Svalbard's unique geology

NCS – what now?
Prized Åsgard project
Technology optimist

NORWEGIAN CONTINENTAL SHELF

A JOURNAL FROM THE NORWEGIAN PETROLEUM DIRECTORATE NO 2 - 2016

Photo: Monica Larsen

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Looking ahead The NPD's strategic directors give their views on the challenges facing NCS players in difficult times.

Photo: Thor Nielsen

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Interview Sintef head Alexandra Bech Gjørv is a technology optimist, and wants to see more collaboration between enterprises in different fields.

Photo: Monica Larsen

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Creative surge A number of those left jobless by the oil downturn are seeking new opportunities under a shared roof in Stavanger.

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COVER PHOTO
Starting young. Emil (left) and Paula have collected fossils in the valley above Longyearbyen and set up a stall to earn some money from the tourists. (Photo: Arne Bjørøen)


Photo: Aker Solutions

Quantum leap

The road to the NPD's IOR prize has been long and exciting for the developers of Åsgard subsea compression.

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Photo: Kjetil Kaada

Field work

A group from the NPD visited Svalbard to learn more about carbonates – similar to the rocks containing new discoveries in the Barents Sea.

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Photo: Alexey Deryabin

Rock shot

The photograph in this issue's regular column was taken by a drone over Svalbard.

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Photo: Arne Bjørøen

Svalbard is the Barents Sea exposed to the light of day. The many mountains in these islands are literally showcases for the sub-surface of Norway's northern seas.

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Photo: Arne Bjørøen

NPD profile

Palaeontologist Jan Stenløkk feels a strong attraction to the unique geology in Svalbard.

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Law in place

The Oil for Development programme is yielding results. Ghana has now adopted a new petroleum Act – with Norwegian help.

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Keeping cool

We have had more weather than we need in the oil and gas sector over the past couple of years. And the signs are that we must put up with stormy conditions for a while longer.

The good news is that the resource potential of the NCS remains – even in difficult times. We still have lots of petroleum in the bank. And the companies see that, too, because they are still seeking new opportunities through the licensing rounds.

In cooperation with these companies, we will ensure they take good decisions when discoveries come to be developed – decisions which also allow for improved recovery measures at a later date.

So it is more important than ever that developers opt for flexible solutions which open the way for other resources in the same area to be tied back.

In addition, the surrounding areas must be thoroughly explored, so that reserves there – which are often marginal – can exploit capacity in existing facilities and infrastructure.

Exploration in less mature areas, such as Barents Sea South, is regarded with great anticipation. Our estimates show that the biggest undiscovered resources on the NCS lie in the far north.

A high level of exploration activity will be needed to maintain production. The number of exploration wells in 2016 has been higher than expected, but we fear a downturn in 2017.

The petroleum industry is still crucial for maintaining the prosperity which benefits everyone in Norway. This sector accounts for roughly three-quarters of overall government revenues from industry. It is not easy to see what can replace it.

Many people, myself included, believe we will ride out the storm which has hit our nation so hard – and unfortunately so many workers in the oil sector. That requires us to keep a cool head.

Bente Nyland
director general

Taking new tac

Astri Sivertsen and Thor Nielsen (photos)

Technology can solve problems we still do not know we have, believes Alexandra Bech Gjørv, head of Norway's Sintef research foundation. But that depends on daring to think bigger and to look further ahead.

Restructuring has so far concentrated on similar companies merging to achieve economies of scale. What's happening now is that dissimilar enterprises are joining forces.

Gjørv occupies an unpretentious corner office just outside the centre of Trondheim, Norway's long-standing centre for technical education.

Her room lies no more than a good stone's throw from the corner flag at the Lerkendal stadium – the home ground for Rosenborg, the most successful Norwegian football team.

Unlike many top executives, however, Gjørv does not toss soccer metaphors around when explaining what her job involves and what management means. She prefers nautical images.

She calls her navy-blue costume her "sailor suit", and describes management in terms of tacking – not sticking pins in her subordinates, but advancing against a contrary wind towards distant goals by constantly changing course.

Another characteristic which distinguishes Gjørv from the bulk of Norwegian business leaders is her education. Rather than the ubiquitous economists – and occasional engineer – she is a lawyer.

"Most people with a law degree don't head technological companies," she admits. "But I'm a socially aware person who's devoted her whole life to questions related to managing natural resources and the interaction between technology and organisation. So I feel I've worked on many on the issues we deal with here."

The Foundation for Industrial and Technical Research, to give Sintef its original full name, was established in 1950 by the Norwegian Institute of Technology (NTH).

Corresponding to a European technical university, the latter was then Norway's only institution entitled to award engineering MScs.

It is now the Norwegian University of Science and Technology (NTNU) and still cooperates closely with the research institute, an independent foundation with some 2 000 employees.

Gjørv held management jobs in Norsk Hydro and Statoil for 17 years, and has more than two decades of boardroom experience from companies involved with energy, technology and the media.

She was a partner in the Hjort law firm and chief executive for wind power specialist Sarepta Energi when the Sintef job came up just over a year ago.

Perhaps her best-known role was as chair of the commission of inquiry into the terrorist attack on the government quarter in Oslo and Utøya island north of the capital on 22 July 2011.

The report this body produced ranks as possibly the most widely read official document in Norwegian history, and was praised for its clear conclusions and unambiguous recommendations.

Many of the commission's criticisms were directed at the inability of public agencies charged with security and emergency preparedness to do their job properly.

"Both the head of the commission's secretariat [Bjørn Otto Sverdrup] and I came from the oil and gas industry, where I feel people are under a fairly strong obligation to do what they've said they will," Gjørv observes.

Part of the solution? *The carbon laboratory in Trondheim became operational in 2010, and has since been expanded several times.*

She admits that a government ministry has far more complex goals than an oil company, and needs to deliver across a far wider range of parameters.

So the management job in a public agency is undoubtedly more complicated. Nevertheless, she feels that leadership expertise acquired in the petroleum industry has a transfer value.

Since her commission assignment, Gjørv has been asked to give talks in the health sector and has been much in demand for teaching purposes in the Oslo school system.

Schools must naturally prepare against such threats as gun use. But they also wanted to learn more about how to handle the biggest risk – the many pupils who drop out.

So she has given head teachers and leadership teams, on request, an introduction to understanding risk and drilled them in how to take counteraction.

"I feel that was an excellent follow-up to the commission's work, and a very interesting and rewarding assignment I hadn't expected at all when we submitted our report," she says.

Interaction

A large part of Gjørv's job at Sintef involves getting industry and the public sector to interact. She is an eager proponent of multidisciplinary approaches to solving major social problems.

One example is the expertise built up by the petroleum sector through the development of various methods for draining oil and gas reservoirs.

Sintef, in collaboration with other Norwegian research institutes, is now using simulator modelling and ultrasonic technology from the oil industry to replicate blood flow.

The aim is to make operations on heart valves much safer. Gjørv notes that 15 per cent of all such interventions need to be repeated.

"That obviously involves great suffering for the patient and a heavy cost for society," she says. "We think a more industrial approach to planning operations can yield a dramatic improvement."

In her view, it is unfortunate that few of the funds devoted to health research in Norway are offered by competitive tendering – which would allow multidisciplinary ideas to prevail.

Almost all the money is allocated by the health authorities to their own clinical researchers, but Gjørv wants to see more multidisciplinary parameters for health research and innovation.

Shifts

Addressing the ONS oil show in Stavanger this August, the Sintef head called attention to the technological shifts which will change all sectors of society – including the petroleum industry.

Nanotechnology, microsensors able to be placed anywhere, big data, three-dimensional printing, automation and robotisation will collectively drive the adoption of new business models.

"Restructuring has so far concentrated on similar companies merging to achieve economies of scale," Gjørv observes. "What's happening now is that dissimilar enterprises are joining forces."

She points to the collaboration deal on seabed technology between oil company Det Norske and suppliers Aker Solutions and Subsea 7.

The value chain in a number of sectors has been turned upside down by digitalisation. Work flows and divisions of labour between various players have changed, and business models are increasingly about delivering a service rather than a product.

Gjørv envisages recent developments in the hotel and transport sectors, with such companies as Airbnb and Uber, being transferred to the oil industry.

This is likely to mean that suppliers acquire a bigger role in producing NCS fields, while the oil companies concentrate on finding and owning resources.

"We don't know what's going to happen, of course," she admits. "But these are trends which I feel are in the process of crystallising out."

She thinks that interest in technology is much greater than it was

Since the government has reaped so much capital from the oil sector, it should also sow more.

even 10 years ago, but does not attribute this to the recent focus on cost cuts.

Instead, this trend reflects such aspects as the spread of smartphones and the changes this has led to. When daily life alters, people naturally think the same will happen at work.

More from less

Another trend which, in Gjørv's view, applies very much to the oil industry is the emphasis on getting more out of the resources at a lower price than today.

"Without big new investment, we've got to tie small oil finds back to existing infrastructure," she says. "And we must seek to eliminate cost elements which weren't seen as important before."

She highlights the need to utilise big data, which in her definition involves marrying historical and real-time information with a decision support system.

In her view, the oil industry is not a leader here. She points to the use being made of more accurate measurement, simulations, historical knowledge and data series in the electricity sector.

That allows the players to get more out of their existing infrastructure, which means in turn that they do not have to invest in expensive new transformers, for example.

The process industry provides another example, with Hydro starting to use long-term forecasts of external temperatures in managing electrolytic furnaces at its aluminium plants.

"Saving a milliwatt here and another there adds up to hundreds of millions of kroner over time," Gjørv says. "Energy efficiency at the micro level means a great deal in large systems."

Alexandra Bech Gjørv. *"I'm not a technologist. My role is to make matters explicable to ordinary people. Write that."*

Technology transfer. *Scientists are using simulator models from the oil industry to make heart operations safer.*

In her view, the oil sector has the advantage of being a fully instrumented industry. It has data from all the wells drilled and every Xmas tree subsea or topside.

Going back to historical information, analysing it and seeking patterns for predicting possible events in order to avoid production shutdowns is an example of utilising big data.

"This means you have the capacity not only to store but also to analyse and process huge quantities of information," she notes. "You can then solve problems you didn't know you had."

A third field where new research could have major consequences is molecular and nano-level technology, which could lay the basis for new production methods.

One approach being envisaged, for example, involves adding nanoparticles to fluids being injected into a reservoir to improve recovery.

A lot of energy currently goes on pumping water into formations to maintain pressure as the oil flows out, which is one reason why carbon emissions from the NCS are rising.

"In a more climate-conscious society, where reducing national emissions is important, I'd devote substantial resources to devising a more chemical-based approach to drainage," says Gjørv.

She believes that a better understanding of the properties of oil, rooted in detailed chemical analyses, could be part of the solution to the problem.

Should this approach succeed, energy consumption could be reduced – cutting both production costs and carbon emissions

Capture

Sintef is making a big commitment to research on carbon capture, transport and storage, and a treatment plant was completed at Tiller in Trondheim during 2010.

This facility has since been expanded with a number of test laboratories. And the foundation made its biggest ever investment with a new NOK 170 million electricity lab in 2015.

Norway needs new jobs, Gjørv emphasises – not only to replace those lost in the oil industry, but also to offset big workplace changes stemming from digitalisation and robotisation.

"We particularly want to develop new technology companies," she says. "So it's a pity that Norway has such a thin capital management environment in this field."

Sintef has seed capital funds which have helped to establish a number of innovative companies, and is the first institution in Norway to receive grants from the European Investment Fund (EIF).

But most start-ups end in foreign hands – including two of the companies which originated in Sintef's work with oil and gas technology.

These are Resman, which has developed new methods for monitoring oil reservoirs, and GasSecure's wireless detectors for monitoring and notifying gas leaks on offshore installations.

Gjørv regrets that property is more popular today than jobs with investors, and maintains that the authorities should play a bigger role in creating viable high-tech companies.

"Since the government has reaped so much capital from the oil sector, it should also sow more," she argues – preferably in the form of co-investment projects with private players,

"I'd like to see Norway getting not only cool start-ups, but also cool large-scale enterprises with their head offices in this country."

Ocean space

Norway's sea areas are six times larger than its land mass, and a number of Sintef teams are currently working with the ocean space – marine technology, oil and gas, fishing, aquaculture and such environmental technologies as oil spill response.

After almost a year at the helm, skipper Gjørv is ready for a new tack. Her first structural change will unify all these teams into a single ocean space institute from 1 January.

"My concern has been that we must be able to think on a rather larger scale," she explains. "We have to be primed not only to tackle the assignments our customers have already conceived, but also to contribute to the big ideas."

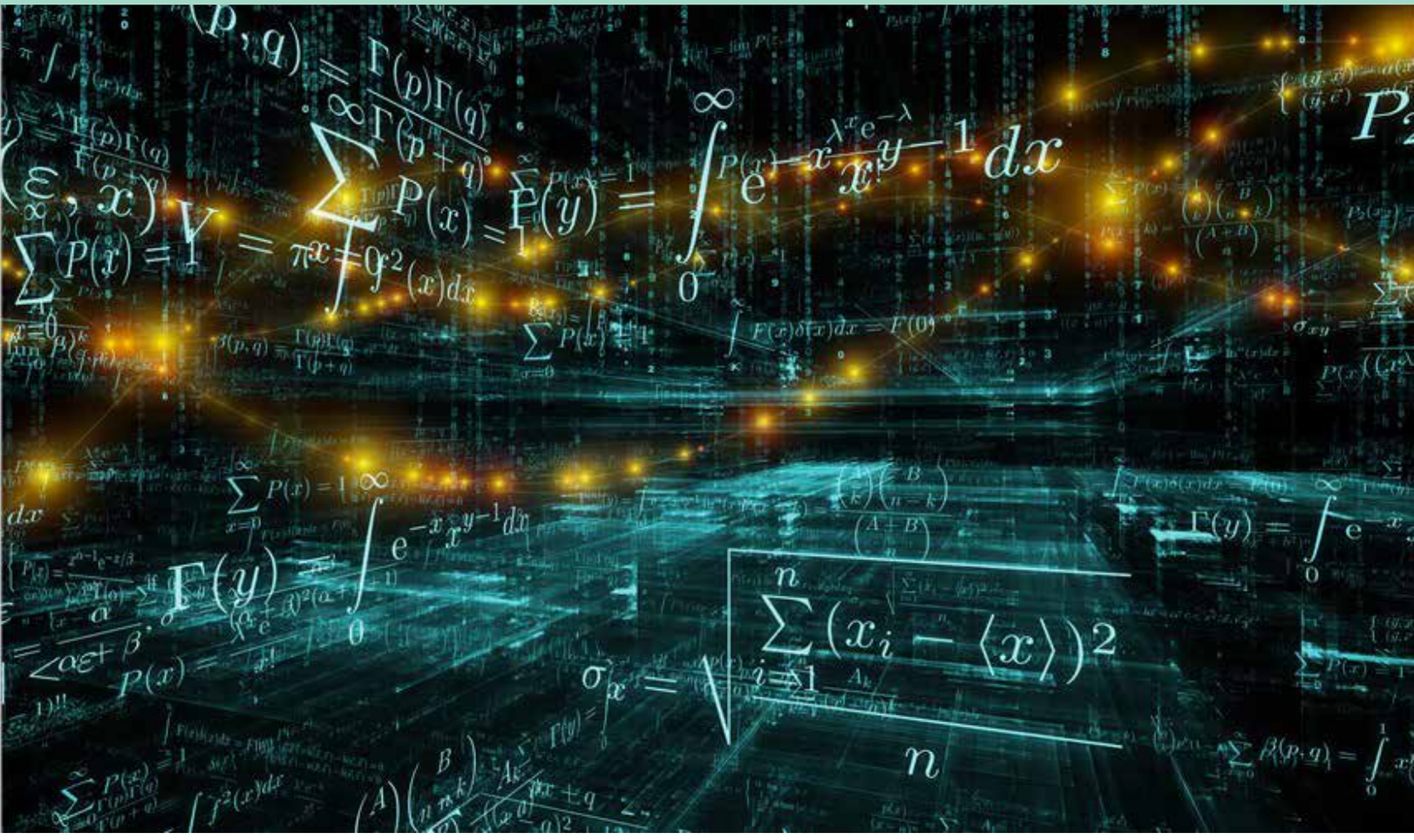
Gjørv says that the Sintef departments working with the oil industry get good feedback on their deliveries. But she feels they can assist the industry even more by raising their dialogue with customers to a more strategic level.

Meeting the goal of zero emissions by 2100, for example, calls for a different view of technology development than is provided by thinking only 15-20 years ahead – the normal time span for company scenarios.

In Gjørv's view, making sure that what must happen anyway eight decades from now occurs much earlier could position the sector for a new and groundbreaking business model.

"I'm a great believer in ploughing a deeper and more fact-based furrow," she says. "I think that working on technology for a better society is the best way of managing our natural resources."

Think bigger. *Alexandra Bech Gjørv urges the industry to have bolder visions.*



Creator. *Arnfinn Matre playing UFO Hunter. He is one of the inventors thriving in the creative environment at Forus.*

Incubator for ideas

Jorunn Braathen Eia and Monica Larsen (photos)

Budding entrepreneurs in Stavanger can now share expertise and equipment. Many are engineers and IT personnel from the oil industry with a dream of creating their own thing.

We're part of the fourth industrial revolution," declares Jan Tore Usken, business developer and founder of the Creator Makerspace company.

Many "hobby creators" are to be found in workplaces, in cellars and in garages, he points out. "But good ideas make no progress because people don't know how to put them into effect.

"They lack the necessary equipment and finance. At our premises, they can meet to try out their ideas on others and to build prototypes."

Characterised by the rapid growth of digitalisation and the web, the fourth industrial revolution promises changes to existing business models, social norms and the political landscape.

"We must think along completely new lines," says Usken. "Things are moving fast, many exciting things are happening, and we want to be part of this. The future is fantastic."

The petroleum sector is a technological locomotive in Norway, and one of the country's most knowledge-heavy, technically advanced and engineer-dependent industries.

Technology from this business has already been transferred to a variety of other sectors – and this is the route that Creator Makerspace aims to exploit.

The idea for the company came from Rogaland Makers, founded in 2010. Run on a non-profit basis, it creates a meeting place and workspace for creatives and entrepreneurs.

This allows its users to test new technological ideas, demonstrate what these can do, and produce prototypes. The goal is to create 100 jobs in two years and 1 000 in five.

"We want to bring together people with ideas and their potential industrial partners, and help them to take the next step to establishing a new company," Usken explains.

"With substantial unemployment and many highly competent people looking for work in our region, we need to take new approaches. Talking together leads to innovation."

Over the past year, he has seen a big influx of engineers and developers from the oil industry who are in full swing with realising their creative dream.

Expertise and tools are shared to produce everything from drones to robots. Workshop facilities include three-dimensional printers, laser cutters and photoplotters.

In addition come milling machines, angle cutters and a lot of equipment for working with metal and wood as well as electrical systems.

According to Usken, producing a prototype at Creator Makerspace is 80 per cent cheaper than doing it at home. "That's because we share everything."

Joining forces. *Creative people work together in Bolder's open-plan office to find more intelligent solutions tailored to each person's interests and needs.*

Helper. *Jan Tore Usken, business developer and entrepreneur in Creator Makerspace, wants to bring creative people and industry together and help them to take the next step in establishing new companies.*

New revolution

The fourth industrial revolution will occur at a speed and at a scope without historical parallel, according to Klaus Schwab, the German professor who founded the World Economic Forum.

In a new book, he talks about the dizzying perspectives which open up when billions of people are linked via mobile units with endless capacity for calculation, storage and accessing knowledge.

New technological breakthroughs will occur in such areas as artificial intelligence, the internet of things, driverless cars, and 3D printing.

Robot, nano and biotechnology, materials science, energy storage and quantum computers are other key ingredients in the revolution.

Sophisticated robots, more artificial intelligence and the use of advanced materials will make their entry in industry, and not least manufacturing.

Automation and digitalisation will allow goods to be produced virtually untouched by human hand, and be distributed to customers and users in innovative ways.

The challenges presented by these developments affect not only the developed west but also developing countries and emerging economies.

The revolution will impact on virtually all sectors, with millions of jobs set to disappear, while many new ones are going to emerge.

Industrial workers will see robots taking over, while academics such as lawyers, doctors and economists could find part of their expertise being handled by new technology.

An intelligent robot can already be taught almost anything. The technology has also become cheaper. Energy costs per kilowatt-hour will decide where enterprises are located in the future.

Happened before

The first industrial revolution is said to have started in 1784, when the steam engine was introduced. Almost a century later, in 1870, the conveyor belt inaugurated the second revolution based on mass production. The third, involving increased use of computers, electronics and automation, began around 1969.

NEW INITIATIVE IN OIL TOWN

Active. *Bolder is working to create Norway's largest indoor centre for an active and conscious lifestyle, and collaborates with the City of Stavanger on digitalising a hiking network. Founder and general manager Eirik Skjærseth is second from left.*

The petroleum industry downturn has cost many people in Stavanger their jobs. But it has also inspired several new companies, making the town a test arena for intelligent technological concepts.

"You can save 10-20 per cent of your ventilation costs if you make the system cleverer," says Sjur Usken, CEO of Smart Plants. "That could work out at NOK 150 000 per annum for a small building of 4 000 square metres."

His company won the Angel Challenge in Stavanger this October with the launch of ClevAir, which makes buildings intelligent through self-regulation of temperature and lighting.

Established in Oslo in 2015, the Angel Challenge brings together start-ups to compete for an investment pot of NOK 1.3 million.

"We're working with Kverneland Group, which has optimised its factory floor," reports Usken. "The system notifies if anything goes wrong with the machinery, so repairs are immediate."

He adds that large-scale greenhouses in the Jæren region south of Stavanger are also among Smart Plants' customers.

Power bike

Per Hassel Sørensen is working in the Elpedal company to develop the Podbike, an electric bicycle with four wheels and an enclosed compartment.

This gives users the environmental and health benefits of cycling with the same personal comfort as a car. In the longer term, Podbike will be able to park and recharge itself.

Inspired

"We had a dream of building an environment where companies with creative personnel worked together – a place where you inspire and get inspired," says Eirik Skjærseth.

With an MSc in marine technology and a background in shipbuilding, he runs Bolder as a lifestyle company backed by technology and as a showcase for personally tailored content.

The idea is to create an arena for an active and conscious lifestyle

concentrated on the individual.

"Our goal is to equip people to use intelligent solutions which are personally tailored in terms of content and education," adds Gian Kolbjørnsen, Bolder's chief technology officer.

"Together with such partners as the Stavanger city council and the University of Stavanger, we want to make the town a testbed for intelligent technological concepts aimed at people."

The company plans to create a regional laboratory, which will include Norway's largest indoor centre for an active and conscious lifestyle.

Enterprises will work together in this space, sharing knowledge, welcoming visiting groups, schools and families, and establishing new growth industries in Norway.

Bolder is also working with the City of Stavanger on an "intelligent citizen" concept, digitalising a network of hiking trails as part of creating, optimising and testing services in the town with its residents as active participants.

Another project being pursued by the company is a new solution for the Nordic Edge conference in 2017, which will be tailored to each participant.

When registering, everyone is asked about their personal interests and purpose with attending. They then get guidance on where to go and who to talk with. Invitations to other relevant conferences will be provided after the event.

Bolder believes these projects have the potential to create 4-5 000 jobs in the region through partners and suppliers, and expects to have 40-60 employees itself during 2017.

Rights

The Håmsø Patentbyrå patent agency in Sandnes south of Stavanger emphasises the necessity of securing rights to newly developed technology.

"We've got a good overview of inventors in this region," explains Krister Mangersnes, who heads the company's patent department.

"Applications for patents, designs and trademarks have increased over the past year, including ones from the petroleum and fish-farming industries."

This is a good time for innovation, he says, and the agency has recruited several new staff. "We had more than 200 applicants for one job, and at least 150 of them were highly competent."

A patent adviser at Håmsø will have a heavyweight technical background, often as a researcher, in addition to legal expertise.

More intelligent solutions come to the fore when companies cut their costs. Many established enterprises have freed up time in recent years and plucked good ideas from their desk drawers.

Awareness is growing about intangible rights and intellectual property assets in general, Mangersnes says, and adds that Norway has been backward where patent protection is concerned.

"Patenting an invention can be very beneficial. It prevents others from stealing your ideas. And a trademark or registered design offers substantial competitive advantages."

Håmsø helps inventors and researchers from all over Norway to establish their own companies and patent their solutions – but regrets that it cannot guarantee commercial success.

Clients operate in such fields as nanotechnology, renewable energy, petroleum, aquaculture, agriculture and the construction sector.

It usually takes two to 10 years from submitting applications for and – if successful – securing patent rights in various countries.

Agent. *Patenting an invention can be useful. Krister Mangersnes at Håmsø Patentbyrå helps inventors and researchers to establish their own companies and secure patents.*

Winner. *Smart Plants launched ClevAir in October and won the Angel Challenge in Stavanger. "We produce systems which make buildings more intelligent," says general manager Sjur Usken.*

Getting to th

Groundbreaking technology is boosting recovery from the Åsgard area of the Norwegian Sea by 306 million barrels of oil equivalent (boe). It also opens new opportunities for other fields.

Arnt Even Bøe

Injecting water and/or gas can improve recovery from an oil reservoir along with drilling a lot of production wells, but has little to offer when draining gas fields.

The challenge with these is usually found in the seabed pipelines. When reservoir pressure sinks, multiphase flow problems rise as gas and liquids are piped to a processing facility.

That could also have been the case with the wellstreams from the Midgard and Mikkel deposits, which lie 40 and 60 kilometres respectively from the Åsgard gas process platform.

The longer the pipeline, the greater the friction to be overcome. More and more of the liquid fractions separated out and accumulated in the lowest sections as natural pressure declined.

As space in the flowlines contracted, the gas increased its speed and drove slugs of liquid ahead of it. These arrived at the Åsgard B process floater as a series of sharp jolts.

The platform had not been designed to handle such loads. Unless the problem was overcome, gas production would have had to be reduced and eventually discontinued.

This was why operator Statoil decided, with the other licensees, to initiate what would prove its most demanding-ever technology project for improved recovery. The outcome is the world's first subsea wet gas compression facility.

Not new

The challenges of piping wellstreams over long distances are not new. An old and widely used solution has been to boost such multiphase flow with the aid of compressors.

That is done by building a separate platform to support traditional compressors or to install

such machinery on an existing topside.

Statoil decided that compression was also the answer for boosting recovery from Midgard and Mikkel, and began planning this around 2004.

"The natural starting point would have been another traditional compressor platform," acknowledges project director Torstein Vinterstø at the operator company.

"But the more we thought about subsea compression, the more fascinated we became. A compressor is also more effective the closer it is to the reservoir.

"That means the seabed is basically a perfect site for it. Once the challenge of keeping out the seawater has been solved, the machine can work in a stable and protected environment."

Innovative

"When we began thinking along these lines, we adopted a completely innovative approach," says Vinterstø, who has worked on Åsgard subsea compression since planning began in the early 1990s.

"To ensure maximum uptime for the seabed equipment, it had to be as simple as possible. We wanted to avoid traditional solutions with motor cooling and separate lubrication for the bearings.

"The first of these was eliminated by using the gas to cool the electric motors, while we wanted to replace ordinary ball bearings with magnets which allowed the shaft to turn freely. Nothing like that had been done before in this setting."

After four years on the drawing board, a full-scale model of the new compressor system began undergoing tests in the K-Lab at the Kårstø process plant north of Stavanger during 2008.

The gas mix, the water temperature and the other parameters were as close as possible to real conditions on the bed of the Norwegian Sea.

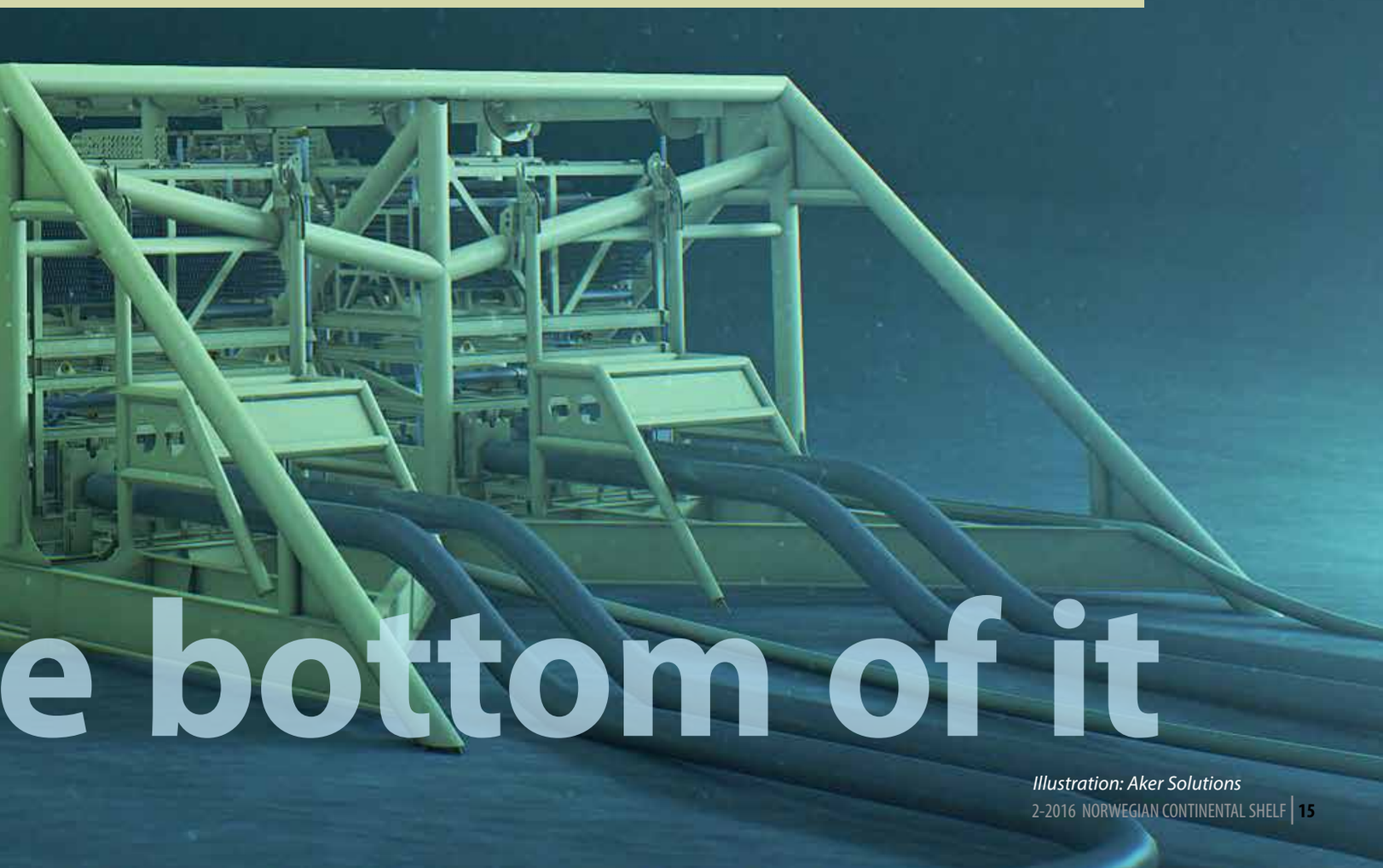
A key question was whether gas from the reservoir had the right temperature to cool the motors adequately. Another was to see if the lubrication-free magnet technology – which gave the crankshaft a clearance of one millimetre – would work.

The licensees for the Ormen Lange field, also in the Norwegian Sea, launched their own pilot project for subsea compression with Aker around 2006.

Development of these two systems then progressed more or less in parallel. After Statoil and Hydro merged in 2007, closer collaboration was established between the projects.

Encouraging

Test results for the Åsgard system were very encouraging. After 3 500 hours, the world's first subsea gas compression facility was ready to be compared with a conventional platform concept.



e bottom of it

Illustration: Aker Solutions

Big savings. *"The price of a similar installation as new can be driven sharply down," says project director Torstein Vinterstø in Statoil.*

The conclusion was that it would be the most profitable and climate-friendly solution, and an amended plan for operation and development (PDO) of Åsgard subsea compression was prepared.

This was submitted to the Ministry of Petroleum and Energy in August 2011. By then, more than 40 new technological inventions had been implemented during the course of the project.

When the Storting (parliament) finally gave a green light for the pilot project in March 2012, time was at a premium if a shutdown of Midgard and Mikkel was to be avoided.

Such a halt would have been very unfavourable, not only because of delayed revenues and possible restart problems but also with regard to the quality of Åsgard B's deliveries.

This platform pipes a blend of various gas types from all the reservoirs in the area for optimisation at Kårstø plant before being transported on to Europe.

A key consideration in this context is that the relatively high carbon content in gas from the other fields can be offset by mixing with the low-carbon output from Midgard and Mikkel.

Without their production, a separator like the ones on Sleipner and Snøhvit might be needed to strip CO_2 from Åsgard gas. So getting the compression unit on stream was a matter of urgency.

An engineering, procurement and construction (EPC) contract was awarded to Aker Solutions, while MAN supplied compressors with the new cooling technology and magnetic bearings.

Nexans delivered a total of 160 kilometres of power cables and Technip was responsible for most of the marine installation work, including all the modules for the compressor station.

This facility was completed in time to prevent any halt to production from Åsgard, and the world's first subsea wet gas compression unit could come on line on 16 October 2015.

Tenterhooks

"We were obviously on tenterhooks," admits Vinterstø. "We as operator, the other licensees and the suppliers naturally wondered whether this would work after all the time, all the millions, all the energy and not least all the prestige we'd put into it."

Today, after a year of operation, the facility is running like clockwork and has had almost 100 per cent uptime. Energy consumption – and thereby carbon emissions – has been halved compared with the platform concept.

This innovative technology has improved recovery from 67 to 87 per cent for Midgard and 59 to 84 per cent for Mikkel. That adds up to 306 million boe – or a medium-sized Norwegian oil field.

When director general Bente Nyland presented the Åsgard licence with the NPD's IOR prize at this year's ONS oil show, she praised its willingness to accept risk and think innovatively at every level.

Vinterstø highlights collaboration between the licensees. The technical committee held monthly meetings, achieving a very good dialogue, while the project team received full backing.

He also commends the suppliers for the purposeful way they worked, for their willingness to take new approaches and for their ability to execute the work.

Late

"The sense of urgency and the technological challenges meant we were four-five months late and roughly NOK 2 billion above the PDO cost estimate of NOK 16.9 billion," reports Vinterstø.

"That was because we costed the project in the depths of the financial crisis around 2009, when prices were low, and started procurement when oil prices had shot up – and costs with them.

"The good news, though, is that the installation itself is profitable even today when the price of crude has slumped."

This is confirmed by Halvor Engebretsen, operations vice president for Åsgard, who notes that production rose by just over 16 million boe in the first year after the facility came on line.

At current prices, that represents an added value of well over NOK 5 billion for these 12 months.

Radical

Subsea wet gas compression is one of the most radical innovation projects in Statoil's history. The technology represents a quantum leap, bringing the company a step closer to a "seabed factory".

This concept involves establishing processing facilities which

make it possible to conduct hydrocarbon transport by remote control.

The compression template stands on Midgard, about 40 kilometres from Åsgard B, so the Mikkel wellstream must travel some 20 kilometres before getting a new boost.

This means that installing another template on the latter field could improve recovery even further.

Simplify

Vinterstø also explains that the experience gained by Statoil through the Åsgard project can be used to simplify and standardise future installations. This could substantially reduce investment for new fields.

He adds that the first user of new technology incurs costs which the next can avoid, such as spending on technology development, testing, installation tools and maintenance on land.

That creates new opportunities for major fields on the NCS, such as Troll, Ormen Lange and Snøhvit.

"Åsgard also taught us that it's very important to make provision for future compression in new field developments if a possible future IOR solution exists.

"A modest facilitation of this kind could significantly reduce the cost of implementing future subsea compression projects."

> "The Åsgard subsea compressor is the result of enthusiastic engineers, ambitious leadership, a long-term strategic approach and the stamina needed to follow through."

Proud prizewinners. *From left: Fredrik Sønstabø (ExxonMobil), Halvor Engebretsen (Statoil), Gunnar Einang (Total), director general Bente Nyland, Erling Bergerød (Petoro) and Vidar Kråkenes (Eni). Photo: ONS.*

This conclusion was drawn by director general Bente Nyland when she awarded the NPD's prize for improved oil recovery (IOR) in 2016. The ceremony took place at the ONS oil show in August.

She emphasised that the interaction demonstrated by the licensees in this project was perhaps especially important in today's demanding position for the industry.

"So is keeping world-class, dynamic engineering clusters. My message is: make sure you don't cut so much that it becomes impossible for Norway's oil and gas industry to continue making world-class technology advances."

Nyland said the NPD would challenge more players to achieve such a collaboration.

The Åsgard subsea compression technology not only represents an important contribution to improving recovery from that field, but also provides opportunities to recover more oil and gas from other reservoirs on the NCS.

Subsea processing – and wet gas compression in particular – could make it easier to develop discoveries in deep water and in areas far from existing infrastructure.

In a comment on the prize, Nyland pointed out that recovering all commercial resources is part of the each licensee's work commitment.

"That naturally involves risk, and we therefore acclaim technology development and pilot projects.

"When we see that these succeed, as has been the case with Åsgard, we must recognise the inventiveness and boldness displayed by the companies. They have taken an investment risk, and can now reap the reward."

She said that such a project would have been more difficult to launch with today's cost and oil price regime. "At the same time, this shows that the profitability of a field is determined when it ceases production, and not by current oil and gas prices."

The government has also contributed through its support for basic research and the backing provided in the early 2000s for testing subsea compression by the Demo 2000 programme.

This scheme is intended to help reduce costs and risk for the petroleum industry in achieving the commercialisation of new technology.

Answers on the hoof

Aker Solutions had to accept binding contracts for the Åsgard compressor project despite a string of unanswered questions. "We were clearly on tenterhooks," says project director Øystein Haukvik.

Øystein Haukvik, project director, Aker Solutions. (Photo: Aker Solutions)

The company was given responsibility in December 2010 for all engineering, procurement and construction (EPC) covering the subsea manifold and compressor station.

Everything in this groundbreaking job was bigger than usual, and new technology had to be developed on the hoof to implement it.

Keeping the number of operational shutdowns to a minimum was crucial for making the concept – a world first – competitive with platform-based compression.

"Operator Statoil set extremely tough requirements for this installation, with an uptime of almost 100 per cent," reports Haukvik.

"It also had to have a high flow capacity and be efficient and flexible. That called for extensive use of advanced pipe connections, high-voltage connectors and fibre optics."

In his view, developing new control system units which could give the earliest possible warning that something was wrong represented the most demanding single part of the project.

Magnetic bearings and gas cooling had never been tried on the seabed before, either. "Things could quickly pile up here if we made a misstep."

Haukvik adds that this project was unquestionably one of the most challenging assignments the people in his team had worked on.

"Subsea compression also undoubtedly represented one of the most demanding assignments our company has pursued in the field of technological development.

"It was a relief along the way to see how good and effective the collaboration became between us, Statoil, other contractors and suppliers large and small."

He is particularly complimentary about MAN, which had the job of qualifying a new type of compressor capable of working effectively on the seabed.

Although Statoil had done a lot of good preliminary work, an installation of this size had never been built before – and it was also required to stand in several hundred metres of water.

"But MAN did a great job, and must get its share of the acclaim for Åsgard's success," affirms Haukvik, who also highlights the collaboration with installer Technip.

This aimed to ensure that the individual modules could be positioned without damage and efficiently hooked up during the complex offshore installation process.

Immediately after the completion of the Åsgard project, Aker Solutions formed an alliance with MAN Diesel & Turbo to develop the next generation of subsea compressor systems.

The aim is to cut the size and weight of such facilities by 50 per cent, thereby sharply reducing their price and enhancing the competitiveness of this technology in stormy waters far from land.

Squeezed for

Subsea compression on Åsg against the clock and for the input factor. The results exce partner Total Norge.

Gunnar Einang, asset manager, partner-operated assets and development studies, Total Norge.

The position of the Midgard and Mikkel gas fields in 2005 was quite simply that production would cease in May 2011 unless something was done.

One problem was that a well on Midgard had been shut down after water intrusion. At the same time, problems would arise as natural reservoir pressure fell.

Simulations showed that water, condensate and antifreeze in the well-streams would then separate out and form powerful slugs which the process system on Åsgard B could not handle.

A permanent shutdown of these two fields in 2011 would leave recoverable reserves exceeding 300 million barrels of oil equivalent (boe) behind.

None of the licensees were interested in such an outcome. So these companies had less than six years to come up with a solution.

"Statoil was operator for both fields and very technology-oriented," says Gunnar Einang, asset manager for partner-operated assets and development studies at Total Norge.

"It wanted to challenge a new compressor platform for Åsgard by developing the world's first subsea gas compression facility. The other partners liked this aggressive approach and agreed."

"As we saw it, the challenge was to secure the time needed to develop and test the new technology," explains petroleum architect Johnny Kolnes at the French oil company.

"One move was testing with reduced production on Åsgard to see when

time

ard became a struggle e future, with quality as the eeded all expectations for

the problems would arise. After several trials, we could postpone the start of unstable production until around 2014."

Another step to buy time was to bring the small nearby Yttergryta field on stream. This supplemented flow in the pipeline system, and pushed the deadline further forward.

But development time was still short, and the investment was heavy. Total Norge devoted a lot of time and effort to entrenching the project properly at its Paris head office.

"Our bosses were well aware that this was groundbreaking work and involved great technological and economic risk," says Einang. "Our contribution wasn't small change.

"On the other hand, top management also saw the opportunities such a technological breakthrough could bring, both on the NCS and in our other international offshore projects.

"We can say now that Åsgard subsea compression is established as an important step towards the goal all oil companies dream of – moving offshore activity from the surface to the seabed."

Both he and Kolnes praise Statoil for being technology-driven in its search for new solutions, and give the company most of the honour for the innovation on Åsgard.

They also highlight a good and open collaboration in the licences, and suppliers who were positive and willing to make a commitment.

"With the new compression facility in place, wellstreams have increased sharply and made a big contribution to producing the volumes we risked losing," says Kolnes.

"Costs ended up a good deal higher than the original estimates, but it's not unusual for the bill to be fairly high in this type of pilot project," adds Einang.

"Given the experience and knowledge which have been gained in this phase, the price tag can undoubtedly be driven down in subsequent projects.

"Following up this success isn't so easy right now, with today's low oil prices. But it'll come. The best guarantee of this is that the facility has been operational for more than a year, virtually without a stop.

"That's payback for the decision taken by the project to make a commitment to quality at all levels from day one. Statoil again deserves praise here for its role as a driving force."

Lifting with success

French group Technip developed new technology through its involvement in Åsgard subsea compression. "That strengthens our position in the market," affirms project director Sven Guderud.

Sven Guderud, project director, Technip.

One job pursued on Åsgard by this company, which does field development and marine installation work worldwide, was to convert the existing seabed infrastructure.

That would allow the new compressor system to be connected without interrupting production – normally a standard operation. But complexity and volumes were much greater than usual.

"The assignment was very dynamic, with a great many people involved," says Guderud. "Thanks to good collaboration with Statoil, however, we managed to avoid shutting down Åsgard."

Lifting the equipment into place from the *North Sea Giant* subsea construction vessel and assembling the modules on the seabed presented the biggest challenge.

This operation was very delicate, with demanding tolerances, sensitive equipment and limited space in the module frame. Careful planning and close cooperation were essential.

The most demanding aspect of such work is eliminating vertical motion by the modules during their installation in the seabed template. Too much movement can damage expensive equipment.

"Given Statoil's demanding requirements for uptime, we've had to develop a new lifting concept which allows us to replace modules in greater wave heights than normal," explains Guderud.

That was accomplished in collaboration with Norway's Axtech company in Molde, which has a reputation as a world leader for this type of lifting and module-handling system.

The result was a new crane type able to work in significant wave heights up to 4.5 metres. In practice, modules on the subsea installation can thereby be replaced in virtually any weather.

This means in turn that the vessel can lift out and remove a defective module before replacing it without affecting the target of virtually 100-per-cent regularity.

"Personally, I found it both fun and exciting to be part of such successful teamwork," says Guderud. "However, this pioneering project has not been entirely without challenges.

"These demanded both more time and greater resources, but that's forgotten now. The equipment plays an important part in Statoil's vision of a subsea factory, which we hope will materialise in the future."

Technologically demanding

A number of oil companies have long been seeking to establish new remote-controlled subsea solutions in order to improve recovery from oil and gas fields.

In the mid-1990s, Shell and Statoil installed multiphase pumping and metering stations on Draugen in the Norwegian Sea and Lufeng on the Chinese continental shelf respectively.

And Norsk Hydro initiated a pilot project on Troll in the Norwegian North Sea in 2001 for seabed separation of gas and water, with the latter injected into the Utsira aquifer.

The world's first full-scale facility for separating water and sand from a wellstream was installed on Norway's Tordis field in the North Sea around 2007.

Two years later, a seabed pump for injecting seawater into the subsurface became operational on the Tyrihans field in the Norwegian Sea.

A subsea compression station started up on Gullfaks in the North Sea about the same time as the Åsgard facility, but has failed to function as intended and is currently off line.

Parallel with the Åsgard project, development began for subsea wet gas compression on the Ormen Lange gas field in the Norwegian Sea. However, this work has been suspended since 2014.

Big dimensions. *The subsea compressor station on Åsgard is the size of a football pitch. (Photo: Statoil/Øyvind Hagen)*

Åsgard

Statoil (operator) 34.57 per cent, Petoro 35.69, Eni Norge 14.28, Total 7.68 and ExxonMobil 7.24.

Åsgard lies on the Halten Bank in the Norwegian Sea, about 200 kilometres off Trøndelag and 50 kilometres south of Heidrun.

Surface facilities comprise the Åsgard A oil production ship, the Åsgard B gas production floater and the Åsgard C storage ship for condensate.

In addition to Mikkel, two fields in other licences – Yttergryta and Morvin – are tied back to Åsgard's infrastructure. Both are Statoil-operated.

The subsea compression facility on Åsgard is the size of a football pitch and handles gas produced from 2 500 metres beneath the seabed.

Measuring 74 x 45 x 26 metres, the template weighs 1 800 tonnes and comprises two parallel process trains. It was installed in 300 metres of water during the summer of 2013.

Each compressor train consists of 11 modules containing pumps, scrubber and cooler, weighs 1 500 tonnes and was installed in the spring of 2015.

The compressors are powered by submarine cables from Åsgard A and have an output of 11.5 MW. A third train is held in reserve on land.

The saga of Åsgard

The story of one of the biggest and most complex field developments on the NCS began when Saga Petroleum discovered Midgard in 1981. Statoil found Smørbukk in 1984 and Smørbukk South a year later in the same area. That initiated a lengthy process to get the three discoveries on stream.

By 1994, the two Norwegian oil companies had each spent hundreds of millions of kroner in seeking to realise these proven assets on the Halten Bank in the Norwegian Sea.

Saga's dilemma was that it could not progress with Midgard until a market for its gas was found. But buyers would not commit themselves without serious development plans, including a transport infrastructure.

That was easier said than done at a time when Statoil and Norsk Hydro had fields with much spare gas in the North Sea, where a pipeline network to continental Europe already existed.

Statoil's starting point was that Smørbukk and Smørbukk South, which contained oil, condensate and gas, could be developed as a single unit.

Its problem was simply that these reservoirs were among the most complex on the NCS, with unusually high pressure and temperature. The challenge was to find a development concept which was both safe and sufficiently profitable.

Party

The solution was found at the traditional garden party thrown by Statoil at its head office during the 1994 ONS oil show in Stavanger.

After working for a long time

Precision: *A module is moved with Åsgard A in the background. (Photo: Statoil/Øyvind Hagen)*

on the Smørbukk challenges, the state-owned oil company had detected signs that private-sector Saga could be interested in a collaboration.

Following introductory drinks at the party, Statoil vice president Kyrre Nese invited Lars Bjerke, Saga's head of exploration and development, up to his office.

Nese's starting point was that Midgard lacked sufficient gas for a stand-alone development, and had a hand-written outline proposal with him.

He and Bjerke draw up two new outlines, and suddenly saw a solution. Two months later, a collaboration deal on developing the three fields was ready and the Åsgard project was born.

The big challenge was naturally the division of roles. Statoil became the formal operator for Åsgard, with Saga in a new role as deputy operator.

To get the collaboration accepted, moreover Saga had to be compensated with the operatorship for the Varg field in the North Sea.

Special

Åsgard has represented very special challenges right from the start for its licensees and the supplies sector, with the unitisation process one of the most complex on the NCS.

The next step was to plan an offshore development which still ranked among the most complicated projects of its kind in the world.

After 16 months, it became clear that this would embrace the world's largest oil production ship (Åsgard A), its biggest floating gas process platform (Åsgard B), and the Åsgard C storage ship.

These facilities supported the world's largest and most complex subsea development, with 17 seabed templates and 59 wells over a radius of 50 kilometres.

Other elements included the Åsgard Transport gas pipeline to Kårstø north of Stavanger, an expansion of the latter and the Europipe II gas pipeline from there to Dornum in Germany.

Costed at NOK 47 billion, this development on the Halten Bank set new standards for subsea technology and was characterised by records and technological breakthroughs.

Another key element was the spirit created by Norsok, a collaboration between government, oil companies and suppliers to cut time taken and costs on the NCS by about 50 per cent.

This giant project was the first of its size in deep water off Norway, and marked in practice the end of the Norwegian Contractors concrete platform saga at Hinnavågen in Stavanger.

The Heidrun floater was Norway's 18th and last concrete and steel structure when it was towed to the field in 1995. Subsea solutions combined with ships or semi-submersibles then took over.

Overrun

In April 1999, it became clear that the Åsgard project would overrun the original cost estimate by NOK 17 billion. Acting petroleum minister Anne Enger Lahnstein was not amused.

When she carpeted Statoil chair Kjell O Kran to explain, he was unapologetic beyond admitting at a pinch that the enhanced bill was "unfortunate".

He and the rest of the board were dismissed and chief executive Harald Norvik saw no other option but to resign as well along with his deputy, Terje Vareberg.

Norvik had replaced Statoil's first CEO, Arve Johnsen, after the Mongstad scandal in 1988, but – unlike his predecessor – was careful to keep the directors informed about the rising costs.

Before his resignation, Norvik had unexpectedly called for the part-privatisation of the state oil company. This proposal came in January 1999 at a prestigious annual oil conference outside Oslo.

The Ministry of Petroleum and Energy was not pleased, and its relations with the Statoil management were still icy when the Åsgard overrun emerged.

Oil production from Åsgard A began shortly after the dramatic events in Statoil, on 19 May 1999. Processing of gas and condensate on Åsgard B started on 1 October 2000.

Gods and humans

In Norse mythology, Åsgard (or Asgard) was the home of the Æsir or gods. Bounded by thick walls, it lay in the centre of Midgard – Middle Earth – so that humans would not feel alone or abandoned.

Midgard was surrounded in turn by massive defences against the wild, unknown and fearsome giants and trolls outside. Beyond that again lay the world ocean, home of the Midgard serpent.

Clearly, these myths are readily transferrable to the Halten Bank in such terms as dimensions and the concern with safety. Heads undoubtedly rolled in Norse mythology too.

But the comparison between the Åsgard legends and today's world breaks down over creativity and the ability to think along new lines. That is a human attribute.

Course participants. *From left: Atle Mørk (NTNU), Hilde Krogh, Kristina Louise Hansen, Atle Dalva, Nina Pedersen, Kjetil Kaada, Lina Leknes, Katrine Ljones Karlsen, Lars Stemmerik (Unis), Andreas Bjørnestad, Eli Bjørkum, Bård Heggem (Polar bear watch) and Espen Simonstad (in front). (Photo: Luca Blazic)*

Seeking in-depth answers

The Alta and Gohta discoveries in Barents Sea South have increased interest in understanding their reservoir rocks. To learn more, 10 NPD staff attended a field course in Svalbard during September.

This expedition was headed by Lars Stemmerik, professor of geology at the University Centre in Svalbard (Unis), and Atle Mørk, adjunct professor at the Norwegian University of Science and Technology (NTNF) in Trondheim.

The aim was to boost the NPD's general expertise on carbonate geology, since both discoveries are located in such rocks from the Permian and Carboniferous 250-360 million years ago.

Operated by Lundin, Alta and Gohta lie in karstified and brecciated limestones of the Røye and Ørn formations as well as the Gipsdalen group. Good analogues for these reservoirs can be studied on land in Svalbard.

Stemmerik says that carbonates are very different from the other reservoir rocks on the NCS for exploring in and producing from.

Previous discoveries off Norway have usually comprised permeable sandstones with good flow properties or less permeable chalk.

"A special aspect of carbonates is that these rocks may be changed chemically through various processes," explains Stemmerik.

"The main features of their geology has been known for many years. A number of discoveries have been made in them globally, but only these two on the NCS. So people want to understand the details better."

According to the NPD, the Barents Sea has the highest level of undiscovered resources on the NCS. And the estimate may change after new data from Barents Sea North has been evaluated.

Close look. *Lina Leknes and colleagues study carbonate rocks on Svalbard to increase their knowledge of the sub-surface in the Barents Sea.*

Svalbard fortress

Both rocks and land forms vary greatly in Svalbard. These islands are a unique location for geologists who want to study structures which form petroleum reservoirs further south in the Barents Sea.

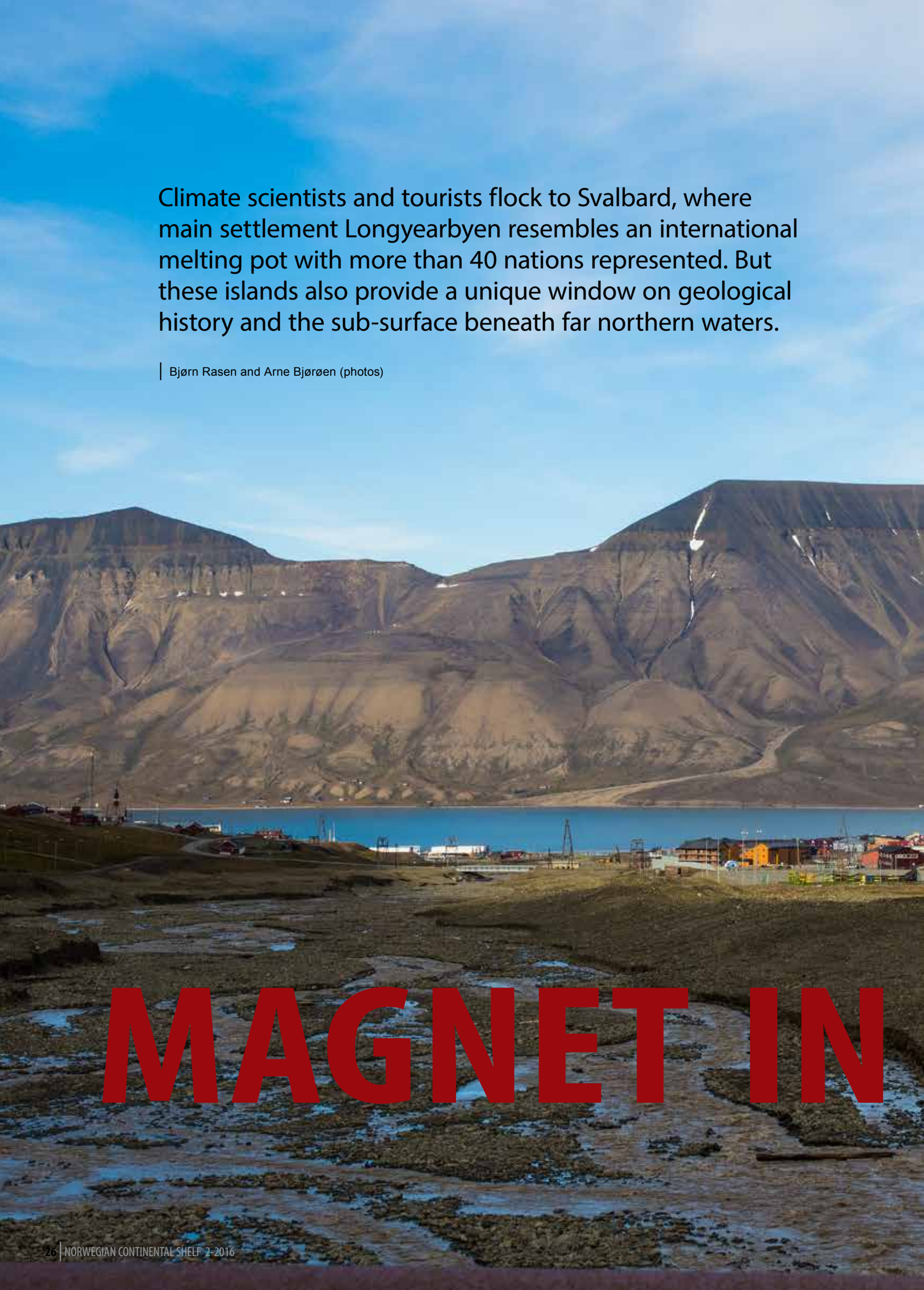
The landscape depicted here lies at the head of the Bille Fjord, and was photographed during NPD field work in 2013. Called the Fort, it is well known and frequently visited.

This area comprises karstified carbonate rocks laid down in warm seas and subsequently dissolved to create fissures, caves and so forth.

These Carboniferous rocks are 300-330 million years old and belong to the Ørn formation, the same lithological unit which forms the reservoir for the Alta discovery in the Barents Sea.

The NPD's geologists used a drone-mounted camera to take photographs during their field trip. This provided good overview shots as well as detailed images of steep slopes.

Text and photo: Alexey Deryabin, NPD)



Climate scientists and tourists flock to Svalbard, where main settlement Longyearbyen resembles an international melting pot with more than 40 nations represented. But these islands also provide a unique window on geological history and the sub-surface beneath far northern waters.

Bjørn Rasen and Arne Bjørøen (photos)

MAGNET IN

THE NORTH

78°N. *Longyearbyen offers a unique starting point for research on geology and the climate. It is home to 2 200 people from 44 nations.*

"With this White Paper, the government wants to make provision for existing activities and varied new ones. Longyearbyen will remain a viable community which is attractive for families." (White Paper 32, 2015-2016)

The snowmobiles are the first thing to catch your eye on arrival in Longyearbyen. They stand everywhere, in big parking spaces, in the passages between the countless warehouses and temporary buildings, along the roadside or outside each home.

These vehicles look as if they have just been tossed aside where they were when the snow vanished in the spring. Virtually every resident has not just one, but several of them.

This August day is free of snow in the lowlands and the temperature is 8°C – almost a balmy summer's day for an Arctic settlement of roughly 2 200 people – including 1 200 Norwegians.

Dump

"Longyearbyen looks like a dump," exclaims Snorre Olaussen, a professor in Arctic geology, who asks what sort of impression it gives the thousands of tourists who arrive on cruise ships.

"We certainly have some fine buildings, but most of the place is a shambles – a kind of hillbilly culture where people show no sense of ownership."

Suggesting that this could be because people who move to Longyearbyen only remain for four years on average, he wants the government to take the initiative on clearing the place up.

In his view, visitors deserve to get a cleaner impression of the unique natural environment in these far northern islands.

Olaussen has spent a long time there, and enjoys his daily walk to work at the University Centre in Svalbard (Unis) a few hundred metres from his home.

Almost all his neighbours drive to work and virtually everywhere else – by car in the "summer" and by snowmobile during the long winters. Each trip is only a few hundred metres.

Veteran. *Driven by an unquenched thirst for knowledge and motivated students, Arctic geology professor Snorre Olaussen spends weeks out in the field in Svalbard.*

Unis occupies one of the little town's more impressive buildings. Founded in 1993, it concentrates on high-quality research in Arctic biology, geology, geophysics and technology.

Its location at 78°N gives the centre a unique advantage, because students and staff can use the natural environment as a laboratory – perfect for observation and data acquisition.

Collaborates

With 690 students from 44 nations in 2015, Unis collaborates with a number of international research institutions through a number of projects. Half its staff and students are non-Norwegians.

"They mostly study the climate," explains Olaussen. "And many people want to join them."

He argues that too much of it is confined to Svalbard with insufficient attempts to increase understanding of the wider Arctic Ocean.

In his view, lack of funding to conduct expeditions in these waters means that Norway's position as a far northern nation is being undermined.

Increased activity in this part of the world makes studies of Arctic

technology, geophysics and geology more important than ever, Olaussen maintains.

"Svalbard's like a textbook on geological history, where we can study rocks from the Precambrian 3.7 billion years ago right through to more recent Jurassic and Cretaceous formations."

Generally speaking, the Unis leadership is slightly concerned because its financial support is conditional on half the students being Norwegian.

Olaussen notes that many students from Norway fail to find Svalbard as exotic as their foreign counterparts do, and choose places like Hawaii instead.

"We benefitted from good times a few years back, and financed long-term projects. A number of these will be expiring soon, and the outlook after that is a little more uncertain.

"Five years ago, competition over getting a place here was really tough, and the best students are graduating now. New undergraduates are more uncertain today."

He explains that Unis has close ties to the University of Bergen, the University of Copenhagen and certain others in Europe – but not to the University of Oslo.

The centre has pursued a number of collaboration projects with the NPD, which cover field work as well as supporting MSc students.

"Statoil, Lundin and Aker BP [previously Det Norske] are among the companies which show an interest, support logistics and contribute technical assistance," Olaussen adds.

The most relevant project currently under way is a three-four year study of carbonate rocks, which have gained relevance following the Alta and Gohta discoveries in the Barents Sea.

Unis has received top-quality data from Lundin and Aker BP to support its research work, and Olaussen is full of praise for the trust the companies have shown.

A similar good collaboration has been developed with Russian institutes and universities, providing access to information Unis has not had before.

Olaussen accordingly sees a number of exploration opportunities to the east, which paint a more optimistic picture than the data published by the NPD in its resource report.

Coal is another key asset for Svalbard. Everyone arriving in Longyearbyen sees the transport lines and mine adits on the mountain slopes.

Most of these are merely monuments to an industry which once symbolised the islands, and nearly all the mines have shut down. Number seven is the only one left.

Olaussen notes that its output is needed to fuel the power station in Longyearbyen. "A majority here will soon be opposed to burning coal, but it used to be crucial for this community."

He lists four cornerstones for human activity in Svalbard – natu-

Northern learning. *The University Centre in Svalbard is a cornerstone in Longyearbyen.*

re management, industry, research and tourism. "And when one leg disappears, the table gets more unstable."

At the age of 70, he remains an enthusiast for research and field work, and reckons he has devoted six weeks to the latter during 2016.

"Young students out in the field, who wake up and understand – and often teach me something as well – are what gives me the drive to carry on."

Fortune hunters

The Svalbard Museum shares the same building as Unis, but with its own entrance. Described as a cross-disciplinary institution, its exhibits are dominated by animal life and hunting.

However, curator Sander Solnes also knows a great deal about geology and petroleum. Objects covering those subjects are packed away in store.

"Svalbard's like a history book," he agrees. "It was under water 150 million years ago and had a warm climate. As the land rose, new sediments were deposited with associated fossils."

That formed the basis for the coal reserves still found in large quantities. In the early 20th century, a string of fortune hunters also came looking for minerals and oil.

Solnes retrieves claim signs dating to that period from the collection – including one appropriately heralding Arctic Oil.

"Norway understood at an early stage that it was important to safeguard Svalbard," he says. "Such signs were removed – an action which led to the Svalbard treaty."

That document was signed on 9 February 1920. The government saw a need to secure sole rights to land and mineral deposits in the face of mining projects and other attempts at development.

The treaty recognises Norway's sovereignty over the islands, but requires the country to give a number of other nations equal rights with Norwegians in certain areas.

These include the right to access and live in Svalbard, fish and hunt, and pursue all types of maritime, industrial and trading activities. Norway is responsible for environmental protection.

Oil opportunities have also been explored in more recent times. Belgium's Fina drilled on Edgeøya in the 1970s, and Norwegian interests had a rig working in Berzeliusdalen outside Longyearbyen in the 1960s and 1970s.

But only coal mining has been commercial in the islands, even though Solnes says that operator Store Norske made no money for its first 55 years of operation.

A further NOK 1.5 billion was invested in the Svea mine south of Longyearbyen two years ago. But declining prices in the coal industry forced a temporary closure.

That is a problem, Solnes admits: "A mine left idle for three years will need fresh investment." And it is not certain operations will ever resume.

Roughly two-thirds of the coal produced in Svalbard has been exported, with the remainder used locally for electricity generation.

Resources

"It's reasonable to ask what we're going to do with Svalbard if we aren't going to exploit the natural resources up here," says Peter J Brugmans.

He bears the imposing title of department director for the com-

Pioneers. *Quite a few prospectors sought "black gold" in Svalbard during the early 20th century. The Longyearbyen museum has a collection of the signs used to stake claims.*

Rich history. *Curator Sander Solnes can offer plenty of petroleum history. Exploration for oil in Svalbard began before the drilling rigs ventured onto the NCS.*

"The seas around Svalbard have not been opened for petroleum operations. Exploration wells have been drilled on land in Svalbard earlier without making commercial discoveries. Since the Svalbard Environmental Protection Act came into force in 2002, no permits for exploration drilling on land have been issued either." (White Paper 32, 2015-2016)

missioner of mines at Svalbard in the Directorate of Mining in Trondheim, and spends almost 200 days a year in the islands.

His office in Longyearbyen is on the first floor of a building which stands on the main street at the point where the shops cluster.

He wants to see more geological research because there is so much unique material to study, and points to the tonnes of bones from ancient reptiles found by palaeontologist Jørn Hurum.

"What he's doing is interesting," emphasises Brugmans. "This work and other scientific discoveries show that Svalbard's geology has not been sufficiently studied."

More detailed geological mapping is needed, he thinks, because the islands might contain interesting minerals which could benefit companies involved in such areas as electronic components.

His office contains glass cases with a broad array of Svalbard minerals, including copper and gold. Volcanic rocks 300-400 million years old along the west coast hold ores of interest to industry.

Brugmans has written a book about the hunt for oil in the islands as a forgotten slice of Norwegian history. Interest in drilling there during the 1960s predated North Sea exploration.

Companies involved included Caltex and Shell, but they eventually gave up. "They drilled 17 wells on pure speculation," says Brugmans. "That was before seismic surveying in the 1970s and a gas discovery in Sør-Spitsbergen."

Incidentally, Unis also found gas a few years ago while drilling in connection with a project to map possible sites for carbon-dioxide deposition.

The mining commissioner's role includes handling applications for claims which confer the right to exploit minerals and rocks found within its confines.

But he is not under much pressure from new enterprises. The areas which might be interesting for mining coal or minerals are now largely covered by conservation orders.

Mineral-rich. *"Commissioner of mines" Per J Brugmans wants to create valuable commercial activity by exploiting Svalbard's rich mineral resources.*

Carrying less. *Cable car for coal transport. Many of them are no longer in operation.*

Brugmans finds it difficult to say anything about the future for industry in the islands. "Most of the issues relating to Svalbard are political. And it's the presence or absence of political will which decides whether we'll hunt for minerals."

He adds that "tourism and research, particularly on the climate, get the attention. It's a paradox that nobody studies the impact of tourists. We see daily snowmobile caravans from February to the end of April."

Even without the snow, the tourists arrive. Two cruise ships moor and 6 500 visitors are put ashore. Longyearbyen's few streets are soon filled with excited people from many nations.

The peace is disrupted by clicking cameras and buzzing voices. A few hours later, laden with obligatory souvenirs, the visitors return to the harbour and set off for their next destination.

Conscious

"The tourist industry is conscious of the need to avoid leaving traces," says Stig Henningsen, who runs Henningsen Transport & Guiding.

"Organisers try to avoid having too many people in the same place at the same time. And visitors who come here to experience Svalbard have done their homework and know the rules.

"But the cruise passengers who drop by don't particularly care whether they're calling in Greenland, Iceland or Svalbard."

He has followed developments in Svalbard for over 50 years, and is more than averagely interested in social changes there. And he wants a more diversified local economy. "Professors and students aren't enough. We must have a rounded society."

Henningsen thinks the hotels are feeling the effects of reduced

In charge. *The governor of Svalbard has the finest ship in the islands. Paul Lutnæs works on nature management in his office.*

Logistics. *Stig Henningsen has created a living by leasing snowmobiles and operating two boats which take scientists and tourists out into Svalbard's varied landscapes.*

coal mining, with many commuters gone. Service industries are also affected because their staff are often married to miners.

And times are set to get tougher for plumbers, electricians, schools and nursery schools. He is happy that his wife works for the government, so that the family's finances are secure.

He arrived in Svalbard as a child in 1964 and worked for Store Norske in the mines before setting up his own business in 1997 with a tourist boat, expanding later to snowmobiles.

His fleet of the latter has been reduced from 50 to 30 units because the time they take does not pay off. He now operates two boats with a total crew of 13 as well as guides, office staff and a mechanic. Annual turnover is NOK 18 million.

"I've invested so much that the bank probably wants to keep me here," Henningsen muses. "Svalbard's impressive landscapes make it unique. It's my childhood home, and I haven't found a better place to be. I could have been unlucky and lived in Oslo."

The heavy international presence is good for the community, he believes. And "those who return to the mainland because they feel isolated up here aren't getting out among people enough."

Cultural life in Longyearbyen is good, with various festivals arranged every year and few performers refuse a booking there. The sports hall and swimming pool are filled to capacity.

Henningsen seldom feels a need to get away, beyond a holiday trip in the winter and an occasional week in the summer. "I go aboard. Nowhere in mainland Norway is better than here."

Open-air

Living and working in Svalbard is by definition an open-air existence. Some take that even further by having a holiday cabin in the islands, like NPD geologist Steinulf Smith-Meyer.

"I visited Svalbard for the first time as an 18-year-old, before

Holiday cabin. *Geologist Steinulf Smith-Meyer has held various jobs in Svalbard in the past, and was so entranced that he obtained his own holiday home there.*

starting at university," he recalls, standing beside some boathouses close to Henningsen's office.

"Since then, I've worked up here for Store Norske, the mining commissioner and the Norwegian Polar Institute.

"And I've also spent a winter as a hunter on the northern tip of Svalbard. Today, my wife and I have a cabin at Reveneset on the other side of the fjord."

He tried life as a coal miner for six months, and found the experience "cramped and physically demanding" – the exact opposite of life as a fox hunter with his wife.

"Being in full control and dependent only on yourself was a great feeling. We caught 52 Arctic foxes during our stay."

With the NPD since 1992, Smith-Meyer has only been on one expedition in and around the islands in connection with work during that time.

He feels the NPD's presence in Svalbard is important since it is responsible for charting resources on the NCS – including unopened areas.

"And the rock strata are exposed to the light of day here. This is the best place to explore in order to understand the geology of the far north."

Logistics

Owning a cabin calls for a lot of logistics because the infrastructure is limited, he admits. A boathouse is useful for storing the family's four snowmobiles.

"They're a necessary means of transport and a kind of 'pleasure boat'," he observes, adding that he also has a rubber dinghy for crossing the fjord.

"Holidaying here is like being in the Norwegian mountains," Smith-Meyer says. "It's clean and clear."

But the journey to the cabin is long and an ordinary weekend too short. It takes three hours by air from Oslo, and he often stays overnight in Longyearbyen before heading to Reveneset.

On arrival, he has to get things ready and secure supplies. Food and fuel must be purchased. In the summer, he fetches drinking water from Longyearbyen.

Melted snow takes over in the winter. Without electricity, paraffin and battery lamps have to be used for lighting.

Even with little wind, a survival suit is essential. And a rifle is always to hand during the walk up from the beach to the cabin or when moving about outside.

A Polar bear broke in once and rummaged around the cabin – fortunately while the family was absent. On this trip, two were observed close to the cabin a few hours after he returned to Longyearbyen.

Long way. *Smith-Meyer depends on a boat in summer and a snowmobile in winter to reach his holiday paradise.*

Researchers. *Two professors keen to learn more about the far north in their respective fields: Arctic scientist Yngve Kristoffersen (left) and palaeontologist Jørn Hurum during a rare encounter in Longyearbyen.*

Smith-Meyer is not frightened by that, but has great respect for the animals. Svalbard has about 2 500 of them, according to Paul Lutnæs, senior adviser in nature management at the governor's office.

A shot from a signal gun is enough to frighten them off. Using a rifle – which means shooting to kill – is exceptional. Two Polar bears have been shot in Svalbard during 2016.

Each incident leads to headlines in the press and a detailed police investigation. The shooter can expect a stiff penalty if they were not in imminent danger of death.

Lutnæs says it is also forbidden to hunt walruses in Svalbard, and the governor's office keeps a close eye on expeditions to ensure compliance out to 12 nautical miles off the islands.

During my visit to Svalbard, I am privileged to witness an encounter between two academics who are both, in their different ways, dedicated to digging out more details about the far north.

Arctic researcher and geology professor Yngve Kristoffersen is in Longyearbyen for work on the hovercraft used in his expeditions far out on the ice cap (see *Norwegian Continental Shelf* 1-2016).

He regards Svalbard as a jumping-off point for pursuing more research in the Arctic Ocean, and not just in the islands themselves.

And Professor Hurum, already mentioned above, is also in town with an expedition team after excavating almost a tonne of fossil bones.

The two scientists meet at Spitsbergen Hotel, where Hurum's party has called in for a much-anticipated shower, a cold beer and a good meal after many days out in the field.

This work has involved standing up to their knees in mud and recovering the remains of animals who lived in Svalbard almost 250 million years ago.

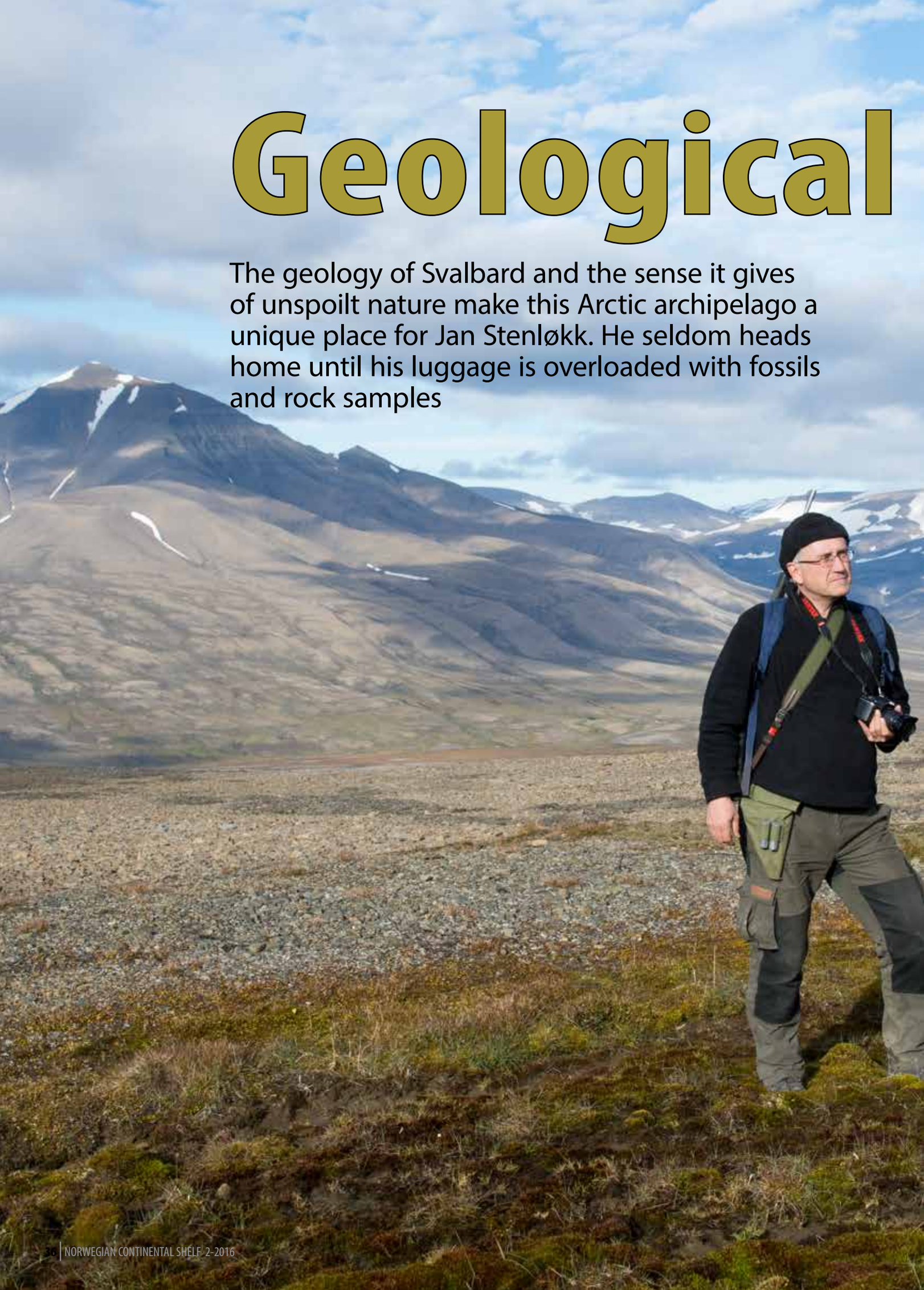
The scientists had to dig out 70 tonnes of shale to reach the strata containing these fossil. Afterwards, they put the spoil neatly back in place, as required by the governor's office.

"We've found the bones of big sharks who could have been five to 10 metres long as well as fragments of a reptile jaw," reports Hurum.

He has spent many seasons in Svalbard, but cannot say whether more expeditions will follow. "We've enough material now to keep us busy for a decade. But there's plenty more to find here."

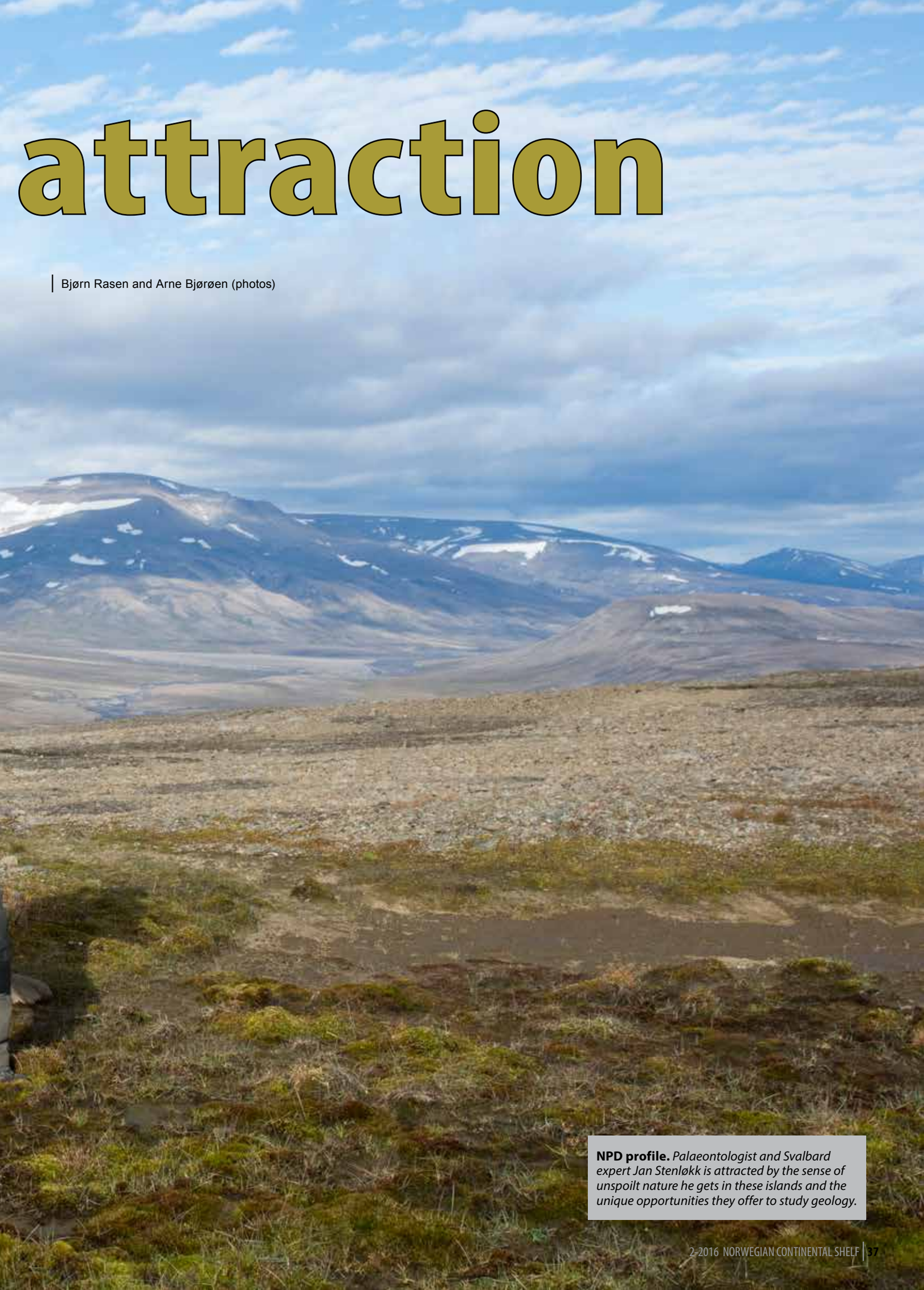
Geological

The geology of Svalbard and the sense it gives of unspoilt nature make this Arctic archipelago a unique place for Jan Stenløkk. He seldom heads home until his luggage is overloaded with fossils and rock samples



attraction

Bjørn Rasen and Arne Bjørøen (photos)



NPD profile. *Palaeontologist and Svalbard expert Jan Stenløkk is attracted by the sense of unspoilt nature he gets in these islands and the unique opportunities they offer to study geology.*

His suitcase is not the only thing which weighs on this NPD palaeontologist and Svalbard veteran every time he flies south. He longs to return and explore more.

These islands are certainly part of Norway – but different, Stenløkk emphasises. Its landscapes are unlike those on the mainland, and its rock formations can be found only here.

These belong to the same lithological units found beneath the Barents Sea to the south, but are exposed in Svalbard to the light of day.

"This is an exceptional place to teach geology," Stenløkk says. "We can study Barents Sea geology on a large scale and understand its petroleum systems. That's very useful when hunting for oil and gas."

He maintains that "everyone" has heard of Svalbard as a mystical place far to the north. And few places this close to the Pole are so easy to access.

Scheduled flights depart daily. In addition, a growing number of cruise ships call in the Is Fjord and at the main settlement of Longyearbyen.

Thousands of adventurous tourists want to enjoy a taste of its distinctive nature, and dream of seeing a live Polar bear or two.

Stenløkk himself has caught a whiff of these beasts – although it was probably the other way round – several times on his trips, most recently twice this August. Two turned up at places just after he had left.

"You don't mess with a Polar bear," he emphasises. "They're fearless predators. So the rules require us to carry signal guns and rifles as soon as we're outside Longyearbyen."

Chair of the Norwegian association for amateur geologists, Stenløkk knows the islands well and takes groups of members and others on expeditions.

"Little infrastructure has been developed here," he notes. "Mobile phone coverage is poor and weather conditions change quickly. You've got to be careful and think about getting home."

Spraining an ankle or – even worse – breaking a bone out in the field can quickly become a big challenge.

Desire

Despite all the dangers, Stenløkk has a burning desire to get even further into the landscape or up the fjords. Svalbard is a geological Eldorado which is far from fully explored.

"No trees grow here, but we can spilt a stone and find the fossil imprint of a fine leaf," he says. "One nobody has seen for millions of years – since Svalbard's climate was roughly the same as in central Europe today."

He also recalls the fantastic discoveries of ancient reptiles made by professor Jørn Hurum and his team in Svalbard, including a large number of complete skeletons in Triassic and Jurassic rocks.

Unearthed not far from Longyearbyen, these remains make the islands one of the world's richest areas for discoveries of marine reptiles.

The NPD has also found a complete skeleton on Edge Island, which the geological museum in Oslo helped to recover. It has been named Oda, after the NPD's initials in Norwegian and the museum's better-known primate fossil called Ida.

Movement is restricted on Svalbard, and private visitors find it almost impossible to get beyond the Longyearbyen or Is Fjord areas. Expeditions are also expensive and demand much logistics.

Fieldwork

But geologists – including NPD personnel – occasionally conduct fieldwork in Svalbard. A chartered ship usually functions as their base, and they head ashore in light boats to study selected areas.

The aim is either to understand Barents Sea geology (see the main picture) or to go into more detail in order to grasp the depositional history which helps to clarify its petroleum systems.

Licensing rounds with new exploration acreage in these waters could enhance interest in Svalbard fieldwork. Such activities are likely to expand when times improve for the oil industry.

"We're not in Svalbard to explore for oil," Stenløkk stresses. "But this is where the seabed and 200-300 metres of the sub-surface emerge and offer excellent conditions for study."

He first collected fossils in the islands on a private visit in the early 1990s, but has since clocked up 20 trips – a number of them for the NPD.

The original visit remains fixed in his memory. "I went at my own expense to the Fort at the head of the Is Fjord, which is now a conservation area.

"Going ashore in this well-known geological locality to collect fossils was like standing by the Egyptian pyramids. Up here you feel as if you're the first-ever visitor – there's no well-trodden paths."

International

Svalbard is home to an international community, and both Stenløkk and the NPD have carried out joint fieldwork with the Russians on several occasions.

Although their aim has always been to understand Barents Sea geology, climate and environmental questions are attracting ever-growing attention in the islands today.

The NPD is involved in work and studies related to these issues, including a project for depositing CO_2 in

sub-surface formations known as the carbon laboratory.

In addition to contributing to management plans, the directorate has collaborated with the University Centre of Svalbard to support PhD students.

"We feel scientists can get a good view of climate change up here," says Stenløkk. "That includes changes in vegetation, water temperature, marine species, bird migration patterns and much more."

Pressure

The seas around Svalbard have been more or less free of ice in recent years. Stenløkk believes that this could boost pressure for more activity in the islands. Fishing is one possibility, and tourism perhaps the biggest.

He has noted that a discussion is under way on how many visitors Svalbard can cope with. After all, they leave an environmental footprint. Growing numbers also want to do more than trudge along the main street in Longyearbyen.

But he is not particularly concerned: "The lack of infrastructure and the restrictions everyone must observe limit opportunities and mean that Svalbard preserves itself."

Stenløkk has no concerns about pursuing geological work in Svalbard, despite today's heated discussions on the climate.

"Petroleum operations in the Arctic are under debate. That's a political matter and not something the NPD has a view on. Our job is to acquire data as the basis for political decisions."

Since Svalbard is Norwegian territory, he believes it is important that national interests pursue more work and research there in a number of disciplines.

Such activities should not be left solely to the scientists from other nations who are queuing up to conduct studies in the islands.

He still feels strongly attracted to Svalbard – even after 20 trips – because so many highly interesting fossils and rocks remain to be collected.

Collector. *Jan Stenløkk meets the young fossil-sellers Paula (left) and Emil. A deal is struck.*

Shipmates. *Jan Stenløkk accompanied Arctic researcher Yngve Kristoffersen on an expedition by hovercraft over the Polar ice cap a few years ago. They met again by chance in Svalbard this August.*

Way forward fo

The following questions on the challenges facing operations on the NCS have been put to the NPD's strategic leadership – the four directors who sit on the management committee with director general Bente Nyland:

1. What are the two most important issues for your area of responsibility, and what can the NPD contribute?
2. How can resource loss be prevented – does the government have the sticks and carrots needed in today's circumstances?

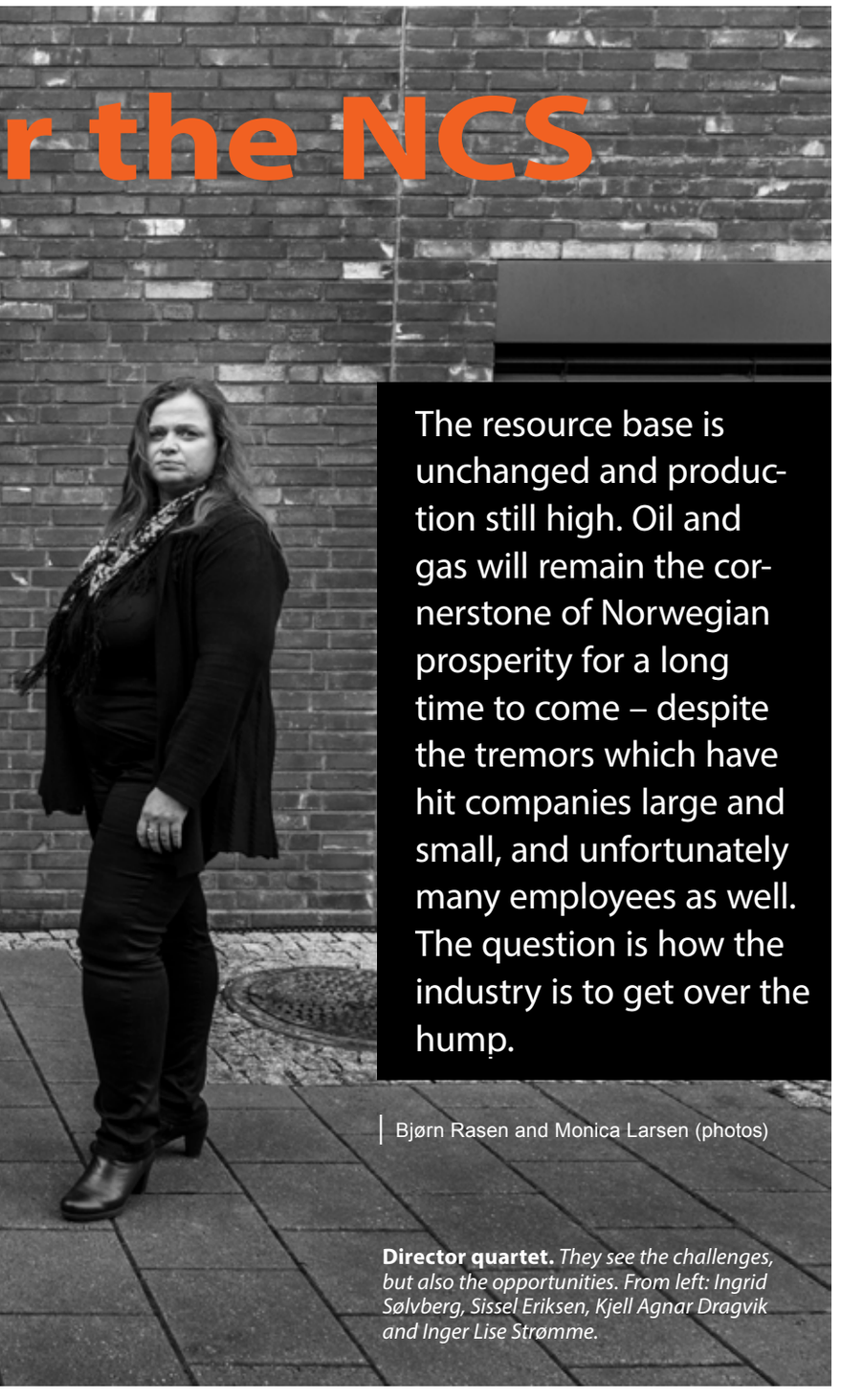
Kjell Agnar Dragvik, director analysis and framework

At a time of big oil price movements, producing good forecasts for activity on the NCS is challenging in both short and long terms. That also provides a good reflection of the main challenges facing the industry.

The NPD believes a long-term resource potential still exists which can create big value for Norway as a nation. Our primary observation is that production is being maintained in both long and short terms, even though investment has fallen substantially in recent years. What we do not know is whether the cost reductions are so large that they will affect long-term resource extraction. We are therefore keeping a very close eye on this.

My responsibility also covers the Oil for Development (OfD) programme. This is challenging work, because it often takes place in and with countries whose institutions differ from Norway's.

As a result, they may not be as well placed to manage their resources. At the same time, our people involved in this activity find that seeing the contrasts helps them to develop.For us as an institution, it is



The resource base is unchanged and production still high. Oil and gas will remain the cornerstone of Norwegian prosperity for a long time to come – despite the tremors which have hit companies large and small, and unfortunately many employees as well. The question is how the industry is to get over the hump.

Bjørn Rasen and Monica Larsen (photos)

Director quartet. *They see the challenges, but also the opportunities. From left: Ingrid Sølvberg, Sissel Eriksen, Kjell Agnar Dragvik and Inger Lise Strømme.*

important to provide relevant players, and the general public, with correct and updated information about operations on the NCS.

The system in Norway makes it profitable for the companies to produce commercial resources, and we pay close attention when players apparently promote short-term interests.

And there are milestones in both petroleum legislation and agreements when the companies must document that they are making a prudent assessment and taking account of long-term interests.

But it is important to emphasise how large a role is played in competitiveness by producing cost-efficiently and in line with prices in the oil and gas markets.

The authorities do not play the principal role there. That is something the industry must do.

Inger Lise Strømme, director data management and organisation

Renewal and digitalisation are important terms for the future. We must ensure that the organisation, the tools and the instruments are tailored for tomorrow's needs – internally, with the government and with the petroleum industry.

We must seek new ways of working and exploit the opportunities offered by new technology. That makes demands on our competence, and we must pull in the same direction.

This is not only about technology, but also about people and organisation. We need to develop and highlight the NPD as a good and attractive workplace.

It must offer development opportunities and interesting challenges for staff, and possess the expertise and capacity to do its important job for society.

We are also concerned about the same issues in the industry. One challenge is to identify our role in this. What needs no intervention and where can we make a difference?

A specific challenge is to ensure that we manage data from the NCS in a good and secure manner. We must ask whether the way we have acted so far is the right approach for the future. In any event, we have a need to renew the technological platform for reporting, management and communication.

Regardless of the price and cost regime, it is important to share data and knowledge, and to interact intelligently. The industry could benefit from exploiting economies of scale, standardisation and sharing experience.

In this picture, the NPD has a role as a driving force for good interaction and through operating or supporting common arenas.

Ingrid Sølvberg, director for development and operations

We see a changing offshore sector. This means our commitment must be strengthened so that time-critical oil and gas resources are given priority and existing facilities are exploited to the maximum before being shut down and removed.

A greater degree of coordination across production licences – good area solutions – is becoming increasingly important. It could help to make a larger number of marginal fields commercial. Adopting new technology boosts opportunities for success.

In recent years, we have seen that companies are giving increasing emphasis to short-term thinking when deciding on investment in developing discoveries and on measures for improving recovery from fields.

Our most important job is therefore to shift attention and decision criteria towards solutions which provide the highest overall value creation – including for society – and protect

future upside opportunities.

After a period of very high costs, we have seen reductions of 30 to 50 per cent over the past 18 months. We then expect the companies to see that more projects have become commercial.

The current climate debate creates uncertainty about the size of production from the NCS. We are also seeing a decline in the number of young people choosing petroleum subjects at university.

This fuels fears of an aging workforce and an expertise deficit. We must therefore help to maintain an understanding that oil and gas will be produced for several decades to come.

The NCS is globally competitive. The companies do a good job. But we also see that pressure from the government is sometimes needed to secure decisions which maximise value for society.

Our set of instruments has so far been adequate for securing profitable management of the oil and gas resources.

A close dialogue is being maintained between government and companies, and we find that the companies are listening to signals from the government.

We want things to stay that way in the future.

Sissel Eriksen, director exploration

The decline in the number of exploration wells worries me. Several years of high activity were replaced by a downturn in 2016, and I fear the reduction could be even greater in 2017. This is not a unique Norwegian development, but part of an international trend as the companies adjust to lower oil prices.

Maintaining a high level of drilling on the NCS is important for sustaining oil and gas output from around 2025. But production is not a matter of course – exploration and discoveries are needed. Cutting spending here is like eating your seed potatoes – it will hurt in the long run.

Good access to data, a steady supply of new acreage and good operating parameters are the government's contribution.

It is particularly important for us that the continuous geological evaluation of possible prospective acreage is maintained in order to allow timely and efficient exploration.

That ensures good resource utilisation and a sound basis for maintaining oil and gas production.

Internationally, we see the big companies consolidating and paying less attention to long-term and demanding projects. Signs of the same can be seen on the NCS.

In that context, it was unfortunate that several of the large companies failed to apply in the 23rd licensing round. This is my second worry.

We need the big players to continue developing the Barents Sea in the same way they did in the North and Norwegian Seas. Substantial investment will needed to establish the Barents Sea as a petroleum province.

More than half Norway's undiscovered resources lie in these waters. The willingness and ability to take risk by testing new plays and innovative technologies are very important for realising this potential.

Exploration today is very advanced high-tech. We need a diversified player picture with a substantial share of solid and innovative players.

We consider it very important to map and prove resources in mature areas and around time-critical facilities in order to avoid losing key infrastructure too early. We will be very proactive here over the next few years.

Attractive acreage with petroleum resources remains on the NCS if people want it to be exploited. To maintain the production curve, these areas must also be opened and explored.

Access to attractive exploration acreage is important. And exploration and development take time, so this cannot be delayed for too long.

Still optimists. *The NPD's strategic management. From left: Kjell Agnar Dragvik, Inger Lise Strømme, Sissel Eriksen and Ingrid Sølvberg.*

Accra *is the capital of Ghana, where the Norwegian authorities have been the preferred adviser for adopting a new petroleum Act. (Photo: OMG Voice)*

Ghanaians put rules in place

A legal and regulatory framework for managing its oil and gas resources has finally been created by Ghana, a relative newcomer to the industry. This process has enjoyed good support from Norway's Oil for Development (OfD) programme.

Bjørn Rasen

Everything's now up to the powers that be," says Gilbert Aboagye Da Costa, publisher and editor-in-chief of *Ghana Offshore*. "The question is whether we can break the oil curse which has hit several other African countries."

He has followed developments in the west African nation since returning there in 2010 from a period as Nigeria correspondent for the BBC, the Associated Press and Time.

His view of what has taken place is largely positive, but he remains concerned: "To succeed, it's essential to create openness about and transparency in the petroleum economy."

Ghana passed a petroleum Act in the 1980s but needed to revise it, explains Erik Abrahamsen, the NPD's coordinator for the OfD programme from 2008 to 2016.

"Work on new legislation began in 2010. Our contribution has been to give the Ghanaians ownership of the process, so that the product was 'theirs'.

"We've backed them in ensuring good petroleum administration, good data management and operating parameters for safety. They've now got the tools to manage their resources well."

The new petroleum Act was adopted in August and, with a new Petroleum Commission similar to the NPD in place, the country should be well placed to achieve good resource management.

Advisers from Norway became involved in the process at an early stage to provide suggestions when the Ghanaians needed them most.

Abrahamsen feels it has been a rewarding journey and that the collaboration has gone well. A number of delegations from Ghana – including one with the president – have visited Norway.

"It remains to be seen how successful all this will be," Abrahamsen adds.

His successor in the project, Svein Arne Svilosen, reports that the NPD and the Petroleum Safety Authority Norway (PSA) will now support the Ghanaian government in writing regulations under the new Act.

One for metering was adopted in November, and others on data management, health, safety and the environment, and general petroleum provisions are in the pipeline.

Once these have been adopted, Ghana will have finished the job of erecting a legal framework for its petroleum industry. This currently involves a daily output of roughly 100 000 barrels.

This production derives from the Jubilee and Ten offshore fields, both operated by Tullow. Start-up preparations are under way on the Sankofa field operated by Eni, which also contains a good deal of gas.

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B-blad

Norwegian continental shelves

A stand resembling a classic Victorian library served to visualise the government's knowledge bank at the ONS 2016 oil show. This concept hit it off both with visitors and the best stand jury.

The joint presentation by the NPD and the Ministry of Petroleum and Energy was acclaimed by the judges as the finest among this year's exhibits in the class larger than 50 square metres.

According to the award citation, using an old-fashioned library to illustrate the management of petroleum data and the transition from books to bytes was surprising and novel. It also praised the stand's apt title: The Norwegian continental shelves.

Genuine books are essential for recreating such a setting, and the NPD was fortunately able to borrow 3 000 volumes from the Stavanger city library.

These were supplemented by a number of computer screens where visitors to the stand could call up information from the government's databases.

The Norwegian authorities possess information from all petroleum activities on the NCS, which can be accessed from their databases and websites.

Most of these data are open to all. Both their scope and this openness are unique – also by comparison with other oil and gas producer nations.

Norwegian petroleum policy is based on knowledge. Good knowledge-based resource management benefits the whole country.

The government's philosophy is therefore that companies who want to work on the NCS will compete not over information, but on the way they use the available data.

NORWEGIAN PETROLEUM DIRECTORATE

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