

Injection of new gases (H_2 and O_2) in UGS in deep aquifers

J. MURA¹, M. RANCHOU-PEYRUSE^{1,2,3}, M. GUIGNARD², P. G. HADDAD¹,
M. DUCOUSSO^{1,3}, F. CASTERAN^{1,3}, P. SÉNÉCHAL⁴, M-P. ISAURE¹, P.
MOONEN⁴, M. LARREGIEU², I. LEHECHO^{2,3}, G. HOAREAU⁵, A. PETIT⁶, P.
CHIQUET^{3,7}, G. CAUMETTE^{3,8}, P. CÉZAC^{1,3} AND A. RANCHOU-PEYRUSE^{2,3}

¹ UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR, E2S UPPA, LATEP, PAU, FRANCE

² UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR, E2S UPPA, CNRS, IPREM, PAU, FRANCE

³ JOINT LABORATORY SENGA, UPPA-E2S-TERÉGA, PAU, FRANCE

⁴ UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR, E2S UPPA, CNRS, DMEX, PAU, FRANCE

⁵ UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR, E2S UPPA, CNRS, TOTAL, LFCR, PAU, FRANCE

⁶ STORENGY - GEOSCIENCES DEPARTMENT, BOIS-COLOMBES, FRANCE

⁷ TERÉGA - GEOSCIENCES DEPARTMENT, PAU, FRANCE

⁸ TERÉGA - ENVIRONMENT DEPARTMENT, PAU, FRANCE



Acknowledgment



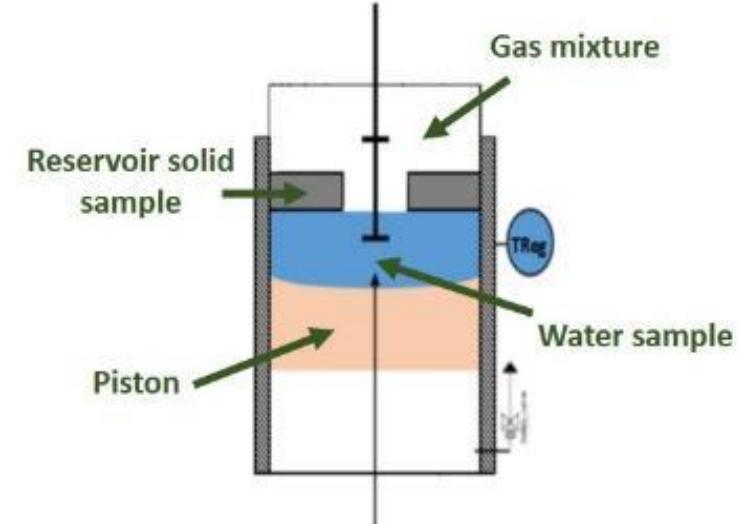
Outline

- 1 Injection of H₂ (Power-to-gas) and O₂ (biomethane) in the natural gas network**
- 2 Expected arrival of these gases in the UGS**
- 3 Is there a risk to the storage facilities ?**
- 4 How do indigenous microbial communities respond ?**
- 5 Is there an effect on the quality of the stored gas ?**

1

Recreating the UGS in situ
conditions in a laboratory
reactor

Recreating the UGS in situ conditions in a laboratory reactor

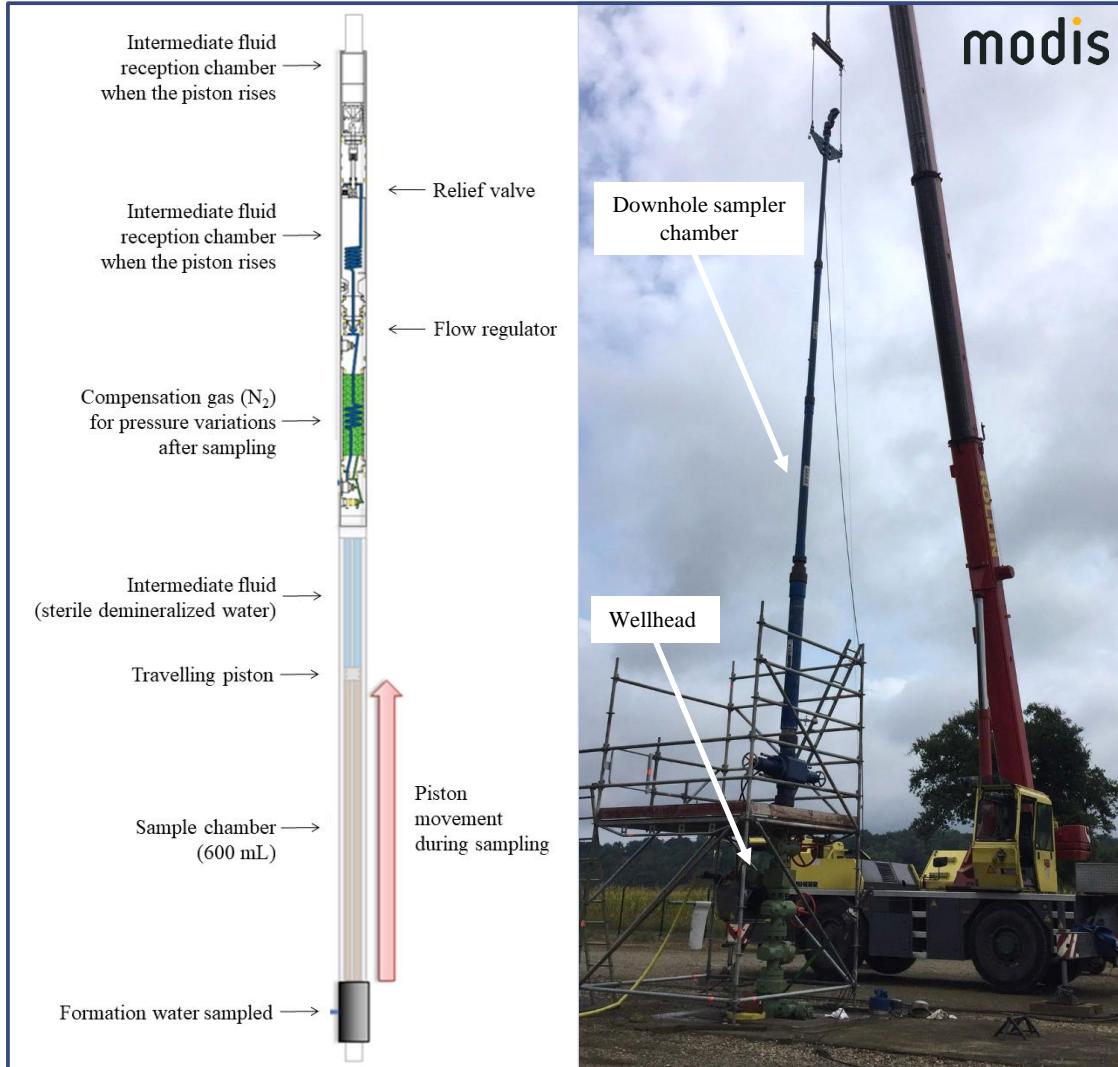


- RINGS reactor can work up to 150°C and 150 bars
- Downhole water (containing microorganisms) and rock phases are sampled in the real UGS
- The initial gas phase is composed of CH₄ (99%), CO₂ (1%) and traces of monoaromatic hydrocarbons (benzene and toluene).
- Deformable reactor (Piston to compensate for the pressure drop)

2

Formation water sampling

Formation water sampling



- Sampling of the formation water (- 580m to - 1200m)
- Guarantee the non contamination of the microbial community
- Control the pressure / depressurization

 frontiers | Frontiers in Microbiology

TYPE Original Research
PUBLISHED 04 January 2023
DOI 10.3389/fmicb.2022.1012400

A deep continental aquifer
downhole sampler for
microbiological studies



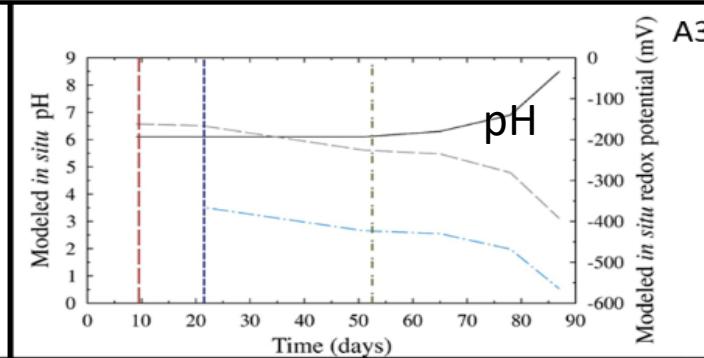
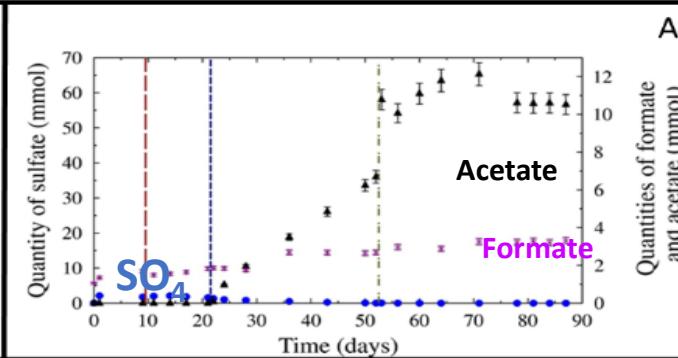
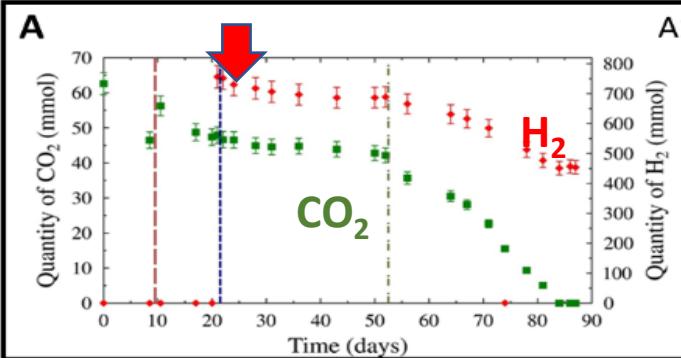
Magali Ranchou-Peyruse^{1,2,3}, Marion Guignard¹, Perla G. Haddad², Sylvain Robin⁴, Fabrice Boesch⁴, Maud Lanot⁴, Hervé Carrier^{3,5}, David Dequidt⁶, Pierre Chiquet^{3,7}, Guilhem Caumette^{3,7}, Pierre Cézac^{2,3} and Anthony Ranchou-Peyruse^{1,3*}

3

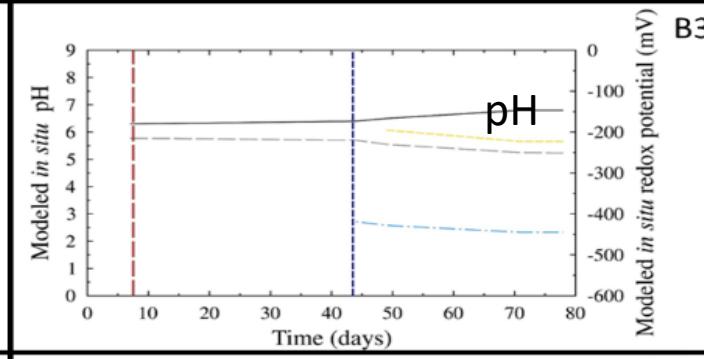
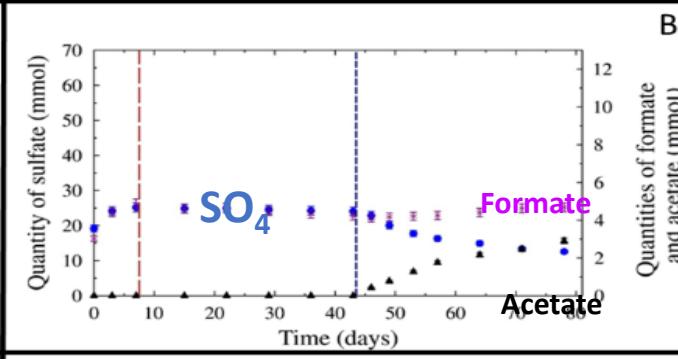
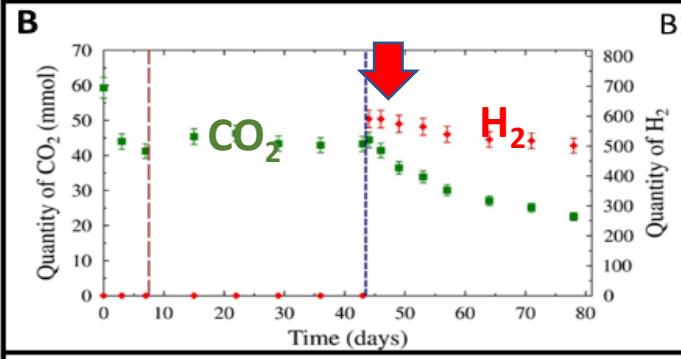
Three aquifers tested for the
injection of H₂

Three aquifers tested

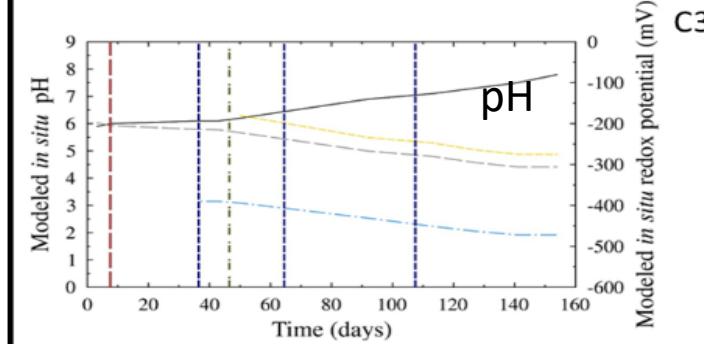
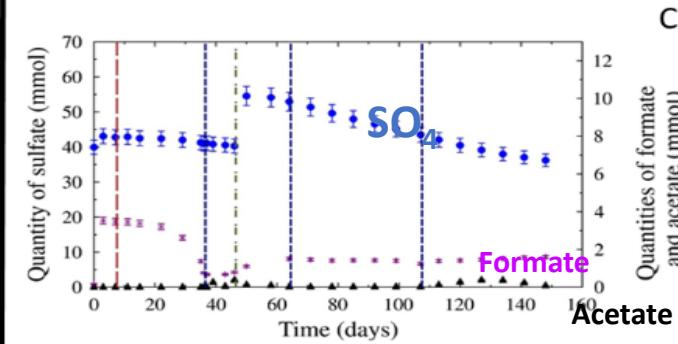
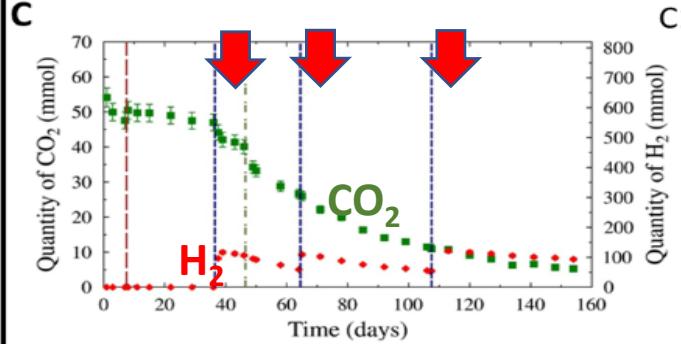
Aquifer 1
+ 10% H₂



Aquifer 2
+ 10% H₂



Aquifer 3
+ 3 x 2% H₂

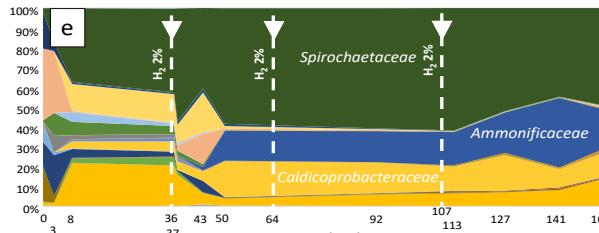
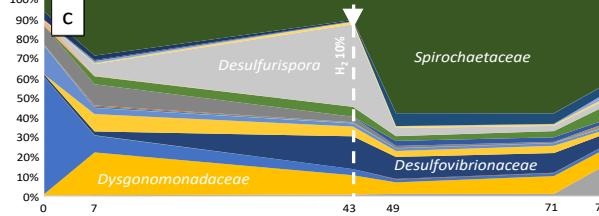
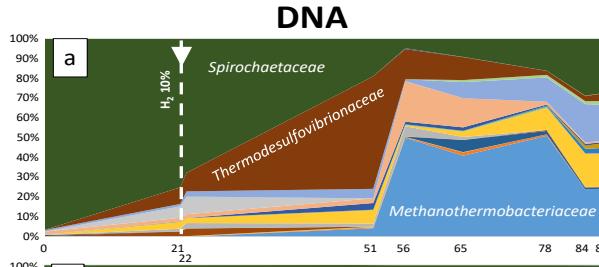


4

Microbial communities monitoring

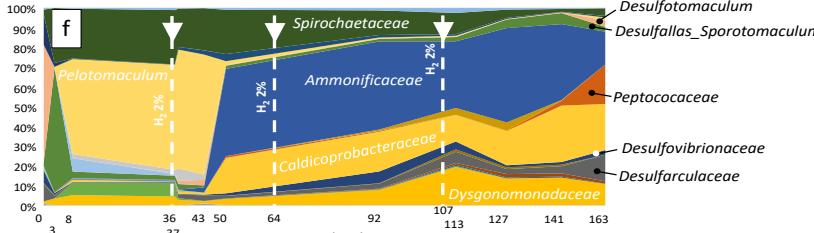
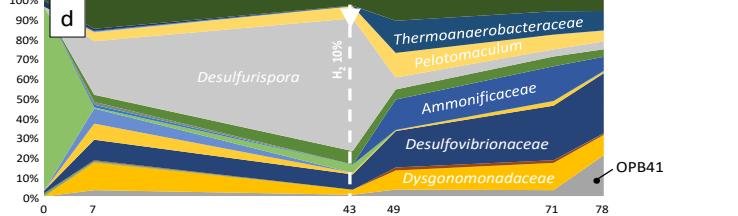
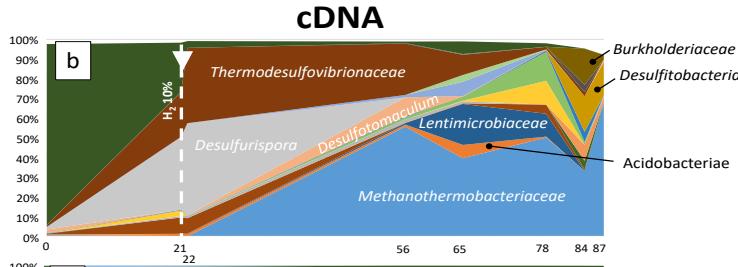
Microbial communities monitoring

Aquifer 1



Legend for Aquifer 1:

- Methanothermobacteriaceae
- Tannerellaceae
- Desulfuriclavaceae
- Erysipelotrichaceae
- Clostridiaceae
- Candidatus_Dichloromethanomonas
- Desulfovibrionaceae
- Desulfobaculum
- Desulfobacteraceae
- Sphingomonadaceae
- Synergistaceae
- Acidobacterae
- Williamwhitmaniaceae
- Paenibacillaceae
- Eubacteriaceae
- Burkholderiaceae
- Spirochaetaceae
- Thermodesulfovibrionaceae
- Methanothermobacteriaceae
- Desulfurispora
- Thermoanaerobacteriaceae
- Pseudomonadaceae



Legend for Aquifer 1 (continued):

- OPB41
- Lentimicrobiaceae
- Desulfovibrionaceae
- Brevibacillaceae
- Hungateiclostridiaceae
- Ammonificaceae
- Desulfurispora
- Thermoanaerobacteriaceae
- Pseudomonadaceae
- Dysgonomonadaceae
- Anaerolineaceae
- Brevisphaeriaceae
- Caldicoprobacteraceae
- Peptococcaceae
- Desulfallas_Sporotomaculum
- Pelotomaculum
- Thermodesulfovibrionaceae
- Spirochaetaceae

→ A community initially dominated by fermenters and sulfate-reducers

→ The Ammonificaceae family includes sulfate-reducers

→ Formate production (assumed by (homo)-acetogens)

→ Methanogenesis does not necessarily take place



[View PDF Version](#) [Previous Article](#) [Next Article](#)

 This Open Access Article is licensed under a Creative Commons Attribution-NonCommercial 3.0 Unported Licence

DOI: [10.1039/D2EE00765G](https://doi.org/10.1039/D2EE00765G) (Paper) *Energy Environ. Sci.*, 2022, **15**, 3400-3415

Geological storage of hydrogen in deep aquifers – an experimental multidisciplinary study

P. G. Haddad ^a, M. Ranchou-Peyruse ^a , M. Guignard ^b, J. Mura ^c, F. Casteran ^{ab}, L. Ronjon-Magand ^c, P. Senechal ^d, M.-P. Israël ^c, C. Moonen ^{de}, G. Hoareau ^d, D. Dequidt ^b, P. Chiquet ^{bg}, G. Caumette ^{bb}, P. Cezac ^{ab} and A. Ranchou-Peyruse ^{ab} 

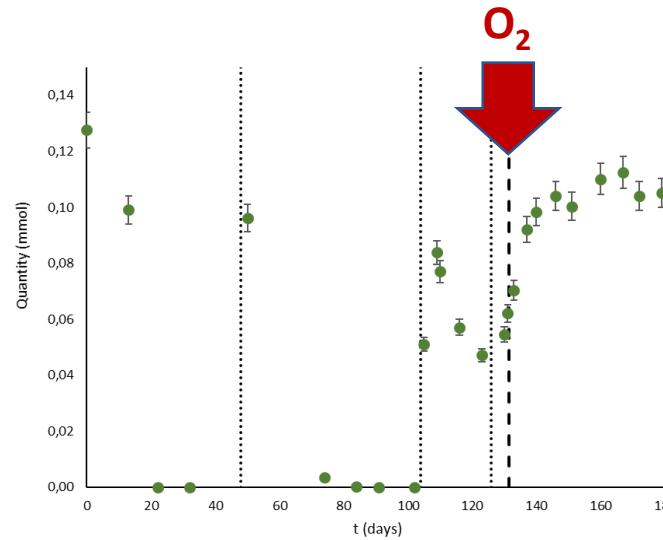


+ Comparative study of three H₂ geological storages in deep aquifers simulated in high pressure reactor (in process)

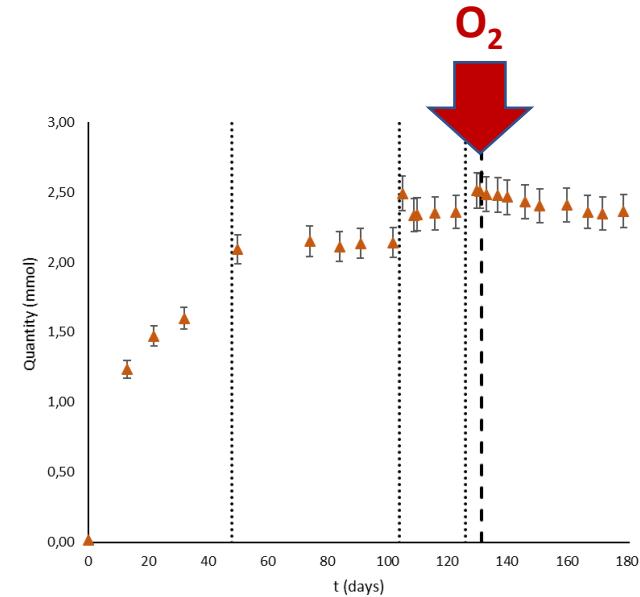
5

An aquifer tested for O₂
injection (1% & 100 ppm)

An aquifer tested for 1% O₂ injection (=10 000 ppm) → changes observed on the water



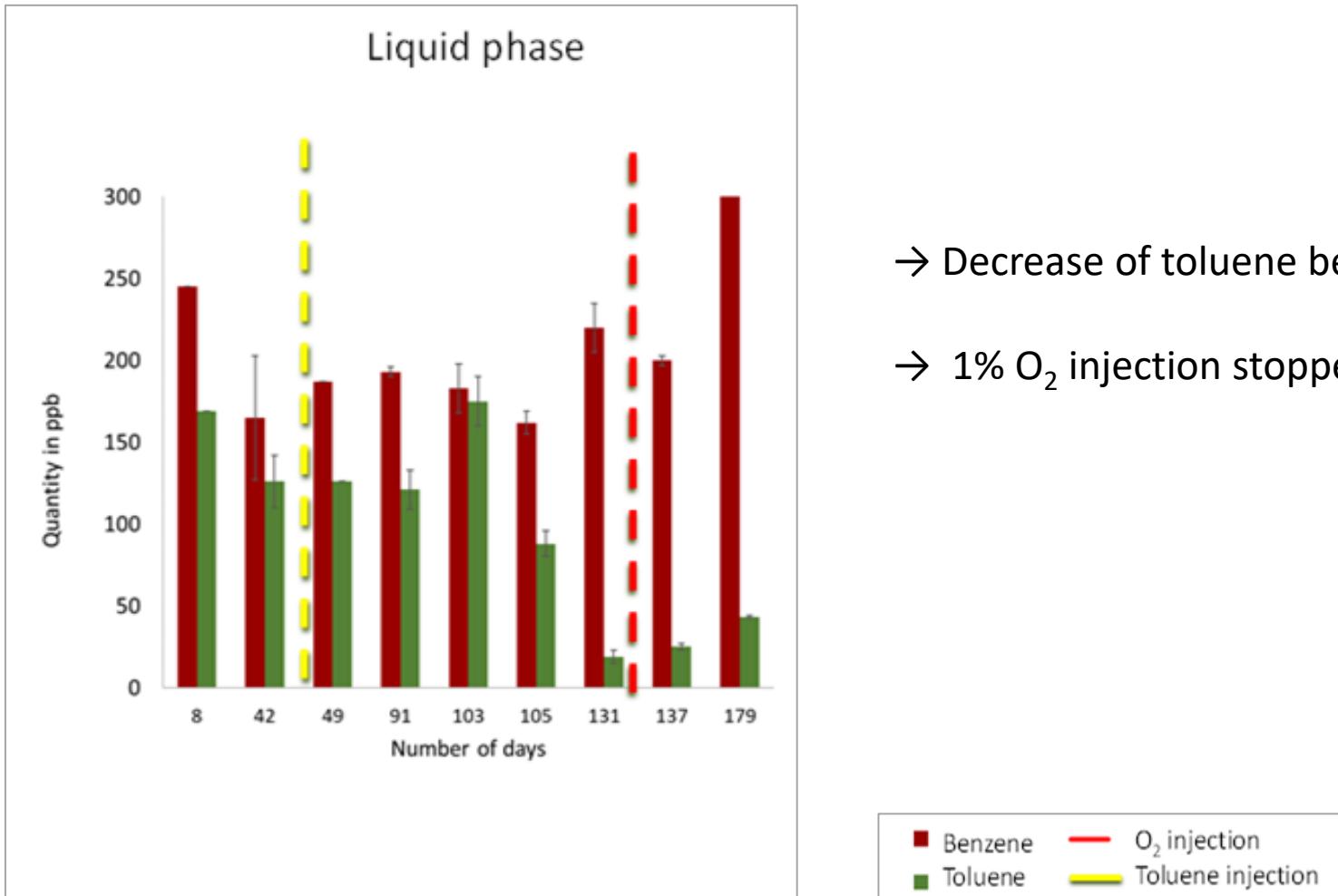
Sulfate evolution



Acetate evolution

- sulfate was consumed by sulfate-reducers
- O₂ injection stopped the sulfate consumption (death or inhibition of sulfate-reducers)
- Acetate is produced from micro-organisms at the beginning of the experiment

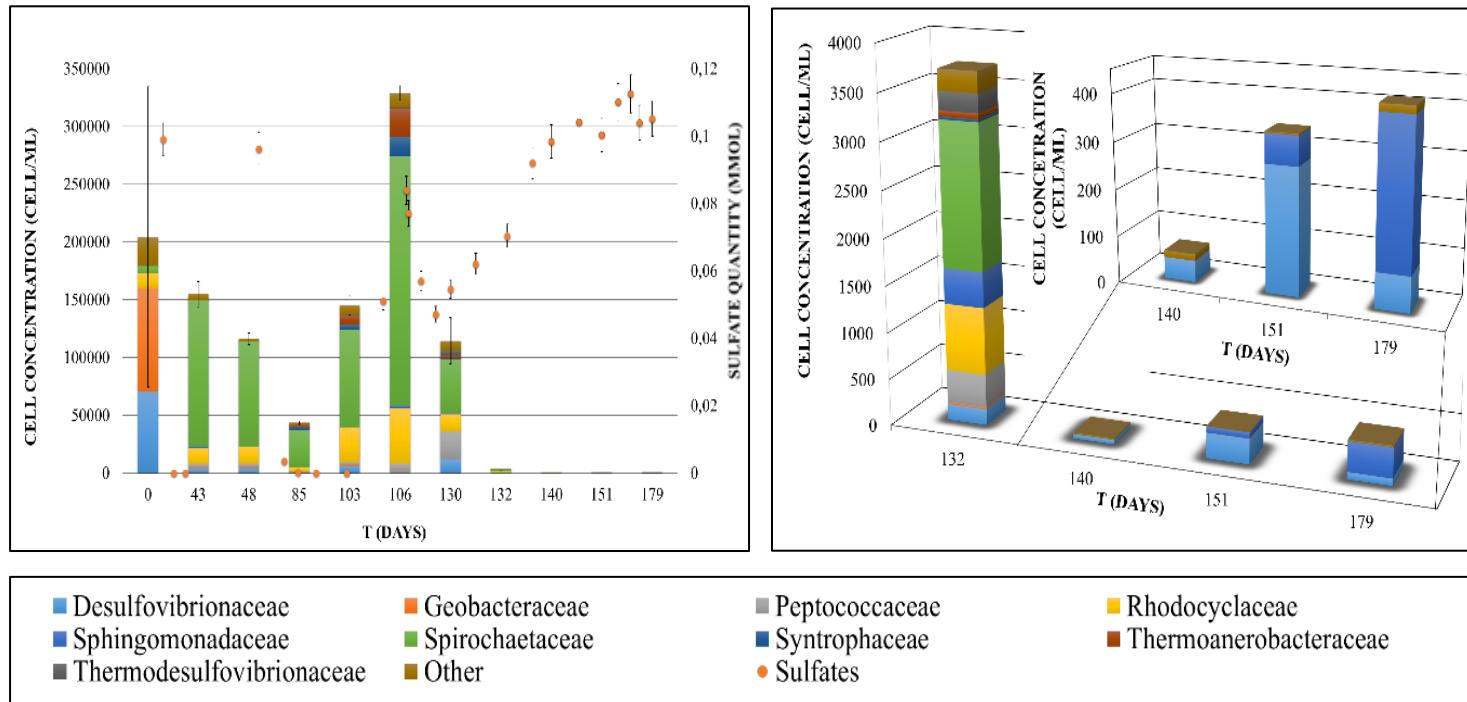
An aquifer tested for 1% O₂ injection (=10 000 ppm) → changes observed on the water



→ Decrease of toluene before O₂ injection

→ 1% O₂ injection stopped the toluene disappearance

An aquifer tested for 1% O₂ injection (=10 000 ppm) → changes observed on the microbial community



→ Negative effect of the 1% O₂ injection on the microbial community = hyperoxic conditions = toxicity

Science of The Total Environment
Volume 806, Part 3, 1 February 2022, 150690

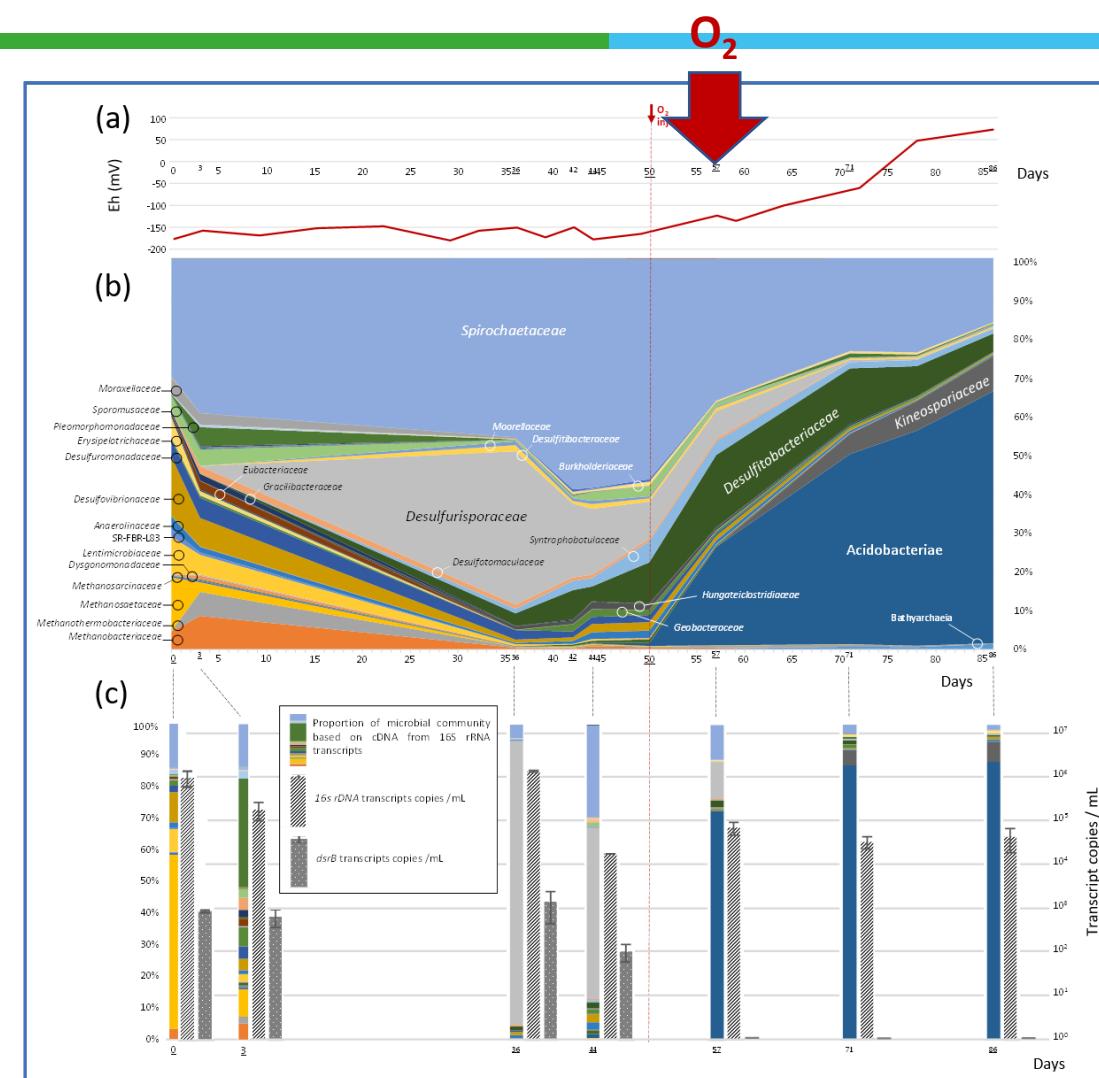
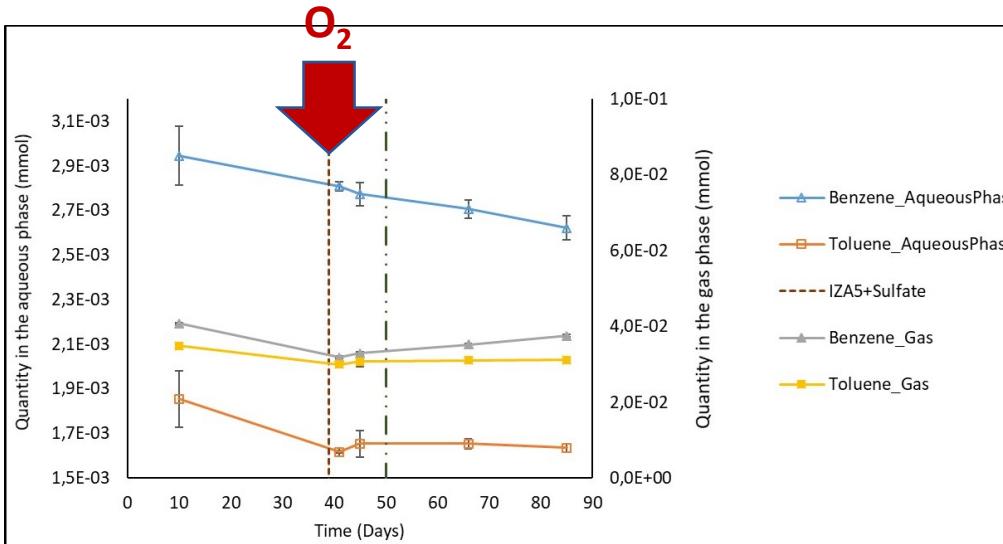
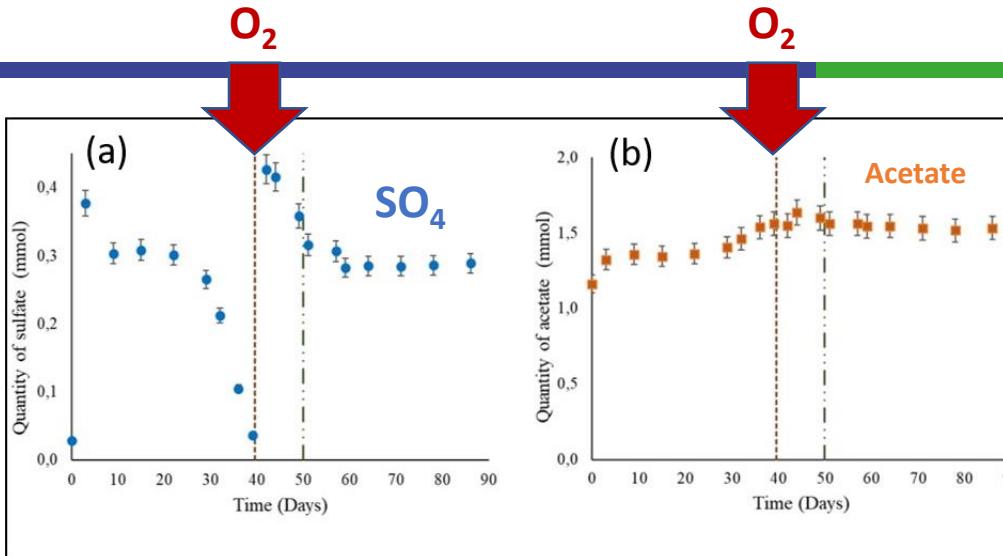


Biological, geological and chemical effects of oxygen injection in underground gas storage aquifers in the setting of biomethane deployment

Perla G. Haddad ^a, Jean Mura ^a, Franck Castéran ^{a,b}, Marion Guignard ^c,
Magali Ranchou-Peyruse ^{a,b,c}, Pascale Sénéchal ^d, Marie Larregieu ^c, Marie-Pierre Israë ^c,
Isabelle Svahn ^e, Peter Moonen ^d, Isabelle Le Hécho ^{b,c}, Guilhem Hoareau ^f, Pierre Chiquet ^{b,g},
Guilhem Caumette ^{b,g}, David Dequidt ^h, Pierre Cézac ^{a,b}, Anthony Ranchou-Peyruse ^{b,c}  



An aquifer tested for 100 ppm O₂ injection → changes observed on the microbial community



Thank you !