Formation of Oil and Gas, Sources, Reservoirs and Traps

- Origin of Oil and Gas
- Sources - what are good source conditions?
- Migration - how does hydrocarbon migrate and what influences migration?
- Reservoirs - what makes for good storage potential?
- Traps - how is hydrocarbon trapped?
Formation of Oil and Gas

- Decay of algae and bacteria
- Burial
- Cooking (temp+press)
Formation of Hydrocarbon

Favourable Preservation Conditions

- High organic production (over 10%)
- Anaerobic depositional systems
- Moderate to low rate of sedimentation

Lake (thermal stratification)
Ocean strat.

Barred basin
Salinity contrast

Continental shelf
Upwelling
## Hydrocarbon type

<table>
<thead>
<tr>
<th>Material</th>
<th>Shallow burial</th>
<th>Deep burial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algae and Bacteria</td>
<td>Oil</td>
<td>Gas (e.g. N. North Sea, Jurassic)</td>
</tr>
<tr>
<td>Plants</td>
<td>Coal</td>
<td>Gas (e.g. S. North Sea, Carboniferous)</td>
</tr>
</tbody>
</table>
Changes on Burial

Diagenesis (up to 50°C)
- Biological
- Chemical
- Physical

Catagenesis (50-200°C)

Metagenesis (200-250°C)
Formation of Oil and Gas

Fats, waxes, oils → Kerogen → Heavy Oil → Gas

Cellulose, wood → Woody Kerogen → Coal → Gas

HEAT + PRESSURE
Oil Formation Process

**Biopolymers**  
Carbohydrates, Proteins, Lipids, Lignin

**Microbial Alteration, Hydrolysis**

**Biomonomers**  
Sugars, Amino Acids, Fatty Acids, Phenols

Condensation, Maillard Reaction, Deamination, Reduction, Cyclization, Polymerization

**Geopolymers**  
Nitrogenous and Humic Complexes

50°C (122°F)

Thermocatalytic Cracking, Decarboxylation, Hydrogen Disproportionation

**Geomonomers**  
Petroleum Hydrocarbons and Low Molecular Weight Organic Compounds

200°C (392°F)

Thermocracking

**End Products**  
Gas and Pyrobitumens

From Hunt, 1979
The Oil Window
Hydrocarbon Needs

Source Rock
Reservoir Rock
Trapping Mechanism
Timing
North Sea

Oil - 3.5-5km
Gas - 4-6km
Migration

- Physical Compaction - burial
- Oil and gas formation (chemical)

Factors controlling migration?
Migration

• Porosity
• Permeability – primary and secondary

High                                Low
Connected                   Unconnected
Migration

Differentiation of Water, oil and gas
Hydrocarbon Traps

Types of Trap
- Structural
- Stratigraphic
- Diagenetic
Trap type
North Sea – Key Hydrocarbon Events

- Mesozoic extension and rifting, Jurassic-Cretaceous high organic input to rift valley
- Permian (Pangaea) basin formation (crustal subsidence) on Variscan folding
- Variscan Orogeny – Southern North Sea
- Crustal Extension – Carboniferous, equatorial swamps, high organic content
- Caledonian Orogeny – closing of Iapetus, volcanic activity in back-arc basin, land of lakes (Devonian ORS)
North Sea Examples – Salt Gas Traps, Southern North Sea
North Sea Examples - Salt Gas Traps, Southern North Sea

Deposition of salt layer

Permian desert lake bordered by vast sand dunes
Rotliegend Sandstone

High organic input
Carboniferous Coal
North Sea Examples – Salt Gas Traps, Southern North Sea

Indefatigable and Leman Fields in Rotliegend Sand
North Sea Examples – Salt Movement and Basin Inversion

Salt flow through Permian e.g. Fulmar and Gannet Fields
North Sea Examples – Deep (Permian) Basins
North Sea Examples – Deep (Permian) Basins

Half-graben
“trap-door mechanism

e.g. Faeroe-Shetland Basin,
giant Morecambe field
North Sea Examples – Mesozoic Rift Valleys & Extension
North Sea Examples – Rift Valleys & Extension

Rifting for 100MY
Most active in Jurassic
Jurassic - highest source potential
Kimmeridge Clay (140Ma) source
Kimmeridge (Brent) delta sands reservoir from upland volcanic centre
North Sea Examples – Rift Valleys & Extension

Source – slow subsidence and large accumulation
Maturation still in progress today
North Sea Examples – Rift Valleys & Extension

Reservoir in delta sands off active rivers e.g. Brent Field
North Sea Examples - Rift Valleys & Extension

150ma (Jurassic-Cretaceous)
- Rapid subsidence and slumping -
- Large low relief deposits of sheet-like sands
  e.g. Brae, Galley, Claymore and Magnus fields