NOVEL MASS SPECTROMETRY TOOLS FOR PETROLEUM GEOCHEMISTRY ASSESSMENTS: NORWEGIAN NORTH SEA OILS

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Over a decade has passed since the first published application of FTICR-MS in petroleum geochemistry. Since then, a variety of petroleum system processes have been investigated under these novel analytical lenses, such as biodegradation, thermal maturation, thermochemical sulfate reduction and others where non-hydrocarbon species can reveal relevant geochemical information. In this work, we revisit FTICR-MS proxies reported in the literature and show a set of newly proposed ones to discuss the value, as well as the challenges and limitations, associated with such data. A challenging petroleum system is used to exemplify how the FTICR-MS fingerprinting can provide key geochemical insights for oil exploration.

The Southern Utsira High (SUH) in the Norwegian North Sea is a prolific exploration target where, burial, tectonic and glaciation events have influenced current oil placement. Attempts to untangle oil families and fluid movement over time within SUH have faced a very complex scenario where further geochemical research is needed to reduce exploration uncertainties. In total, 13 oils from 10 different wells located in five fields within the SUH were analyzed using both ESI-N (electrospray ionization in negative mode) and APPI-P (atmospheric pressure photoionization in positive ion mode) ion sources, aimed to detect acidic and aromatic/basic compounds, respectively. Ion intensities for the 15,000+ unique molecular formulas detected within the sample set (assignment error < 400 ppb) were compared and used to assess multiple FTICR-MS-based geochemical proxies. For example, the DBE (double bond equivalent) pattern within class N acidic compounds allowed the classification of oils based on thermal maturity (%R_0 0.75-0.85), while class-specific averaged molecular mass measurements suggested three distinct oil families from at least two charging events. Biodegradation levels of SUH oils, as measured by the acidic class O_2 compound distribution, indicated minor compositional alteration within certain fields, potentially associated with the time of charging events. Relative intensities of sulfur-bearing compounds were proven useful to distinguish two sets of slightly biodegraded oils from different fields, suggesting these are not genetically related. Such interpretations are complemented and/or compared with GC-MS biomarker data, whenever applicable, thus a comprehensive story of SUH petroleum systems, from different viewpoints, is achieved.

Although well-developed, traditional biomarker geochemistry methods may capture the most relevant SUH geochemical info, FTICR-MS fingerprinting, even at an early development stage and not fully calibrated with worldwide sample sets, takes petroleum system geochemical assessments one step further. Moreover, we discuss the practical aspects related to FTICR-MS proxy implementation focused on oil exploration.