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ANAEROBIC HYDROCARBON DEGRADATION IN PETROLEUM RESERVOIRS AND METHANE GENERATION

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Biodegradation of petroleum is an important alteration process with major economic consequences for oil and gas production. Evidence is emerging to support the hypothesis that in-reservoir petroleum biodegradation is caused by anaerobic hydrocarbon degrading bacteria (e.g. Aitken *et al.*, 2004). Geochemical and isotopic evidence also suggest that in many cases the end-product of hydrocarbon degradation in petroleum reservoirs is methane (e.g. Pallasser, 2000). From thermodynamic considerations, hydrocarbons are feasible substrates for anaerobic degradation to methane (e.g., $4C_{16}H_{34} + 30H_2O \rightarrow 15CO_2 + 49CH_4$, ΔG -1596 kJ $mole^{-1}$), However, until recently these compounds were thought to be largely microbially (resistant) inert in the absence of oxygen, nitrate or sulfate (e.g. Rozanova *et.al.*, 1997). Because of the potential importance of methanogenic crude oil biodegradation, our limited knowledge of the organisms involved and of the mechanisms by which components of crude oil are degraded, it is important that we learn what governs the microbial conversion of oil to methane.

Saturated hydrocarbons comprise the quantitatively most important fraction of crude oils but very little is known about the methanogenic degradation of them and there are currently very few reports in the literature that provide strong direct evidence of methanogenic degradation of aliphatic hydrocarbons or crude oil (Zengler *et al.*, 1999; Anderson & Lovley, 2000; Townsend *et al*., 2003).

We have recently adopted a combined geochemical and molecular genetic approach to study the key processes and microbial drivers of methanogenic degradation of crude oil. In our study we have demonstrated methanogenic degradation of the alkanes in crude oil added to anaerobic microcosms inoculated with estuarine sediment (e.g. Figure 1). We have determined temporal changes in methane production, oil chemistry, and microbial community composition in replicated anaerobic microcosms. These data were then compared with control microcosms which contained no oil or which contained a specific inhibitor of methanogenesis. Methane production in microcosms amended with oil was significantly enhanced and 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. The methane

production and n-alkane degradation profiles indicated that the process of degradation was slow with an initial lag phase during which comparatively little degradation activity was observed. Following this lag phase methane production and the concomitant degradation hydrocarbons increased markedly. The changes in the microbial communities and hydrocarbon compositions during the laboratory anaerobic degradation experiments provide new insights into the mechanisms of hydrocarbon degradation in petroleum reservoirs.

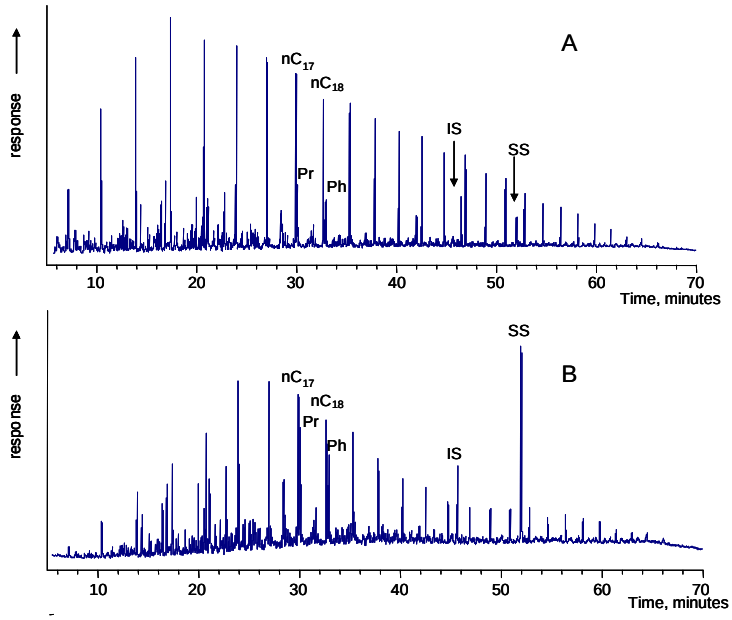

Figure 1. Gas chromatograms showing total hydrocarbon fractions from an undegraded North Sea crude oil (A) and the same oil after 15 months laboratory degradation under methanogenic conditions (B) IS and SS are added standards, Pr and Ph are pristane and phytane.

REFERENCES

Aitken, C.M., Jones, D.M. , Larter S.L.,2004. Anaerobic hydrocarbon degradation in deep subsurface reservoirs. Nature 431, 291-294.

Anderson, R.T., Lovley, D.R., 2000. Hexadecane decay by methanogenesis. Nature 404, 722-723.

Pallaser, R.J., 2000. Recognising biodegradation in gas/oil accumulations through the $\delta^{13}C$ compositions of gas components. Organic Geochemistry 31,1363-1373.

Rozanova, E. P., Savvichev, A. S., Miller, Y. M. , Ivanov, M. V., 1997. Microbial processes in a West Siberian oil field flooded with waters containing a complex of organic compounds. Microbiology 66, 718-725 .

Townsend, G.T., Prince, R.C., Suflita, J.M., 2003. Anaerobic oxidation of crude oil hydrocarbons by the resident microorganisms of a contaminated anoxic aquifer. Environmental Science and Technology 37, 5213-5218

Zengler, K., Richnow, H.R., Rosselló-Mora, R., Michaelis, W., Widdel, F., 1999. Methane formation from long-chain alkanes by anaerobic microorganisms. Nature 401, 266-269.