The ambitious search for more gas





New Play Concept

Paleocene thickness map northwest of the Helland Hansen Arch. The thick Paleocene unit has been inverted to form the northern part of the Helland-Hansen Arch. The thickness variation suggests that the northern portion of the Helland-Hansen Arch is different from the region tested by the Helland-Hansen well to the south. A new play concept suggest that the thickest reservoirs, dominantly gravity driven sedimentation, was deposited in synclines between the proto-domes drilled until now.

Illustrative analogue

Amplitude map of potentially gas-filled channels in Tampen turbidites. This is a good analogue to all Cretaceous and Tertiary units within the Møre and Vøring basins which is dominantly gravity-driven turbidites.





Huge areas remain underexplored in the Norwegian Sea. Now is the time to find gas in vast quantities. But do not forget there is a fair chance to discover oil.



With new and better eyes

Europe needs gas. Norway's deep water Atlantic Margin might be the right place to explore.

Take a quick look at the cultural map offshore mid-Norway. The majority of the wells, and all but two fields, are located in mostly shallow waters (<500 meters).

The two exceptions are **Ormen Lange** with initial reserves of 307 billion m³ of gas (1.9 Bboe) in the Paleocene Egga Formation and the **Aasta Hansteen** field with reserves totalling 51 billion m³ of gas (320 MMboe) in the Cretaceous Nise Formation. While Ormen Lange started producing in 2007, Aasta Hansteen will be put on stream in 2018.

Under-explored basins

"Even if the APA-area now extends far west, the deep-water areas of the Norwegian Sea should definitely be considered under-explored," says Bent Kjølhamar, Director Project Development Europe & Russia at TGS.

"Several wildcats in the Møre and Vøring basins have found hydrocarbons, but these are all technical discoveries not considered to be commercial," he adds.

In the **Møre Basin** this applies only to 6302/6-1 **Tulipan** that found gas in Palaeocene sandstones, while in the **Vøring Basin** the majority of the wells drilled so far have hit pay. This includes 6604/10-1 **Gro**, 6605/8-1 *Stetind* (Norsk Hydro), 6705/10-1 **Asterix** and 6706/6-1 **Hvitveis**.

The promising news is that Wintershall with 6604/5-1 **Balderbrå** lately discovered up to 22 billion m³ (140 MMboe) of gas and condensate in the Cretaceous Springar Formation. Certainly not gigantic, but it once again proved that the Vøring Basin is gas prone with a potential for more discoveries. The licensees will evaluate the discovery together with other discoveries and prospects in the area with regard to a potential further development, NPD says in a press release.

The only oil discovery in deep water was made 15 years ago with 6405/7-1 **Ellida** that found a 52 m thick oil column in Upper Cretaceous sandstones. At that time, NPD concluded that the Møre Basin must have generated significant amounts of oil.

Low interest

Quite a few blocks, more than 100 (!), in the deep waters of the Norwegian Sea have been licensed or are currently licensed. Most of them are, however, relinquished, and we are left with only five operators: **Statoil** (in the vicinity of Aasta Hansteen), **Wintershall** (3 tracts, APA 2015, APA 2016, APA 2017), OMV (APA 2015), **Repsol** (22nd round) and **Shell** (APA 2015). With the exception of the Shell acreage, these licenses are all located in the northern part of the Vøring Basin.

Most of the recent exploration has been focused in the northern Vøring Basin whereas the Møre Basin has been neglected for a long time. The deep water of the Norwegian Sea was not looked upon as a hot spot in the 24th round that was closed last year. While 93 blocks were nominated and announced in the Barents Sea, only five blocks were nominated in the southern part of the Vøring Basin and two blocks in the very southern part of the Møre Basin.

There were eleven applicants in the $24^{\rm th}$ round (Shell, Aker BP, Centrica, DEA, Idemitsu, KUFPEC, Lundin, OMV, RN Nordic, Statoil and





Norwegian gas export

Norway is the third largest exporter of natural gas in the world. Nearly all Norwegian gas is sold on the European market and Norway supplies about 25 per cent of the EU gas demand. Norwegian natural gas exports set

an all-time record in 2017, with shipments via pipeline hitting 117.4 billion m³ (740 MMboe). To sustain this export level Norway needs to find, develop and put into production two Aasta Hansteen fields every year.

Wintershall). We will know which of these companies are most eager to get access to these seven blocks in late spring.

Gas prone basins

The highly successful North Sea play models, with an Upper Jurassic source rock feeding Lower, Middle and Upper Jurassic sandstone reservoirs, do not work in the central parts of the deep water sedimentary basins in the Norwegian Sea.

The reason being massive subsidence during the Cretaceous and Paleogene/Neogene that has buried the source rock to depths where it is generating gas or is overmature. The Upper Jurassic source passed through the oil window long time ago and most of the oil – if not all – might have leaked to the atmosphere. The Norwegian Sea is therefore largely considered gas prone.

In addition, potential Jurassic reservoir rocks are left at depths unreachable by the drill-bit in the larger part of the deep-water area. However, new data and revised interpretation gives hope for the westernmost parts where rotated fault terrain likely lies within the oil window.

The oil companies are therefore pursuing younger play models in the deep-water Norwegian Sea. The focus is on Upper Cretaceous and Paleogene sandstones deposited in a deep-water environment, including the Lysing, Kvitnos, Nise, Springar, Våle, Lista, Tang, Egga, Tare, Balder and Brygge formations.

Europe needs gas

Norway started exporting gas to Europe with the pipeline Norpipe in 1977, 41 years ago. Since then Norwegian gas has been a stable and welcome supply in addition to deliveries from the huge gas basins in

The question raised by EU is what Norway can do to continue to deliver gas in large quantities. Reserves are dwindling, and the current prognosis indicate that Norwegian gas export will be halved in 20 years without sizable new discoveries. In short, to continue gas export to Europe at a high level, Norway need to find more gas in vast quantities. The question is where. The North Sea is a mature province with a small chance to find lots of gas. The same is true for the Halten Terrace.

Seismic acquisition &

The AM17 3D seismic utilized 12 streamers, each one 8 km long, and three seis-

mic sources (two is the norm) that crea-

ted dense 3D sampling in a cost-efficient

way. A total of 5 large seismic vessels

from Polarcus and Shearwater acquired

a record volume from April to October

2017. TGS used it's Clari-Fi[®] processing

technology and delivered fast track 3D

data in time for 24th round work last fall.

Final delivery of the AM 2017 data is late

processing

Russian Siberia. Future supplies will also include NGL from the US.

summer 2018.

Two huge areas may have a gas potential. The Barents Sea and the Norwegian Sea. The Norwegian Sea is closer to Europe, and there is already a pipeline connecting Aasta Hansteen with the pipeline network further south. Polarled is a 480 km pipeline that connects Aasta Hansteen to Nyhamna outside Molde. It was finished in 2015 and has spare capacity.

The Norwegian Sea is therefore the preferred choice to look for gas that can source Europe's needs in both the short and long term. The question is if the deep-water Norwegian Sea has a potential for major and – even better – giant discoveries.

Superior data is key

With only a limited number of wildcats in a huge area, the potential of the Norwegian Sea *is far from* exhausted. In order to continue exploration and prepare for more wells there is, however, a strong need for modern and better data.

The 3D grid now being made available in selected areas by TGS is thus a prerequisite for continued, meaningful exploration.

"The old data were of such poor quality that prospects were difficult



to define, with the obvious consequence that few wells were drilled," says Kjølhamar.

"High quality data is key, and our mission and vision are to produce data that allows for improved imaging of both shallow and deep targets. This applies in particular to the important task of identifying new play models to replace the classical Jurassic models that do not work here, but it also applies to the sedimentary layers within and below the basalt flows and sills that makes in particular the Møre Basin infamous."

"TGS has joined forces with VBPR and ideas for new plays and ideas are being proposed on an almost daily basis," Kjølhamar says.

In 2017, TGS acquired 17,000 km² in the Møre Basin and 16,000 km² in the Vøring Basin, with ties to all the wells in adjacent areas. This year the two surveys will be extended by another 12,000km².

About time

The TGS survey, coupled with the European thirst for Norwegian gas and the oil companies' urgent need for new discoveries, may constitute a strongly desired revitalization for exploration in the Norwegian Sea.

Within the southern segment of AM17 survey area there is only one wildcat (Tulipan gas discovery), while three dry wells have been drilled within the northern segment. It's an understatement to say well density in these vast areas is scarce.

"Almost all of the few wells drilled in deep water have targeted large anticlinal domes created by Miocene inversion. We have reasons to believe, after investigating the new data, that the same domes were subtle highs or barriers for the mainly gravity-driven sedimentation in late Cretaceous and Palaeocene times. This means that the best reservoirs may sit in the synclines and create donut shaped stratified traps around the same domes. We might have to drill all the domes again, but then the flanks will be in focus," Kjølhamar says.

"We look upon the AM17 surveys with this year's extensions as pioneering work. Good quality 3D data is a pre-requisite to define new play models, and our first look at the data is encouraging. We see lots of hydrocarbon indicators, the potential for unconventional plays that need to be tested, and – best of all – we are able to look through both basalt flows and sills and thereby identify possible Jurassic to Palaeocene prospects on the Møre Marginal Plateau," concludes Bent Kjølhamar.

It's about time for the innovative geologist to identify new play models and define big prospects in the Norwegian Sea. New data may make it possible.

HALFDAN CARSTENS

Next edition of GEO

In GEO no. 4 TGS will tell more about play models. Among these: cap rocks formed by shallow gas hydrates, Palaeocene donut anomalies, Eocene sand injectites and in particular the Jurassic potential of the outer Møre Basin.