A WORLD-CLASS SOURCE ROCK: KEROGEN COMPOSITION AND QUALITY OF THE UPPER JURASSIC MARINE FARSUND FM SHALES, DANISH NORTH SEA

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Introduction

The primary source rocks in the North Sea are Upper Jurassic–lowermost Cretaceous marine black shales, corresponding to *inter alia* the Farsund, Mandal and Kimmeridge Clay Formations. These shales in the North Sea show significant lateral and vertical variations in source rock quality (Justwan et al., 2005; Keym et al., 2006; Petersen et al., 2010). In the Danish Central Graben in the North Sea the vast majority of the produced oils can be typed to different facies of the Farsund Fm (Petersen et al., 2016).

The Jude-1 well drilled in the central part of the Danish Central Graben provides a unique possibility to address kerogen composition and quality variability of the Upper Jurassic shales in more detail due to dense sampling and because a 43 m (140 ft) core was taken.

The current study reports the results of a comprehensive study of the shales, including source rock screening, Pyrolysis-gas chromatography (Py-GC), measurement of bulk kinetics, and organic petrography.

Results

The shales are thermally immature rendering the samples suitable for investigation of kerogen composition and original source rock quality. The uppermost part of the Farsund Fm, including the so-called Bo Mb defined by increased GR readings ('hot' shales), and two deeper intervals are highly organic-rich and oil-prone. The average TOC and HI values of the hot Bo Mb shales are c. 7 wt% and 460 mg HC/g TOC, respectively, corresponding to an excellent oil-prone source rock. The total Ultimate Expulsion Potential (UEP) of the over 850 m thick Farsund Fm is ~142 MMboe/km^2, but the quality varies significantly through the section.

The organic facies corresponds to Type II kerogen or Organofacies B (*sensu* Pepper and Corvi, 1995). Reflected light microscopy in white and fluorescing-inducing blue light shows a sapropelic kerogen composition characterized by a groundmass of yellowish fluorescing amorphous organic matter (fl. AOM) and liptodetrinite intimately associated with the mineral matrix and less abundant *Tasmanites*- and *Leiosphaerida*-type telalginites (Figure 1). PY-GC analysis shows the characteristics of marine shales yielding almost similar GOGIs (Gas-Oil Generation Index) of c. 0.20. The predicted oil composition corresponds to 'paraffinic low wax oils'. The kinetics for bulk petroleum generation reveal activation energy (E_a) distributions ranging from 41–43 kcal/mol to up to around 56 kcal/mol with 2–4 dominant peaks centered at 51–53 kcal/mol. TR50 temperatures range from c. 130–140^{o}C. Low activation energies possibly relate to S_1 carryover (S_2 shoulder on Rock-Eval pyrograms) caused by a combination of pre-oil solid bitumen and drilling mud contamination (and perhaps some early reactive kerogen?).

Organic petrography, Py-GC and bulk kinetics indicate a fairly homogenous kerogen composition. The quality variation may thus mainly reflect differences in preservation potential of the organic matter, although the general depositional environment was oxygen-deficient.

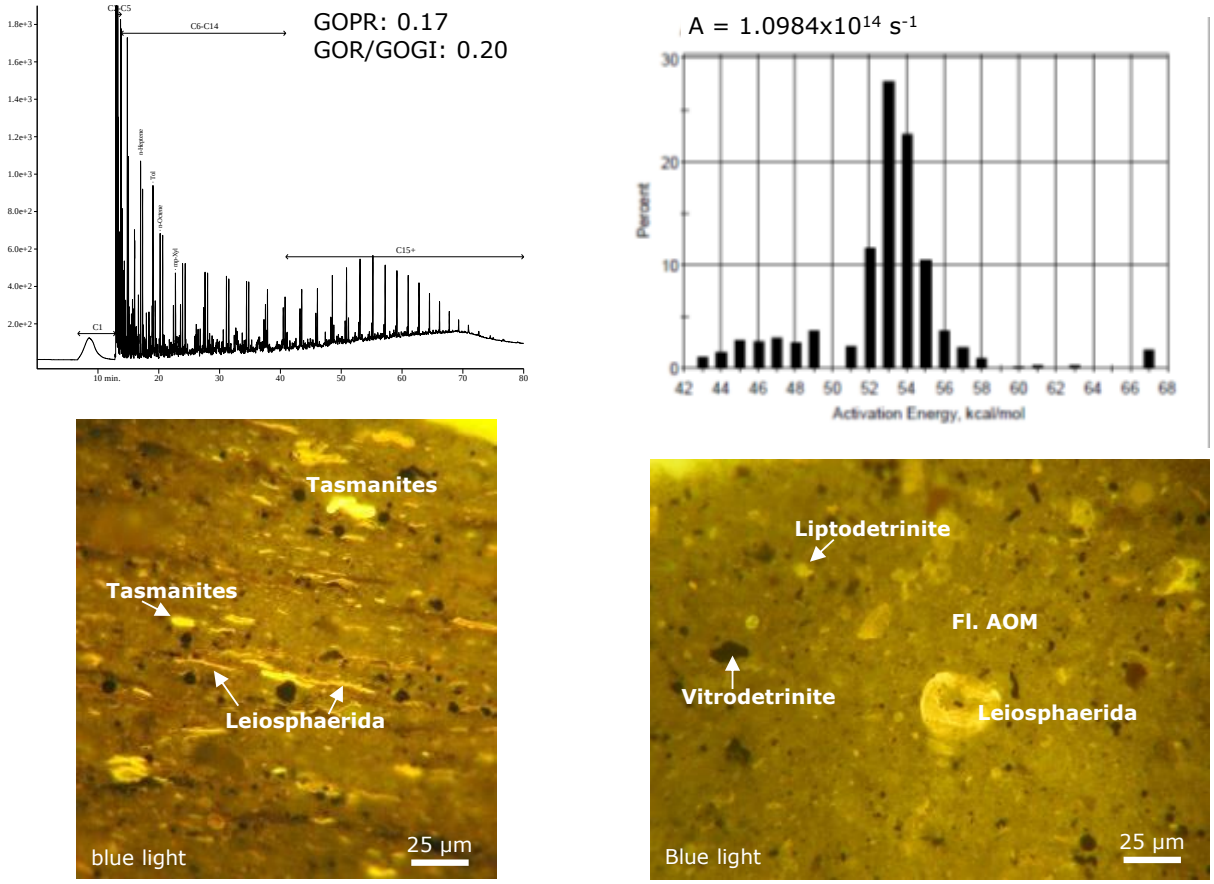

Figure 1 *Py-GC, measured bulk kinetics and organic petrography of a shale sample (core) showing a highly oil-prone sapropelic kerogen composition.*

Conclusions

The Farsund Fm shales are composed of sapropelic kerogen with variations in source rock quality likely related to organic matter preservation potential, terrigenous kerogen input and lithofacies (shale vs calcareous shale). The generation potential varies through the section, but several intervals display world-class quality and will charge paraffinic low wax oils.

References

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