Untangling the Details of North Sea Crude Oil

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Reservoir Fluid Characterization

A detailed knowledge of the molecular composition of crude oil and reservoir fluids is fundamental to understand 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 links 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 crude which is also evident in the data.

Distribution patterns for saturated hydrocarbons. Insert shows the n-C17, pristane, n-C18 and phytane region.

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 monomethers, however full SAXS-distribution was not determined due to lack of method specificity for these type of samples. The oils have low asphaltene content, and due to the high uncertainty associated with asphaltene precipitation at these levels, values are reported as ±0, without further specificity. The percentage of resins 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 indicators, not absolute evidence. Compounds were identified by a combination of deconvoluted of high-resolution mass spectra and comparison of retention using a reference sample (NIST NHO-1) of known composition.

The alkane distribution is noticeable different between OIS1 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/n-C17 and Ph/n-C18 add further evidence, as biodegradation affects linear hydrocarbons before branched. OIS2 and OIS3 are the most affected samples. For the condensates, the distribution shifted towards lighter hydrocarbons as expected. Only very low levels of saturates biomarkers were detected in the condensates, which indicates that evaporative fractionation / gas-condensate migration in the source has taken place.

Geochemical Parameters

| Parameter | Oil | C17 | C18 | C19 | Pr | Ph | Ts | Np | CPI | t | Ts/Pr | Ts/Ph | CPI/Pr | CPI/Ph | m/z 191 |
|-----------|-----|-----|-----|-----|----|----|----|----|-----|----|-------|-------|--------|--------|--------|--------|
| OilS1     | 1.03| 0.96| 0.73| 0.83| 1.5| 1.5| 0.72| 0.75| 2.81| 2.0| 1.05  | 0.75  | 1.15   | 1.15   | 1.15   |
| OilS2     | 1.03| 0.95| 0.69| 0.82| 1.4| 1.4| 0.74| 0.75| 2.81| 2.0| 1.05  | 0.75  | 1.15   | 1.15   | 1.15   |
| OilS3     | 1.03| 0.95| 0.69| 0.82| 1.4| 1.4| 0.74| 0.75| 2.81| 2.0| 1.05  | 0.75  | 1.15   | 1.15   | 1.15   |
| OilS4     | 1.03| 0.95| 0.69| 0.82| 1.4| 1.4| 0.74| 0.75| 2.81| 2.0| 1.05  | 0.75  | 1.15   | 1.15   | 1.15   |
| OIS1      | 1.03| 0.95| 0.69| 0.82| 1.4| 1.4| 0.74| 0.75| 2.81| 2.0| 1.05  | 0.75  | 1.15   | 1.15   | 1.15   |
| OIS2      | 1.03| 0.95| 0.69| 0.82| 1.4| 1.4| 0.74| 0.75| 2.81| 2.0| 1.05  | 0.75  | 1.15   | 1.15   | 1.15   |
| OIS3      | 1.03| 0.95| 0.69| 0.82| 1.4| 1.4| 0.74| 0.75| 2.81| 2.0| 1.05  | 0.75  | 1.15   | 1.15   | 1.15   |

Experimental Details

Sample Preparation

Crude oils and condensates were freeze-dried into an evacuated and argon-flushed hydrocarbon. Using Permanax Silica 80/100 under a pressure of 2 mmHg. The samples were collected as a suspension in methanol, and were used as a suspension in methanol. The samples were then dried under vacuum.

GC/MS: Mass spectrometry was carried out using an Agilent 7890B gas chromatograph coupled to an Agilent 5975C inert MSD mass spectrometer. Compounds were separated on a 50 m x 0.25 mm, 0.25 µm film thickness, fused silica column using a temperature program from 50 °C (1 min) to 300 °C (20 min) at 3 °C/min. The mass spectrometer was operated in ionisation mode. The samples were quantified using a 7-point calibration curve prepared from standard solutions of 69 mass. Calibration of the mass spectrometer was carried out using regular standards of n-C19, n-C21, n-C23, n-C25 and n-C27. The mass spectrometer is equipped with a multiple ion detector and a polyphonic hydrocarbon/natural gas detector. The samples were analyzed in triplicate, and the results were averaged.

GC/MS Analysis: Analysis was carried out using a GC (8850B) and a GC-QP2010 system, as well as a GC-MS. The GC was used to separate the samples, and the GC-QP2010 was used to quantify the compounds. The GC-MS was used to determine the concentration of the compounds, and the GC-QP2010 was used to quantify the compounds.

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