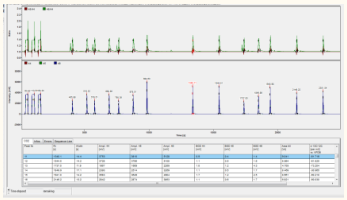
Monitoring of microbial processes during underground hydrogen storage using CSIA

Geological formations such as salt caverns and porous formations provide large storage capacities for hydrogen. Although underground gas storage has been standard for engineering for decades, the impact of microbial processes on underground gas and especially on hydrogen storage has hardly been explored. Hydrogen can be oxidised by indigenous microorganisms under formation of methane (CH_4), acetate (CH_3COOH), hydrogen sulphide (H_2S) or other sulphur compounds. Compound-specific stable isotope analysis (CSIA) on gas components such as H_2, CO_2 and CH_4 is a valuable tool to trace and characterise microbial degradation processes of the stored hydrogen.

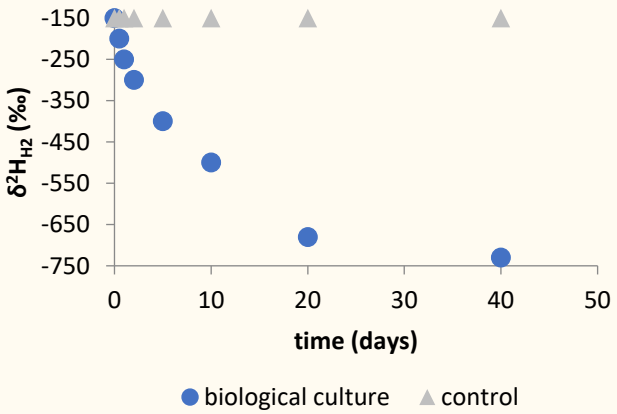
Preparation

Sampling

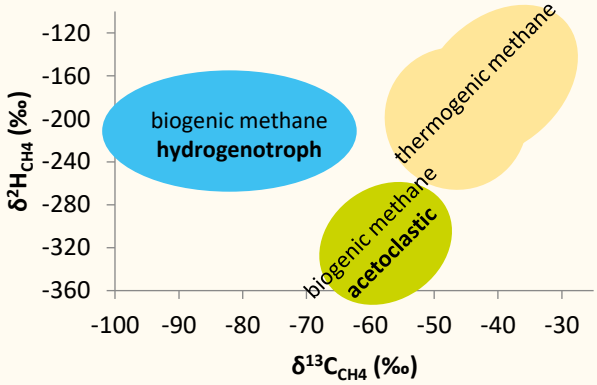
Analysis



Expertise



Hydrogen is comprised mainly by the two stable isotopes ^2H and ^1H. The ratio of the heavy to the light isotope ($^2H/^1H$) is given by the delta value (δ^2H_{H2}). Microbial hydrogen consumption leads to a change of the isotope ratios towards more negative δ^2H_{H2}-values (blue).



Microbial and thermogenic methane have characteristic carbon ($\delta^{13}C_{CH4}$) and hydrogen (δ^2H_{CH4}) isotope ratios. The combination of $\delta^{13}C_{CH4}$ and δ^2H_{CH4} values allows identification of microbial methane formation. Methanogenic archaea use hydrogen or acetate as energy sources resulting in the formation of methane.

Workflow

- We evaluate the potential for microbial hydrogen consumption for geological formations in the planning phase of underground hydrogen storage.
- We trace sensitively microbial hydrogen consumption processes in underground hydrogen storage facilities (salt caverns, porous formations).
- We identify microbial risks during hydrogen storage.

Further reading

Löffler M, Kümmel S, Vogt C, Richnow HH (2019) H2 Kinetic isotope fractionation superimposed by equilibrium isotope fractionation during hydrogenase activity of D. vulgaris strain Miyazaki. *Front. Microbiol.* 10: 1545.

Kawagucci S, Toko T, Ishbashi J, Takai K, Ito M, Oomori T, Gamo T (2010) Isotopic variation of molecular hydrogen in 20°–375°C hydrothermal fluids as detected by a new analytical method. *JGR Biogeosciences* 115: G03021.

Buzek F, Onderka V, Vančura P, Wolf I (1994) Carbon isotope study of methane production in a town gas storage reservoir. *Fuel* 73(5): 747-752.

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