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Unveiling petroleum fluid residence time in subsurface reservoirs

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In a recent publication (Larter et al., 2019), our team scrutinized the geochemical landscape and the challenges associated with the use of radiolysis geochemical proxies as chronometers that ultimately allow for the age dating of petroleum residence time in a subsurface trap, arguably the most important constraining information in a petroleum system model. Both R&D and early-stage commercialization components are being actively developed around such a novel approach. In this work, a brief introduction to sedimentary organic matter radiolysis is offered, including potentially groundbreaking findings in gas geochemistry (Silva et al., 2019). The viability and issues relating to the first putative fluid residence age measurements of oils in reservoirs, based on two case studies from petroleum systems worldwide, are also presented. The first case study involves oils recovered from Cambrian, Ordovician and Devonian reservoirs in the Northwest Territories – Canada. Burial histories are poorly constrained, as are heat flows and eroded section thicknesses at unconformities. Probable source rocks are Cambrian (possibly Proterozoic), Devonian and Cretaceous. One particular oil, hosted in Cambrian sandstones, has shown a very long residence time. In such a highly unconstrained petroleum system and exploration frontier, any fluid residence age assessments are key inputs for refining petroleum system models. In the second case study, a large set of genetically-related crude oils from an active exploration setting is analyzed. While some of the inferred oil residence ages were in agreement with the current basin model retrodiction for the first main charge out of the source rock, other oils notably showed much younger residence ages. Even if conceptual, analytical or other calibration-related uncertainties may still be too large to determine absolute residence age estimates in this play, relative fluid residence age measurements are per se intrinsically valuable. Such results are also thought-provoking in terms of future exploration target definition. We examine these and other case histories and conclude that while the approach and technology is still under assessment, the accumulated radiation doses implied from geochemical markers are indeed useful for estimating in-reservoir fluid residence time.

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