The Association for the Study of Peak Oil

Presentation on Oil Depletion

Part 1.

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Introduction

- Man's growing energy demands
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• Man appeared on the Planet about four million years ago. Earliest man discovered the power of fire, which later led him from the Stone Age to the Bronze and Iron Ages.

• The pace of change accelerated from the Industrial Revolution to the Space and Computer Ages of to-day in only 300 years.

• The demand for energy grew in parallel, as did the population, which has expanded six-fold since oil production began.

• The sources of energy have changed from firewood and muscles through wind and water to coal, oil, gas, nuclear and to new solar methods. Coal, oil and gas are finite fossil fuels formed but rarely in the geological past.

• Accordingly, they can be extracted but not produced, and when they are gone, they are gone. Oil is the most useful and efficient of such sources, providing 40% of all energy consumed. It is important for transport and agriculture, which means food.

• The modern economy runs on energy, not money, as some would have us believe.

• Geological knowledge reveals that the rate of extraction will soon start to decline. That cannot fail but have a radical impact, threatening even the very survival of Mankind.

• It is an important subject, requiring some basic geological insights. It should be at the top of everyone's agenda, but it is not.

The Geological Origins of Oil

- A few brief epochs of extreme global warming gave the bulk of the world’s oil
- Algal blooms gave organic matter, which was locally preserved in stagnant troughs
- It was converted to oil and gas on burial
- The processes are well understood.

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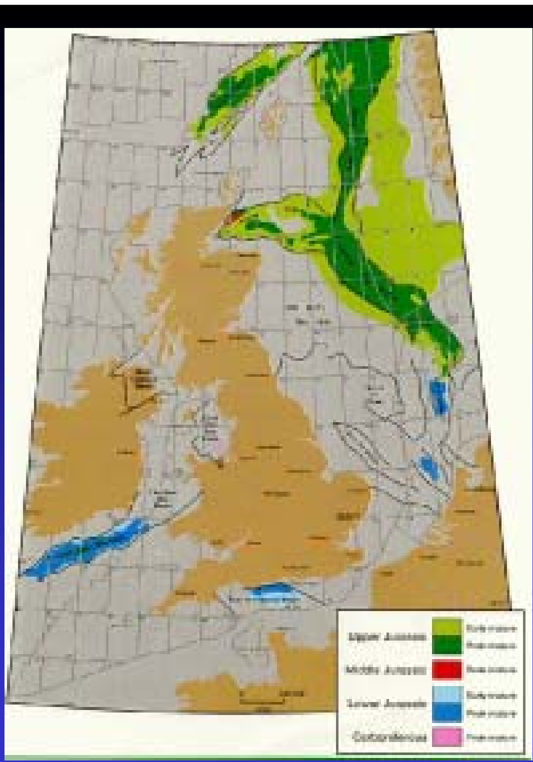
• Isotopic evidence shows that oil comes from **algae**, whereas gas comes from vegetal material. Deep, over-heated oil also breaks down into gas.

• Another theory that oil comes from deep in the Earth's crust from inorganic sources, as proposed by certain academics, can be confidently rejected.

• The Earth's climate has fluctuated greatly in the geological past. The bulk of the world's oil comes from a few epochs of extreme global warming, when seas and lakes were effectively poisoned by algal growths.

• The organic material was preserved in stagnant troughs, especially in rifts, formed as tectonic plates moved apart. It was heated by the Earth's natural heat-flow as it was buried below younger sediments. When it reached a depth of about 2000m, chemical reactions converted it into oil and gas.

• **Generation** was a short-lived episodic event. Once formed, the oil began to move through the rocks, being locally trapped in geological structures. Much has been lost over geological time.



North Sea Oil Generating Trends - Where oil is and where it is not

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• One such period of extreme global warming occurred 145 million years ago, near the end of the Jurassic Period.

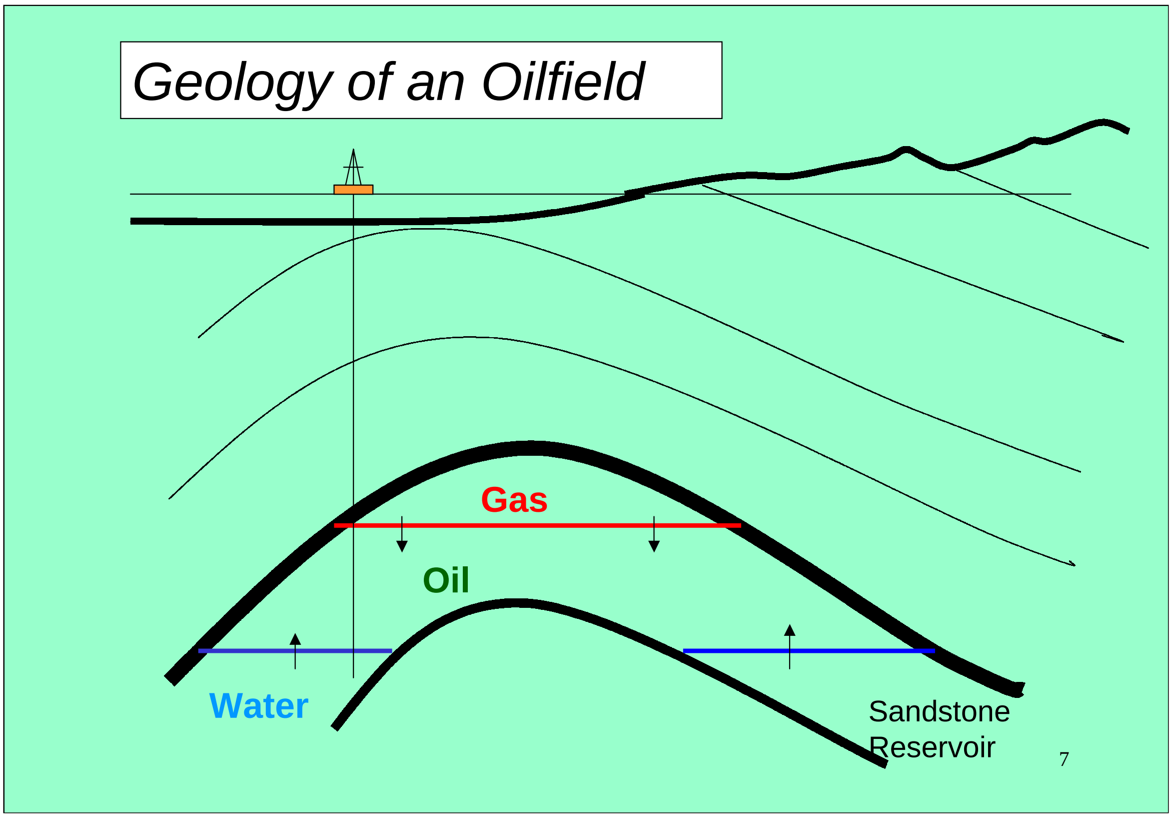
• It was responsible for much of the oil in the Middle East, Russia and the North Sea, when a few hundred meters of organic-rich clay were laid down. You can see this clay in southern England, where it crops out near the village of Kimmeridge in Dorset.

• The map shows where it was buried enough to generate oil in the North Sea. It was just starting to generate in the light green areas, reaching a maximum in the dark green areas.

• Other leaner, older sources are shown in other colours, yielding much less oil.

• There are many areas outside the productive belts that are barren because they lack the essential geology and will remain so irrespective of technology or investment

• The World has now been so extensively mapped that nearly all the prolific oil generating belts have been identified.



• Oil is formed under very high pressure. The pressure caused hair-line fractures to develop in the overlying rocks, allowing the oil to **migrate**.

• If this migrating oil encountered a porous stratum, such as a sandstone, it preferentially flowed through this conduit. If it led straight to the surface, the oil escaped, but if it was folded or faulted, the oil may have been trapped.

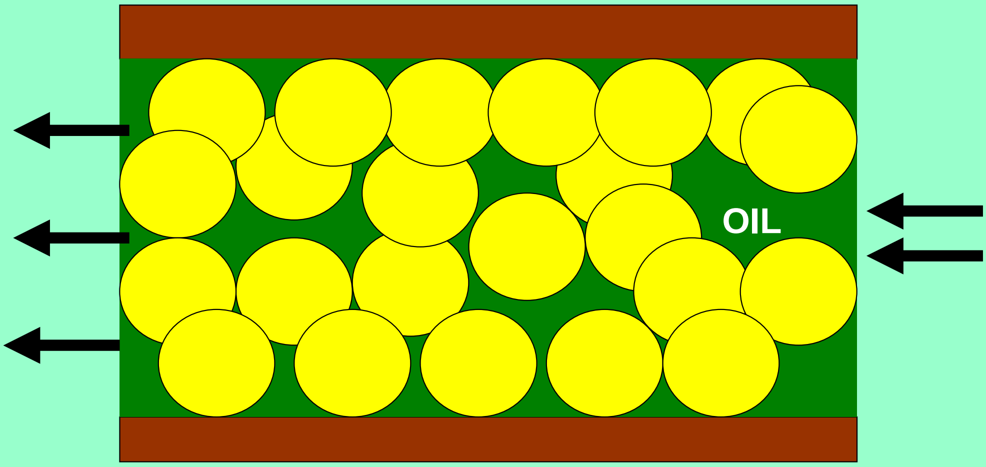
• This shows the crest of a geological fold, called an **Anticline**. Oil collected in the crest, and gas commonly separated from it to form a gas cap. The oil floats on the water-filled pore-space in the rocks beneath it.

• The oil and gas leak from the trap over time unless the overlying rocks form a good seal. Clay and salt are good seals, but no seal is perfect.

• As the oil is extracted, the gas above it expands, and the water below it encroaches.

• This example shows a simple anticline, just offshore. Most structures are more complex, being broken up by faults or containing subsidiary reservoirs.

What a Reservoir looks like



Oil fills the pore-space between the grains of sand, which are often coated in a film of water. It has to flow through these constrictions.

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• Oil does not occur in an underground cavern, but lies in the pore-space of the **reservoir** rock. This is called ***Porosity***. Sandstone is such a reservoir rock, but there are others too.

• The grains of sand are commonly coated with a film of water, left over from when they were deposited in the sea or a lake.

• The oil has to make its way through many constrictions between the grains as it moves towards the wells. This example shows well-rounded and equal-sized grains, forming the best kind of reservoir. There are many inferior types. Porosity in reservoirs generally ranges from about 10% to 30%.

• The oil is forced through the rock towards the wellbore by the pressure of the expansion of the oil itself, by the expanding gas above, and the pressure of the encroaching water from below.

• Water and gas may be injected into the reservoir to encourage the oil to flow.

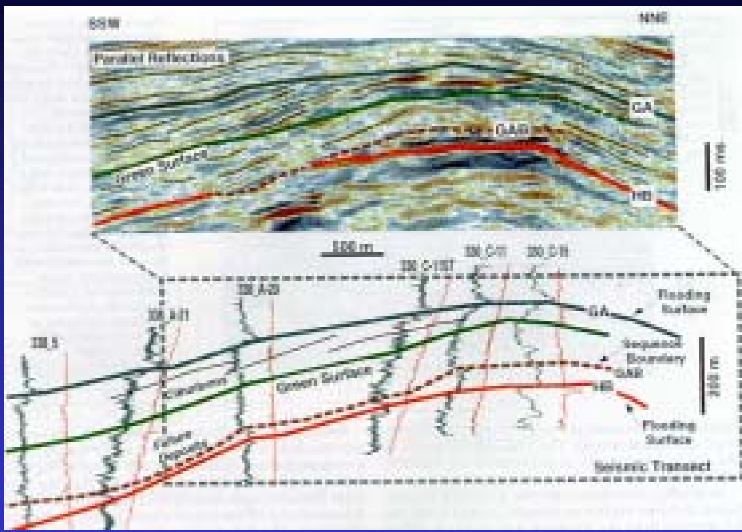
• As the oil interval shrinks with extraction, the encroaching gas and water in the wellbore have to sealed off, and replacement wells may have to be drilled.

• At the end of its life, when most of the movable oil is gone, attention turns to producing the gas cap, effectively turning the oilfield into a gasfield.

• Only a percentage of the oil in a reservoir is recoverable, much being held by capillary attraction and as residual water around the grains clogs the pores.

•Oil contains dissolved gas, and gas contains dissolved oil in a delicate balance controlled by pressure and temperature..

Amazing Seismic Resolution



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• Some structures can be mapped at the surface, and in earlier years, much of the World's oil was found in this way.

• But, the search for oil offshore and in deep onshore basins, depends on **seismic surveying**. It involves releasing energy at the surface from an explosive charge, or in other ways, and laying out recorders to pick up the echoes. Computing the time taken for the echoes to return from the deeply buried geological formations allows geophysicists to map the prospective structures.

• There have been amazing advances in seismic surveying, allowing the smallest and most subtle features to be identified..

• It is sometimes possible to identify even the oil itself.

Conclusion

- Knowledge of petroleum geology has advanced greatly
- The world has been intensively explored
  - The more promising areas were investigated first
  - The larger fields were also found first, being too large to miss
- The record of the past points to declining future discovery

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• Knowledge of petroleum geology has made **great advances**, the processes of generation and entrapment are well understood, and **technological progress** has greatly improved the surveying and production methods.

• Oil exploration and production is now a very sophisticated business.

• The Planet has been **intensively explored** with modern mothods by an industry deliberately searching out the more prospective areas and testing the larger traps first.

• Oil companies work in an advantageous **tax regimes** whereby exploration is taken as a charge against high marginal tax on past discovery. Exploration is not therefore much affected by economic constraints. Prime prospects are viable under most economic conditions, but high-risk speculative prospects are drilled at times of high oil price with tax dollars.

• Accordingly, it is hard to imagine better economic incentives to explore. **Extrapolating the record** of the past is, therefore, a good way to determine what is left to find in the future..