

When will the clouds lift?

Vexing Valhall wells
Up front in the Arctic Ocean
Breaking through in science



NORWEGIAN CONTINENTAL SHELF

A JOURNAL FROM THE NORWEGIAN PETROLEUM DIRECTORATE

NO 1 - 2016



Photo: Audun Tholfsen

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The interview. The world is thirsting to know more about the Arctic Ocean. But few in Norway share this interest. Geophysics professor Yngve Kristoffersen is one of the exceptions. He and a colleague spent a year acquiring seismic data on the ice cap.



Photo: Monica Larsen

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Valhall. One of the most complex fields in the North Sea will soon have yielded a billion barrels of oil equivalent. Developing Valhall has cost much sweat and tears, particularly during the oil slump.



Photo: Morten Berentsen

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Cheerleader. Geologist Astri Fritsen is among the NPD staffers who follow up fields. She makes demands on the companies, but cheering them on is equally important.



NORWEGIAN PETROLEUM
DIRECTORATE

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VOLUME 13

RESPONSIBLE PUBLISHER

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PRODUCTION

Printer: Kai Hansen
Paper: Arctic Volume 200/130 g
Print run Norwegian: 10 000
Print run English: 1 500

LAYOUT

Arne Bjørøen

SUBSCRIPTIONS

www.npd.no/magazine
Free of charge

**NORWEGIAN CONTINENTAL
SHELF**

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The biggest player on the NCS is looking for ways to cut drilling costs and boost efficiency. The alternative is not to drill.



Photo: Roger Hardy

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Photo: Sverre Christian Jarild

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Photo: Sverre Christian Jarild

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Photo: Arne Bjæren

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The NPD is continuing to acquire geological samples and deepwater minerals in the Norwegian Sea.

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Time of change

If we want something to endure, we must change it. That message was conveyed by US president Bill Clinton in his 1993 inaugural address. Some would argue that we were too slow off the mark in making changes when the oil industry downturn began. Since then, however, many companies have got a grip and are now working well to emerge unscathed from these demanding times. Many people have unfortunately lost their jobs and, in the worst case, valuable expertise may have been lost.

Nor do we at the NPD believe all the players have everything in order. A few too many decisions are still being taken in a short-term time frame for us to think that. My job, as it was described by the Storting [parliament] when I took office, remains unchanged: the NPD must ensure optimum utilisation of all profitable resources.

We don't know how much value a field has generated until its resources are recovered. The oil price today isn't what counts then, but what it's been over the life of the field. Too much emphasis gets placed on quarterly results on our industry, which is long-term by nature. That's particularly true when fields like Ekofisk, Troll and Johan Sverdrup are set to produce for roughly 50 years.

That said, we see old branches putting out new shoots. The companies are – once again – showing a great wealth of ideas and the ability to adapt when circumstances demand it.

As Statoil's drilling supremo Geir Tungesvik says in this issue, "this is more a case of attitudes and efficiency than new technology for us".

If only the industry had been more conscious of such thinking when costs shot up and bespoke technology was commissioned – without adequately checking whether a simpler solution wouldn't have done the job just as well.

And when oil prices slumped on top of this, we ended up in the impoverished position which many are now painfully making their way through.

But developing and implementing technology which can meet tomorrow's needs is important. The NCS has always been regarded as innovative. Perhaps that position has been lost? Perhaps the industry didn't have the time to think innovatively in the recent good times – and now can't afford to?

What remains to be seen is whether enough of a lesson is drawn from this downturn. Petroleum is a cyclical business, after all. A future where the ups and downs recall rolling English scenery is preferable to an Alpine landscape.



Bente Nyland

Bente Nyland
director general

One of Norway's veteran oil fields, Valhall, faces something of a mid-life crisis as high costs and low oil prices continue to dog the industry. Operator BP is working to meet the challenge.

| Bjørn Rasen and Monica Larsen (photos)

Making haste slowly

Getting more out. *Jan Norheim, managing director of BP Norge, does not think a recovery factor of 30 per cent for Valhall is satisfactory. "I'm unlikely to be involved with Valhall 30 years from now. But I'd undoubtedly be disappointed and surprised if we ultimately have to leave more than 50 per cent of the oil behind."*



- Just before NCS went to press, it was announced that BP Norge and Det Norske are to merge.



VALHALL

– en historie om å s

Velkommen til et innblikk i norsk sokkels sør – og kanskje mest kompliserte felt. Å produsere fra kalkreservoar som er mekanisk svakt og hvor trykket lett kan rase sammen, gjør boring av brønner krevende og brønnenes levetid ganske kort. Produksjonsbrønnene må overvåkes kontinuerlig og trykket må styres nøye for å oppnå god produksjon og unngå brønnskollaps. Samtidig slutter feltet å overraske: Dette er også historien om feltet som har avdekket mer olje og gass i takt med produksjonen.

A story about making haste slowly

Welcome to an insight into the southernmost – and perhaps the most complex – field on the Norwegian continental shelf. Producing from a chalk reservoir which is mechanically weak and can easily collapse makes wells very demanding to drill and their lifespan fairly short. The production wells have to be monitored constantly and pressure needs careful management to achieve a good flow and avoid well collapse. At the same time, Valhall never ceases to surprise. This is also the story of the field which has actually seen its oil and gas reserves increase as production continues.





New look. How the Valhall field will appear when the old installations have been removed. (Photo: BP)

Go here for more Valhall facts: <http://www.norskpetroleum.no/en/production/field/valhall/>

Investment and timetables on the NCS are being reassessed and delayed. What impact does this have on field development? Is there really a standstill which could hit long-term value creation?

Valhall ranks as one of the most demanding fields in the North Sea. Oil first flowed from its chalk reservoirs on 2 October 1982, seven years after a well found them to be commercial.

The exploration drillers originally struck oil in Valhall as early as 1969 with well 2/11-1, but this discovery did not appear to be worth developing at the time.

More years were to pass before *Waage Drill 1* encountered a thick oil zone with the eighth exploration well – 2/8-6.

The soft reservoir chalk has created major challenges over the years by causing many wells to collapse – and poses the eternal dilemma which makes the field special.

They say producing Valhall is like squeezing oil out of toothpaste, since the rock is even softer than the nearby Ekofisk chalk reservoirs.

Various parts of the field have contracted by 10-16 metres since production began, while the overlying seabed itself has subsided almost seven metres.

These problems mean daily output cannot match the levels achieved from the sandstone reservoirs further north in the Norwegian North Sea, so that recovering the oil takes longer.

To reach the main reservoir, a well must penetrate eight different layers of rock formations – and, once through these, a sidetrack is sometimes required for technical reservoir reasons.

The refrain in BP is that those who have worked on this demanding field are well qualified to participate in most offshore projects – regardless of their location.

And many of them must have had excellent qualifications, because Valhall's estimated producing life has been extended by 40 years to 2050.

A wide range of technological measures, new installations and – not least – additional wells will make this longer life possible. Probably.

Challenges

Because Jan Norheim, managing director of BP Norge, has challenges enough. When we met in the spring, oil prices were in the USD 30s per barrel.

Last year, the drilling campaign on Valhall was suspended. "It was

too expensive to proceed with and wasn't good enough," Norheim admits.

He is now charged with downsizing the organisation even further, in line with the rest of the industry. But great efforts are being made to give Valhall its planned life extension.

Billions of kroner have already been devoted to replacing old installations, with more than NOK 73 billion in money of the day invested up to 2015. And over NOK 12.5 billion in 2015 value is still due to be spent.

"Putting a stop to drilling in February 2015 was a dramatic decision," Norheim says. "But we had to take a break in order to improve."

That affected some 300 people who were left without work and perhaps jobs. Instead, 12 engineers were given a budget of NOK 250 million over 18 months to come up with solutions to ensure good production wells.

Well costs have now been cut and expertise enhanced, and BP believes that drilling can be done for half the cost. Work is due to resume in the first quarter of 2017.

Norheim and BP have acquired fresh insights. The new wells will be less prone to collapse than before, and are calculated to extend Valhall's producing life

Already a museum piece

Exactly 33 years and two months after Valhall came on stream, the North Sea field became a slice of national industrial heritage at the Norwegian Petroleum Museum (NPM) in Stavanger. And it is expected to continue producing for at least another 35 years.

This history project took three years to complete under the museum's leadership. The National Library of Norway and the Norwegian Oil and Gas Archive were important contributors.

So mediaeval wooden stave churches in east Norwegian valleys are not the only objects which can become part of the country's cultural heritage.

That was emphasised by Aslak Sira Myhre, head of the National Library, when he conducted the official launch of the comprehensive Valhall industrial heritage website.

This took place during an event at the NPM on 2 December 2015. The site covers everything from technical drawings to radio and TV broadcasts about the field.

Large parts of the population lack a relationship with the Norwegian oil industry "because they don't see it physically and most people have never been on an offshore platform," Myhre said.

Valhall is known for its soft chalk reservoirs (often described as being like toothpaste) and the famous attempt in the 1980s to keep fractures in the rock open using glass marbles.

Jan Norheim, managing director of operator BP, notes that "everyone" in the company has to serve on Valhall. "Then they know they've worked with the most difficult field" and are well qualified for their next BP project.

Asked what he thinks about becoming part of a museum exhibit when so much work and production remains on the field, he says it feels "strange".

Valhall is the fourth industrial heritage project at the NPM, following Ekofisk, Frigg and Statfjord. The fifth will be Draugen, and the process of documenting this Norwegian Sea field is in full swing.

Read more about Valhall's incredible history at the NPM: <http://www.kulturminne-valhall.no/eng/>



Eventful past. US oil company Amoco developed and operated Valhall until BP took over in 1999. (Photo: Guri Dahl/BP)

from 15 to 24 years. That represents a lot of money saved.

The field currently has 45 producers flowing roughly 45 000 barrels per day. That compares with a peak output of almost 140 000 daily barrels. Set many years ago, this record is unlikely to be overturned.



Big value. "Improving recovery by one-two per cent would represent substantial value," says Jan Norheim.

Plugging

BP will not only be drilling new Valhall wells, but also plugging 31 redundant boreholes. That is mandatory under the licence terms and means additional expense.

Permanently plugging and abandoning a well represents a big job, which is intended leave it protected against future leakages.

The company calculated 18 months ago that its plugging programme would take 10 years. But Norheim reports that detailed studies, lessons from well work and seismic data in recent years have reduced that to five-six years – at significantly lower cost.

"Instead of isolating five of the eight zones the wells pass through, we now feel three-four may be enough," says Norheim. He compares that with Ekofisk, where plugging isolates two zones.

Exceeded

Despite persisting reservoir and well challenges on Valhall since it came on stream, oil volumes delivered have far exceeded the original expectations.

The field was forecast in 1982 to stay on stream for

about 20 years, and yield 247 million barrels of oil. Some 912 million barrels of oil equivalent have been produced so far, including the Hod satellite.

Valhall output will pass a billion barrels of oil equivalent towards the end of 2016 – placing it among the biggest fields on the NCS.

"We have plans for producing a further 250 million barrels from the field," says Norheim. "In addition, projects under way for the west flank will mean 250 million more can be recovered."

BP is looking at ways of maintaining reservoir pressure, including the possibility that "subsidence energy" could influence future production.

Another issue is how possible water injection on the flanks might improve recovery on Valhall, where a permanent seabed seismic array can help to identify new well targets.

The latter has allowed the operator to conduct repeated three-dimensional surveys – known as four-dimensional seismic – no less than 18 times over the past 13 years.

Valhall is the world's first offshore field to benefit from an installation of this kind, which gives geologists a good picture of how water and oil are moving in

“Improving recovery by one-two per cent would represent substantial value.”

the reservoirs over time.

That in turn makes it easier to determine new well targets – although use of the array has not been without its problems. A gas cloud over the reservoirs distorts the seismic images so that their interpretation becomes more demanding.

Norheim reports that this form of 4-D seismic is now outdated, and that BP adopted a new technology in 2015 based on mobile seabed signal units.

Recovery

Norheim identifies two main challenges faced by BP in seeking to improve recovery on Valhall when

oil prices have been “too low” for Valhall to show a profit over the past two years.

So prices must improve [they have in fact since risen more than USD 15 per barrel since this interview], while BP is turning new stones in the hunt for more efficient operation.

“Even though we’re taking a long-term view on Valhall, the technology we want must be adopted in good time,” Norheim says. “The most important requirement is better drilling methods, which we all believe in and are hoping for.

“We’re also continuing work on simulation technology in order to

enhance our understanding of the reservoir. Improving recovery by one-two per cent would represent substantial value.”

Asked whether Valhall will still be producing oil in 2050, Norheim admits that he does not know. “But if you could tell me the oil price ...”

While noting that Valhall is exposed to price fluctuations, he also recognises that the present recovery factor of 30 per cent is too low.

“I’m unlikely to be involved with Valhall 30 years from now. But I’d undoubtedly be disappointed and surprised if we ultimately have to leave more than 50 per cent of the oil behind.”



Profitable. BP has found its solution with power from shore to be more profitable than gas turbines installed offshore.

On the grid

Valhall turned much quieter in January 2013, when the noisy old gas turbines were switched off and the field became the first on the NCS to be powered solely via a 294-kilometre cable from land.

This link was established in connection with a general enhancement of the offshore facilities. A new production and hotel (Valhall PH) platform allowed production equipment to be modernised and upgraded for sustaining operations through to 2050.

BP had already assessed opportunities for an electricity supply network connect-

ing certain offshore fields through the North Sea power projects in 2000.

Together with ConocoPhillips, the company and its partners looked at supplying power from shore to the Ekofisk area, Valhall, Ula and various nearby UK fields.

The different concepts were ultimately shelved, in part because existing gas turbines could be modernised and the solution proved too costly. BP resolved to go it alone on Valhall.

“We learnt from this, reviewed the project, and found it profitable,” explains

Jan Norheim, managing director of BP Norge. “We’ve also seen that electricity prices have fallen more than the cost of gas.”

Including a transformer station at Lista, Norway’s southernmost point, the solution cost more than putting in new turbines. But operating costs are lower, and Norheim says that regularity has been up to expectations.

When push comes to shove



Low oil prices have made the oil companies more nervous than before about taking investment decisions. Astri Fritsen's job is to urge them to act – which is often all it takes.

| Alf Inge Molde and Morten Berentsen (photos)

“Our goal is dialogue and mutual trust.”

Think of a mature fruit tree where you only have one chance to harvest its crop. If you remove the ladder, it will never go back up again. But you set to work.

First you pick the low-hanging fruit, which are easiest to reach. You then climb higher up and further out. Finally, you stand and stretch as far as you can for the final take.

Although you want to gather as much as possible, the time comes when your motivation fails. The time and effort look like being too much, and you give up.

“Our job is to stand on the grass below and push the pickers with encouraging shouts,” says geologist Fritsen, who follows up many of the fields in the northern North Sea.

And the NPD certainly cheers the companies on, she observes. “You can accomplish this,” we cry. “Don’t give up, use your creativity!”

Important

This is one of the directorate’s most important jobs, covering every aspect from pressing for new developments to encouraging maximum value creation and the most cost-effective area solutions.

It also represents a very necessary role. The NPD sees that a number of operators are struggling with reduced profits, and fears that low oil prices mean required action will not be taken.

That in turn could mean leaving petroleum in the ground, a challenge when more than half the oil and gas resources on the NCS remain to be produced.

Fritsen says the project studies being conducted by operator companies are more detailed than before, and discussions between partners last longer than when crude prices were high.

Several rounds of discussions are needed before decisions are

taken, with uncertainty and risk as key issues. Norwegian projects also battle for investment within the big international companies.

The NPD understands the dilemma, says Fritsen, who notes that developments are not necessarily as profitable as they were. “But there are limits to how anxious the companies can be.”

She points out that an apparently uneconomic project today could be profitable in a lifetime perspective. So the NPD must sometimes go beyond pushing the companies. Many means of enforcement are enshrined in legislation and regulations.

Technical

This shoving preferably begins with technical meetings. The NPD then seeks more information by e-mail, asks clarifying questions, gives advice and provides positive feedback.

If that fails to do the trick, meetings are called at a higher level to express the government’s expectations. Supplementary studies can also be requested and action encouraged.

The next step is to follow up with letters to the licensees, contacts at senior management level with a clear message, and committee meetings where the government’s views are made clear.

Ultimately, the Ministry of Petroleum and Energy can decide to impose orders and demands. It can also reject formal applications or set conditions for approving them – particularly relevant when the licence is approaching its end.

“We prefer not to get that far,” says Fritsen. “Our goal is dialogue and mutual trust. Amicable meetings at a lower level usually suffice.”

Change

She joined the NPD in 1994 after 12 years as a geologist at Norsk

Hydro. The need for a change was supplemented by a desire to work for society.

“Resources on the NCS belong to the Norwegian people,” she notes. “At the NPD, we work on behalf of the community to ensure that it gets as much as possible of the value and to prevent somebody simply skimming the cream.”

But moving from the commercial side to public administration was not a simple matter. One comment Fritsen heard was: “Oh, so you don’t want to work at a more professional level.”

That almost made her turn tail. Although the NPD is a technical regulator, she sees today that it does not provide the same opportunities for in-depth work as an oil company.

More than 50 specialists are employed by the licensees on studying the sub-surface structure of Statfjord, for example. The NPD devotes less than two work-years to this field.

The challenge is to learn what is significant and where you are going to draw the line, rather than taking a detailed approach to everything.

Massive changes have also occurred, Fritsen notes. From making a big effort to monitor a few big discoveries, the NPD now has to deal with more than 80 fields.

Through close follow-up and by applying good methods for setting priorities, the regulator knows where it has to make a commitment and where its own technical work has the biggest effect.

Adapt

Low oil prices may be challenging, but they are not all bad. Fritsen says a number of specialist teams are working well to adapt to the new conditions.

Professionals become inventive when the times get tougher. And the NPD understand that the point



will ultimately be reached when no more can be achieved.

Before then, however, every avenue must be explored. Has anything been overlooked? Is new technology available? Should research be done? Can neighbouring discoveries contribute?

When oil prices were at their lowest, some Norwegian fields were close to a negative cash flow. The companies cut back and implemented improvements while waiting for prices to bounce back.

Shutting down a field and removing installations is expensive, so it can

pay to bide one's time. And cessation plans for a field must be submitted at least two years in advance.

These proposals must make it clear that every stone has been turned in the hunt to recover the final drops from the reservoir concerned.

"There's a limit to how far you can stretch," Fritsen admits, even though this can be hard to accept. "You sometimes have to leave the smallest fruit on the thinnest outer branches behind."

Dilemmas. *Projects which were profitable before are not necessarily commercial today. "But there are limits to how anxious the companies can be," Astri Fritsen emphasises.*



Drill cheaper – or not at all

The old saying that necessity is the mother of invention has been confirmed again by the present slump in the petroleum industry. In any event, wells are the key to recovery – something the biggest driller on the NCS is painfully aware of.

| Bjørn Rasen



Turnkey. Statoil is now awarding turnkey contracts which make a single contractor responsible for a complete well delivery. A typical package covers all completion, well services and mud/fluid treatment. (Photo: Statoil)

when oil prices topped USD 110 per barrel about three years back. "That price level and the excessive costs we saw prompted us to launch an improvement programme in 2013," he says.

The aim was to boost efficiency and get more out of Statoil's capacity at a time when the market was tight, rigs were in big demand and order books at the yards were full.

Action

"So we were already taking action when oil prices dropped like a stone," says Tunesvik. "We've used a reference from 2013 in the form of our Step programme.

"That was a good initiative until improvement halted and we've concentrated solely on measures which really had an impact on the bottom line. One of these was end-to-end delivery."

This commitment yielded results, he reports, with metres drilled per day up by 50 per cent for production wells. Days per well and costs fell by 30 and 20 per cent respectively.

"It remains to be seen whether that's good enough with today's oil prices," Tunesvik acknowledges. "At the same time, we can report our best-ever safety results.

"So we haven't forgotten that aspect. We're applying the same medicine for working efficiently that we use to ensure safe operation."

Asked whether he is passing the bill on to the contractors, Tunesvik says that he and his colleagues have had several rounds of discussions to find the breakeven price.

"If the cost per barrel exceeds the oil price, we have to call a halt," he emphasises. "[But] I'm not interested in working with anyone who's making a loss. That's the worst possible position, because people then take short cuts. We don't want that."

He also recalls that vessel owners sought three-year charters, which left them on good rates. "Rigs and ships on long contracts are paid far too much in relation to today's costs."

In his view, a number of owners failed to take strong action when this proved necessary. He now wants to talk with contractors on how the work can be done in other and more efficient ways.

Technology

"We must first exploit the technology we already have, and then look at opportunities for a single company to do several jobs rather than many small firms doing one job each," he says.

Tunesvik notes that a number of contractors want to offer turnkey packages. "Our response is OK, let's do that. We've done it on Johan Sverdrup and Britain's Mariner field. The next step is to put this approach to the test."

A typical package includes all completion, drilling service and mud/fluid treatment. Tunesvik admits this has both advantages and disadvantages, and that not everyone likes such solutions. But they are being tried out in the hunt to cut costs.

Overall, he is reasonably satisfied with the improved efficiency of well and drilling work. The most critical elements he wants to do more about are logistics and downtime.

These account for 30 and 20 per cent of costs respectively, he says. "We want to halve downtime. The key is that systems to work first time and that we avoid having to pull out equipment."

Not idle

Statoil's many drilling teams have not been idle, despite the downturn. They drilled 103 wells in 2014 and planned another 95 for 2015 – but ended up doing 117.

Boreholes are and will remain the petroleum sector's Achilles heel, and its biggest cost. How Statoil, operator for some 80 per cent of the NCS portfolio, intends to drill enough – and more efficiently – in a low-price regime is therefore an interesting question.

Geir Tunesvik, senior vice president for drilling and well at the company, emphasises that these activities account for a quarter of its costs.

"We were worried last year whether the oil price would fall below USD 60 [per barrel]," he observes. "Right now, I'm glad it's over USD 30." [Prices have since risen about USD 15.]

But his brow was also furrowed

“To get more out of the fields, I need to drill more cheaply if I’m going to be able to afford to drill at all.”

At the same time, the company has removed 10 derricks to cut costs. Tungesvik says improved efficiency has boosted the acceleration in production.

That has been worth an estimated USD 200 million to Statoil. But it is not enough. Work must become even more efficient, and errors have to be reduced.

The question is whether Tungesvik is being penny wise and pound foolish. His response is to ask what he loses by using standardised solutions.

“We’ve shown that we can get out more resources in this way. Reserves are growing faster. We’re not cutting anything in the reservoir, but may be doing things simpler on the way down.

“To get more out of the fields, I need to drill more cheaply if I’m going to be able to afford to drill at all.”

He adds that reducing the level of costs actually increases opportunities for improving recovery.

Perfect

Statoil has put together the perfect well from the best sections of reference boreholes. In theory, it should be almost impossible to do better than the sum of these sections in a single well.

But Tungesvik is seeking an improvement and something to strive for. “Getting 10-20 per cent better will help. We’ll be constantly trying to beat individual elements in these sections.”

He claims that Statoil actually achieved several wells last year which were better than the perfect case. But these are the exceptions.

In his view, it is more important that “we’ve breached the barrier and are delivering more stably. The NCS is where we drill the most, and the trend is now good. This is more a case of attitudes and efficiency than new technology for us.”

Response

Tungesvik says that the response to Statoil’s initiatives has been

good, and that the whole industry “is fantastic in its ability to turn around.”

This means the breakeven price on the fields has already improved, he reports. “Narrow doors can be opened in bad times –ones which are shut when everything’s booming.

“That may permit collaborative efforts which weren’t possible before. In addition, though, we must undoubtedly have a little help from oil prices in the rather longer term.”

Statoil is planning just as many production wells in 2016 as it did last year. According to Tungesvik, however, the drawback is that these wells have yet to be approved by the licence partners.

He says that the number of exploration wells is likely to fall this year. “I need to find more gaps to close. The alternative is to halt projects.”

Improvement. Geir Tungesvik, senior vice president for drilling and well in Statoil, says the company has had a good response to its improvement initiatives from the whole supplies industry. (Photo: Statoil)





BarentsWatch



Useful tool. Testing the FiskInfo service on the Arctic Swan trawler. (Photo: BarentsWatch)

Fishermen get the plot

Information from the NPD on seismic surveys is now being distributed through the BarentsWatch service directly to chart plotters on fishing vessels.

| Bjørn Rasen

Launched in January, this FiskInfo service represents a collaboration between BarentsWatch and the NPD, the Norwegian Meteorological Institute and the Norwegian Coast Guard.

NPD data on the location of subsea installations and on current and planned survey work now go straight to fishermen. They can subscribe to the service and get daily updates.

Information from other providers shows the position of the marginal ice zone and where fishing gear has been set out. The list of chart layers available for download

will eventually be expanded in line with user demand.

BarentsWatch, a monitoring and information system for much of the world's northern seas, also aims to ensure that the service is useful for other vessel types and maritime-related users. These will therefore be involved over time.

FiskInfo provides the oil and fishing industries with a common information base where users can, for example, obtain an overview of seismic surveys.

That in turn allows them to identify and avoid possible conflicts of interest when planning

and conducting fishing. Oil companies can be similarly informed in the other direction.

The NPD is one of the partners in BarentsWatch (see www.barentswatch), which is backed by 10 government ministries and 26 administrative agencies and research institutes.

Fridtjof Nansen's heirs are weaklings with insufficient scientific curiosity, says Norwegian Arctic veteran Yngve Kristoffersen. So he maintains Norway is lagging behind as a Polar nation.

| Bjørn Rasen



Flows swift



Swiftly over it

Inaccessible. Special ice conditions mean that certain parts of the Arctic Ocean are inaccessible even to icebreakers. Yngve Kristoffersen and Audun Thølfsen accordingly used the Sabvabaa hovercraft – whose name means “flows swiftly over it” – to explore the area between Canada and Greenland. (Photo: Audun Thølfsen)

This 74-year-old has recently put his money where his mouth is by spending a whole year collecting seismic data from a hovercraft out on the Arctic ice.

A greater contrast to such a life under endless starry skies would be hard to find when entering the brutal concrete colossus known as the Science Building in Bergen.

I find the nation's least conventional Polar explorer in a tiny office filled to the overflowing on the first floor. He has retained this modest cubicle despite having ceased to lecture as a professor of geophysics or to advise students.

But Kristoffersen remains committed to sharing his knowledge and data – a unique fund of information he has personally collected on long field trips right up to the North Pole.

At the University of Bergen on Norway's west coast, far from the Arctic, he seems happy to be squeezed in among all the rolled maps, books, piles of paper and computer screens.

He is used to living and working in confined spaces from his time on expeditions, of course. That includes the year he spent with a single colleague on the little hovercraft.

"Arctic Ocean data are in great demand internationally," the professor explains. "So it's paradoxical that Norway isn't making a bigger commitment up there.

"It's too naive to concentrate solely on Svalbard. That puts you at the entrance to a sea twice as big as the Mediterranean – without knowing what goes on there. You've got to get *in*."

Kristoffersen feels it is obvious that people need to learn as much as possible about how the planet is put together, what it looked like millions of years ago, and how it has developed.

And since most of the globe lies beneath wide oceans, the only way to find the answers is to



“ I like stillness. ”

strike out into the unknown.

A covering of ice should be no obstacle. All you need is practical solutions.

Kristoffersen spent his first Norwegian programme at an ice station in 1979. Since then, he has sought to get the country to play an active part in the Arctic Ocean.

He has worked at five different ice stations, living on the frozen sea for more than 18 months, and has participated in four icebreaker expeditions.

These journeys have taken him to the Pole four times, whether he wanted to or not. "Geologically, it's completely uninteresting. The



Inquisitive. Yngve Kristoffersen, professor of geophysics, in his office at the University of Bergen. At 74, he is still collecting as much information as possible – even from remote ice-covered regions – to understand how the planet is put together. (Photo: Arvid Steen)

Pole's on a turbidite plain."

Simply being somewhere is not his style. He is very committed to his discipline, which helps him to tackle longer spells on the ice than many others could manage.

An interest in geology, rather than mechanics or electronics, was sparked in the 1950s via a local unemployed person taken on by the Norwegian Geological Survey (NGU).

His job was to look for erratic rocks on the Finnmark plateau in northern Norway to see whether they contained ores and where

they originated.

Kristoffersen then studied geophysics at the University of Oslo. During the summer, he borrowed instruments and returned to the plateau. As he puts it, "things just snowballed".

Graduating from Oslo in the early 1970s, he secured a one-year grant in the USA from the geotraverse project led by Knut Heier to study a 200-kilometre corridor running across southern Norway and on towards Jan Mayen.

"I couldn't go home with-

out taking a PhD, and my thesis described how the Labrador Sea between Canada and Greenland originated," he explains.

While a doctoral student, he was allowed to use a vessel for two months. "Get into the box and don't get out until you know the story," ordered Manik Talwani, his supervisor.

Two job offers were on the table when he came home in 1977 – one from Canada and the other from the Norwegian Polar Institute (NPI). Taking the latter, he worked on the Barents Sea project.

“We got a free lift into the area, and they received a copy of everything – but we have the first right to publish.”



Fauna. In their year on the ice, Yngve Kristoffersen and Audun Tholfsen saw Polar bear tracks and received daily visits from these animals for a time. And an Arctic fox hung around their camp for a couple of weeks. (Photo: Audun Tholfsen)

The NPI wanted to become active in marine geology, and fights developed over funding and research posts. Kristoffersen’s critical views of the institute’s role in the far north have subsequently been an open secret.

“It doesn’t understand that it’s a national institution intended to help realise the potential of the whole Norwegian scientific community for the benefit of Norway,” he maintains.

“Facilitation is important. But what we find is a tragically introverted institution. The latest survey by the Research Council of Norway shows that 86 per cent of work-years on Arctic research is done by other bodies.”

He says that Norway as a nation needs the whole scientific community to compete freely, with the best projects being automatically supported by reasonable Arctic logistics.

“The icebreakers enter the Arctic Ocean two-three times a year, but Norway and the NPI don’t participate. That seems a willed inaction. Our national problem sits in our heads, and has less to do with resources.”

Sweden uses a different model, Kristoffersen notes. Its Polar Research Secretariat facilitates the institutions, and the best proposals get help with logistics and funding. The USA has a similar system.

But he praises the NPD for appreciating the significance of regional geological understanding and for supporting Arctic Ocean research. Like all other physical parameters in the environment, geology knows no national boundaries.

Findings

So what does Kristoffersen want to achieve in the Arctic Ocean? And what are his findings. The geologist harks back to 1963 and a proposal by Canada’s Tuzo Wilson.

This concerned the 1 700-kilometre Lomonosov Ridge, a mountain chain in 1 000 metres of water which extends from Canada towards the North Pole and the New Siberian Islands.

Wilson suggested that it was probably a “splinter” of continental margin from north of Svalbard and Franz Joseph Land, shifted to its present position by plate movements.

Sailing with German icebreaker *Polarstern* in 1991, Kristoffersen was able to acquire the first seismic profile of this feature.

“If Wilson was right, we’d find inclined layers building out on the slope facing Alaska and only vertical faults on the Svalbard side,” he explains.

“As the data appeared on the monitor, that’s exactly what we saw – an incredibly powerful scientific experience.

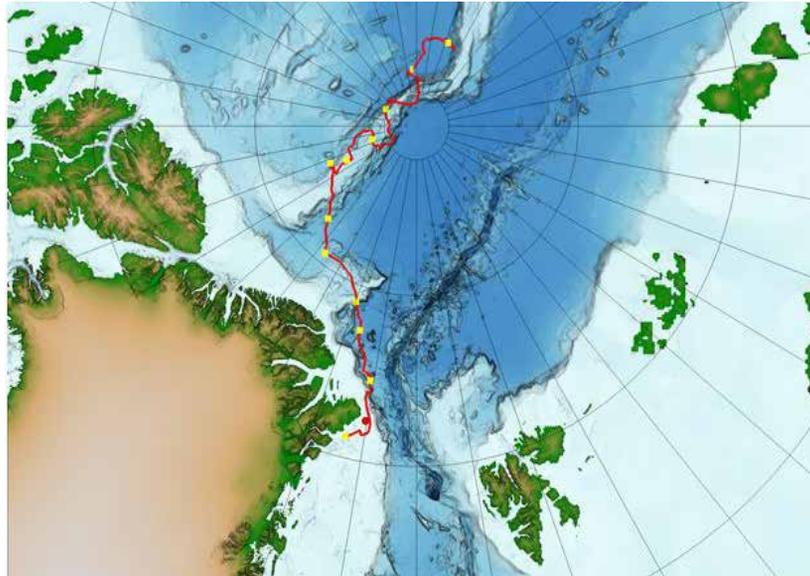
“We know that the Norwegian Sea was created over the past 56 million years, and that the area between the Pole and Svalbard has emerged in the same period. I think it’s important that we understand these relationships.”

Scientific drilling was carried out in 2004, and penetrated a 420-metre-thick layer atop this continental ridge to reach Eocene rocks.

From there, the bit went straight into a layer which was 85 million years old. This means that the ridge was elevated above sea level during the breakup phase.

Its top was eroded down to a flat plain which sank beneath the waves again 56 million years ago, and the uppermost sediments were then deposited.

“I regard that first trip over the ridge as one of my greatest scientific experiences,” says Kristoffersen. “The ingredients were there – a bold hypothesis and its test. We wrote the paper on our voyage home.”



One-year journey. The central Arctic Ocean with the expedition route marked in red and the first day of each month indicated by yellow points.

Inaccessible

Parts of the Arctic Ocean are inaccessible to icebreakers, including half the flat-topped Lomonosov Ridge. This has the same length as Norway’s north-south extent and rises 3 000 metres – higher than the Alps.

The easiest way to access this area is to establish a station on an ice floe which simply drifts into

it – or a hovercraft can be used instead.

Kristoffersen had pursued the idea of deploying a hovercraft in this region for 25 years before he finally got to fulfil his ambition.

The Germans had planned an expedition to the Alpha Ridge, where sediments dating back 50-70 million years had been found in the seabed.



Data acquisition. Yngve Kristoffersen deploys hydrophones to pick up seismic signals. About 1 000 kilometres of such data were acquired during the expedition. (Photo: Audun Thølfesen)

Kristoffersen and colleagues published a hypothesis in 2007 which suggested this was the result of a pressure wave from the impact of asteroid fragments about 2.5 million years ago.

They struck a deal with the Germans to drop off Kristoffersen and colleague Audun Tholfsen, along with the hovercraft, to conduct a Norwegian expedition of their own.

A condition was that plans were submitted for rescue and for storing 20 tonnes of diesel oil on the ice. The solution for the latter was to use cushioned tanks.

The rescue plan was approved. In 2011, the coastal states in the Arctic Council agreed that the nation which had the equipment would be asked to respond to a possible emergency.

When the expedition began in the American sector in the autumn of 2014, the camp was 1 000 kilometres from the nearest outpost of civilisation.

The two men then spent a year crammed together in the freezing darkness. Their office and quarters were on a vessel measuring just 12 by six metres.

Its cabin provided only 3.6 square metres, but was good and warm. With a top speed of 35 knots, the hovercraft had been named *Sabvabaa*, an Inuit term meaning “flows swiftly over it”.

“So we collaborated with the Germans, who eventually gained confidence in us,” says Kristoffersen. “They saw we delivered the goods

from areas where even nuclear icebreakers couldn’t get through because of the difficult conditions.

“It was win-win. We got a free lift into the area, and they received a copy of everything – but we have the first right to publish.”

He estimates the value of the partnership at several tens of millions of kroner.

Acquired

Sabvabaa crossed the Lomonosov Ridge and then the Morris Jesup Plateau north of Greenland no less than five times, and acquired 1 000 kilometres of seismic data from an unexplored sea area.

The surveys were conducted with a simple airgun as the sound source in the water, which obtained its air pressure in turn from a small diving compressor.

Echoes from the seabed and underlying strata were registered by a simple hydrophone. Despite the unsophisticated equipment, results were good because of low noise levels in the water.

Kristoffersen is very pleased with the data he and Tholfsen collected – and he avows that the pair are still friends.

“Such expeditions aren’t for everyone. There’s not much room. But we’re experienced and knew what awaited us. Most people ask about the 24-hour darkness, but we both feel it passed surprisingly quickly.”

He admits that such an experience can be a trial even for experi-

enced Arctic explorers. Something happens to you after three months, and you begin to get frayed after half a year.

“You’ve just got to avoid starting to quarrel. That calls for strict mental control over everything you say. You need to think before you speak.”

Kristoffersen feels this is easier for somebody like him, who has a scientific interest, than for a person only concerned with logistics.

“There are limits to how inspirational it is to fill the day tank with diesel oil in darkness and a snow-storm, while I’m entering new information and know what it means. But Audun managed well, and was always asking about the significance of the data.”

A natural question to ask is what drives him – what gets him to devote a whole year to such a special expedition. His spontaneous response is that he likes stillness.

“I enjoy reflecting over things, and you have plenty of time to think up there.”

He also finds the scientific problems interesting. “When you work a lot and see the data coming in, it feels fantastically rewarding. You can carry on for ever then.”

Lyrical

Being alone on the ice provides a strong sense of the natural world, and Kristoffersen waxes lyrical about the white landscape under the stars and a full moon. “A fantastic experience which pierces you to the mar-

Winter dark. Anyone wanting to collect information in the Arctic Ocean must tackle 24-hour winter darkness and temperatures down to 40°C. (Photo: Audun Tholfsen)

row – it’s really powerful.”

It must also be said that the weather is often grey and boring in those parts. And the ice does not stay still. A lot of people want to know how the pair killed time, but Kristoffersen says this is a silly question.

Just living and surviving is a full-time job. They had their most wearisome periods when their base camp – a temporary structure – was destroyed because the ice broke up.

This hangar contained a work bench, with tools neatly hung up. “When you’ve got to start again four times in -30°C, it eventually gets tiring,” admits Kristoffersen.

The cold can be tolerated, even though he feels that the few days when the thermometer crept below -40°C were a bit excessive. But the seismic surveying continued every day, whatever the temperature.

They had few visitors, but saw Polar bear tracks once and the animals themselves after 10 months. For a time, the bears visited the camp daily. The most interesting guest was an Arctic fox who circled around for 14 days in December.

Their equipment also included an underwater camera, which they lowered in 15 locations and obtained images of unknown species. These were passed to marine biologists.

“They really woke up when they heard about this,” says

Kristoffersen. “We saw tusk 1 400 metres down, and other fish as deep at 2 000 metres. Twenty hours of footage have been sent to the biologists.”

Changes

Looking back on his own 37 years of experience at ice stations, he observes that it is difficult to detect changes in the Arctic Ocean.

“But measurements show that the ice is thinning. The problem lies with people who come up, see an open channel and some water, and claim the ice is disappearing. That’s misleading. Open channels come and go all the time.”

He points out that the atmosphere and the ice form a dynamic system. “But we seem to expect that nothing alters. Every geologist knows that dramatic events have occurred earlier which far exceed what we’re seeing now.”

New measurement systems help to dramatise the position “because we can document changes. The discussion suddenly gets out of proportion. Our data aren’t actually good enough to say that developments today are unique. At least for the moment.”

Climate change is high on the agenda in the international Polar research community. The ice is thinner, and that is creating concern.

But Kristoffersen argues that warm periods have occurred before. “Temperatures were higher

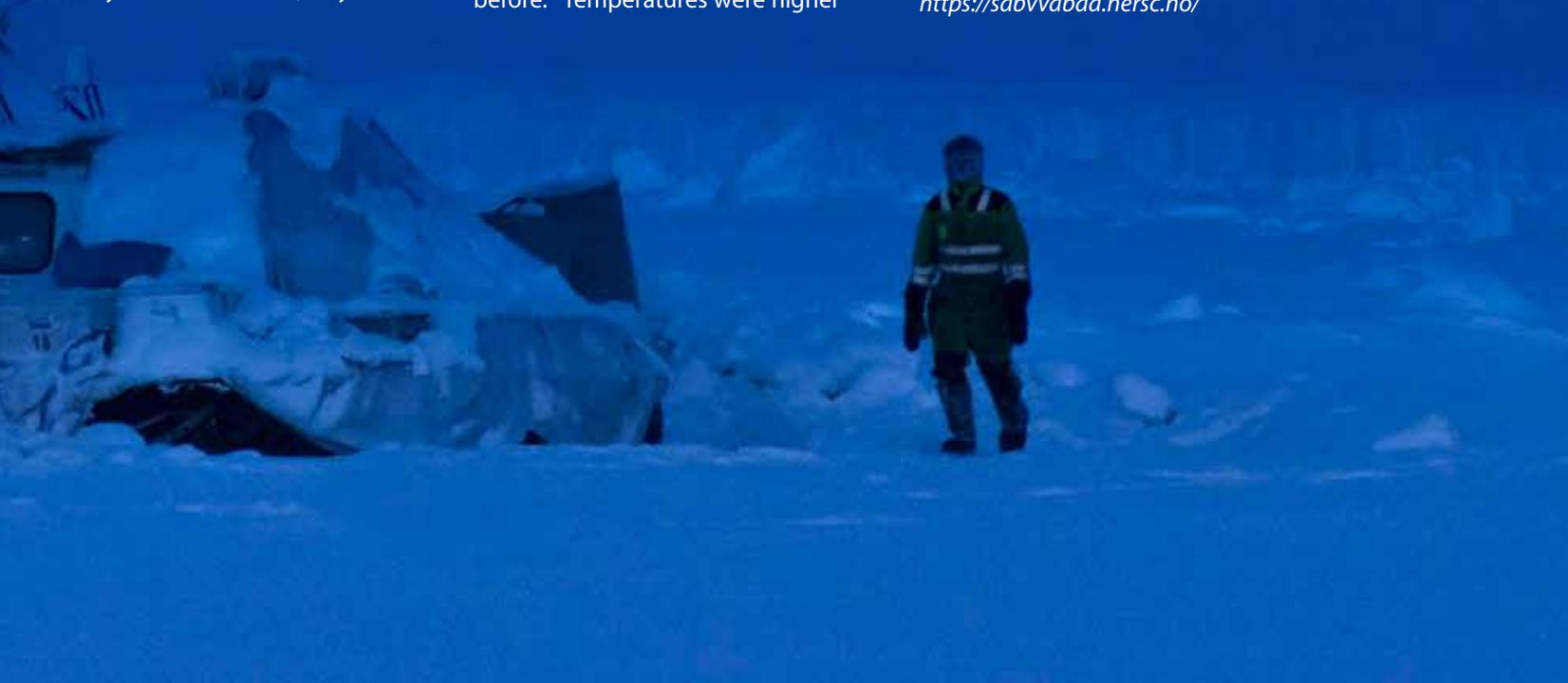
than today 6-8 000 years ago, and it was even hotter 120 000 years back.

“If we go back 50-70 million years, the temperature of the Arctic Ocean was 10°C. Crocodiles lived on Ellesmere Island, and the redwood trees were 30 metres high.”

Sabvabaa is now in Svalbard. Kristoffersen is planning to devote a couple of months this summer to maintaining and repairing it. That counts as a holiday for him.



Read more about the hovercraft and the expedition: <http://www.polarhovercraft.no/>
<https://sabvvabaa.nersc.no/>



A climate for action

Agreement on cutting greenhouse gas emissions was reached by 186 nations in Paris during December 2015. This ambitious plan can only be achieved through a major and binding commitment – which includes the oil and gas industry.

| Jorunn Braathen Eia and Monica Larsen (photo)

Five national priorities on the climate have been set by the Norwegian government, including the development of low-emission and clean production technology in industry.

The others are carbon management, strengthening Norway's role as a renewable energy supplier, a green transition in shipping, and the transport sector – where challenges are greatest.

After signing the Paris agreement on 22 April, the government submitted a Bill on ratifying this deal to the Storting (parliament).

"Norway and Norwegian companies are [to be] early adopters of and leaders for the green transition," the Ministry of Climate and the Environment wrote in a press release.

Temperatures

A limit on how much carbon dioxide the atmosphere can absorb without the global temperature

probably exceeding 2°C has been set by the UN intergovernmental panel on climate change (IPCC).

The effects of a rising greenhouse gas concentration are already visible across much of the world, and curbing such warming is essential if matters are not to get worse.

While the IPCC has set 2°C as the ceiling, the climate summit in Paris agreed to aim for a limit of 1.5°C. The global temperature in 2100 is to be no more than 2°C higher than in 1850.

Energy production accounts for the largest share of world greenhouse gas emissions, which the IPCC maintains must be cut by 90 per cent in 2040-70 compared with 2010.

The goal is for humanity to become climate-neutral at some point between 2050 and 2100, so that greenhouse gas emissions are balanced by their capture or removal.

Norway, for example, can go on producing oil and gas as long as it supports afforestation projects and other measures to eliminate carbon dioxide – and thereby becomes climate-neutral.

Commitment

"The Paris agreement was a stroke of genius for getting all the nations to sign up," says Eirik Wærness, chief economist and head of market analysis and strategy at Statoil.

Noting that this boosts the probability of achieving such a commitment, he feels Europe and the USA face a big challenge while China, for example, can meet its targets more easily.

"If measures follow in the wake of targets, the Paris agreement will also have an impact on the Norwegian oil and gas sector.

"The industry hasn't reached agreement on action yet, but there's great willingness to do something. In Statoil, we're pre-

Paris agreement

All states have accepted legally binding commitments to reduce emissions under the Paris deal.

Key points

1. ALL countries have obligations – they must produce a national plan with a specific goal. This must be renewed every five years up to 2020.
2. Temperature will not increase more than 2°C, and preferably 1.5°C – the rise will not exceed 2°C before 2100.
3. The countries have a plan for achieving this – the world will be climate-neutral some time between 2050 and 2100.
4. The rich nations MUST pay, the less wealthy CAN pay – the former will help to fund efforts by poor countries to cut emissions and adapt to climate change.
5. All countries must adapt to climate change – they will collaborate, share knowledge and experience, lay plans and come up with good methods for dealing with loss and damage.

ple who're going to do that aren't born yet."

Important

Coal-fired electricity generation has traditionally played an important role in boosting economic development for a number of countries.

A full transition from coal to gas could cut greenhouse gas emissions by 50 per cent while helping to meet the rising demand for energy.

The world will also have to move away from natural gas, but this fuel is set to remain important for a number of decades to come.

About 20 per cent of Norwegian gas is sold to the rest of Europe for electricity generation, helping in part to reduce the use of coal.

Just over one per cent of total global energy demand is met by solar and wind power, but how much this proportion can increase remains uncertain.

Wærness notes that the need for oil and gas as feedstock for products is also set to grow, from about 10 per cent of petroleum production today to an estimated 20-25 per cent.

"It's difficult to find replacement raw materials for manufacturing such commodities as asphalt and plastics," he points out.

pared for higher carbon costs and stricter climate rules."

Noting that Norway has had a carbon tax since 1991, Wærness finds it paradoxical that these emissions are regulated more strictly offshore than for land-based activities – such as the process industry or agriculture.

In his view, different sectors should be subject to the same operational parameters if the climate targets are to be reached as efficiently and cheaply as possible.

"It's also important that we view the Paris deal in relation to other agreements," he argues, and points to the 2030 agenda for sustainable development adopted by the UN last September.

This aims in part to ensure that the world has access to cheap, reliable and modern energy services by 2030.

Lack

The global population is expected

to reach 10 billion by 2050. Close to 1.5 billion humans lack electricity today – including more than 90 per cent of people in Malawi, one of the planet's poorest countries.

While world demand for energy is rising sharply, output from existing oil fields is declining by three-six per cent annually. So finding alternative sources of supply is a matter of urgency.

"The question is whether we can deliver enough energy to meet global demand," says Wærness. "It's therefore important that we invest in new energy while also producing oil and gas as carbon-efficiently as possible."

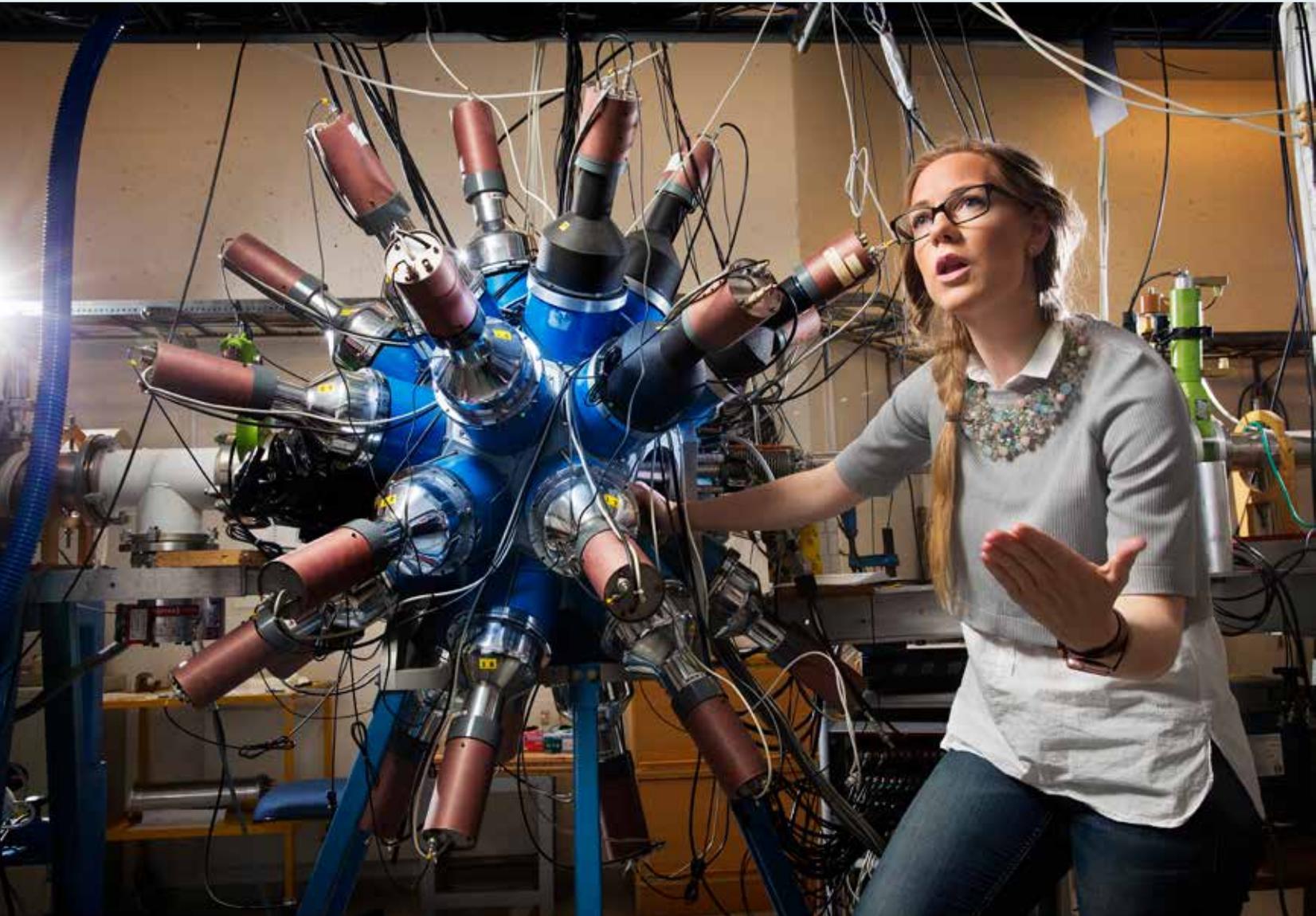
Emphasising that green energy is needed to ensure sufficient supplies, he maintains that people must be positive to both sources.

Wærness is optimistic about the oil sector, and quotes Tord Lien, Norway's petroleum and energy minister: "There's no reason to turn off the lights yet. The peo-



Genius. "The Paris agreement was a stroke of genius for getting all the nations to sign up," says Eirik Wærness. "It increases the probability of achieving such a commitment." (Photo: Statoil)

Communicating a commitment



Cactus *"This is the detector system for the cyclotron," explains Sunniva Rose. The lab is a mini-mini-version of Cern in Switzerland.*

Popular science blogger Sunniva Rose originally wanted to be a ballet dancer, but became hooked on nuclear physics instead. She admits that her path to this career has not been trouble-free.

| Bente Bergøy and Sverre Christian Jarild (photos)

I've been at the University of Oslo [UiS] for about 13 years," Rose reflects. "If I'd followed the schedule, I should have completed my PhD ages ago."

She guides me from the physics building at a brisk pace in high heels. We are heading for the cyclotron laboratory, which contains Norway's only accelerator for research on ionised atoms.

Known as Cactus because of its long spines, the cyclotron's detector system lies in a bunker-like room with strip lighting and past a timeless control panel.

"This lab is a mini-mini-mini version of the set-up at the European Organisation for Nuclear Research (Cern) in Geneva," Rose explains.

She is intimately acquainted with the facility after devoting hours and days and weeks to preparing and running experiments on it.

Her research focuses on how

thorium could be used to fuel a nuclear power station and thereby possibly reduce radioactive waste. She is hoping to complete her thesis this summer.

Attractions

Rose talks rapidly about the attractions of nuclear physics, about isotopes and uranium, and about how she was mesmerised as a little girl by pictures from Hiroshima in World War II.

Many people associate her subject with atom bombs and dubious power stations, but she stresses that it is far, far more than that.

"It's nuclear fusion, for example, which gives us sunlight," Rose points out. But much about the atomic nucleus remains unknown, more than a century after its discovery.

She is actually far too busy to devote a morning to me. And she probably also has too much to do to talk at conferences, schools and exhibitions, and to be a blogger.

But she has something to convey. "Roughly speaking, universities are supposed to do three things – teach, research and communicate," she notes.

"Unfortunately, too little weight is given to the last of these. Academics feel that communication steals valuable time which should be devoted to research."

Popular

Her own attitude is the opposite, and finds expression in blogging and in serving as a popular speaker. She is happy to talk science – her own project, nuclear power,

research and prejudices.

But she is often invited to share her experience, because her journey to a physics doctorate has not followed the line of least resistance.

"I wanted to be a ballet dancer," Rose recalls. "In my second year at upper secondary school, however, I decided I'd rather study physics. That meant I had to repeat the year to get properly to grips with maths, physics and chemistry."

She joined the physics, astronomy and meteorology programme at the UiS in 2003, and found it a big disappointment – to put it mildly.

"The course didn't meet my expectations, and I failed to settle in at the university. The subjects were more difficult than I'd thought, and I wasn't used to feeling so stupid."

Matters were not helped by failing courses and having terms where she only just managed to get through an exam. "I wondered for a long time what I thought I was doing," she admits.

Her progress in maths was not particularly good, and she disliked experimenting. "I really doubted whether there was room for somebody like me, who had a handbag full of pink lip gloss, wore high heels and taught dance part-time."

Then things started to look up. She took a couple of courses which broke the logjam. One dealt with energy challenges and realistic solutions, and Rose discovered that nuclear power is currently an important part of the answer.

High speeds

A cyclotron drives electrically charged atomic particles to higher speeds. The largest such accelerators are used to study the nuclear reactions which occur when the particles collide.

Less powerful versions produce radioactive isotopes for medical and research use. Cyclotrons create them for use in positron emission tomography (PET) scanning. *Source: Wikipedia*



Reading room.

"Nothing just happens," affirms doctoral research fellow Sunniva Rose. "If you're going to be good at something, you must work – and work hard."

“*If my story can motivate somebody, that’s great.*”

Applied

“I’m not a theoretician or a classic experimenter, but somewhere between or possibly outside them,” she says. “I wanted to do applied physics, and to learn a lot more about nuclear energy.”

Put briefly, much went better thereafter. Rose took up subjects and secured her BSc (“by the skin of my teeth, and taking a year longer than I should have”).

She started work on an MSc, and thrived on long days in the lab and on the in-depth study of a topic she found exciting. Enjoyment, involvement and commitment paid off in top marks.

In the autumn of 2010, Rose became a doctoral research fellow in nuclear physics at the UiS.

The obvious question is why a woman who is well launched on a dance education should decide to transfer to science studies and nuclear physics.

“I was good at science and liked it,” Rose explains. “And I did well at these subjects in upper secondary school. But good results and learning naturally don’t just happen.”

Hard

She makes the point that to be good at something, you have to work for it, and hard. And the only way to overcome the widespread aversion to maths is to stop saying

the subject is so difficult.

Pointing to Norwegian chess champion Magnus Carlsen and cross-country skier Petter Nordtug, she says they have only achieved success by combining talent with a lot of training.

Rose is good at driving herself. After all, she has a background in ballet and is used to discipline. That has been no disadvantage in her academic career.

She struggled through the adversity and unhappiness of her first years at university before landing in the right place and finding that she and others believed in her project.

This is something the young scientist both talks and blogs about: “I’m not afraid to be honest and to share experiences and feelings,” she says.

“I’m a human being – I get unhappy when I fail to achieve something. That’s probably the same for everyone. If my story can motivate somebody, that’s great.”

It probably does, too, to judge by the good feedback she gets from both blog and talks. “People recognise themselves in me. Many struggle to find the right track when they start studying. I also get told I’ve inspired people to make a commitment to science.”

Opportunity

The question is why young

Norwegians should opt for science studies when the oil industry seems to be in decline and many engineers are having trouble finding a job.

Rose’s answer is that these subjects provide the opportunity to work with everything from people to medicine, oil, space travel or the environment – and to help develop society.

“But I genuinely believe that knowledge of science should form part of a general education,” she affirms. “It helps you to think critically. Nothing is black-and-white, and not everything you read in the papers is true.”

Rose experienced that herself when the Fukushima I nuclear power station in Japan was wrecked by an earthquake and tsunami five years ago, and the tabloid press went bananas.

“A lot of what appeared in print was completely hair-raising,” she says. “These reports played on people’s fears, and fear sells.”

The more you know, the better you are equipped to see the nuances. Nothing is completely fine or entirely bad. Nuclear power has advantages and disadvantages – just like oil.

“But it’s important that you believe in yourself and in what you do, and that you’re proud of it,” adds Rose.



Communication. “I had a tough time at university to start with, just like many others,” says Sunniva Rose, who shares her experiences through blogging and giving talks.

Sunniva Rose’s blog – written in a mix of Norwegian and English – can be found at www.sunnivarose.no.

Black beach



| Jon Arne Øverland and Terje Solbakk (photo)

Parts of the Kvalbein beach in southern Rogaland, the county embracing Stavanger, change character completely in winters with much strong wind.

Its normal covering of pale quartz sand gives way to dark, almost black, grains which consist largely of magnetite and ilmenite plus a little zircon.

Weight differences mean that wind and waves carry the quartz out to sea, leaving behind the dark minerals. But this process is cyclical. Changes in wind direction and less intensive wave action in the summer months usually bring all the pale sand back.

Ilmenite – an important industrial mineral – and magnetite are common in Rogaland's anorthosite

province, which extends west roughly to Kvalbein.

Sokndal lies centrally in this province, and the Titania company operates a big opencast ilmenite mine there.



Taking survivor symptoms seriously

Roughly 30 000 oil-related jobs have disappeared in Norway over the past couple of years. Getting fired is never fun, but many of those who remain are also struggling.

| Bente Bergøy

Research worldwide shows that many of these 'survivors' feel a sense of guilt and a bad conscience at having retained their jobs," explains philosopher Øyvind Kvalnes.

An associate professor in the department of leadership and organisational behaviour at the BI Norwegian Business School, he adds that their motivation may be

significantly reduced, affecting job satisfaction and productivity.

This phenomenon, known as "survivor syndrome", is often associated with traumatic incidents such as shipwrecks, natural disasters, epidemics or war.

Those who emerge from such events frequently blame themselves for pulling through, and can suffer such symptoms as anxiety, depression and insomnia.

"Exactly the same thing can happen with workplace downsizing, and employers need to take this seriously," says Kvalnes.

Change

He is interested in the subject of change and what it does to people, and has given talks to organisations and union officials on the survivor syndrome.

The problem can be averted

“Those made redundant usually get a lot of attention and good follow-up with advice and perhaps severance packages. The others must usually fend for themselves.”

or alleviated by putting good processes in place, he emphasises. “Managers must set a positive example.

“Openness, good communication and involvement are crucial. Decisions on who stays and who goes, for example, must be based on clear criteria and principles.”

The approach taken must be transparent and fair, the organisation must comprehend the reasons for the downsizing, and it must grasp why these are having such an effect.

And the employer could benefit greatly from taking particular care of those who will be staying – by motivating them, for example, or by facilitating professional development.

“Those made redundant usually get a lot of attention and good follow-up with advice and perhaps severance packages,” Kvalnes observes. “The others must usually fend for themselves.”

Not only that, but the survivors must also often tackle new jobs and different work routines. Change management specialists know full well that such alterations are not necessarily welcome.

That is particularly the case when those affected do not necessarily know where these innovations could lead. You know what you have, but not what you are getting.

To cap it all, good colleagues have disappeared – something which can trigger feelings of loss and sorrow in itself.

Identity

People who subsume much of their identity in their work usually suffer the most, Kvalnes says. Those who have more social resources will be best equipped to tackle change.

“We’re social beings who need companionship,” he points out. “That’s completely fundamental. We need to be rooted, to be seen and to be mirrored in others.”

That also applies to people in the driving seat, who take the decisions and lay the plans – and who conduct the difficult conversations.

Downsizing processes are naturally very demanding for them as well. Union officials and managers also need to be rooted in the community.

The importance of the social collective is well documented, Kvalnes observes. That applies not least to research on the human brain.

“When a community, like a workplace, is broken up and you or others are excluded from it, the brain reacts in the same way as if you’ve lost a limb.”

Underlining the way humans are social beings, he says this phenomenon is rooted in their evolutionary past. Break-ups are hard, as is shown by the feelings unleashed and the terms used.

“Those who’ve survived a downsizing often use strong words to describe what has happened, such as life, death, executioner, pain and sorrow. It’s clearly dramatic.”

Famed Greek philosopher Socrates proclaimed that one should “know thyself”. But Kvalnes believes many have misinterpreted this maxim.

“It’s not a matter of sitting in a cabin by yourself and knowing who you are in isolation. This is about who you are in the community.”



Suffer. People who subsume much of their identity in their work often suffer most in a downsizing process, says philosopher Øyvind Kvalnes. (Photo: Sverre Christian Jarild).

The Force be with you

Our goal is to develop expertise and technology," explains Hans-Oddvar Augedal, who chairs the Force organisation. "We're an important driver in these areas."

A principal geologist in oil company Lundin, he believes the non-profit, low-subscription forum has been strengthened by the cut-backs in the petroleum industry.

"Our meetings and seminars meet high quality standards, but are cheap and usually take place in the Stavanger region where most of the companies are based.

"In addition, information is spread over the web or participation at other office locations is offered with the aid of videoconferencing."

The brainchild of NPD geologists Dag Bering, Force was founded 20 years ago with 13 member companies and a focus on improved recovery.

It currently embraces about 50 licensees on the NCS, and works on improved exploration (IE) plus

improved oil and gas recovery (IOGR). Each of these areas is headed by a technical committee drawn from eight of the companies.

Seminars and meetings are organised by various networks. Through these, the companies have identified common issues posing specific challenges and established projects across licensees.

Unique

Augedal believes the Force concept is unique on a world basis because of its openness and the way it shares databases.

"We're a big group of companies which compete over licences on a daily basis, but which share knowledge and experience in order to improve ourselves collectively."

He adds that Force also works to create meeting places for developing expertise and technology in collaboration with suppliers and research bodies.

Lundin has been very active in and committed to Force, Augedal

reports. Although companies can be passive members, he feels they get much more out of vigorous involvement in meetings and discussions.

They can also benefit from shared databases on such subjects as drilling and seismic surveying, and from collaboration in an open forum with licence partners and, in principal, competitors.

These exchanges take place at seminars and network meetings, and through joint industry projects (JIPs). Events are usually oversubscribed.

About 10 seminars and excursions are staged annually by the members themselves on subjects of their choice. These are often specific and in-depth, compared with the more general programmes at major conferences.

"I'm impressed at how good the members are at sharing knowledge, experience and information," says the NPD's Eva Halland, project head and administrative manager for Force. "Our feedback is that they get a lot out of taking part."

Network meetings, sharing knowledge and exchanging experience are the drivers for a cross-industry forum which is refusing to be affected by industry cutbacks and savings.

| Jorunn Braathen Eia and Arne Bjørøen (photo)

Projects are a spin-off from meetings. Companies which want to continue work on a specific issue form a JIP and report to a dedicated management committee.

According to Halland, Force has become stronger over the recent past despite downsizing and cutbacks in the Norwegian industry.

Collaboration

An example of its seminar activities is Joining Forces, a programme which aims to encourage collaboration and communication between the petroleum sector and Norwegian scientists.

The aim is valuable research and development projects, Augedal explains. "We want to promote our IE and IOGR priorities in line with the goals of our two technical committees."

Through discussion fora, panel debates and opportunities for network building, this seminar compares future company needs with the expertise, specialities and plans of the research teams.

"The idea is to update members on existing research activities and to give them an understanding of what the various departments and institutes do," says Augedal.

Future

Force also wants to motivate young people to seek a future in the industry through a project called Ring – which stands for science, inspiration, industry and happiness.

Led from the start by former Statoil staffer Kjell-Sigve Lervik, this venture was initiated and supported financially by Force.

It runs an annual workshop with exhibits and talks by member companies to stimulate and inspire upper secondary school pupils to study science, and to show why these subjects are important.

The project will continue after 2017 as part of the school system, Augedal reports. "Six-nine years pass between 16-year-olds choosing their subjects and finally graduating as engineers.

"It's important to maintain initiatives on recruitment to the sciences and to professions needed by society, even if the labour market fluctuates."

A preliminary Force assessment of a careers advisory centre in the Stavanger region has found that establishing such a facility should be studied.

This conclusion is based on the facts gathered about society's requirements and young people's educational choices, says Augedal.

In his view, a centre of this kind must differ from other measures by meeting the needs of its target audience for insight into and advice on the options available to them.

Rogaland county council, which embraces Stavanger, and the Ring project are pressing hard to achieve this goal, reports Halland. "A careers advisory centre could fill a very important need which has so far been relatively unmet."

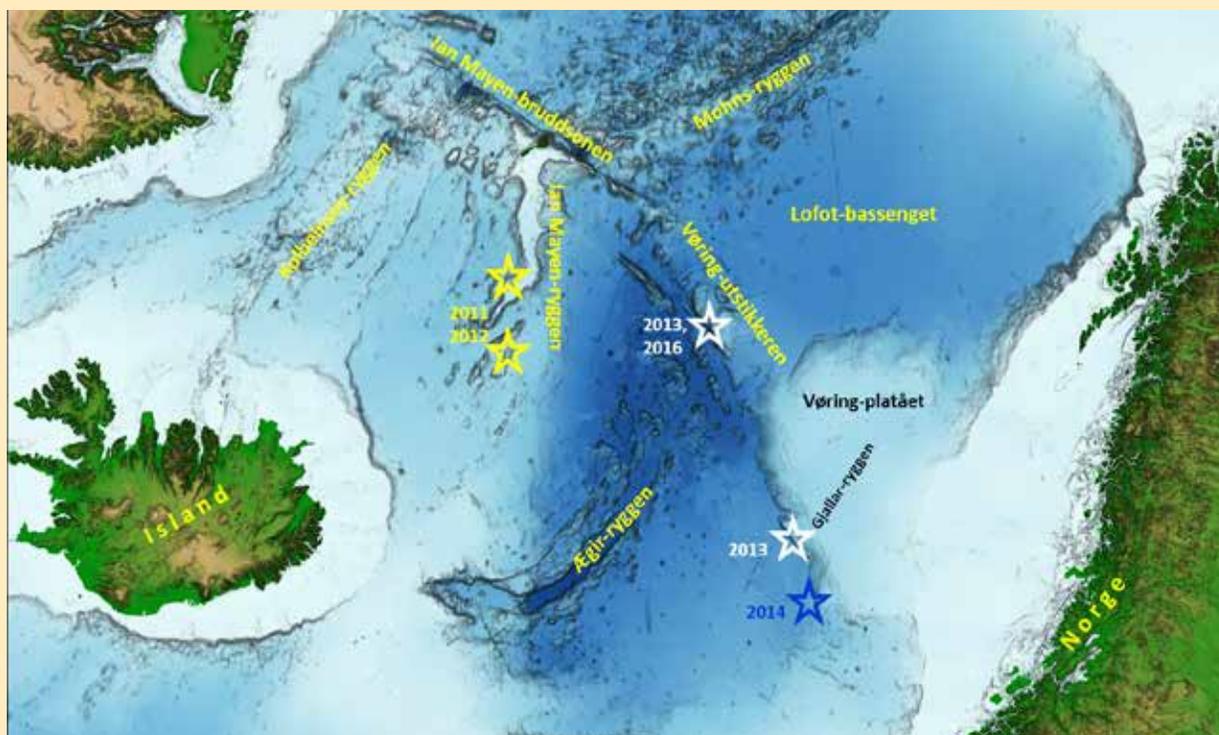
Force stands for the forum for reservoir characterisation, reservoir engineering and exploration cooperation. See www.force.org.



Searching more in deep

Acquisition of geological samples and deepsea minerals from the Norwegian Sea will continue this summer in order to boost understanding of resources and geological developments in the North Atlantic.

| Nils Rune Sandstå



Locations of underwater bedrock sampling by the NPD. Yellow stars indicate sites on the Jan Mayen Ridge where samples were taken by grab in 2011 and chainsaw the following year. Shallow wells drilled in 2014 are indicated by the blue star. White stars show where samples were taken on the Gjallar Ridge and the Vøring Spur in 2013. Materials will also be acquired there this year.

Funds have been allocated by the NPD for the collection of seabed samples from the Vøring Spur by the University of Bergen (UiB), a project which builds on a collaboration under way since 2010.

Bathymetric data on subsea terrain acquired for the NPD around Jan Mayen in 2010 provided the basis for collecting seabed material with a remotely operated vehicle (ROV) in 2011 and 2012.

Several successful ROV dives were subsequently carried out in 2013 on Gjallar Ridge South and

the Vøring Spur in the Norwegian Sea. This work included acquiring material in 3 600 metres of water in the second of these areas.

In 2014, the NPD acquired shallow cores from the outer parts of the Møre Basin. The map above shows the areas which have been explored as well as those due to be examined further.

All this sampling forms part of efforts to identify reservoir rocks on the Jan Mayen Ridge and the outer NCS in the Norwegian Sea.

Norway, Jan Mayen and Greenland were previously joined

as part of a single continent, which split apart about 60 million years ago when the North Atlantic began to open up.

As a result, reservoir rocks on the Jan Mayen Ridge and Norway's outer continental shelf are likely to be similar to those found on land in Greenland.

But the fracturing process itself was complicated, so that determining in detail how Greenland, the Jan Mayen Ridge and the NCS once fitted together is a bit of a jigsaw puzzle.

Samples are therefore being

per water

acquired to secure data points which can help solve this conundrum and support the search for the types of reservoir rocks seen in Greenland.

Moreover, the samples acquired have been very important for learning more about metallic seabed minerals on the NCS, and the NPD will follow up this aspect in its continuing investigations.

In addition to straightforward chunks of rock, samples of manganese crust were acquired on both the Jan Mayen Ridge and the Vøring Spur.

Representing a coating of metallic minerals precipitated from seawater onto exposed seabed rocks, such crusts consist mainly of manganese and iron.

But other and far more valuable metals are also present. These include cobalt, nickel, titanium, platinum, scandium (used in aluminium alloys, for example) and rare soil types.

With their metal content varying around the world, deposits of this kind are currently attracting considerable international interest.

The image below shows one of the NPD's sampling locations on the Vøring Spur, where a manga-

nese crust has grown on the sheer rock face.

The UiB is in the process of completing a detailed geochemical study of NPD crust samples from the Jan Mayen Ridge to identify which metals could be interesting resources in this area. Further studies of such manganese crusts are due to be carried out by the NPD and the UiB.

Bathymetric data have also been made available by the NPD for studies of the Mohs Ridge, a mid-oceanic spreading ridge which extends from Jan Mayen to Bear Island.

Such underwater features are volcanic and produce metallic sulphide minerals through hydrothermal vents known as "black smokers".

These deposits are again the focus of worldwide financial interest today. The most interesting metals in this context are copper, lead, zinc, gold and silver.

The UiB has conducted scientific investigations to identify the geological and biological processes at work in the volcanic systems on the Mohs Ridge.

These studies also form the basis for current knowledge of

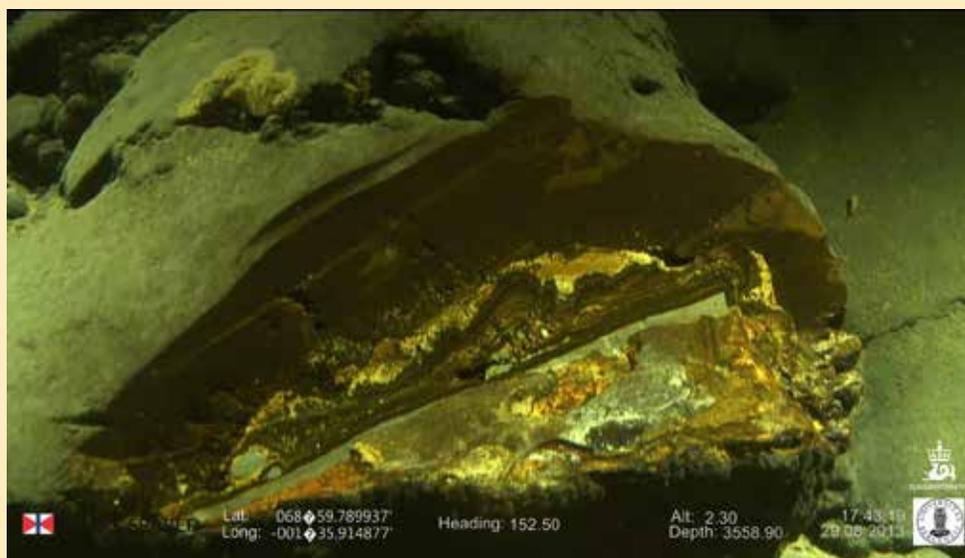
the metal resources located there. Research and acquisition missions by the UiB and the NPD have largely been mobilised on a joint basis throughout the Norwegian Sea.

Moreover, the Norwegian University of Science and Technology (NTNU) is due to conduct its first mission to examine sulphide minerals on the Mohs Ridge this year.

Based on the NPD's bathymetric data and the long-running UiB surveys, funding for this work comes largely from the Research Council of Norway.

The NPD will continue to investigate the Vøring Spur during the UiB mission this summer. Previous experience suggests that basalt, thick manganese crusts and straightforward sediments will be found.

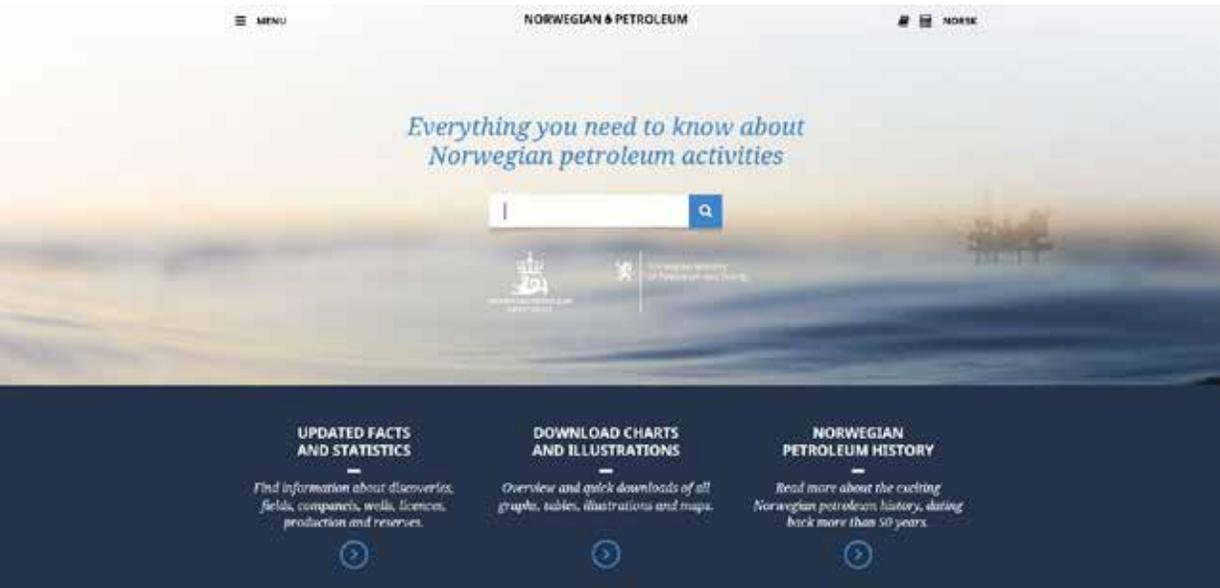
Metallic components contained in manganese crusts could become an important deepsea resource. This year's sampling will give the NPD a better foundation for continued mapping of the scope, quality and size of such deposits.



The site showing manganese crust on the Vøring Spur where samples were acquired in 2013.

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New look for Facts website

A revamped design has been launched for www.norskpetroleum.no.

The content has been reorganised on the new website to tie descriptions and facts more closely together. Articles and facts are illustrated with photos, graphics and maps.

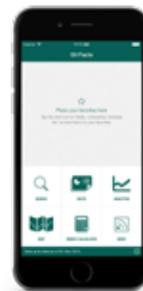
All information is accessible from any digital platform, and the content can be downloaded, printed out and shared by mail or on social media.

Links to more detailed information are provided for each topic. As with Oil Facts, part of the factual information will be synchronised on a daily basis with the NPD's fact bases.

The new site is intended for a broad audience, and accordingly represents a supplement to the NPD's own fact pages and maps. These are aimed to a greater extent at professional users.

Provided in both Norwegian and English versions, www.norskpetroleum.no contains information on such aspects as:

- the significance of the petroleum sector for the Norwegian economy
- a description of current activities on the NCS
- organisation of the petroleum sector
- regulatory parameters throughout the industry life cycle, from opening new exploration acreage to field cessation
- facts about fields, discoveries, companies, exploration activities, production and the resource base on the NCS
- emissions/discharges, measures to reduce them and oil spill response
- the supplies industry and the commitment to research and technology
- explanations of terminology and an energy calculator.



Oil Facts

The iPhone app from the NPD and the Ministry of Petroleum and Energy is available in an updated version. This can be accessed in the App Store by searching for *Oil Facts*. The app is also available for Android and Windows phones.