The Oil Age in an Historical Perspective

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1. INTRODUCTION

Geologists study the Earth's long history, spanning billions of years, and identify the sequence of rocks laid down, each having its own characteristics reflecting whatever environmental conditions obtained at the time of its deposition. Some of these rocks contain fossils which have provided a record of evolution that led to the species *Homo sapiens*, about 200,000 years ago. It is therefore natural for geologists to have a long view of history and try to identify the changes that unfolded.

Over the past two centuries, geologists have been employed to identify oil deposits, which led them to understand the conditions under which the resources were formed and preserved. It was far from an exact science, and in earlier years they relied on technology no more advanced than the hammer, hand lens and notebook with which to describe the rocks, using their logic and imagination to interpret circumstances at depth and between isolated outcrops. While they naturally understood that oil and gas were finite resources formed in the geological past, meaning that they were subject to depletion, they were barely conscious of the practical limits. The world was a big place, much of it being unexplored.

Later, came more advanced geophysical techniques whereby an explosive charge was released at the surface, and recorders measured the time taken for the echoes from deeply buried rock surfaces to return to the surface, allowing the geology at depth to be mapped in detail. In addition, geochemical studies began to reveal the precise nature of the rocks in which the oil was formed, allowing them to be identified with more confidence.

These few words provide a background justifying the recognition of an *Oil Age*. It is not only a fleeting epoch in geological terms but also represents no more than a brief span in human history. It lasts only about three hundred years, with significant production spanning no more than about a century.

What could be called *Modern Man* evolved about 12,000 years ago when he took to settled agriculture. For energy, he relied mainly on his own muscles and those of his horses or oxen. Trade in food and other commodities also developed, and money based on gold and silver was increasingly used to facilitate barter. Various communities prospered, leading to growth of kingdoms and empires. However history shows that often an epoch of expansion was followed by one of contraction when the empire exhausted the resources at its disposal. Climate changes also led to bad harvests and sometimes starvation. The transitions were often associated with serious wars and conflicts.

This suggests that the *Oil Age* will wax and wane, as have all other ages in history. The expanding supply of easy energy that oil provided during the *First Half* of the *Oil Age* made it one of the most remarkable chapters of human history, prompting rapid economic growth and trade as well as great technological progress. The human population expanded six-fold in parallel. But logic suggests that the *Second Half*, which now dawns, will be marked by a corresponding contraction of supply, changing the world in radical ways. While this seems so obvious in an historical context, it is very difficult for people living to-day to come to terms with the reality of what unfolds.

The issue of so-called *Peak Oil* has attracted much attention over the past decade or so. A debate rages as to the precise date of peak production, but this misses the point when what really matters is the vision of the long decline in production that comes into sight on the other side of it. Economic theory has it that market forces and technological advances solve all. Indeed this is justified to a degree, insofar as soaring oil prices over the past few years have led to the development of costly *Non-Conventional* sources including so-called *Tight Oil and Gas* which are obtained by artificially fracturing rocks lacking adequate natural porosity and permeability.

2. THE STATUS OF DEPLETION

Before addressing the status of oil and gas depletion it may be useful to briefly cover petroleum geology to explain its occurrence in Nature. There are four main elements: source, reservoir, trap and seal which are briefly described below:

Source: Restricted seas and lakes became stagnant when the surface waters were heated in a warm climate inhibiting circulation. Anoxic conditions developed at depth in these circumstances such that the organic remains from algae and other sources were converted into a chemical known as kerogen. Much of the world's oil comes from just two epochs of global warming, 90 and 150 millions ago. The rocks laid down in such circumstances are dark-coloured clays and claystones, which sometimes smell of oil. When buried to a depth of about 2000 m, the kerogen is heated enough to be converted into oil. Once formed, it migrated upwards through the rocks to zones of lesser pressure provided that fissures or porous and permeable carrier-beds provided pathways. Gas was formed in a similar way from more carbonaceous material as found in the deltas of rivers. Oil overheated by deep burial was also converted into gas.

Reservoir: We are all familiar with a damp sandy beach with the water being held in the pore space between the grains of sand. When buried such beach sands are compressed into sandstones, and some continue to contain sufficient preserved porosity and permeability to form reservoirs for migrating oil, with fractured limestones being another common type. Typically a good reservoir has as much as 25% pore-space, but there is a wide range.

Trap: In some cases, the migrating oil encountered an inclined porous and permeable sandstone carrier bed leading to the surface, in which case it escaped and was degraded, with the tar sands of Canada being a well-known example. But in other cases the rocks were folded by earth-movements into dome-like features known as anticlines, in which the migrating oil and gas collected at the crest of the structure. Other traps were formed by geological faults and where the reservoir thinned and pinched out.

Seal: Oil and gas would have leaked from a reservoir over time from a trap unless it was capped by an effective seal of impermeable rock such as clay or salt.

This summarises some of the geological factors for the entrapment of oil and gas, with relative timing being another important factor. For obvious reasons, the prime prospective tracts were identified first as were the larger fields within them, being too big to miss. But as the prime provinces were depleted, attention has turned to ever smaller and subtle prospects which occasionally deliver a surprise find. As the onshore regions were depleted, the industry explorers turned offshore looking in ever deeper waters, which called more advanced technology. Oceans cover much of the Planet's surface but only a few areas beneath them have the right geological conditions to hold oil or gas, and most of these have now been identified.

It is also important to distinguish the different categories of oil and gas, each having its own costs, characteristics and depletion profile.

Status of Depletion

It is obvious that the production in any oilfield commences after the first well is drilled and the necessary facilities installed. Production then grows as more wells are added, to reach a peak or plateau before declining as the pressures fall and less remains to be extracted. Every effort is made to extract the last drop, where this is helped by higher oil prices and the application of costly specialized technology.

But eventually the field is no longer viable and is abandoned. Norway is one of the countries to publish valid field data, and the graph in Figure 1 shows the depletion of the Draugen Field as a typical example. Production commenced in 1993 and peaked in 1999 when 36% of its oil had been extracted. 90% of its oil has now been extracted, but the tail may drag on for a few more years.

A country's profile is the sum of its fields, being influenced especially by a small number of giant fields, and naturally also moves from growth to decline as illustrated by the production of the United Kingdom as shown in Figure 2. The anomalous fall near peak was due to an accident at the Piper Field that temporarily cut overall production as safety work was carried out across the industry.

It is of course not always as simple as that, because a field may have multiple reservoirs and subsidiary minor traps. This in turn poses difficulties in defining an oil field and the exploration boreholes (known as *New Field Wildcats*) drilled in the search. Many of such boreholes in the

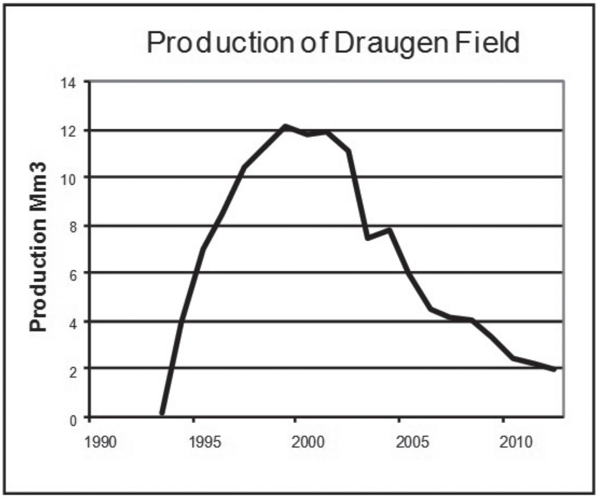

Figure 1: Production of Norwegian Draugen oil field. Source: NPD

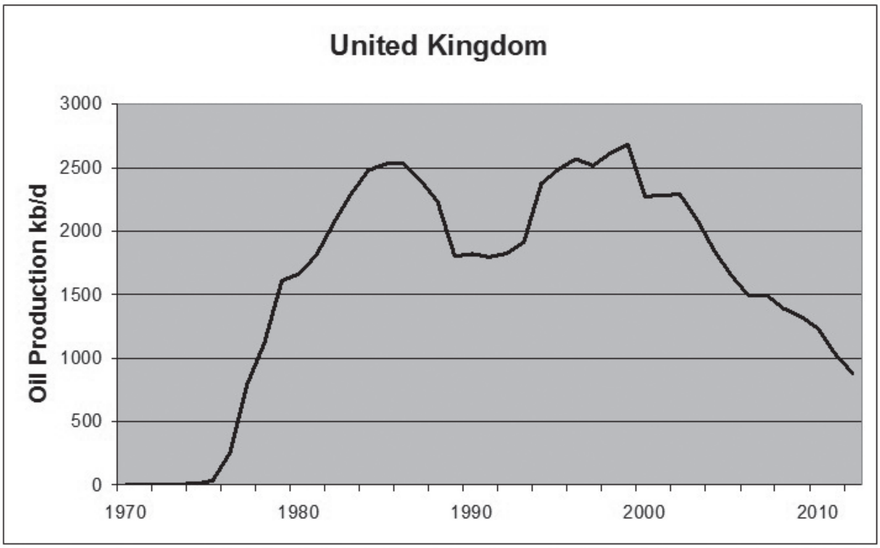

Figure 2: UK Oil Production. Source: DECC.

United States would be better defined as *New Pool Wildcats*, searching for minor outsteps from existing fields.

The depletion profile of a country consists of the sum of its existing fields in production plus provision for new discovery. There are two principal techniques for determining the size of the resource: the so called *creaming curve* on which cumulative exploration boreholes are plotted against cumulative discoveries, and the *parabolic fractal* of field size against rank. Ideally such should be applied to *Petroleum Systems* having common geological characteristics, but they give reasonable results when applied to countries.

Determining the status of depletion is not advanced science, but severe difficulties are faced because the public data are so unreliable, and even the confidential industry databases face increased challenges in tracking the activities of the minor exploration companies that have proliferated in recent years, and in dealing with political distortions imposed on some national statistics, especially those of OPEC countries, where the production quota is in part set by reported reserves.

Figure 1 in the article that follows represents a reasonable representation of the global oil and gas position, although naturally the details evolve over time as more valid information becomes available. *Regular Conventional Oil* peaked in 2005 and that of all categories of oil may do so not too far from now. The peak of all categories of gas may follow around 2020. The decline rates of both oil and gas are at no more than a few percent a year, so unforeseen political and economic factors may well shift the indicated peaks by a few years. That said, the overall profile shown in the Figure is believed to be realistic, suggesting that oil production will have fallen to about half its present level by 2050, and that gas production will be about 20 percent lower by the same date. There will be little left by the end of this century, as the Oil Age draws to a close.

3. ADDRESSING THE CONSEQUENCES

An adage, sometimes attributed to Schopenhauer, may have got it right which said: ‘All truth passes through three stages: first it is ridiculed, second it is opposed, and third it is accepted as self-evident.’ We may still be in the second stage in relation to addressing Peak Oil.

The transition to the *Second Half* of the *Oil Age* has probably already been characterised by tension, with riots and revolutions breaking out in many countries. It seems these were often triggered by soaring food prices and growing unemployment, which are largely the consequence of soaring oil prices. Agriculture has been described as a process that turns 'oil into food', so dependent has it become on oil and gas for energy. The countries of the Middle East and North Africa seem to have been particularly affected.

In addition, many countries built up massive debts as their economies expanded in the latter parts of the *First Half* of the *Oil Age*, and are now in deep deficit, suggesting perhaps that inflation may prove the only practical method to dispose of this debt.

By contrast, some countries have already recognised the significance of oil-based energy, and more may follow the example of Argentina that has already banned exports. It makes eminent national sense to preserve as much as possible for future national use, although this offends against a principle of globalism, where the resources of any country are deemed to belong to the highest bidder. Al Gore, the former US Presidential candidate, sums up the challenges in coming to terms with what unfolds in his excellent book: (see box)

He also addresses the many adverse environmental impacts of the *Oil Age*, when forests were cut down, and ever more people move to live in urban circumstances, depending on trade and food imports from distant places; with transport making heavy demands for oil. The streets of even remote villages are choked with traffic, while airliners leave vapour trails in the skies above. Manufactured goods contain a large amount of embedded energy, and even the climate may be

> *"We find it hard to imagine, much less predict, a sudden systemic change that moves our world from beneath us and takes us from one equilibrium to a new profoundly different equilibrium, although it can sometimes be anticipated if we can identify a threshold beyond which an obviously different pattern must obtain."*
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> Gore A., 2007, Earth in the Balance – Forging a new Common Purpose. ISBN 978-1-84407-484-6

changing as a consequence, as it has done many times in the geological past.

A moment's reflection of these factors indicates what an exceptional age it has become. The aim of this journal is to raise awareness of the many facets of the *Oil Age*, and to help encourage positive responses to the problems that are not too far away.

Postscript

The foregoing does not cover the recent collapse in oil price. It is a large and complex subject but in brief results from the following factors. The previous high prices prompted a fall in demand and a move in the United States to tap more non-conventional Tight Oil by fracking. The wells are expensive and short-lived, and it is reported that on average they require an oil price of at least $80 a barrel to be viable, but large numbers were drilled causing a glut of oil. This put pressure on OPEC, especially Saudi Arabia, its largest producer, which finally decided to ignore its OPEC obligations to cut production to support price. This led to a collapse in price to around $50 a barrel. It has led to a fall in fracking and prices have recovered to around $60 a barrel. It is too soon to forecast the future trend, but it is likely to be upward.