« ROSTOCK'H » Geodenergies project:

Risks and Opportunities of Hydrogen geological Storage in salt caverns in France and Europe

Communication (n°17949) in virtual EGU General Assembly (4-8 May 2020)

Development of monitoring tools in aquifer for underground H_2 storage through an in-situ leakage experiment

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Study aim : Test of monitoring tools for direct/indirect detection of potential H_2 leaks from a deep saline cavern storage into a shallow aquifer (using an experimental site in Paris Basin).

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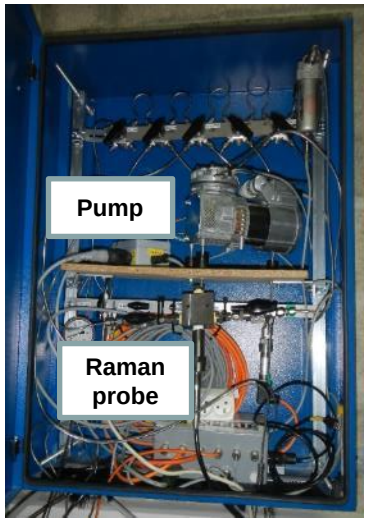
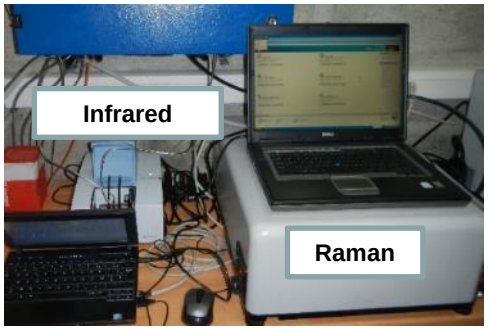
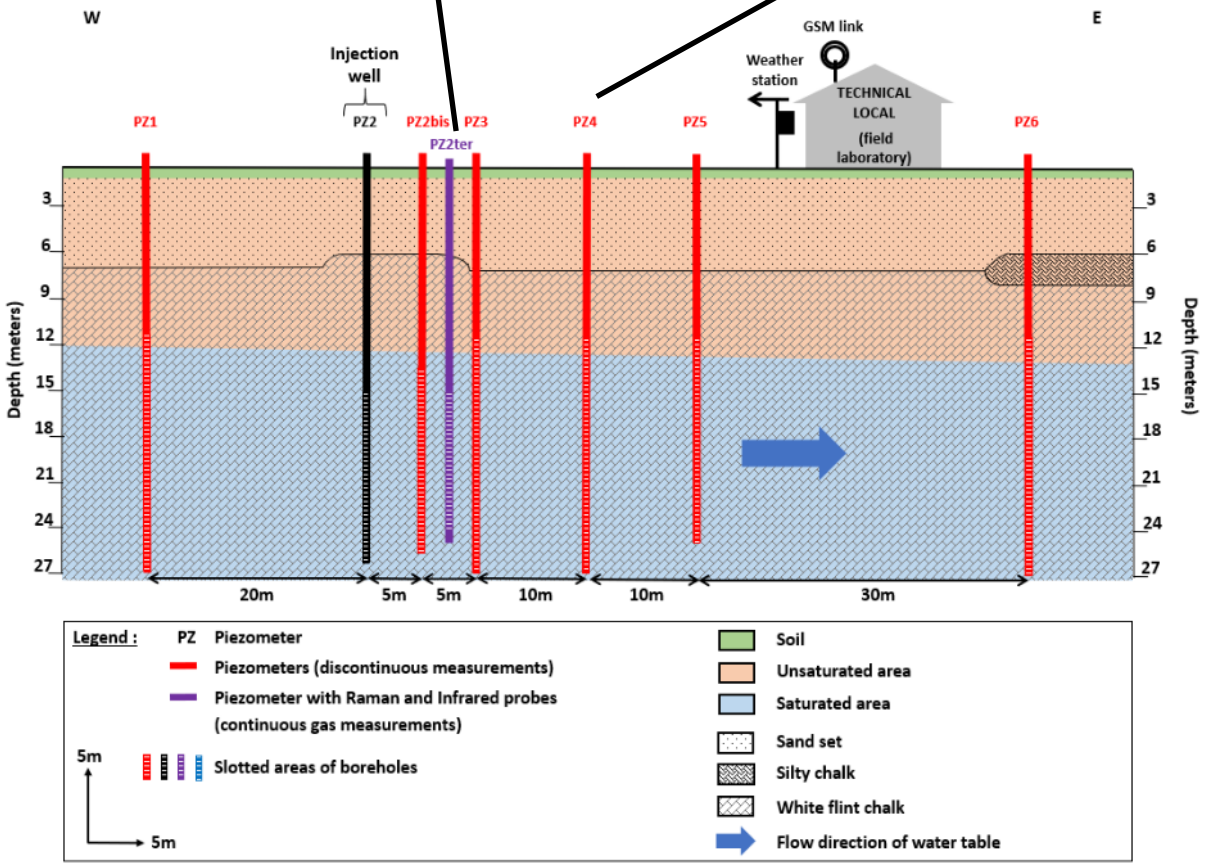
Development of monitoring tools for H_2 direct/indirect detection





Monitoring well PZ2 ter is used for continuous measurements by Raman and Infrared spectroscopy (N_2, O_2, CO_2, CH_4, H_2)

Downstream monitoring wells PZ2bis, PZ3 to PZ6 are used for discontinuous measurements by water sampling and degassing (O_2, CO_2, CH_4, H_2, H_2S)



Experimental protocol:

1. For continuous gas measurements by 2 combined spectrometry (Raman: H_2, N_2, O_2, CO_2, CH_4, H_2S) and IR: CO_2, CH_4, H_2S) : baseline measurements carried out during six months (May to mid-November, 2019).

2. Injection of 5 m^3 of water saturated with H_2 at 1 bar on 19 November 2019 for 2,5 hours.

3. Post-injection monitoring until mid-January 2020.

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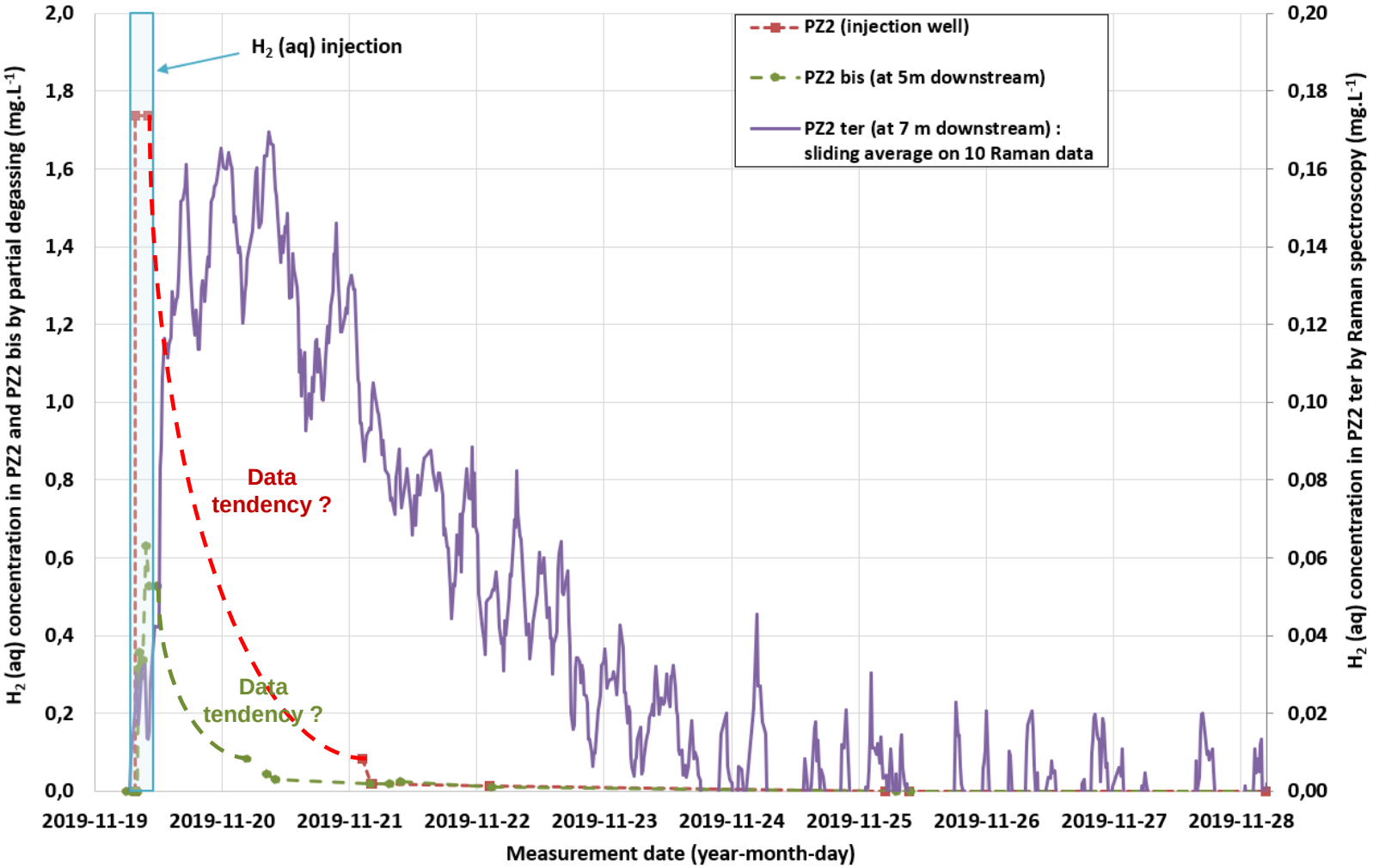
Profiles of dissolved H_2 as a function of the distance to the well (1)

- $[H_{2(aq)}]_{max}$ injected in injection well (PZ2) is 1,78 mg.L^{-1} (90% of theoretical saturation in 5m^3 tank).



Distance downstream from the injection well where the $[H_{2(aq)}]_{max}$ was detected after the injection started:

- At 5m (PZ2 bis), $[H_{2(aq)}]_{max}$ (0,6 mg.L^{-1}) detected after 2 hours by partial degassing method and portable gas analyzer
- At 7m (PZ2 ter), $[H_{2(aq)}]_{max}$ (0,17 mg.L^{-1}) detected after 9,7 hours and during 19 hours by Raman spectroscopy.

At 20 m upstream (PZ1), no $[H_{2(aq)}]$ is detected (monitoring well chosen as reference).

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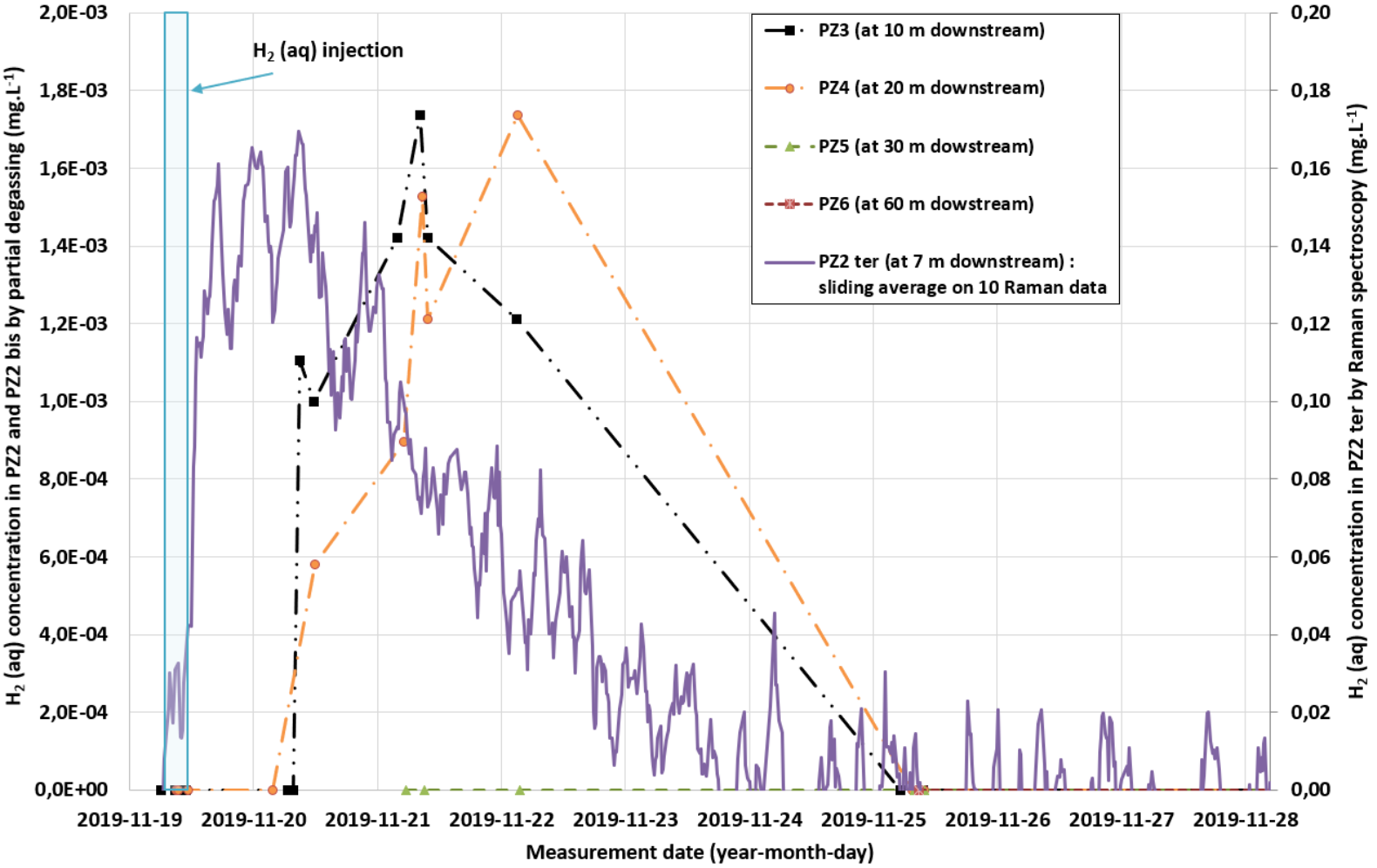
Profiles of dissolved H_2 as a function of the distance to the well (2)



Distance downstream from the injection well where the $[H_{2(aq)}]_{max}$ was detected after the injection started:

- At 10m (PZ3), $[H_{2(aq)}]_{max}$ (1,8 µg.L^{-1}) detected after 71 hours by partial degassing method and portable gas analyzer
- At 20m (PZ4), $[H_{2(aq)}]_{max}$ (1,8 µg.L^{-1}) detected after 90 hours by partial degassing method and portable gas analyzer

➔ Migration speed of H_2 plume is 3-5 m.day^{-1}.

No $[CH_{4(aq)}]$ and no $[H_2S_{(aq)}]$ detected by the portable analyzer used (minimum detection threshold: CH_4 (aq) ~ 1 µg.L^{-1} and H_2S (aq) = 0,6 µg.L^{-1}).

Conclusion

- A H_2 leakage simulation has been carried out in a shallow aquifer by injecting 5 m^3 of water saturated with H_2 at surface conditions.

- The migration of dissolved H_2 plume was detected and monitored both by continuous method (Raman spectroscopy) and discontinuous measurements (degassing of water samples and analysis using a portable electrochemical gas analyzer).

- Beyond 10 m downstream from the injection well, the H_2 plume migrates at a speed of 3-5 $m.day^{-1}$ (which is consistent with the natural flow of the aquifer).

Perspectives

Other measurements by continuous monitoring or sampling were performed but data remain to be interpreted more accurately to study their evolution:

- Other dissolved gas concentration (CO_2 by Raman, IR and partial degassing - O_2 and N_2 by Raman)
- Physico-chemistry (pH, redox potential)
- Ionic concentrations of some chemical elements (e.g. sulfates, nitrates)

⇒ **It will help to assess the environmental impacts of an H_2 leak into a shallow aquifer.**