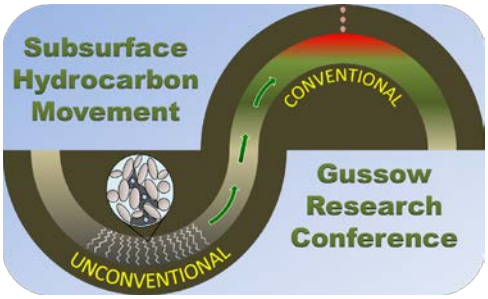

The dating of fluid residence time in subsurface reservoirs. Challenges, strategies and a design schematic for a practical geochemical toolbox

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Summary

The radiometric dating of geological events was a pivotal achievement not only ending the debate over the magnitude of the age of the Earth but also, for the first time, permitting the quantitative elucidation of geological processes. The dating of geological events initiated the modern era of the geosciences. Dating petroleum charge times, oil residence times and fluid charge rates into a trap would be equally pivotal and eliminate at a stroke, much speculation, concerning charging times and routes. In petroleum systems, while much effort has been put into using forward models to estimate the times of petroleum charging to subsurface traps, the reality is that there are no independent constraints on these estimates, yet fluid residence time in a trap is a key factor in many aspects of petroleum systems evaluation. While oilfield locations and oil maturity are often used together to constrain basin models, the direct testing of the locations of accumulations is provided by drilling, and estimates of the times of charging from models are non-unique and unreliable. While forward basin models provide estimates of oil charging times, they are unconstrained by real measurements made on the crude oil and have large errors associated with them, probably extending to a significant portion of the age of a reservoir. Petroleum charge times and rates are key variables in controlling hydrocarbon prospectivity, as they define volumes of trapped petroleum and the dynamics of trap integrity, including leakage and alteration phenomena. The most important constraining information in a petroleum system is currently inaccessible!

Based on over 5 years of research, we have now defined two general types of organic geochemical proxy systems that might in principle find application to the assessment of natural nuclear radiation dose experienced by a reservoir and petroleum fluids. Assessment of radiation dose by an oil provides a basis for a residence age determination geochemical proxy. We describe proxies based on: (a) crude oil component destruction proxies based on the systematic alteration and removal of readily identifiable and quantifiable species in crude oil that relate in some way to the incurred radiation dose; and (b) production of new compounds or species such as C=C species, bi-molecular addition products or low molecular weight fragments of larger structures, produced during radiolysis, with the concentration of produced species relating in some way to the incurred radiation dose. We present our results in the context of these two broad groupings. Sensitive chemical analysis, coupled with an irradiation model and standard petroleum system analysis approaches, can potentially provide fluid residence age assessments at sufficient resolution to be of practical utility.