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Shallow Gas Play in the Netherlands Takes Off

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SUMMARY

Since the discovery of shallow gas in the northern Dutch offshore, this play raised much interest. Nowadays, cost-effective techniques exist and the first three fields have been taken into production. No problems with sand or water production are encountered.

As the state participant in E&P in the Netherlands, EBN B.V. is investigating the development potential of shallow gas in the Dutch offshore sector. A study from 2009 showed that total volumes are significant: 18-62 bcm UR. These volumes, as well as the success of the producing fields, justify analyses in much greater detail. Moreover, the widely available 3D seismic data, including a new survey in the DEF blocks (Fugro), and the tax incentive applicable to marginal fields, make shallow gas very interesting to explore.

This study shows the intermediate results of the shallow gas inventory, based on individual prospect analysis. It includes a bright spot classification scheme to improve the understanding of different types of amplitude anomalies. For prospective bright spots, a volumetric assessment is accomplished resulting in factsheets that can be used as starting point for detailed exploration. More than 100 prospects have been identified, of which some 60 of significant potential, including 20 bright spots in open acreage.

Introduction

The presence of shallow gas prospects in the Dutch part of the North Sea area has been known since the early seventies. Expressions of its occurrence include pockmarks at the seabed and subsurface amplitude anomalies (*bright spots*), flat spots and gas chimneys. Often, these features are situated over salt domes and sometimes associated faults can be interpreted (Schroot and Schüttenhelm, 2003). The gas bearing Cenozoic sands range in depth typically from 300-800 m below a water depth of some 40 meter. In the eighties, the presence of producible shallow gas was proven by several wells. However, early water breakthrough and sand production were expected due to the limited strength of the unconsolidated sands and shallow fields were not developed. Moreover, shallow gas was considered as a drilling hazard and potential shallow gas accumulations were avoided when planning a well targeting deeper reservoirs.

After years of studying the Dutch shallow gas potential, the first shallow gas field offshore Netherlands has been taken into production in 2007 (A12-FA). Secondly, the shallow accumulation F02a-Pliocene started producing in 2009 and a third shallow field is producing since December 2011 (B13-FA). Additional prospects are currently being studied by different operators.

As the state participant in exploration and production in the Netherlands, EBN B.V. is investigating the potential of shallow gas in the Dutch North Sea. First total volume estimates amounted to 36 - 118 bcm GIIP and 18 - 62 bcm UR (2009, report on www.ebn.nl). These significant volumes, as well as the success of the producing fields, justify analyses in much greater detail. Moreover, the widely available 3D seismic data in the area, including a new survey in the DEF blocks, and the tax incentive applicable to marginal fields (www.nlog.nl), make shallow gas very interesting to explore. The play has changed from a tough reservoir and drilling hazard into a resource with significant potential.

The current study shows the intermediate results of the shallow gas inventory, based on an analysis of individual prospects. It includes the mapping of bright spots in the A-H blocks of the Dutch offshore area and a classification scheme to improve the understanding of different types of amplitude anomalies. For prospective bright spots, a volumetric assessment is accomplished resulting in factsheets that can be used as starting point for detailed exploration. A significant number of shallow prospects has been identified of which some 20 prospective bright spots are situated in open acreage.

Background

Bright Spots

The presence of gas in a shallow trap causes a strong decrease in acoustic impedance in the reservoir. This amplitude anomaly, or *bright spot*, can easily be recognized on seismic data (figure 1). However, very low amounts of movable gas or even residual gas can cause amplitude brightening too. Moreover, lateral lithology variations might also cause bright spots, which stresses the importance of validating the trapping mechanism of the accumulation. Features like chimneys and velocity pull-down effects seen on the seismic data might confirm the presence of gas.

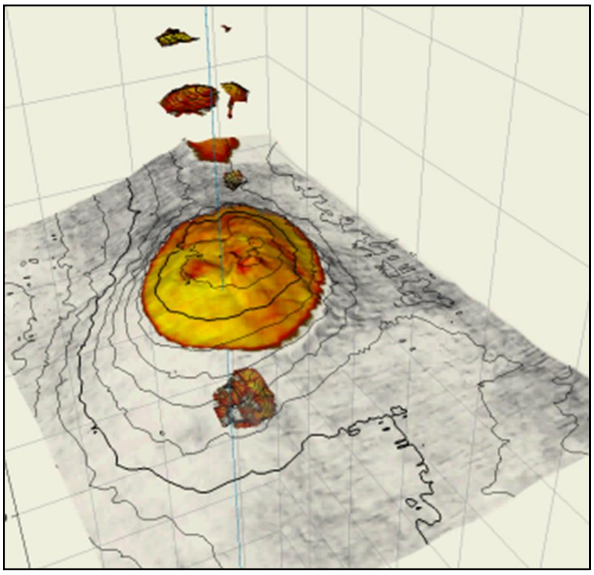

Figure 1 *Time contour map with imposed seismic amplitude of a bright spot conform to structure (~650 ms) in the Dutch offshore F-blocks. Minor other bright spots are also shown.*

Shallow Gas in the Dutch North Sea Sector

In the context of our study, shallow gas is defined as *gas in unconsolidated sediments of Miocene-Pliocene age*. Shallow prospects in the *Upper North Sea Group* formation, situated above the Mid-Miocene unconformity (1000-15000 m depth), have been investigated. Sediments include mainly clean or finely laminated sandstones and shales and are part of a large-scale delta system. This fluvio-deltaic system developed during the Late Cenozoic due to the uplift of the Fennoscandian shield and it is often referred to as the *Eridanos Delta* (Overeem et al., 2001). Originally, sediments were mainly provided by the Scandinavian shield in the north-east (Baltic river system). Later, the sediment source area rotated clockwise towards the south (Rhine-Meuse river system) (Kuhlmann et al., 2004).

The shallow fields and prospects in the study area often consist of multiple stacked reservoirs above salt domes, forming salt-induced, low relief anticlines trapping the gas (figure 1). These structures occur at depths ranging from 300 to 800 m. Also, amplitude anomalies appear in foresets, elongated structures and in very shallow sheet-like structures. Bright spot areas range from 0.01 to 80 km^2. Generally it is thought that the origin of shallow gas in the Netherlands North Sea sector is biogenic, i.e. produced by organisms at moderate temperatures and pressures. This is in line with the composition of the gas being almost purely methane. Alternatively, gas chimneys over salt domes and associated faults, suggest a deeper thermogenic origin (Schroot and Schüttenhelm, 2003). Both generation mechanisms might play a role as is suggested by certain gas samples.

Shallow Gas Outside the Netherlands

The production of gas from unconsolidated sediments is getting more common worldwide. In the Tobago Basin for example, three fields were taken into production in 2002 and more fields in the area are currently under appraisal (Roberson, 2011). Also, east of the Mississippi River in Louisiana, the shallow gas play has been investigated in great detail. Several shallow gas prospects are being studied and a number of shallow fields in Louisiana has been developed successfully now (Clifford and Goodman, 2010). In both examples, the reservoir concept is similar to that in the Netherlands North Sea sector: stacked bright levels at relative shallow depths in unconsolidated, Cenozoic sediments.

Examples of shallow gas in the North Sea area outside the Netherlands include the Dagmar, Skjold and Lille John (shallow oil and gas) (EAGE, 2011) fields in Denmark and the Peon field in Norway. The latter was discovered in 2005 and has a GIIP of 35 bcm. The clean unconsolidated Pleistocene sandstone reservoir has a depth of ~165 m TVDss and the reservoir covers an area of 250 km^2. Production is planned to start in 2014 (http://bergen.spe.no/publish_files/Erichsen.pdf, 2009).

Shallow Gas Inventory

Study Area

The focus of this study is on the A-H blocks of the Dutch offshore (figure 2). Subsequently, the southern Dutch North Sea and onshore Netherlands, where shallow gas is known to occur as well, will be investigated. The A-H blocks are largely covered by 3D seismic data and with the 3D Multi Client Survey shot by Fugro over the DEF blocks (available June 2012), the area will almost completely be covered. Moreover, ample 2D seismic is available as well as multi-component OBC data lines.

Bright Spot Identification and Classification

The detection of shallow prospects has been facilitated by using root mean square amplitude maps. To get a better understanding of the types of bright spots and their potential, a classification scheme is established. Seven bright spot types with varying development potential are identified. Based on depth, size and trapping system, there are three types that we consider as having highest potential at this moment in time: A12-FA (1), F02a-Pliocene (2) and flat medium size (3) type. The former two are similar to producing shallow fields in the Netherlands, amplifying our confidence in their producibility. Currently, over 100 bright spots are identified. These include ~60 prospects of classification type 1-3 of which 20 are currently situated in open acreage (figure 2).

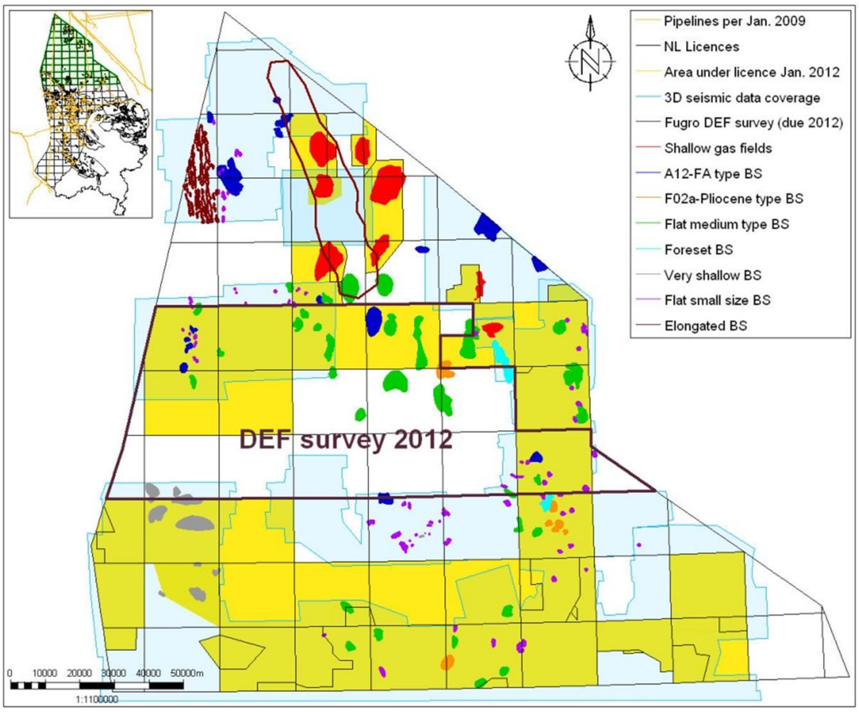

Figure 2 *Study area, shallow gas fields & prospects, 3D seismic data availability and infra-structure. Colours of the prospects refer to the bright spot classification.*

Volumetric Assessment

In order to assess the volumetric potential of the shallow prospects, a workflow has been established resulting in factsheets that describe the individual bright spots in detail. The workflow starts with mapping the amplitude anomaly and defining the structure and trap type. Time-depth conversion is based on checkshot data and/or a regional V0-K relation and is used to refine the seismic-to-well-tie. Subsequently, in place volumes are calculated using: GIIP = GRV * N/G * PHIE * Sg * Exp. factor. Uncertainties in the input parameters are taken into account using a Monte Carlo probabilistic simulation. Since many bright spots have not been drilled yet or have wells in close vicinity without log data other than GR and sonic in the shallow section, uncertainty ranges can be large. However, certain properties can be extrapolated from known fields with fair confidence. Moreover, reservoir properties are being assessed in a Joint Industry Project on shallow gas (TNO). At the time of writing, 13 bright spots have been analysed in detail, with total GIIP of 10-16 bcm (P50-P10).

Shallow Gas Developments in the Dutch Offshore Area

There are three producing shallow gas fields in the Dutch offshore area; A12-FA (since 2007), F02a-Pliocene (since 2009), and B13-FA (since 2011). Development plans for five more fields are pending. The reservoir sandstones have porosities of 20-40 % and generally a high permeability. Reservoir thickness is typically in the range of 5-20 m and pressures are relatively low (50-80 bar). Gas saturation in the producing reservoirs is ~55-60%. Expected recovery factors are around 60-75%.

A12-FA is operated from six wells producing from different reservoir levels. A compressor was installed on the platform from the beginning as initial pressure was relatively low. Some 4 bcm has been produced to date (ultimo 2011). Expandable sand screens as part of the well design are effective in sand handling. For B13-FA a similar development plan has been used, with four wells producing from two main reservoir intervals. Exploration and development of both fields was based on 2D seismic. In none of the producing shallow fields, problems with water production are encountered.

More Shallow Gas Opportunities

F07/F10-P1 is an example of a shallow prospect of type A12-FA that is situated in open acreage. The prospect consists of four stacked bright spots, with an areal size up to 20 km^2, which are conform to structure and formed by a fault-dip closure (figure 3). The prospect is covered by 3D seismic data in the south and the Fugro DEF survey will cover the northern part (2012). P50 GIIP is estimated to be ~3 bcm with a high case volume in excess of 5 bcm. Main uncertainties are porosity, gas saturation, time-depth conversion and the GWC. De-risking probably requires an exploration well.

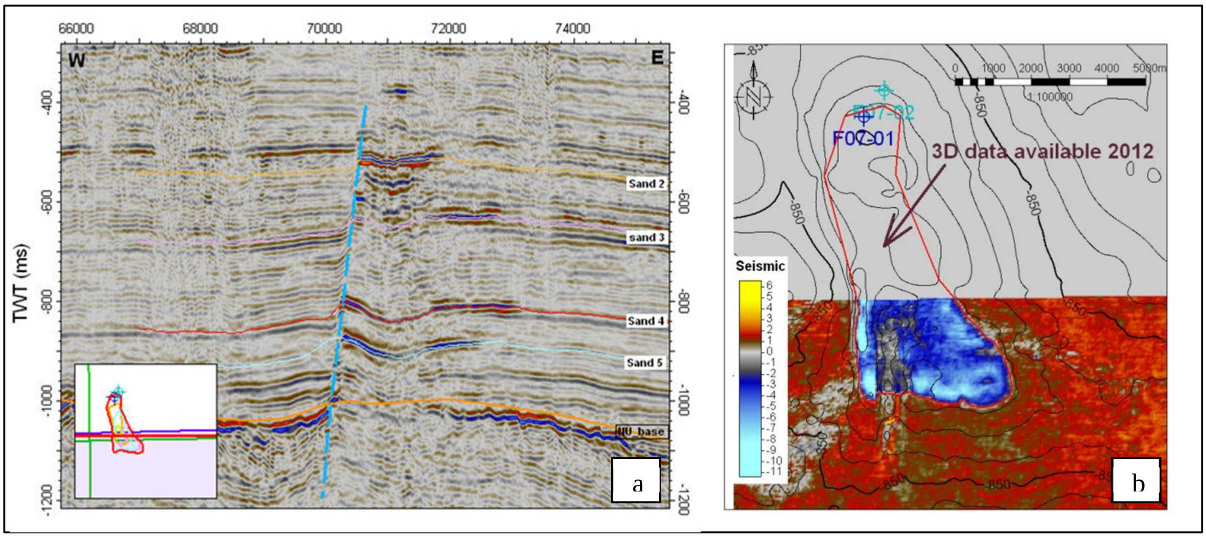

Figure 3 *Xline through the F07/F10-P1 prospect (a) and the amplitude map of sand 4 (contour lines in ms) (b).*

Conclusions

Since the discovery of shallow gas in the northern Dutch offshore in the seventies, these accumulations raised much interest. Nowadays, cost-effective techniques do exist whilst the recently introduced marginal field tax incentive is applicable to shallow gas fields due to their low pressures. Moreover, the area is largely covered by 3D seismic data including the recent Multi Client Fugro DEF block survey (available 2012). Three shallow fields are now successfully operated in the area and the on-going EBN B.V. shallow gas inventory indicates that there are much more shallow opportunities looming. More than 100 prospects have been identified, of which some 60 of significant potential, including 20 bright spots in open acreage.

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References

Clifford, A. and Goodman, E. [2010] Louisiana lagniappe: shallow gas play concept, evaluation techniques, analogs. *Oil & Gas Journal*, 108(46), 68-79.

EAGE. [2011] Miocene comes up trumps offshore Denmark. *First Break*, 29(12), 18.

Kuhlmann, G., De Boer, P.L., Pedersen, R.B. and Wong, T.E. [2004] Provenance of Pliocene sediments and paleoenvironmental changes in the southern North Sea region using samarium-neodymium provenance ages and clay mineralogy. *Sedimentary Geology*, 171, 205-226.

Overeem, I., Weltje, G.J., Bishop-Kay, C. and Kroonenberg, S.B. [2001] The Late Cenozoic Eridanos delta system in the Southern North Sea Basin: a climate signal in sediment supply? *Basin Research*, 13(3), 293-312.

Roberson, R. [2011] Brief biography of a biogenic gas play. *GeoExPro*, 8(6), 54-56.

Schroot, B.M. and Schüttenhelm, R.T.E. [2003] Expressions of shallow gas in the Netherlands North Sea. *Netherlands Journal of Geosciences / Geologie en Mijnbouw*, 82(1), 91-105.