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Influence of carbon capture and storage on the microbial ecosystem in a depleted oil reservoir

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Deep subsurface petroleum reservoirs are candidate sites for carbon capture and storage (CCS). The feasibility of CCS has been mainly studied from a geological perspective. However, little is known about the effects of CO2 storage on microbes inhabiting the reservoirs. In this study, we investigated the effects of the elevated CO2 concentration on the methanogenic microbial community and function in a high-temperature petroleum reservoir by high-pressure incubation experiments mimicking the in situ reservoir (55 ℃, 5 MPa) or CO2 storage conditions. The microcosms were constructed using the production water and crude oil, pressurized with either N2 or N2+CO2 (90:10) at 5 MPa and then incubated at 55 ℃. Methane production was observed with the decrease of acetate included in the production water under both high and low CO2 conditions. However, the stable isotope tracer experiments and molecular biological analyses for both microcosms showed that the major methanogenic pathway under the in situ reservoir condition was acetate oxidation coupled with hydrogenotrophic methanogenesis, whereas acetoclastic methanogenesis occurred under the CO2 storage condition. Based on thermodynamic calculations, the change to acetoclastic methanogenesis by the increase in CO2 partial pressure was energetically more favorable than acetate oxidation. These results clearly indicated that CO2 storage into a high-temperature petroleum reservoir would cause a drastic change in the methanogenic pathways. Importantly, the elevated CO2 concentration invokes the faster and more favorable methanogenic pathway (acetoclastic methanogenesis) for crude oil biodegradation. Our study presents a possibility of CCS for enhanced microbial production of natural gas in high-temperature petroleum reservoirs.

Keywords: Carbon capture and storage, Depleted oil reservoir, Microbial ecosystems, Methane production