Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20013

Changes in hydrogen conversion kinetics and microbial response to variations in temperature and mineralogy.

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Hydrogen is a promising energy carrier, but its worldwide deployment requires the development of long-term, large-scale underground hydrogen storage (UHS) capacities. Nowadays, various geological structures are considered for UHS such as deep saline aquifers, depleted hydrocarbon reservoirs and artificial salt caverns. Although uncertainties remain on the geochemical reactions that may occur between hydrogen and the various subsurface minerals and fluids present in these geological structures, it is globally admitted that microbial activity can significantly modify the chemical reactivity of the gas-rock-brine system. Yet very little is known about the metabolic and structural responses of deep subsurface microbial communities to seasonal hydrogen storage. Moreover, storage alteration will in turn affect storage efficiency over time. To delineate the risks associated with microbial activity during hydrogen storage, it is thus essential to determine the potential impact of the microorganisms under different environmental conditions (i.e., temperature, chemistry, mineralogy...).

In this context, we investigate the influence of the temperature and mineralogy on the metabolic activity of an H_2-specialized anaerobic microbial consortium harboring hydrogenotrophic metabolisms usually found in subsurface environments. The consortium was incubated at 25, 34 et 40°C in anaerobic flasks. Headspaces were flushed with H_2/CO_2 (80/20, v/v, 2 bars). To assess the influence of the mineralogy, different rock powders were added: basalt, calcite, gypsum, and sandstone. An integrative analytical approach combining geochemical measurements with metataxonomic was performed to monitor hydrogen conversion kinetics and pathways as well as microbial response to different geochemical conditions.

H_2 consumption kinetics were significantly influenced by temperature and mineralogy. Hydrogen was converted through three hydrogenotrophic metabolisms: methanogenesis, sulfate reduction, and homo-acetogenesis. Geochemical measurements indicated that metabolisms expression was also strongly modulated by temperature and mineralogy. Therefore, these two parameters seem to directly rule the metabolic competition for H_2. Metataxonomic approach confirmed that these metabolic shifts were associated with radical changes in microbial populations, highlighting the functional plasticity of ecosystems towards the H_2 substrate.