Re-Os ages for a confined petroleum system, Norwegian North Sea

S. V. GEORGIEV[1*], H. J. STEIN[12], J. L. HANNAH[12], G. YANG[1], C. E. DONS[3], J. H. PEDERSEN[3]

[1]AIRIE Program, Colorado State University, USA
*georgiev@colostate.edu
[2]CEED Centre of Excellence, University of Oslo, Norway
[3]Lundin Norway AS, 1366 Lysaker, Norway

We critically evaluate hypotheses for the timing and mechanisms of oil formation based on new Re-Os data for a confined petroleum system in the Norwegian North Sea.

First, we separated a crude oil into maltene (MALT, heptane-soluble, ~95 wt% of oil) and asphaltene (ASPH, heptane-insoluble, ~5 wt% of oil) fractions. Re-Os contents and $^{187}Os/^{188}Os$ and $^{187}Re/^{188}Os$ isotopic ratios systematically increase from MALT to crude oil to ASPH. All samples form a precise Re-Os isochron with an age of ~110 Ma (late Early Cretaceous) and initial $^{187}Os/^{188}Os$ ratio (Os_i) of ~0.52.

Second, we leached with chloroform Lower Cretaceous siltstone-sandstone reservoir rocks to extract impregnated hydrocarbons (~1.8 wt% of rock). Leached hydrocarbons have higher Os and significantly higher Re contents than ASPH from the related crude oil, and notably different Re-Os isotopic ratios. All leached samples yield a precise Re-Os isochron with an age of ~7.3 Ma and high Os_i of ~ 4.86.

Third, calculations show that ingrowth of ^{187}Os from the heaviest ASPH could increase Os_i from 0.52 to 4.86 between ~110 Ma and ~7.3 Ma, providing a possible link between the crude oil and the chloroform-extracted reservoir rock hydrocarbons. Hence, the Re-Os ages may represent the timing of oil formation (~110 Ma) and of subsequent oil migration in/out of the sandstone (~7.3 Ma). However, our regional studies on organic-rich shales suggest that at 110 Ma the presumed Upper Jurassic source rocks likely had $^{187}Os/^{188}Os$ substantially higher than 0.52. Therefore, the oil may have been produced instead by Lower Cretaceous shales. Alternatively, the lightest portions of the oil, produced at 7.3 Ma from an Upper Jurassic source, contained little Re and Os and were therefore subject to significant contamination. Through a yet unknown mechanism, this moderately light oil may have acquired Re and Os along its migration path or within the reservoir rock, resulting in a Re-Os isochron that reflects the age and Os_i of the reservoir rock, and not of the oil source rock.

Future Re-Os analyses of pristine (oil-free) resevoir rocks may help discriminate between these hypotheses.

Support provided by the Norwegian petroleum industry under the CHRONOS project.