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Anaerobic petroleum degradation and methane generation in the subsurface: organisms and mechanisms

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Biodegradation of petroleum is an important alteration process with major economic consequences for oil and gas production. Until recently hydrocarbons were thought to be largely resistant to biodegradation in the absence of oxygen, nitrate or sulfate. However, recent geochemical and isotopic evidence suggests methanogenesis can drive hydrocarbon degradation in petroleum reservoirs, furthermore, laboratory studies provided direct evidence of the conversion of saturated hydrocarbons and whole oil to methane. We used a combined geochemical and molecular genetic approach to study the processes and microbial drivers of methanogenic degradation of crude oil. We demonstrated the methanogenic degradation of crude oil in anaerobic microcosms inoculated with estuarine sediment by measuring temporal changes in methane production, oil chemistry, and microbial community composition. These data were compared with control microcosms which did not contain oil or which contained an inhibitor of methanogenesis. In the presence of oil methane production was significantly enhanced. The quantity of saturated hydrocarbons consumed, when compared with the total amount of methane produced, was consistent with their conversion to CH_4 and CO_2. However, this process was slow with an initial lag phase during which comparatively little degradation activity occurred. After 200 days methane production and the concomitant degradation of hydrocarbons increased markedly. Changes in the microbial communities and hydrocarbon compositions during these anaerobic degradation experiments reflected temporal changes in methane production and provide new insights into the mechanisms of hydrocarbon degradation in petroleum reservoirs.