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Anaerobic biodegradation of light hydrocarbons in crude oil: A comparison of laboratory experiments and field data

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Biodegradation of crude oil and natural gas in petroleum reservoirs is of great economic relevance and plays an important role in the biogeochemical carbon cycle. Petroleum reservoirs are an outstanding habitat of the deep subterranean biosphere where hydrocarbons – the main constituents of crude oil and natural gas and potential microbial energy sources – are present in great excess. The effects of biodegradation on oil and gas composition are well-documented but the underlying processes are poorly understood. However, it is clear that geologic environments with significant accumulations of hydrocarbons, particularly petroleum reservoirs, are mostly anoxic. Therefore, it was of great importance that in the last decade numerous anaerobic microorganisms have been described that are capable of utilizing aliphatic or aromatic hydrocarbons with different electron acceptors. Our studies on the mechanism of anaerobic biodegradation of *n*-alkanes for the first time allowed to propose a reasonable pathway for complete oxidation of this main class of petroleum constituents to carbon dioxide under strict exclusion of oxygen [1,2,3]. Laboratory experiments with different types of anaerobic hydrocarbon-degrading bacteria and crude oil as the sole source of carbon and energy have provided insight into the compositional alteration of petroleum and formation of metabolites. These results represent a model of initial to moderate biodegradation in oil fields. This presentation will compare the experimental results with observations on the composition of light hydrocarbons in crude oils from biodegraded rervoirs. It will be shown that specific alteration patterns may be a useful tracer to infer degradation mechanisms and respiration types.

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3.1.31

Geochemistry of an unconventional gas prospect: The Barnett Shale gas model

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The Mississippian Barnett Shale is a tight, over-pressured, organic-rich (4.5% average TOC at >1.1% R_o) black shale with porosities averaging 6% and permeabilities in the 0.1 to 0.02 millidarcy range. Barnett Shale lithofacies are primarily siliceous and calcareous shales containing clay-rich intervals, but cherty and dolomitic units are also common. Oil sourced from the Barnett Shale is produced in the northern and western areas of the Fort Worth basin. Even at low thermal maturity (*ca.* 0.6% R_o), the Barnett expels high quality (low sulfur, high API gravity) oil that appears to be a function of the organic matter type and shale mineralogy. Barnett Shale 'shale gas' is produced from the Newark East field where thermal maturity of shale is greater than 1.1% R_o.

A geologic model for the occurrence of Barnett Shale gas was developed through integration of extensive and diverse Barnett Shale data sets that include geologic, hydrocarbon production, and geochemical measurements. Predictive maps are constructed to high-grade the best prospects for oil versus gas and the highest BTU gas production. The use of basic geochemical measurements (TOC, Rock-Eval, %R_o, TEGC) and gas geochemistry including molecular and isotopic analysis of gas flow-line samples (free gas), desorbed gas from cuttings headspace and gas released from maceration of cuttings, make it is possible to predict sweet-spots within the well bore prior to completion. Tectonic fracturing appears to negatively impact shale gas production as some of the poorest flow rates are obtained in wells with the highest fracture density. Decreasing well spacing from 55 to 27 acres has had no apparent impact on production decline curves demonstrating the temporal integrity of this system. The processes governing the Mississippian Barnett Shale petroleum system provide an excellent model for predictive evaluation of other similar unconventional gas resources.