

SUCCESSIVE OIL CHARGING AND BIODEGRADATION IN THE LUNO II FIELD, NORWEGIAN NORTH SEA

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Abstract

Multiple charging and phases of biodegradation are apparent in the reservoirs of the Luno II (Late Triassic Skagerrak Fm) discoveries in Norwegian North Sea block 16/4, SW of the large Johan Sverdrup Field. Three wells (16/4-8 S, 16/4-6 S and 16/4-9 S from E to W) were drilled on three structural blocks representing individual inlier basins. The wells proved live oil and gas columns as well as significant residual biodegraded oil legs. Evaluating the extent of biodegradation from component concentrations in reservoir extracts is hampered by the presence of oil-based mud contamination, but it can be achieved using ratios of compounds of similar volatility and provides insight into the filling history.

Acyclic isoprenoids, dimethyl- and trimethylnaphthalenes, and possibly dimethylphenanthrenes are affected by the biodegradation, but not apparently biomarkers. Interestingly, acyclic isoprenoids show increasing resistance towards biodegradation from C₁₅ to C₂₀. In well 16/4-6 S the live oil zone is characterized by a distinct high asphaltene zone at its base directly above the oil-water contact (OWC). Below the OWC residual oil saturation is encountered, in which biodegradation is more pronounced. The 16/4-9 S well, in the NW, exhibits the greatest range of variation in *n*-alkane content, from virtually pristine live oil to almost complete removal of *n*-alkanes in the deepest residual zone. In contrast, samples from the 16/4-8 S well in the SE are more uniformly degraded in terms of acyclanes. Di/trimethylnaphthalenes of the live oil zone in 16/4-8 S exhibit greater influence from biodegradation than in wells to the NW in Luno II. Recharging with fresh oil appears to be focussed in the NW of the discovery. This inference from ratios in reservoir extracts is supported by absolute concentration of acyclanes in test oils.

Within Luno II there appears to be a source related compositional gradient from 16/4-9 S to 16/4-8 S in the SE. There also appears to be fairly minor source-related compositional differences between the deeper, most highly biodegraded, oil and that in the live zone. However, similar maturities of ~0.8% R_o are suggested throughout, and a fairly typical upper Jurassic marine source is inferred. CSIA of acyclanes supports the suggested compositional difference of the Luno II 16/4-9 S live oil, which is significantly isotopically lighter (>5‰) than equivalents from the other Luno II wells, to an extent that is unlikely to be entirely attributable to biodegradation differences. A small decrease in relative abundance of C₂₉ steranes to the NW in Luno II could reflect a slight decrease in relative contribution from humic OM. It appears there are at least two main phases of migration into the Luno II reservoir: an earlier, now extensively biodegraded phase, and a recent-current phase focussed in the NW of the field. Assuming similar oil charges (particularly volatility ranges) have contributed throughout, an estimation of degree of biodegradation can be obtained from variation in the concentration of recalcitrant biomarkers, which are progressively enriched in the more severely biodegraded samples. Relative to total oil/extract, ~50% of the oil has been degraded in 16/4-8 S, from 35 to 60% in 16/4-6 S as biodegradation increases with depth, and from ~0 to 60% in 16/4-9 S. This level of oil loss in the most severely biodegraded samples is

consistent with the level of biodegradation suggested by compound distributions. Problematically, negative values are estimated in the zones of high asphaltene content in Luno II, even where concentrations in just total hydrocarbons are considered, suggesting mass loss due to extensive deasphalting is not the sole cause. However, detailed mapping of residual and live oil compositions and levels of biodegradation allow making inferences on the timing of the respective charges, as well as field communication.

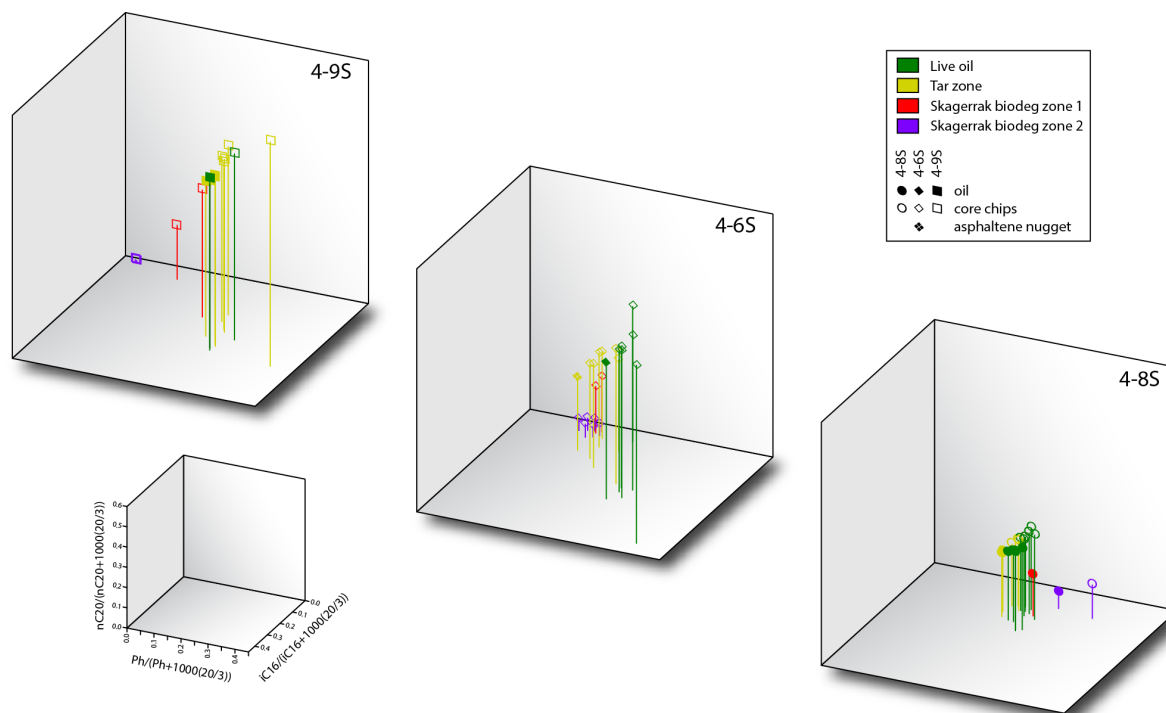


Figure 1. Abundance of acyclanes relative to C_{20} cheilanthane (20/3).