Examining the potential for using bacterial endospores in de-risking offshore petroleum exploration

Daniel Gittins, Anirban Chakraborty, Carmen Li, Casey Hubert

University of Calgary

Introduction

De-risking oil and gas exploration requires a multitude of strategies including conventional geophysical and geochemical techniques to identify the presence of a working petroleum system. To maximize exploration efforts, development of new microbiological assays that exploit distributions of marine bacteria and archaea have been proposed as complementary tools. Oil seepage by physical advection from deep hot subsurface reservoirs has been invoked to explain the presence of thermophilic bacterial endospores, i.e. “thermospores”, in cold seabed sediments. A biogeography informed approach to quantitatively assessing thermospore abundance gradients around seeps could offer a marker for hydrocarbon presence and a strategy to contribute to de-risking offshore prospects.

Theory and/or Method

Marine sediment samples were obtained during piston coring expeditions aboard the CCGS *Hudson* in prospective areas offshore Nova Scotia, Canada. Geochemical analyses on subsections of cores permitted an evaluation of the presence or absence of hydrocarbons, with further classification into oil-positive and oil-negative cores. To test for endospore-forming bacteria, deep water (2500 m) sediments were amended with 20 mM sulfate and organic substrates, pasteurised at 80°C, and incubated at intervals between 25 and 90°C for 56 days in a temperature gradient block.

Examples

Sulfate and organic acid profiles indicated both thermophilic and mesophilic, spore-forming populations, in an oil-positive core. Comparatively, only a mesophilic, sulfate-reducing, spore-forming population, with optimum activity at 30°C, was indicated in an oil-negative core. DNA sequencing results from the oil-negative sediment incubation showed an increase in *Desulfotomaculum* spp. This group of sulphate-reducing bacteria is well known in oil fields (i.e. causative agent of reservoir souring), however, comparative gene sequence analysis suggested this mesophilic spore-former shares a closer phylogenetic relationship with bacteria detected in deep-sea mid ocean ridge habitats. The 30°C temperature optimum for the mesophilic bacterial community suggests these cells may be unlikely to have originated from a hot subsurface petroleum reservoir. However, the thermophilic community, active at 60°C, signal the potential to have originated in a warm deep biosphere setting, and are candidates for further investigation as potential marker species for hydrocarbon seepage from oil reservoirs.

Conclusions

Ongoing efforts to correlate microbiological and geochemical data within the Nova Scotia offshore prospect and elsewhere will reveal the utility of microbial biosensors, including thermospores and/or identified “mesospores”, for de-risking offshore oil and gas exploration. Further efforts to elucidate if these mesospores can be active at lower *in situ* temperatures, will be helpful in further assessing their provenance and whether they can be considered reservoir derived.