Oil and Gas in the North Sea

Franziska Krause

TU Bergakademie Freiberg

Abstract. The importance of the North Sea as reservoir of hydrocarbons today with regard to the world hydrocarbon production is more subordinated. The most reservoirs generated of the two economic important “floors” Westfal A and B and the Kimmeridge- Clay are discovered. In future it trends to loosing more and more on importance after achieved a peak of gas production forecast in 2008 because of declining production rates. Here it is to distinguish between Norway and Great Britain as main producers. Norway is able to increase its gas production because they can fall upon very lucrative projects in the next years. Instead UK gas production already decline like the oil production in the whole North Sea area. Consequently a big expenditure of exploration work is done now.

Status in the world economy – economic data

First it is useful to know, that the North Sea is divided into five sectors corresponding to the five adjacent countries: Norway, Great Britain, Denmark, the Netherlands and Germany (Fig.1). In this connection the different size of the sectors of economic claim have to be pointed out. So Norway and Great Britain shares the whole northern and central North Sea. Because of this aspect the following report mainly refers to these two countries.
In 2003 2.2 billions barrel oil and about 6.5 trillion cubic feet gas are produced in the whole area of the North Sea. This is around 8.2 % of the world oil- and 7.9% of the world gas production (Fig. 2+3).

Fig.1. North Sea mineral rights (HYNE 2001)

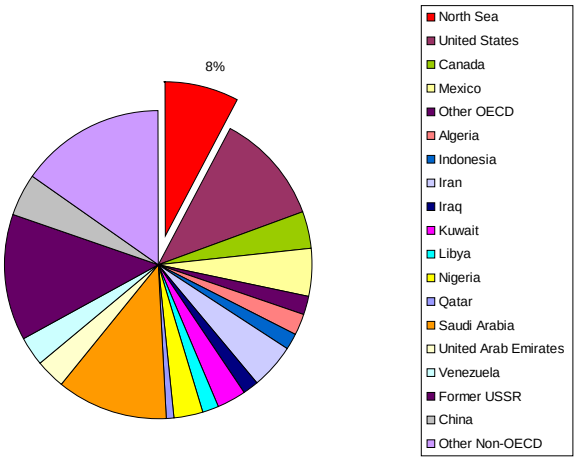

Fig.2. World oil production, after data of EIA (2006)

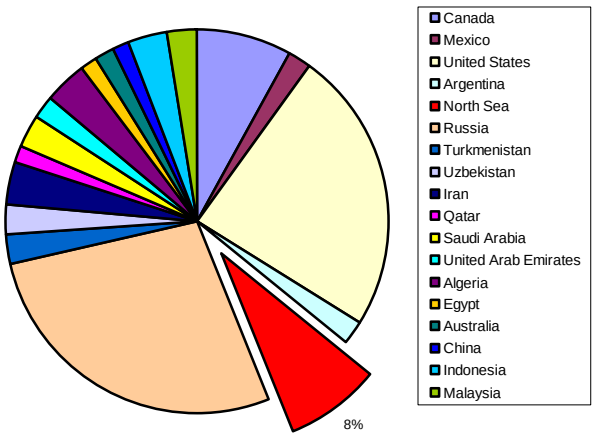

Fig.3. World gas production, after modified data of EIA (2006)

The two main areas of the North Sea and their petroleum relevant stratigraphy

Central and Northern North Sea

This part contains the East- Shetland- Platform along the Viking- and the Central Graben including the Central Ridge build up of the Mid- North- Sea- High and the Ringkøbing- Fyn- High. Here the fields hardly include oil. The reason for this phenomenon is that the Upper Carboniferous layers which are the gas source rocks are only accumulated in the southern basin, because the Central Ridge was lifted up and so delimited as geomorphologic barrier both North Sea Basins from each other (after WALTER, R.).

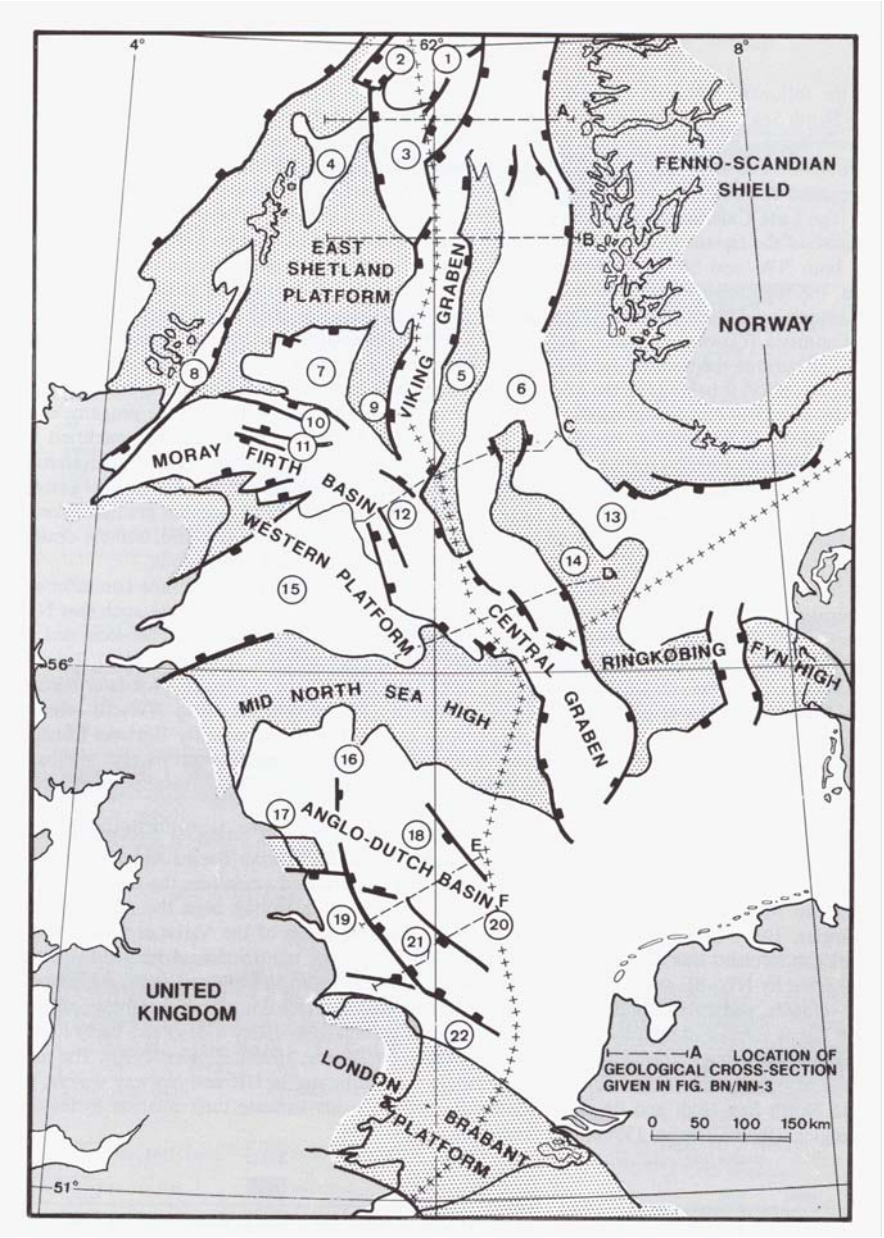

Fig.4. Structural map the British and Norwegian sector (KULKE 1994)

An important oil prone source rock (shale) is the about 580 m thick Kimmeridge-Clay- Formation. Furthermore the Draupne Formation is to name. These are marine mudstones with a high content of organic carbon. They were generated in the Upper Jurassic and Lower Cretaceous while a domal upwards where Central-, Viking Graben and the Moray Firth basin run into one point at a time of regressive and paralic conditions. After rifting the beds were subsided thermally. Further subsidence act to these layers in Cretaceous and Cenozoic times as a result of the increased sedimentary loading. Hydrocarbons could mature along the trench axis since the Paleocene. Not only vertical migration took place, but also lateral ways are known which are limited to the Upper Jurassic and Paleocene layers. Sandstones of the Middle and Upper Jurassic function as reservoir rocks, for example the Brent- and Humber Group. There the Claymore sandstones and the Brae Conglomerate Sandstone are very important. Also Paleocene and Eocene sands and sandstones deliver a noticeable amount of oil and gas. In the central basin the Forties, the Andrew and the Maureen Formation have to be point out. The Balder, Heimdal and Frigg Formation are the equivalent ones in the north. On this occasion it is a matter of fan sands, delta beds and turbidites too. As third significant play are to mention; the Middle and Late Triassic. Here is the Triassic Group with the Lewis Formation in the north and the Skakerrak Formation in the central North Sea the well known oil prone reservoir. It consists of fine clastics and evaporates (after KULKE, H.). One effect of the rifting is a big variation of traps. Especially the traps near to tilted blocks are word mentioning. This trap type is in connection with salt stocks and so only to find in the central North Sea. On the one side Mesozoic traps are very deep subsided on the other side Paleocene ones are located in relatively shallow spheres. Liquid hydrocarbons were also generated before and after the main rifting in the Upper Jurassic. First off all oil is produced from clastic and carbonatic beds. Halotectonic has only little influence on structures, because the Zechstein salt thickness increases towards the south of the North Sea basin.

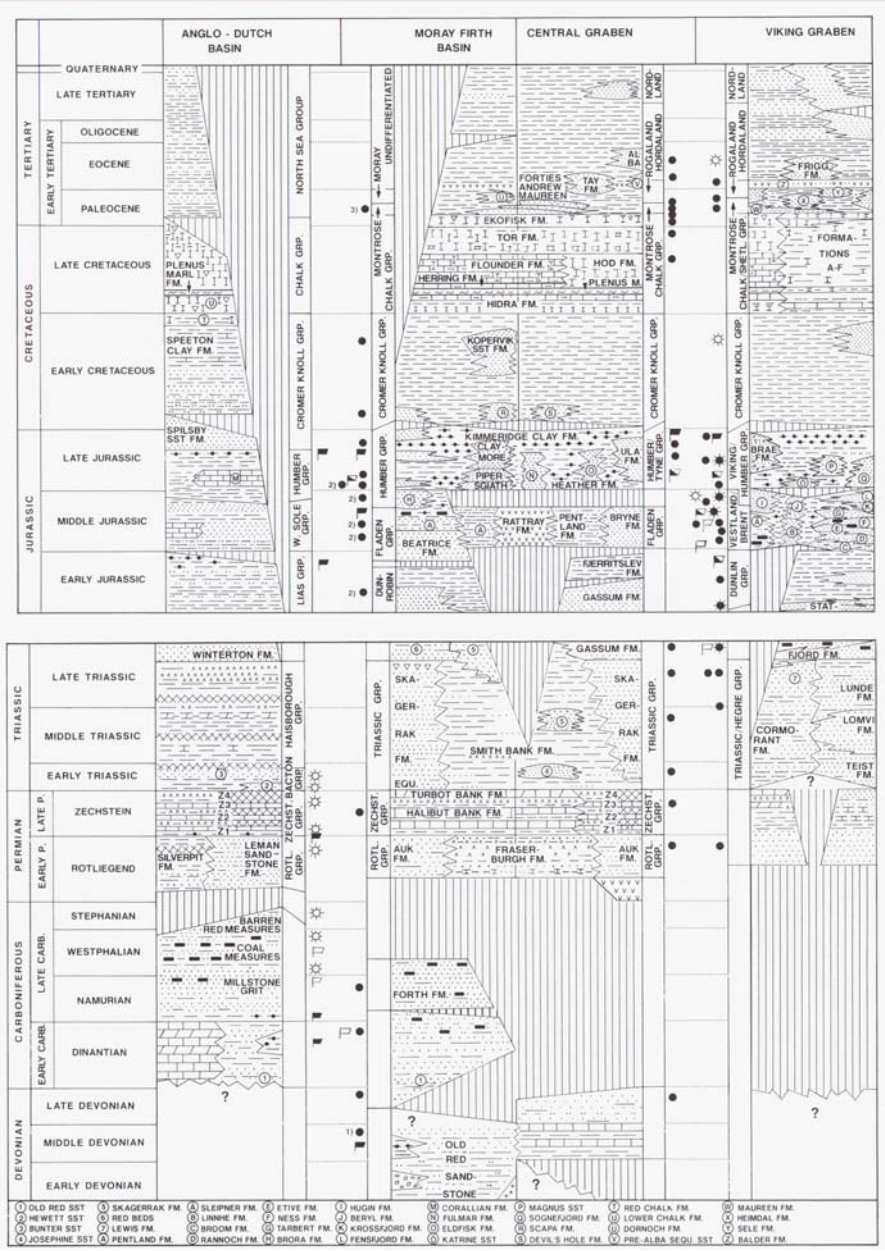

Fig.5. The UK and Norway North Sea generalized stratigraphy. Compilation chart with HC productive reservoirs and potential source rocks (KULKE 1994)

Southern North Sea

This area reaches from the Anglo- Dutch Basin to the German- Danish Basin. Here are the most of the gas fields of the whole North Sea located. As main gas prone source rocks operate here coal bearing layers of the Upper Carboneferous, especially Westfal A and B which have a thickness about 800m. As main seal Zechstein salts are acting. Also sandstones and clay shists of the Namurian are coal bearing. Here the upper parts are gas prone and the lower parts of these beds are oil prone source rocks. As a consequence of ingression from the Variscan foredeep in the south there is a strong accumulation of shallow-water sediments as basis beds. Following under paralic conditions the coal bearing layers were generated. After thermal subsidence they underlie the Permian layers discordantly. The gas generation was made in the Jurassic. In the southern North Sea prolific reservoir rock for gas are the Rotliegend Leman- sandstones. In addition, early Triassic sandstones (Hewett and Bunter) function as reservoir rocks, too. They are sealed up by Zechstein salts evaporated during a transgression through the intermarine street between Greenland and Norway. Hydrocarbons could migrate into Triassic layers because the Permian evaporates are very thin on the flanks of the elevations for example the London- Brabant- Platform. Migration path to the Triassic reservoir rocks are given by the faults. Here the halokinesis has a decisive influence on the trap structures. 85% of the gas is produced from Permian rock and from Triassic reservoirs 13%.

Importance of the North Sea as hydrocarbon supplier in the future

The North Sea oil and gas production has only a less share of the world hydrocarbon production. But still it is a very important area in the point of view of the neighbour countries, because for them it is more lucrative to use their own sources of energy than to buy expensive energy from other countries. Therefore much money is invested in the exploration of new hopeful oil and gas fields. For example Norway expected to start two new fields (Enoch and Blane) producing off in 2006. One Year before two others Kristin and Urd started up. If you want to get a general idea of the entire North Sea production history and give an outlook, it is useful to begin by asking how the situation and development of Norway's and Great Britain's hydrocarbon production are. The year 2005 was a notable point on the production scale of Norway. It was a record- breaking year for gas production, but the oil production declined more as they thought. Sure one reason is the lost production on Snorre.

As further reason quoted the delayed start up of Kristin. Thirdly delayed drilling plans have a negative effect. This year oil production forecast is even lower. In the next years up to 2010 there will be smaller declines because new fields may come on. It is expected to continue to decline from the 2001 peak. This is a consequence of reduced production from giant fields because of markedly reasons. Even though Norway has some lucrative prospects and increasing natural gas liquids the oil output curve will tend to overall decline. So Norway will produce in 2010 around 2.8 million b/d in comparison to 2005 with nearly 3 million b/d. On the other side the gas production describes a converse trend. Gas output will continue to rise from 83 billion m³/year up to 114 billion m³/year by 2010. Largely the increase will come from the hopeful Ormen Lange project. UK oil production becomes apparent in a similar pattern like the Norway's one. In forecast UK oil production will continue to decline to around 1.65 million b/d in 2010. Its peak was in 1999 with a production about 2.7 million b/d. The reason is the "dieing out" of the giant old fields additionally there are not enough smaller fields prospected to fill this gap. Although Clair and Buzzard fields, Callanish/ Brodgar, and Tweedsmuir are able to sustain their production levels through to 2007. In contrast to the gas production of Norway the production of the UK will decline. It peaked in 2000 at 115 billion cu/year and it presumed to decline to 83 billion cu/year by 2010. To sum up, the increasing gas production of Norway compensates the current UK gas decline. So the North Sea gas production should extend from present 9 million boe/d production plateau out until 2010 (Fig.5+6). In long-lasting forecast a long- term production decline will be expected. North Sea oil production will decline all over the time. Although it has been to point out the displacement of production peaks of oil and gas (after WESTWOOD, J). Because of this trend much money is invested in exploration.

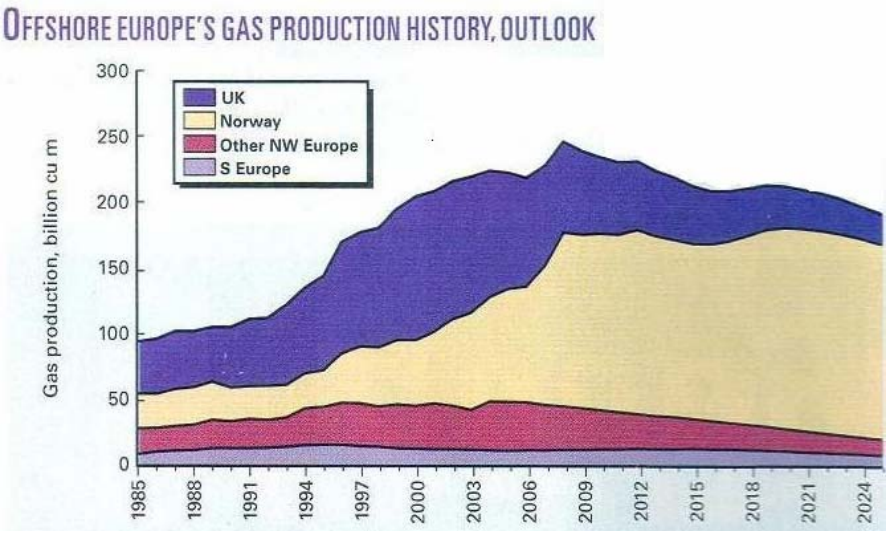

Fig.6. Europe's gas production trend reflecting the one of the North Sea (The World Offshore Oil & Gas Forecast 2006-2010, DOUGLAS- WESTWOOD)

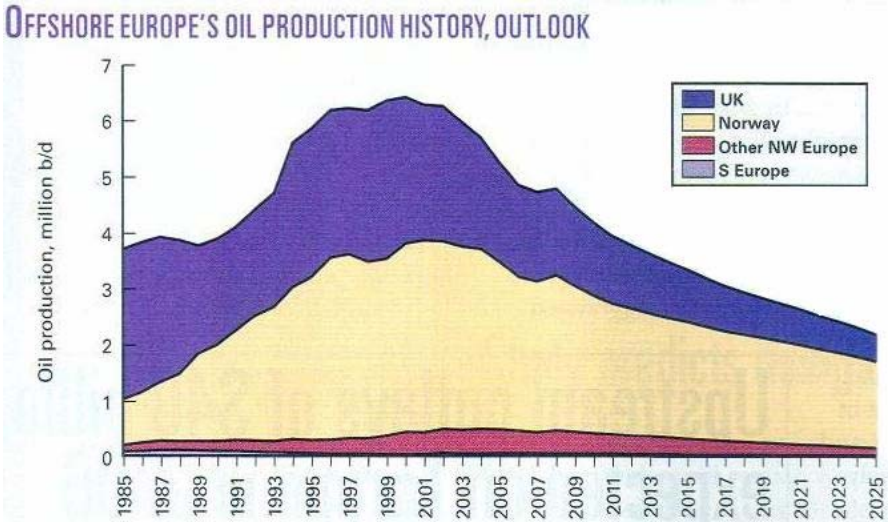

Fig.7. Europe's oil production trend reflecting the one of the North Sea (The World Offshore Oil & Gas Forecast 2006-2010, DOUGLAS- WESTWOOD)

Future exploration in the North Sea

In Fig. 7 the North Sea basin as hydrocarbon source is shown in a stage in which all obviously plays are already discovered. So there is only a little chance to explorate on new fields that will be of a minor amount. And there is also only little room to compensate unsuccessful wells, because of economic reasons. In relation to this aspect a decrease of drilling activity is identified over the last years (Fig. 8). In spite of that new hope is generated by an integration of various disciplines of geosciences and engineering. In this connection the following methods are handled: revisiting overlooked areas with new high quality seismic data, creative thoughts arising from new methods of visualizing how play work, taking a global perspective and learning from case studies of other regions and basins (after GULYAS, J. G., GARRETT, S. W.). For these methods like 4D- seismic, designer wells and a more detailed reservoir characterization were used. Another issue is to look at stratigraphic units which were in the past not interesting. For example the North Sea Chalk is a underexplored and underdeveloped play that gets more and more important for future investigations (after MEGSON and TYGESEN).

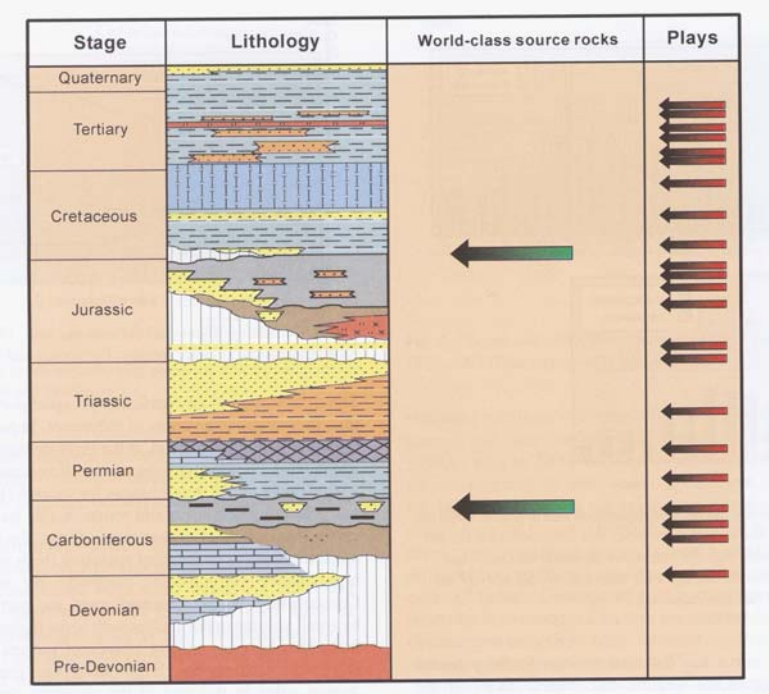

Fig.8. Known plays of the North Sea in the UK sector (VINING ET AL. 2005)

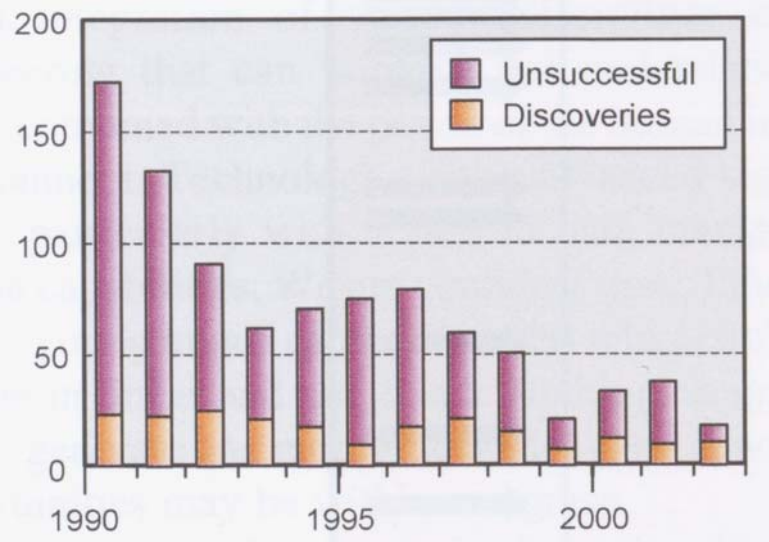

Fig.9. Number of discoveries and unsuccessful wells 1990-2002 (VINING ET AL. 2005)

References

HYNE, N. J. (2001) Nontechnical Guide to Petroleum Geology, Exploration, Drilling, and Production. PennWell Corporation, Oklahoma

KULKE, H. (1994) Regional Petroleum Geology of the world- part 1: Europe and Asia

WALTER, R. (1992) Geologie von Mitteleuropa, E. Schweizerbart´sche Verlagsbuchhandlung Stuttgart

WESTWOOD, J. (2006) Upstream outlays $40 billion expected off Europe in 2006. Oil & Gas Journal Aug. 7: 37-42

VINING, B. A. ET AL (2005) UK North Sea exploration: a future?. In: DORÉ, A. G., VINING, B. A. (eds) Petroleum Geology: North- West Europe and Global Perspectives – Proceedings of the 6th Petroleum Geology Conference: 35 – 39

MEGSON J., TYGESEN T. (2005) The North Sea Chalk: an underexplored and underdeveloped play. In: DORÉ, A. G., VINING, B. A. (eds) Petroleum Geology: North- West Europe and Global Perspectives – Proceedings of the 6th Petroleum Geology Conference: 159 – 168

GULYAS, J. G., GARRETT, S. W. (2005) Better recovery through better reservoir characterization: overview In: DORÉ, A. G., VINING, B. A. (eds) Petroleum Geology: North- West Europe and Global Perspectives – Proceedings of the 6th Petroleum Geology Conference: 361 -365

WWW.EIA.DOE.GOV