Untangling the Details of North Sea Crude Oil

Sundberg, Jonas Folke; Jensen, Annette Eva; Feilberg, Karen L.

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Jonas Sundberg, Annette Eva Jensen, Karen L. Feilberg

Reservoir Fluid Characterization

A detailed knowledge of the molecular composition of crude oil and reservoir fluids is fundamental to understanding its formation, physical properties and macroscopic behavior. Our objective is to study compositional changes that occur during recovery processes, and gain a better understanding of the underlying mechanisms on a molecular level. Additionally, parameters that correlate to maturity, biodegradation and oil genetics are employed to understand migration patterns. The results will provide input for computational models that link laboratory-scale enhanced oil recovery (EOR) experiments to theory, and ultimately field applications.

Sample Set

Geochemical parameters were determined for a sample set consisting of 5 oils and 2 condensates from different fields and wells in the Danish North Sea. The condensates are visually distinguishable based on colour, and are lighter than the crudes which also is evident in the data.

Group-type Analysis

The crude oil samples show typical distributions of saturates and aromatics, with OilS4 having slightly higher content of polar components than the others. The two condensates show a high concentration of light hydrocarbons and alkanes, whereas the condensate distribution was not determined due to lack of method specificity for this type of sample. The oils have low asphaltene content and due to the high uncertainty associated with asphaltene precipitation at these levels, values are reported as 0.5% without further specificity. The percentage of neutrals is back-calculated.

Maturity and Biodegradation

Semi-quantitative parameters used for maturity, biodegradation and oil source correlation are based upon peak area ratios and should be used with care. Issues such as co-elution, and integration parameters affect the data and interpretation and the values must be used in relation with others and as indications, not absolute facts. Compounds were identified by a combination of deconvolution of high-resolution data and comparison of retention using a reference sample (NIOM N10-1) of known composition.

The alkane distribution is noticeable different between Oil1 and the other samples. Maturity parameters indicate that these oils are of similar thermal maturity, and the difference is likely due to slight biodegradation. Ratios of Pr/Ph-C17 and Pr/Ph-C18 add further evidence, as biodegradation affects linear hydrocarbons before branched. Oil2 and Oil3 are the most affected samples. For the condensates, the distribution is shifted towards lighter hydrocarbons as expected. Only very low levels of saturated biomarkers were detected in the condensates, which indicates that evaporative fractionation / gas-condensate migration in the source has taken place.

Geochemical Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CondS1</th>
<th>CondS2</th>
<th>OilS1</th>
<th>OilS2</th>
<th>OilS3</th>
<th>OilS4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr/Ph-C17</td>
<td>0.05</td>
<td>0.37</td>
<td>0.12</td>
<td>0.09</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>Pr/Ph-C18</td>
<td>0.42</td>
<td>0.38</td>
<td>0.29</td>
<td>0.25</td>
<td>0.32</td>
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<tr>
<td>n-C25/n-C30</td>
<td>0.56</td>
<td>0.42</td>
<td>0.62</td>
<td>0.62</td>
<td>0.62</td>
<td>0.62</td>
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<tr>
<td>Saturates</td>
<td>0.62</td>
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<td>0.62</td>
<td>0.62</td>
<td>0.62</td>
<td>0.62</td>
</tr>
<tr>
<td>Asphaltenes (&lt;0.5%)</td>
<td>23</td>
<td>22.5</td>
<td>22</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>

Experimental Details

Sample Preparation

Crude oils and condensates were fractionated into saturates and aromatic hydrocarbons using a PerkinElmer 8500 GC with flame ionization detector. The IPF column was conditioned with CHCl3 and n-hexane, afterwards aliquots of crude or condensate were combined with internal standards and loaded into the column. Samples were dried with a fraction collector at 80 °C. The asphaltene content was estimated gravimetrically, and the wax content was estimated using a fraction collector at 80 °C. The pristane and phytane content were calculated gravimetrically.

Separation, Identification, Formulas & Applications

SARA Analyses were carried out on a Varian 3400 GC with a 10 meter Carbowax 20M column and a flame ionization detector. Separation of saturates and aromatic hydrocarbons were carried out using a 70:30 DMCS:Petroleum ether (35:65 v/v) mixture as the elution solvent. Polycyclic aromatic hydrocarbons were separated using a 2:1 Hexane:DCM mixture for elution. Polycyclic aromatic hydrocarbons were separated using a 2:1 Hexane:DCM mixture for elution. The asphaltene content was determined gravimetrically.

Quality Control

An asphaltene content of 0.1% or more was used as internal quality control during fractionation and analysis.

Chromatogram of selected terpenes (measured using m/z 191) in the sample from OilS2.

Polycyclic aromatic hydrocarbons in OilS3, where alkylated bicyclic aromatics are the major components. Insert shows region with methylphenanthrene isomers used as maturity indicators.

Sample chromatogram for OilS2, OilS3, OilS4, CondS1, CondS2