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ASSESSMENT OF BIOACTIVITY IN A HIGH TEMPERATURE PETROLEUM RESERVOIR USING BACTERIAL SIGNATURE METABOLITES

A. Gruner[1], R. Jarling[1,2], A. Vieth-Hillebrand[1], K. Mangelsdorf[1], B. Horsfield[1], C. Janka[3], G. M. van der Kraan[4], T. Köhler[4], B. E. L. Morris[4], H. Wilkes[1,2]

[1]GFZ German Research Centre for Geosciences, Helmholtz Centre Potsdam, Germany
[2]Institute for Chemistry and Biology of the Marine Environment, Oldenburg, Germany
[3]RAG Rohöl-Aufsuchungs Aktiengesellschaft, Kremsmünster, Austria
[4]Dow Microbial Control, Horgen, Switzerland

Introduction

Microbial activity in petroleum reservoirs has been implicated in a suite of detrimental effects including deterioration of petroleum quality, increases in oil sulphur content, biofouling of steel pipelines and other infrastructures, and well plugging. This study deals with organic acids in formation waters as tracers of microbial metabolism in different parts of oil production plants (producing wells, topside facilities and injection wells) along the water flow path (Fig. 1). Study area was the Molasse Basin of Upper Austria with specific attention having been paid to an oilfield with an elevated reservoir temperature around 78°C. Methodologically, petroleum hydrocarbons serving as substrates for microorganisms, as well as the organic acid composition in formation water were characterized.

Results

Compositional and compound-specific isotope analyses did not provide evidence that the investigated crude oils have been substantially altered by microbial activity. However, crude oil hydrocarbon characterization provided an inventory of putative substrates available for microbial activity as a framework for the interpretation of the organic acid patterns observed.

Many alkanoic, aromatic and dicarboxylic acids were identified in the formation water samples, which may derive from microbial degradation of hydrocarbons. The patterns of these putative metabolites could be linked to prevailing pathways of hydrocarbon oxidation and thus provided insights into the physiology of the bacteria active in these production plants. Over one and a half years, significant variations of the organic acid composition were detected especially in topside facilities, which may be related to shifts in temperature or electron acceptor availability.

To the best of our knowledge, polyalkylated succinic acids such as 2,2- and 2,3-dimethylsuccinic acids, 2-ethyl-3-methylsuccinic acid and 2,2,3-trimethylsuccinic acid have not been described in formation waters before. Considering the degree of substitution of the marker compounds, we conclude that many of the alkylated succinic acids do not derive from the direct activation of hydrocarbons via addition to fumarate. Instead, we propose that they are formed from structurally diverse alkanoyl coenzyme A-esters which are known to occur at different levels of cellular metabolism. We suggest that these transformations contribute to sustaining solvent stress caused by membrane-disintegrating solvolytic hydrocarbons derived from the oil. Such biochemical self-protection measures may be particularly relevant for microbes thriving at elevated reservoir temperatures.

Conclusions

This study demonstrates that characterization of signature metabolites is a valuable tool for tracing metabolic activity of bacteria in oil fields, particularly in cases where conventional indicators based on crude oil composition may fail or are insecure due to marginal development of the biodegradation signature. Observed patterns suggest that various putative metabolites are not produced for energy conservation but rather play a role in protection mechanisms against high temperature and solvent stress. Our results document, that microbial transformation of hydrocarbons may take place at temperatures very close to the generally accepted threshold for in reservoir biodegradation of 80 °C.

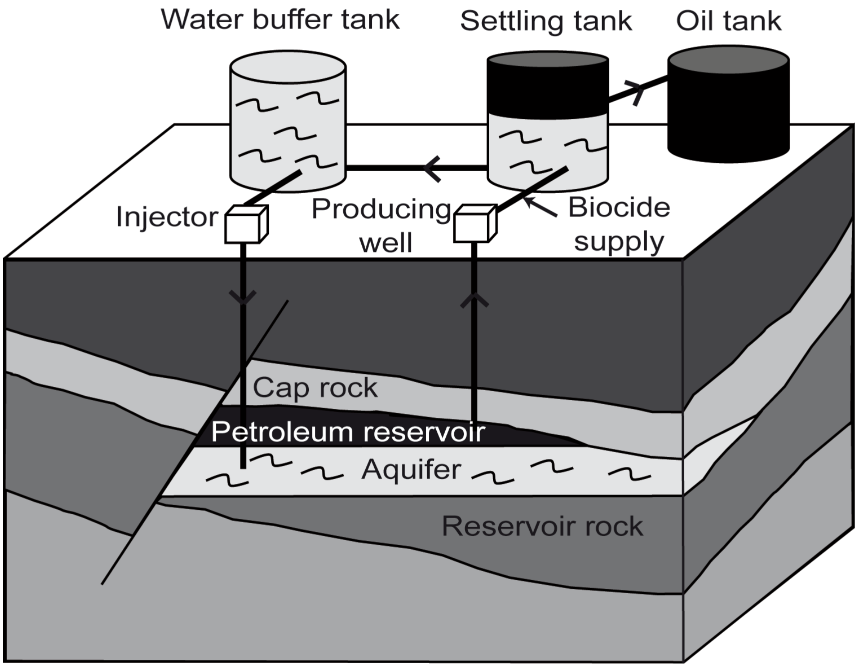

Figure 1 *Schematic view of a petroleum production plant. Fluids are produced from production wells and transferred to a separator tank. The separated oil is stored in an oil tank and the formation water is transferred into a buffer tank before re-injection into the reservoir. For this study, samples were taken at the producing well, the separator tank, the water buffer tank and the injector.*