2 bars)

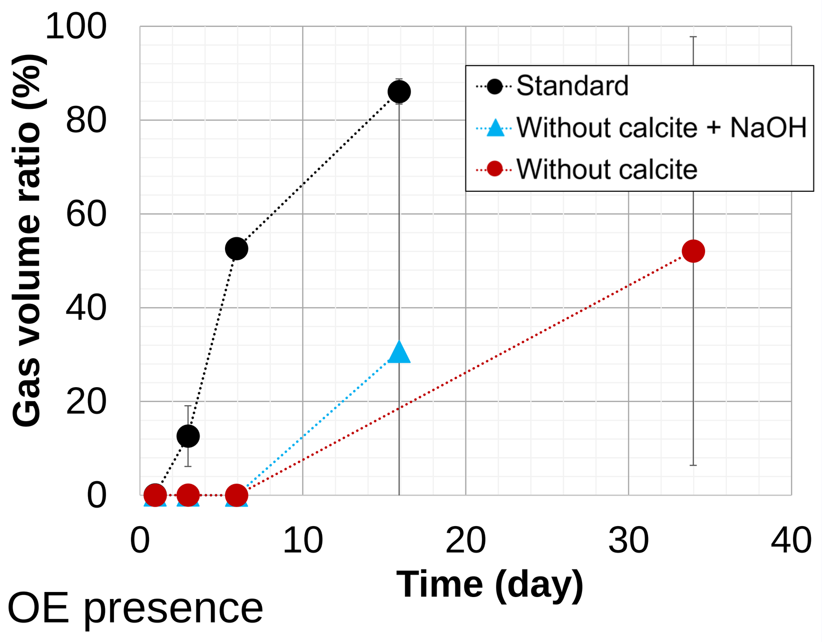
Several tests performed in anoxic environment and with a synthetic water.
The tested variables were:

- Rock composition (carbonates, clays, sand…)
- Temperature increase (+/- 5°C)
- Salinity (variation by dilution)
- Water saturation (+/- 50%)
- Presence of Organic matter (YE) and oligo-elements

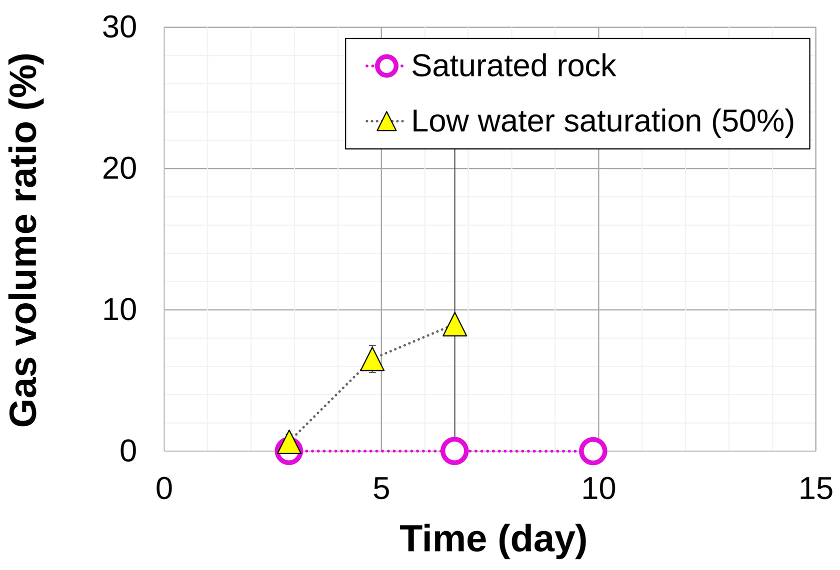
Main results :

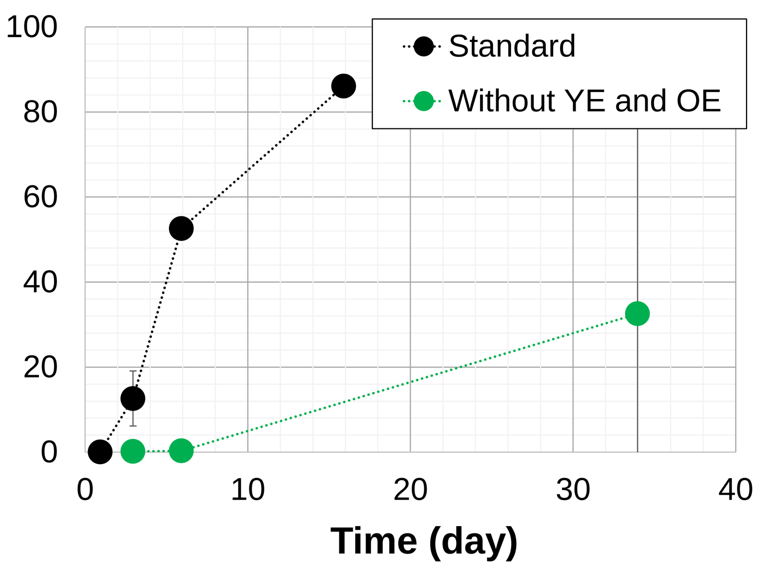
- Methane produced only with carbonates
  ➔ Buffering effect (Sinha *et al.* 2017) ?



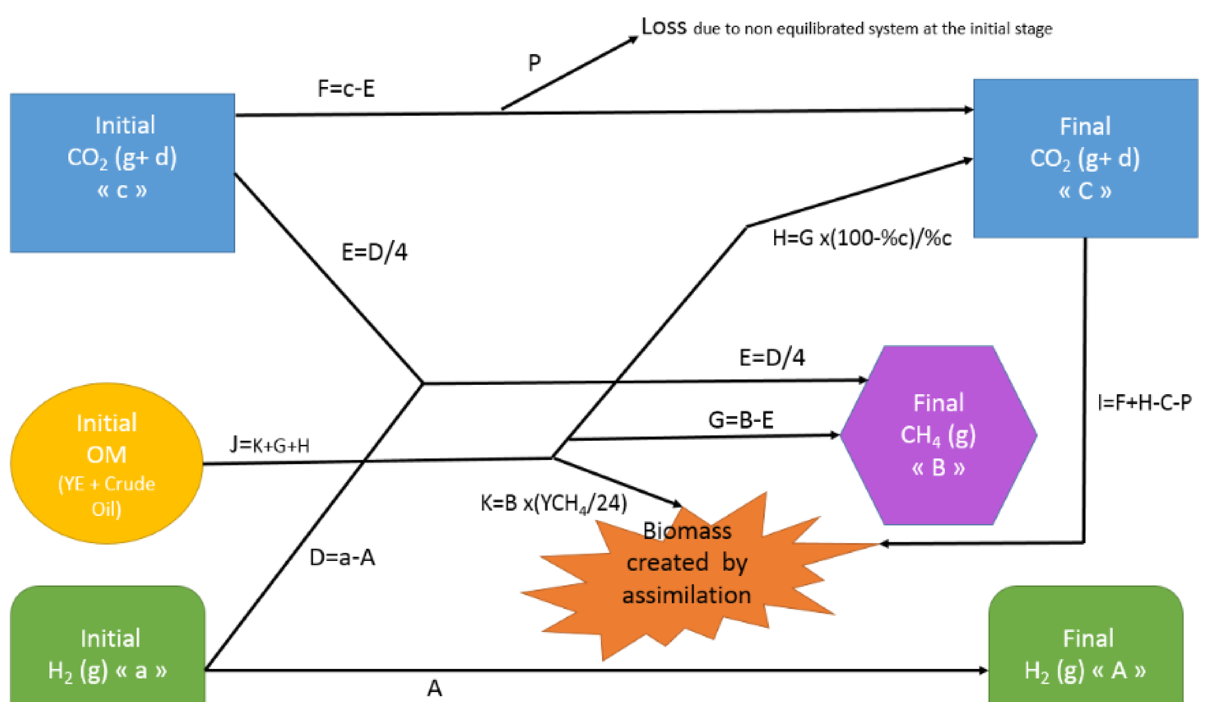


- Methanogenesis is stimulated by YE and OE presence
- A lower saturation increase the methane production





- CH_4 is overproduced regarding initial H_2 content.
  ➔Consumption of organic matter to produce CH_4 (Thauer *et al.*, 2008)?



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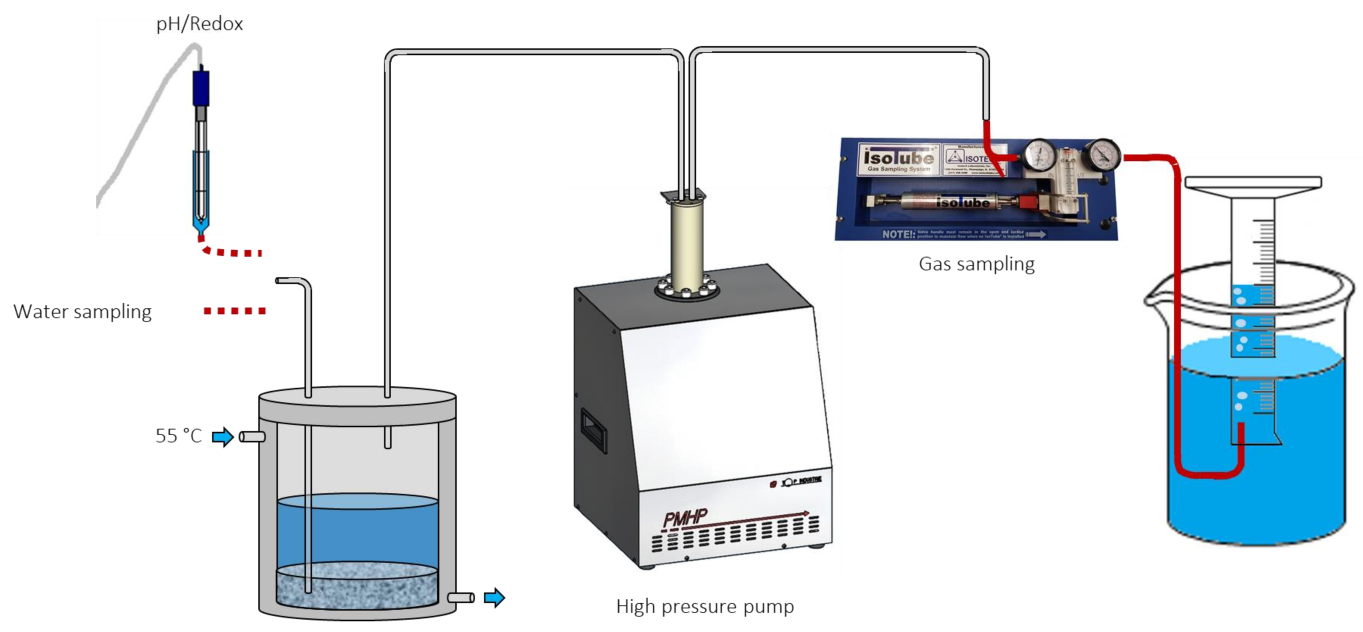
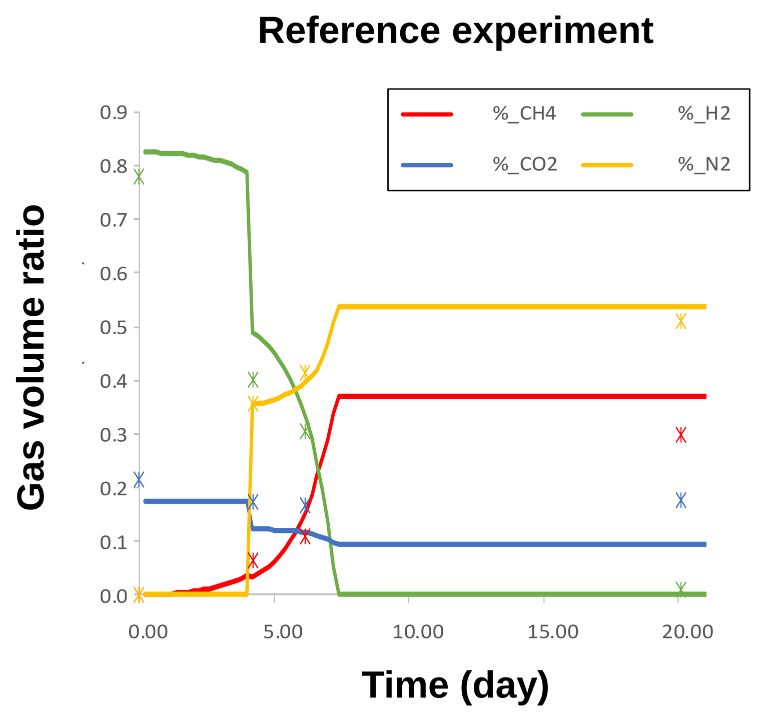
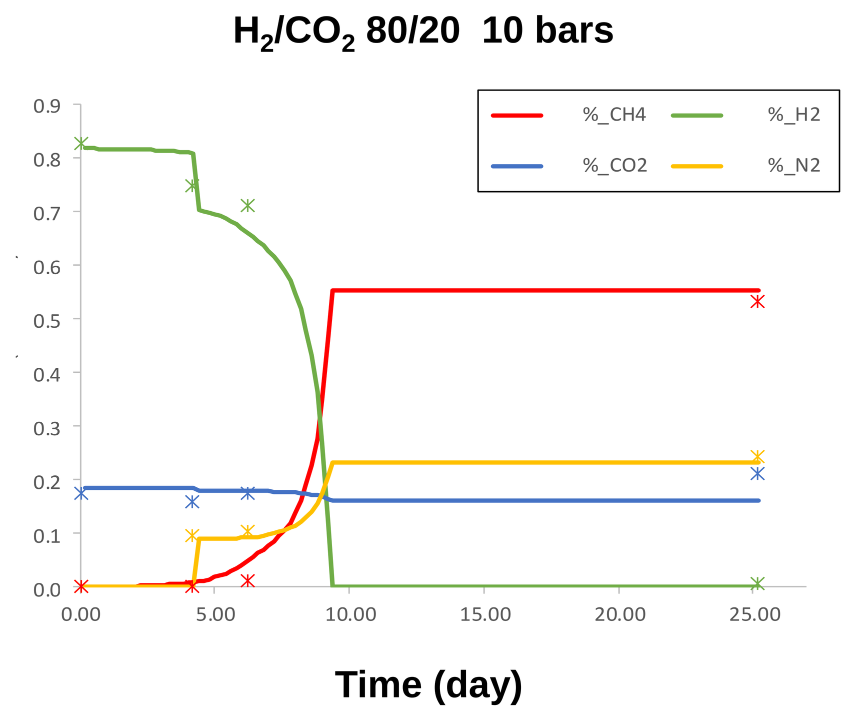
High-pressure experiments

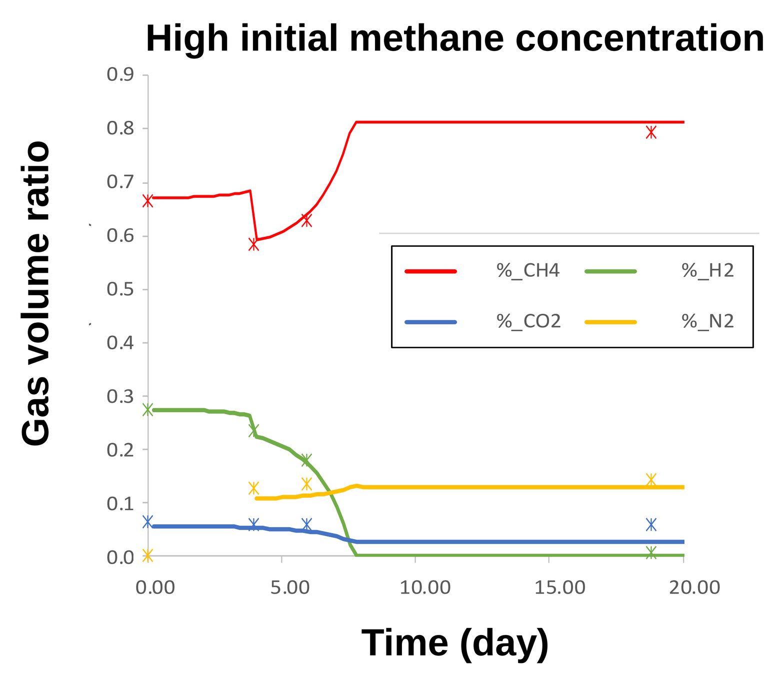
- R1 : H_2/CO_2 80/20, 10 bars
- R2 : Reference experiment (2 bars)
- R3 : High initial methane concentration
- R4 : Without free water column

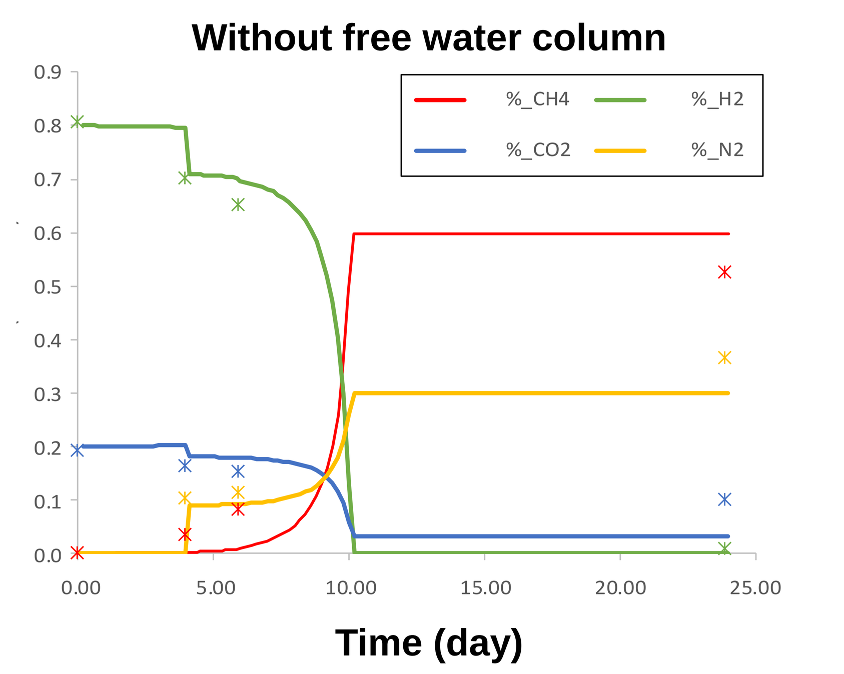


Main results :









- High H_2/CO_2 conversion whatever the initial total pressure are
- Comparable methane production rate
- Good agreement between simulation results obtained with PHREEQC code (Parkhurst and Appelo, 2013) and experimental data (crosses in the above figures)

Conclusion

- CO_2 and H_2 are quickly converted into CH_4
- Overproduction of CH_4 explained by organic fermentation
- Carbonates and yeast extract/Oligo-elements presence strongly impacts methanogen development
- Lower water saturation increases CH_4 production rate

Perspectives

- Test in an underground reservoir