



Second stint

Fruitful fungus
Science space

NORWEGIAN

CONTINENTAL

SHELF

A JOURNAL FROM THE NORWEGIAN PETROLEUM DIRECTORATE

NO 2 - 2013



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FRONT COVER

Bente Nyland, director general
(Photo: Emile Ashley)

Mature commitment

“ This is why we regard Snorre as so important – because of the big assets it represents for Norwegian society. ”

The oil production curve on the NCS has been declining since its peak in 2000-01. A key instrument for slowing a further fall – and maintaining output at the highest possible level – is to improve recovery from producing fields. That was identified in the petroleum White Paper approved by the Storting (parliament) during 2012. Snorre in the North Sea provides a prime example today.

It ranks as the producing field on the NCS with the second-largest volume of remaining oil. Only Ekofisk further south has more. The operator and licensees have calculated that 250 million extra barrels of oil can be recovered from Snorre – if a new platform is built and installed mid-field. That is more than the oil output we expect from the Goliat development in the Barents Sea.

This is why we regard Snorre as so important – because of the big assets it represents for Norwegian society.

The field is one of several which offer big opportunities for improved oil recovery. Along with Snorre and other reservoirs with large remaining reserves, we also give priority to strategically important smaller fields where a big commitment can create great value for both society – and the companies.

This job is demanding. Maintaining planned production is a challenge on a number of fields. At the same time, we ask the companies to look at opportunities for getting out *more* oil than originally expected.

Our operating budget has been increased by NOK 10 million in the government's 2014 budget. This money is earmarked for helping to improve oil recovery from mature fields on the NCS. We aim to accept this challenge and to follow up the companies so that they do their job properly and keep fields going until all commercial resources have been produced.

Why do government and companies have differing views on which investments are positive when a field is mature? One answer is that companies usually have tougher requirements for the rate of return than the Norwegian state.

Moreover, action – capital spending – is required to boost recovery factors. Competition within companies over investment funds is high. Measures to improve recovery must accordingly compete with new developments, both on the NCS and internationally.

A final go-ahead for investing in a new platform on Snorre has

yet to be given. Such a facility is required because the two existing installations lack the capacity and producing life to drill the necessary wells. Moreover, a substantial proportion of the remaining oil lies beyond their reach.

While waiting for a decision, it could be useful to take a look back. Our efforts to improve oil recovery from fields have helped to generate billions of kroner in additional revenues for the Norwegian government.

We like to make particular mention to the commitment to extend producing life on Ekofisk and Troll. Where the latter is concerned, these efforts are said to have boosted oil recovery by 2.5 billion barrels. The goal now is to add Snorre to this list.

Today's project has been dubbed Snorre 2040 – a reminder that recovering all commercial resources in a field calls for long-term work. Snorre was discovered in 1979, and came on stream 13 years later. A decision on investment and development concept is due in 2015. It should be worthy of the Snorre 2040 designation.

Bente Nyland
director general

“Our work will be even more important in the time to come. The key now is to ensure that the companies don't take decisions they're going to regret in 10, 20 or 30 years.”



Taking a longer view

Bente Nyland starts a new six-year term as director general of the NPD at a time when the oil companies want stricter prioritisation of projects. That reflects capital shortages and generally high costs. But Nyland says that the demand for long-term thinking in the industry's investment decisions remains unchanged.

| Bjørn Rasen and Emile Ashley (photos)

Pessimism prevailed in Norway's oil industry when Nyland took office in 2007, but the dark clouds began to lift with time. Activity and investment have since exceeded most expectations.

The sharp decline in the production curve for oil has become less steep, and the forecasts indicate that the current level of output will be maintained beyond 2020.

Nyland was re-appointed director general by the Council of State in December. And the beginning of this second term has again been characterised by a change in the weather.

"When I started six years ago, there were grey clouds on the horizon," she recalls. "Then the sun suddenly came out. Interestingly, my second term has begun with fresh clouds. The biggest worries for the companies now are costs and capital."

So is history repeating itself? When Nyland took office, things were a little "dismal and grey" because the industry expected few large projects on the NCS – even though NPD resource estimates indicated that the end had not yet come.

"Discoveries were small and development largely confined to tie-backs to existing fields, large old fields were in decline and few saw prospects for major new 'elephants'," recalls Nyland.

"Nor did it help that oil prices were low, of course, and nobody foresaw that they could become as high as they have. That was the pic-

ture then – perhaps not sunset, but late afternoon."

But something happened along the way. Oil prices shot up, and the portfolio of discoveries began to be developed because it became profitable.

Exciting new finds such as Edvard Grieg, Ivar Aasen and not least "Johan Sverdrup" were made. Asked what she thought when the contours of that last discovery became visible, Nyland says it proved the future cannot be predicted.

"It demonstrated, after all, that the NPD was right to say the NCS concealed substantial undiscovered resources. But I was surprised that such a big find was made in an established and explored area.

"That wouldn't perhaps have happened without the technological advances made in seismic imaging, and it depended not least on somebody daring to take some other kinds of exploration strategy chances – to think a little out of the box."

Many a champagne cork popped as a result of "Johan Sverdrup," but Nyland describes her own celebration as discreet. She regards the find as a game changer, making the NCS more dynamic and attractive.

"And the new discoveries occurred immediately after the tax regime had been amended, precisely with the aim of stimulating exploration activity. The timing was good."

Now, challenges are queuing up at the start of her second term.

"Our job is to help ensure the right choices for new developments, a strong focus on older fields and installations, and continued efforts to improve recovery," she enumerates.

The question is whether measures to boost recovery from producing fields will be hit when a number of companies warn that they plan to set tougher priorities for their projects.

Nyland promises to keep a close eye on this. "It's very good the companies set priorities, providing they get their preferences right and don't throw the baby out with the bath water.

"That's where we have a unique opportunity to point out that this involves skimming the cream, while our goal is to exploit the whole milk-can.

"Our work will be even more important in the time to come. The key now is to ensure that the companies don't take decisions they're going to regret in 10, 20 or 30 years."

The natural question to ask then is whether the NPD regrets any of its actions over the past six years, or whether Nyland believes she can point to good results.

"We've helped to manifest the potential in new areas, and have completed big seismic survey programmes off Lofoten, Vesterålen and Senja as well as in Barents Sea South-East.

"We've steadily pursued big projects for maintaining oil production,



“I’ve promised the Storting that we’ll ensure optimum utilisation of all profitable resources. That’s what my job’s about.”

NPD director general Bente Nyland with Tord Lien on his first visit to Stavanger after being appointed petroleum and energy minister. Photo: Lise Rist/MPE

such as Troll in the North Sea, and we’ve worked with Ekofisk to help the licensees take decisions which can sustain output for another 40 years.

“Recently, too, our pressure has succeeded – on a preliminary basis – in helping to secure a decision on a ‘Snorre 2040’ project which will be important for Norway’s resource base.”

She wants this development to stand as an important memorial to the government agencies involved: the Ministry of Petroleum and Energy as well as the NPD.

“We’re so spoilt for money in this industry, after all. Personally, I think NOK 1 billion is better than nothing, even if it’s not as good as NOK 2 billion.

“But the outside world doesn’t always appreciate this. Many Norwegians want the oil resources in new areas to remain in the ground.”

That was precisely the chal-

lenge she highlighted in her previous interview with *Norwegian Continental Shelf* in 2008: getting the outside world to understand the petroleum industry and the effect of its revenues on the Norwegian welfare state.

“This challenge is still there,” Nyland notes. “The position hasn’t been made any easier by the public debate in Norway and the conclusions of the Intergovernmental Panel on Climate Change.

“Many people have a tendency to jumble climate issues with bad weather. And a number find it hard to grasp what value creation is. They only see great prosperity, money in the bank. And some say that Norwegians are rich, fat and idle. That’s not good.

“In my view, we must exploit the natural resources we’ve been given in the best possible way. Other countries, with far greater assets than Norway could ever dream of, have wasted them.

“They’ve gone to a small elite.

We’ve managed things better here. This aspect is often forgotten. At the same time, we can put money aside for future generations.”

Nyland certainly appreciates the dilemmas and is no advocate of forging ahead at full speed. She sees it as her job and role to strike a balance.

“In the future, of course, we’ll get an energy regime with more legs to stand on. I believe regardless that we pursue a sustainable exploitation of resources on the NCS.

“Many of us in the industry want natural diversity and a good environment. It’s occasionally forgotten that we work to reduce emissions and discharges, and to find cleaner solutions.

“Nevertheless, we mean little in the big global picture. It’s difficult to get people to understand that our biggest contribution is the one we can make outside Norway.

“But we must naturally also do what we can at home – by reducing emissions from flaring, for example, and by supplying our offshore installations with power from shore.”

She believes that both sides of the debate have a need to sharpen their messages: “A lot gets exaggerated in the public space – in other fora, people talk together.

“We live in a time when everything has to be formulated in black-and-white. Conducting a lengthy debate with good reasoning is hardly possible any longer.”

Nyland still has great confidence in dialogue with the oil companies, even when their project priorities come under pressure and costs have become so high.

“This means we must put much more effort into manifesting asset value and, not least, document the loss of value from failing to take production seri-

ously. We must highlight what the companies and the Norwegian state stand to lose.”

She emphasises that this is about conforming with Norwegian law. There is a reason, after all, why the companies have been allowed onto the NCS and given licences.

At the same time, they must fulfil certain requirements. This is clearly formulated in the Petroleum Activities Act, and Nyland expects the companies to comply with it.

“We’re occasionally accused of not understanding the industry. We understand it all right, but we have our duties. I’ve promised the Storting [parliament] that we’ll ensure optimum utilisation of all profitable resources. That’s what my job’s about.”

“Dialogue between government and companies” has occupied a key place in the Norwegian oil model from the start, and Nyland does not believe she has

to enforce the requirements more vigorously over the next few years.

“That’s what we can do if we absolutely must. For the moment, it’s an instrument we haven’t wanted to use. We see it’s good professional work and good arguments which count – and win through.”

She looks beyond her forthcoming six-year spell at the helm when describing milestones and goals. The key word is “a long-term view”.

“The most important consideration when we shut down Gullfaks, Troll or other fields is that we can say with our hands on our hearts that we did all we could.

“It’s only then that the objective has been reached. My goal is to ensure this during my term of office. I expect more directors general will succeed me and inherit this issue.”



“Other countries with far greater assets than Norway’s ever been able to dream of have wasted them. They’ve gone to a small elite. We’ve managed things better here. This aspect is often forgotten. At the same time, we can put money aside for future generations.”

The interview with Bente Nyland concluded with some pertinent questions on current issues.

Q: You’ve always expressed optimism about the Barents Sea, even in the years when little or nothing happened. Do you feel today’s optimistic view of these waters is a little overdone?

A: What’s happened is great fun. The Barents Sea’s fate is that all the criteria for finding oil and gas are present, but aren’t put together in the optimum fashion we see in the North Sea.

The challenge then is that we don’t find giant fields, which means we must come up with solutions which can develop whole areas in a good way.

Q: Possibly with Russia as a partner?

A: We have a good collaboration today through the Energy Dialogue. When we find more oil and gas, it could be relevant to expand this.

We have experience of cross-border cooperation with Denmark and the UK. It’s also natural to imagine a collaboration with the Russians when the time comes.

Q: We have a new energy mix and import requirements are changing radically, particularly for the USA. How will that affect Norway?

A: That’s not my business, but I’ve noted it. What’s happening in the USA is clearly a game changer. It alters the terms for transporting gas.

Europe will nevertheless remain Norway’s most important customer in any event. Nothing indicates so far that this market will disappear. But the price level could change, and that might mean something for the new developments.

Q: Six years ago, you didn’t exclude of the possibility of going back to being a geologist. Now you’re spending another six years as head of the NPD... ?

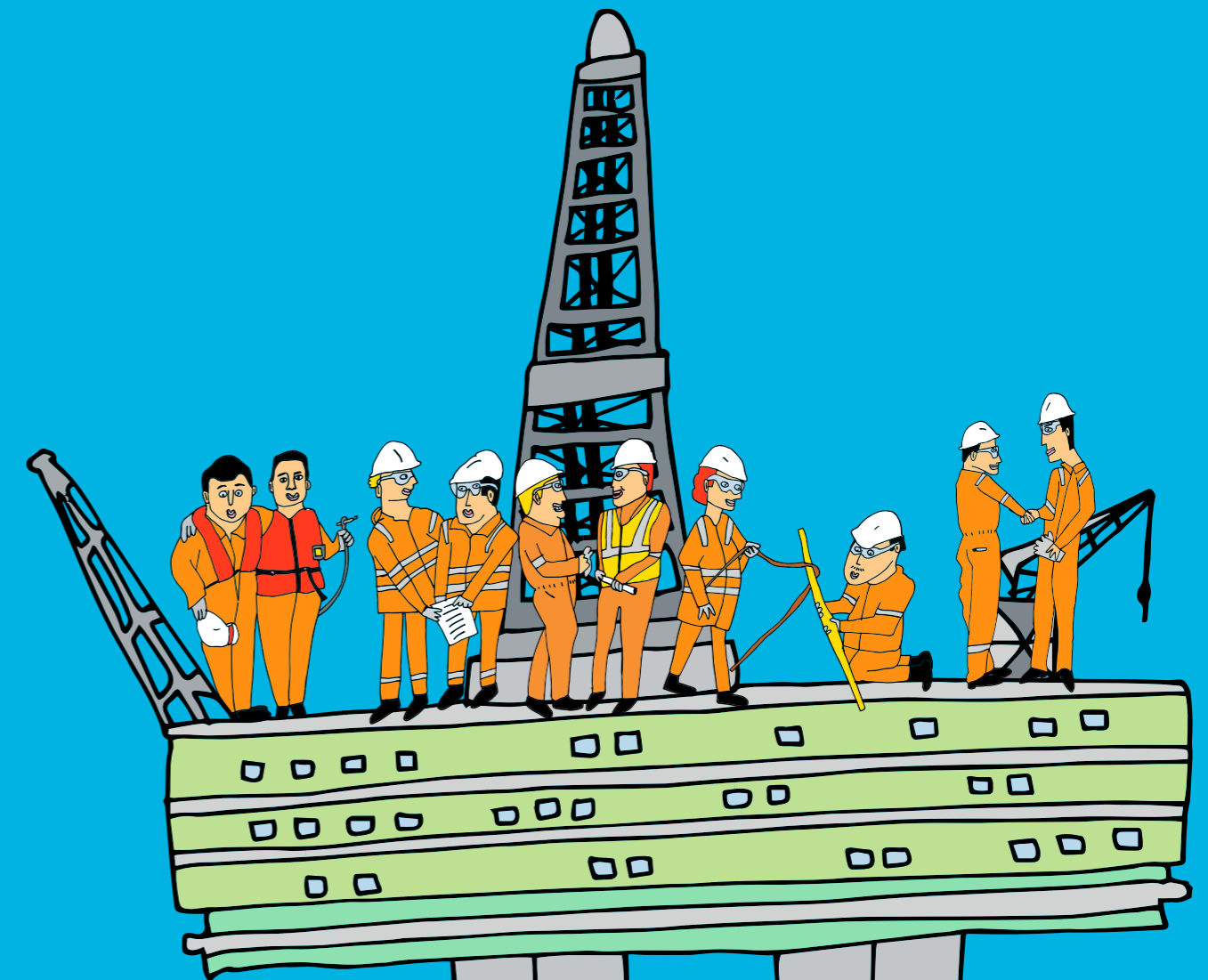
A: I’m undoubtedly going to have to re-educate myself. Fantastic advances have been made in my field. Big changes occurred during my career as a geologist – from working with coloured pencils

in the early 1990s to sitting with multiple displays and working in several dimensions. Returning to a profession where my knowledge derives from some time in the 1990s could be a big challenge.

Q: Is the NPD well supplied with specialists to meet the challenges of the next few years?

A: I’m impressed at how knowledgeable all the new staff we’ve managed to recruit are. And I’m also pleased that we’ve managed to retain many of the able people who’ve been here a while.

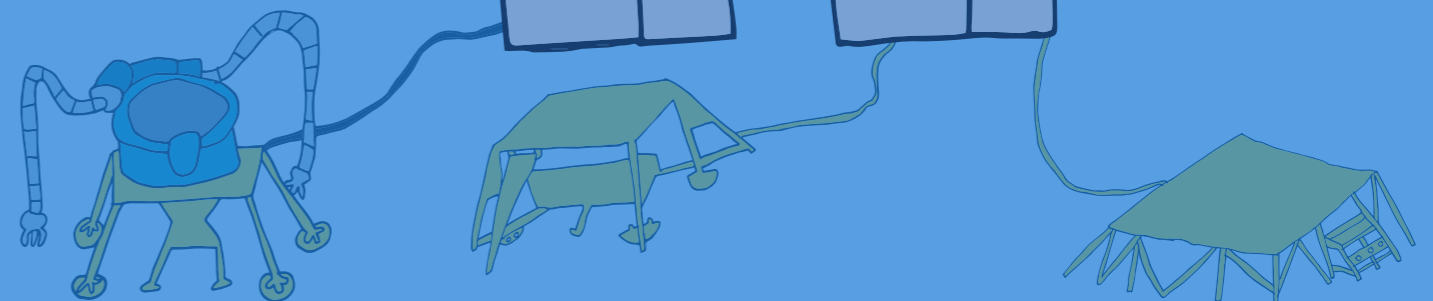
We have little turnover. That indicates we’re doing something right, and not least that we offer many highly interesting jobs. New recruits to the oil company don’t get the same opportunity to work at the interface between profession, politics and administration.



Broad-minded quintet

Five operators on the NCS have lifted their gaze from their individual fields and finds to view a complete quadrant as a whole. The result could be a bigger cake for everyone.

| Astri Sivertsen and Anette Moi (illustration)



Collective effort. Five North Sea operators have collaborated in an area forum for 18 months to outline joint solutions.



Presided. Karel Schothorst served as the first chair of the first NCS area forum.

“It’s incredibly important to keep information at a high and simple level.”

Need for more coordination

The NPD is urging operators on the NCS to join forces in finding solutions for areas larger than a single production licence, discovery or field.

“Companies often sit in their own boxes and draw up separate plans,” says Tomas Mørch, NPD director for North Sea north. He signed the letter to the five quadrant-35 operators 18 months ago.

“The goal of coordination is to exploit existing capacity as well as possible, and not to develop more than necessary. That can increase profitability for both companies and society.”

He reports that collaboration between several operators through an area forum is a new approach, and believes that the quadrant-35 companies have worked well together.

They have shared information in a good way, he notes. The NPD participates as an observer in some of the forum meetings, except those which rank as internal working sessions.

“We’ve kick-started the work and followed it up,” Mørch says. “But it’s the companies which have done the job.”

“When the decisions are due to be taken in the various production licences, we could well see good and long-term solutions for both companies and society.”

He adds that experience with the area forum is extremely good, and that the NPD wants to use the lessons learnt to get similar arenas established in other parts of the NCS.

GDF Suez, Statoil, Wintershall, RWE-DEA and Eni are all operators in quadrant 35 in the north-eastern North Sea. This embraces producers Gjoa and Vega as well as the Skarfjell, Astero, Titan, Grosbeak, Afrodite and Aurora discoveries.

Operated by GDF Suez, the Gjoa platform is the only processing facility in the area at the moment and has spare capacity as oil output from the three-year-old field declines.

This can be exploited by other companies with nearby discoveries, but its use would normally be governed by the first-come, first-served principle enshrined in the regulations.

That means the first to secure a tie-in agreement with the Gjoa licensee could also determine to a great extent how these facilities are to be utilised.

According to Karel Schothorst, project manager for Gjoa area development at GDF Suez, the result could be sub-optimum and even prevent others from securing a tie-in for a long time.

Instead, the five operators sat down together 18 months ago in an area forum to take a broad view and to outline solutions which can benefit everyone.

Collaborate

This arena was established at the initiative of the NPD, which wrote to the five operators urging them to collaborate over developing all the resources in the quadrant.

“That letter did wonders,” says Schothorst. “We wouldn’t have had a forum or established such broad cooperation between so many operators without it.”

“If we or one of the others in the area had proposed this ourselves, it would have taken a long time to create the trust needed for a good dialogue.”

As it was, GDF Suez took up the NPD’s gauntlet and persuaded the others to join in. Schothorst himself served as the forum’s first chair.

He says the initiative was timely, given six discoveries available for development in an area with spare capacity and infrastructure. The need to collaborate was clear.

The quintet’s first step was to draw up a charter or statement of purpose, followed by a road map for the way the forum was to develop and rules to govern their interaction.

Commercial discussions were prohibited within the arena, for instance. Nor was it permitted to promote one’s own concepts and solutions.

“That often leads to a dialogue for or against, instead of a focus on facts, common issues and possible synergies,” Schothorst says. “Some try to convince others, which isn’t fruitful.”

Instead, he explains, the participants assumed they were all licensees for every discovery in the area. A real area perspective meant it did not matter which reservoir the oil and gas came from.

Another important consideration was to withstand the urge to start acquiring data, which is usually the first impulse of engineers when they get together.

“You can be completely sidetracked by data, and are never satisfied,” warns Schothorst. “It’s not even certain that you need all this information.”

“But the worst aspect is that excessive data undermine scenario thinking. It’s incredibly important to keep information at a high and simple level.”

When the work began, the companies where only asked to provide details about the reserve base for the individual fields and finds, and an estimate of when these might come on stream.

“That was all we shared, and it proved possible to have very meaningful discussions on that basis,” Schothorst explains.

Profiles

The forum produced what he calls synthetic or generic profiles for all the oil and gas volumes, and then added these all up in order to identify spare capacity and bottlenecks.

This exercise also showed which parameters were important to follow up, and made it possible to come up with ideas on how the area could best be developed.

Starting cautiously with relatively little information also helped to build trust, Schothorst maintains. When participants learn more than they reveal, they see that cooperation pays off.

That can then encourage them to extend their collaboration, rather in the same way that a fly wheel steadily picks up more and more speed.

The partners issued their first report in October, which identified opportunities for and constraints on and future solutions in the area.

Specific field development concepts have been suggested. The licensees for the Wintershall-operated Skarfjell discovery, for example, are doing a feasibility

study of various options.

One case involves a Skarfjell project related to Gjoa and the Titan and Astero finds. Building on the forum’s work, this concept will be pursued by an engineering study in the licence.

Results

A development concept will normally depend on results from wildcat and appraisal wells. Waiting for these to be drilled is natural, since much more is then known about what can be recovered and how.

But the area forum felt it was useful to have an dialogue on the opportunities in advance. The scenarios are so well defined that well information will not make much difference in any event.

“We’ve saved huge amounts of time in terms of area solutions by not waiting for results from these wells to come in,” Schothorst emphasises.

“Everyone agrees that doing this exercise before drilling has been completed, before we know too much, is actually an important lesson for success as a forum.”

In his view, the companies would have had a less open attitude if they had waited. They would have been constrained by internal processes and expectations from owners and other stakeholders.

The forum was also assisted by a neutral, independent strategy consultant. This helped to keep the process at a high and conceptual level and strengthened trust between the participants.

All the information generated by the forum has been shared between some 15 licensees in the area, with minutes of meetings and other documents posted to the joint License2Share website. Biannual status meetings have also taken place with the licensees.

The forum will continue as long as it is needed, with the chair rotating on an annual basis. Statoil took over in October, and

the aim is for each company to hold this post once.

No decisions

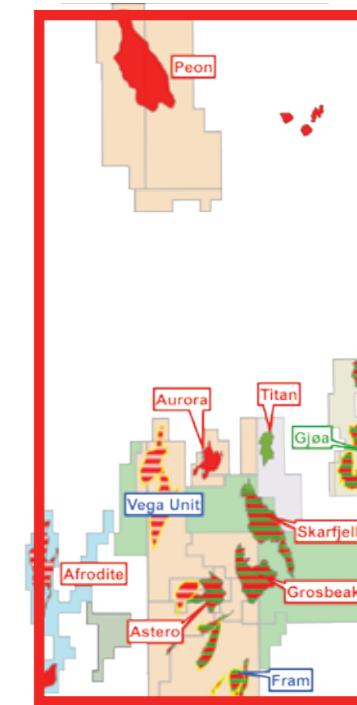
The forum members have made it clear all along that they take no decisions. Development solutions for each discovery are studied and determined by the relevant production licence.

According to Schothorst, the forum is neither a waste of time nor a “super licence” which takes decisions over the heads of the licensees.

“What we do is to secure a coherent area perspective and insights for the benefit of all the licensees,” he emphasises.

Although some of the companies possess more knowledge and experience than others, he is convinced that all the participants have benefited greatly from the work.

“The better we collectively understand the area, the better and more rational decisions we’ll be able to take and the greater our chances are of finding optimum solutions. The cake can then be bigger for all of us.”



Big reserves. Quadrant 35 is estimated to contain some 500 million barrels of proven but undeveloped oil equivalent.

Science of persuasion

Five dedicated teachers with an enthusiasm for their subject have created a “researcher” programme at Drammen College of Further Education near Oslo. It now sends more pupils to Norway’s premier technical university than any other school in the country.

| Tonje Pedersen and Bård Gudim (photos)

When students from Drammen arrive today at the Norwegian University of Science and Technology (NTNU) in Trondheim, they are told that “half the town” is already taking courses there.

For some reason, these youngsters have grasped that Norway’s shortage of engineers gives them the prospect of very good jobs and that science studies are fun.

That may be because of keen teachers with science MScs, or because industry has provided backing in the form of study trips to universities and very informative company visits.

In any event, the Drammen school has achieved what others only dream of doing. Students apply to study there because of its researcher specialisation.

While only 30 per cent of pupils at the college took science subjects before the new course offered teaching tailored for engineering studies, that proportion is now up to 40 per cent.

Pressure

“There’s a bit of pressure in our class,” says student Jenny Røste. “You don’t turn up for a test without having done the preparatory work.”

She is in the first batch of stu-

dents to complete the three-year researcher specialisation at the Drammen college, and has been using science in her daily life from the start.

That has been accomplished through various chemistry experiments, demanding engineering studies and a physics-based philosophy about how the world functions.

The course was set up in the 2010-11 academic year to provide special expertise in various subjects – technology and research, mathematics, physics, chemistry and international English/biology.

A one-off grant of NOK 350 000 from Buskerud county council, which embraces Drammen, helped to set up the course, but it is now funded over the college’s regular budget.

The concept was hatched by three science teachers following the establishment of a new curriculum programme on technology and research learning (TOF) in Norway.

This subject forms the thread running through the specialisation, and means in practice five hours of “engineering subjects” a week – the high point of the course for its students.

They spend these hours building bridges in spaghetti, designing

electric cars and constructing horizontal wind turbines. Their imaginations are the only restriction.

“It’s exciting to build and design things,” says Røste, who is now going to take extra subjects in order to qualify for veterinarian studies.

“When we were building a bridge, for instance, the first step was to design it on a computer. Then we assembled the spaghetti in triangles to make the structure as strong as possible.”

The researcher course suits pupils who liked science and maths in secondary school, and who want degrees and careers in such fields as environmental science, technology or medicine.

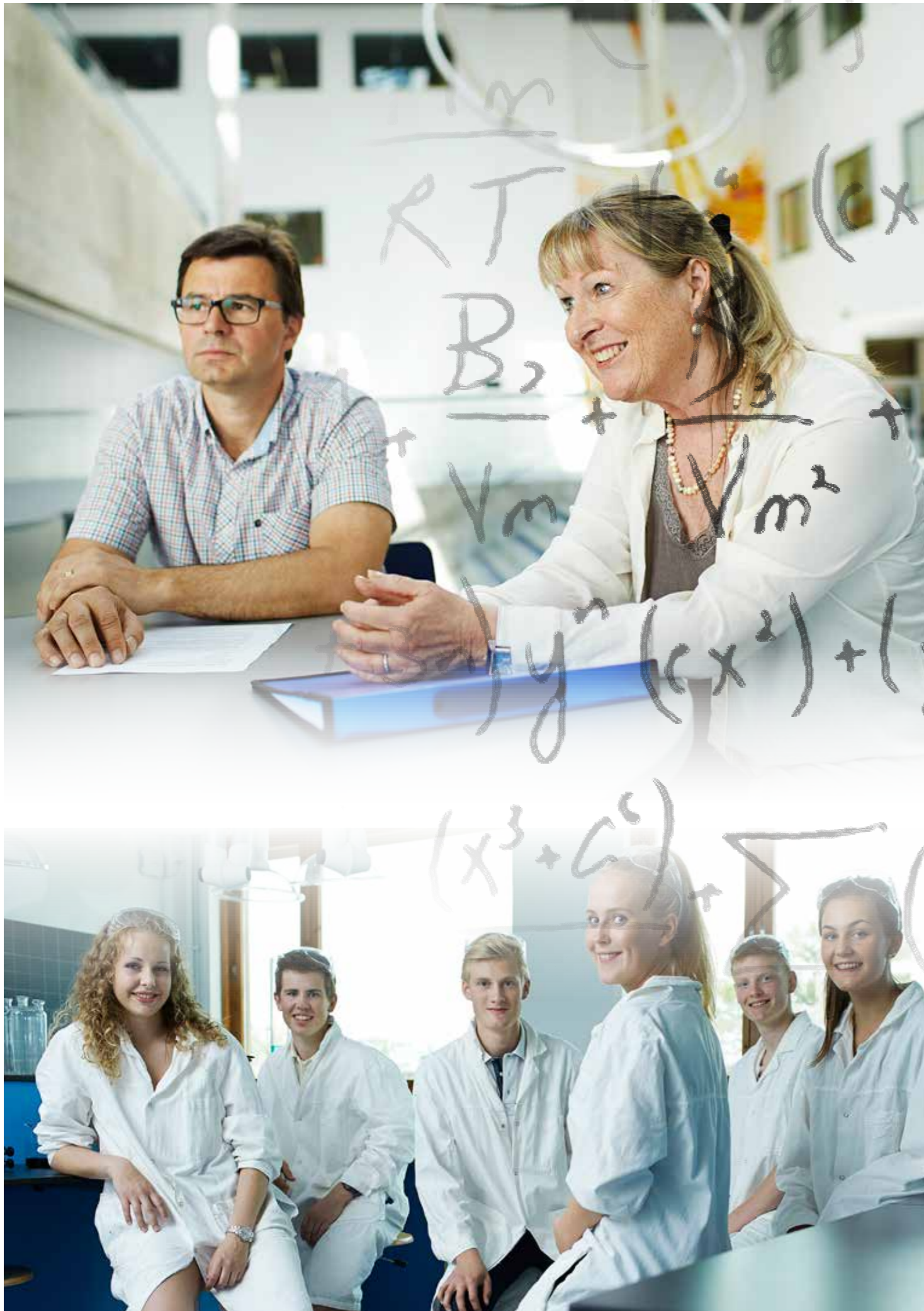
Not everyone wants to be an engineer, of course. Those who are planning to be doctors or veterinarians, for instance, switch to other specialised science-oriented programmes. So flexibility is very much the order of the day.

“I took the researcher course in my first year at college, but switched to more specialised science-related studies in the second year,” another student reports.

“The curriculum is fixed in the researcher programme, while the regular courses allowed me to choose between sciences and such

Facilitators (top left). Careers advisers Trond Kårbø and Anne Vaagland Sørlien work to promote science subjects at Drammen College of Further Education. Openness, discussion groups, close collaboration with industry and class visits by engineers can boost interest, they maintain.

Conscious (left). Forty per cent of the Drammen college’s pupils opt for science studies. From left: Jenny Røste, Jørgen Gustavsen, Lars Petter Johnsen, Viljar Monason Bjørge, Anne Line Hexeberg Henriksen and Jenny Torckveen are either in the researcher programme or taking normal science subjects.





Chemist (top). Jørgen Gustavsen is Buskerud's chemical champion and now ready for the NTNU.

Anthem (above). A growing number of pupils at the Drammen college are opting for chemistry. When Anne Line Hexeberg Henriksen and Viljar Monason Bjørge get difficult experiments right, their teacher urges the whole class to stand and sing the national anthem

subjects as language, sociology and economics."

Like many other students, he felt it was important to be able to take international English. This and biology have accordingly been included as third-year options from 2013-14.

Wide range

Students engage in a wide range of research activities, from design and construction using 3D programmes to get the right angles, via lifestyle and blood sugar levels, to build electric cars through mechanical assembly, soldering and wiring.

"This specialisation is very popular," reports careers adviser Anne Vaagland Sørlien. "You need good marks from secondary school to get in, because the number of places is limited."

She has worked at the college since 1999, and is experiencing sweeping changes in her role. In her view, the school's science commitment has enhanced its status.

At the same time, the job of the careers advisers and the college is to highlight the need for engineers in Norwegian society.

"As advisers, we're responsible for two things: telling the students what jobs are needed, and ensuring that they're not over-ambitious in their choices.

"They have to complete three years and pass the final exams, and we've got to help them make the right decisions so that they succeed in getting through."

Practical

Careers advisers at the college work closely with the secondary schools in Buskerud, and visits by pupils from the latter provide practical insights into further education. They get to meet college students and join lessons on subjects of their choice.

The ablest final-year students in secondary school can now opt for a fast stream in maths and English, which allows them to take these subjects at first-year level in further education.

"This project has only just been launched, but we're very confident that it'll help to boost interest in science and languages," says Sørlien.

"What an opportunity," enthuses Røste, whose own class did not have such a chance. "I'd love to have done that. It's no longer embarrassing to

be clever, but more a source of pride."

A school adviser used to provide guidance both on future job opportunities and on social welfare, but these aspects have now been separated in Buskerud's further education colleges.

That means they can specialise much more, says Sørlien. "This job undoubtedly used to be more a form of semi-retirement. You now need expertise on careers or social welfare advice.

"As advisers, we work the whole time to expand the services we offer and to find attractive new solutions for the students. A lot's happening in this field."

First-year students at the Drammen college have a reception conversation with a careers adviser when the school year begins in order to clarify expectations and provide guidance.

"We ask them a bit about goals and ambitions, what they're interested in and what job they'd like in the future," explains Sørlien.

"If they say they want to work in TV, for instance, we ask them whether they know what the labour market is like in that field. Young people are usually well informed."

Parents are also invited for an initial conversation together with their child and the contact teacher in order to review opportunities at the college and expectations of the student.

A local jobs fair is organised by the college every other year with industry in Buskerud and university representatives to inform students about available educational choices.

"The NTNU gets a full house," says Trond Kårbø, the college's other careers adviser. "Students flock to its stand and want to know everything about Trondheim and engineering studies."

He also teaches first-year maths, and says he has to be sharp. "The students are intelligent and expect a high academic level. That makes the job particularly interesting and demanding."

During their course, the students visit companies and the NTNU as well as gaining practical experience with potential employers. That teaches them how industry functions and who is of interest.

"This is an attractive group of students, and companies are keen to get to know them," says Kårbø. "We've

got Aker Subsea here in Drammen, for instance. It's given us full support."

Commitment

The students praise the commitment of their science teachers, who do not give up until the solutions to the many mysteries of physics and chemistry have been found.

"When we accomplish something we've worked on for a while, one of the teachers gets so enthusiastic that we have to stand and sing the national anthem," claims Jenny Torkveien.

The other students laugh, and point to chemistry teacher Trond Olav Stensen. His classes are very popular, and he is pleased that the subject generates involvement.

"These pupils are particularly able," he observes. "We're lucky to get to work with them. Many achieve top marks in the most demanding subjects."

But a lot of the students find physics offers them that little extra stimulation. They include Jørgen Gustavsen, a third-year student who aims to study at the NTNU.

"I'm undoubtedly fondest of physics. It's about seeing how things hang together, and we get an expanded understanding. That's very interesting.

"I think I'll get into the NTNU, and know that I want to be an engineer. An oil company gave me a work experience job last year, which provided me with contacts and goals to pursue."

Although many pupils in Norway drop science studies in further education college, the Drammen students believe that this is more about lack of self-confidence.

"Some people feel science is difficult, and don't think they can manage it," says Torkveien. "They believe it's worse than it actually is."

Students taking the research specialisation find that a number of their fellows shift to other courses after the first year, she adds.

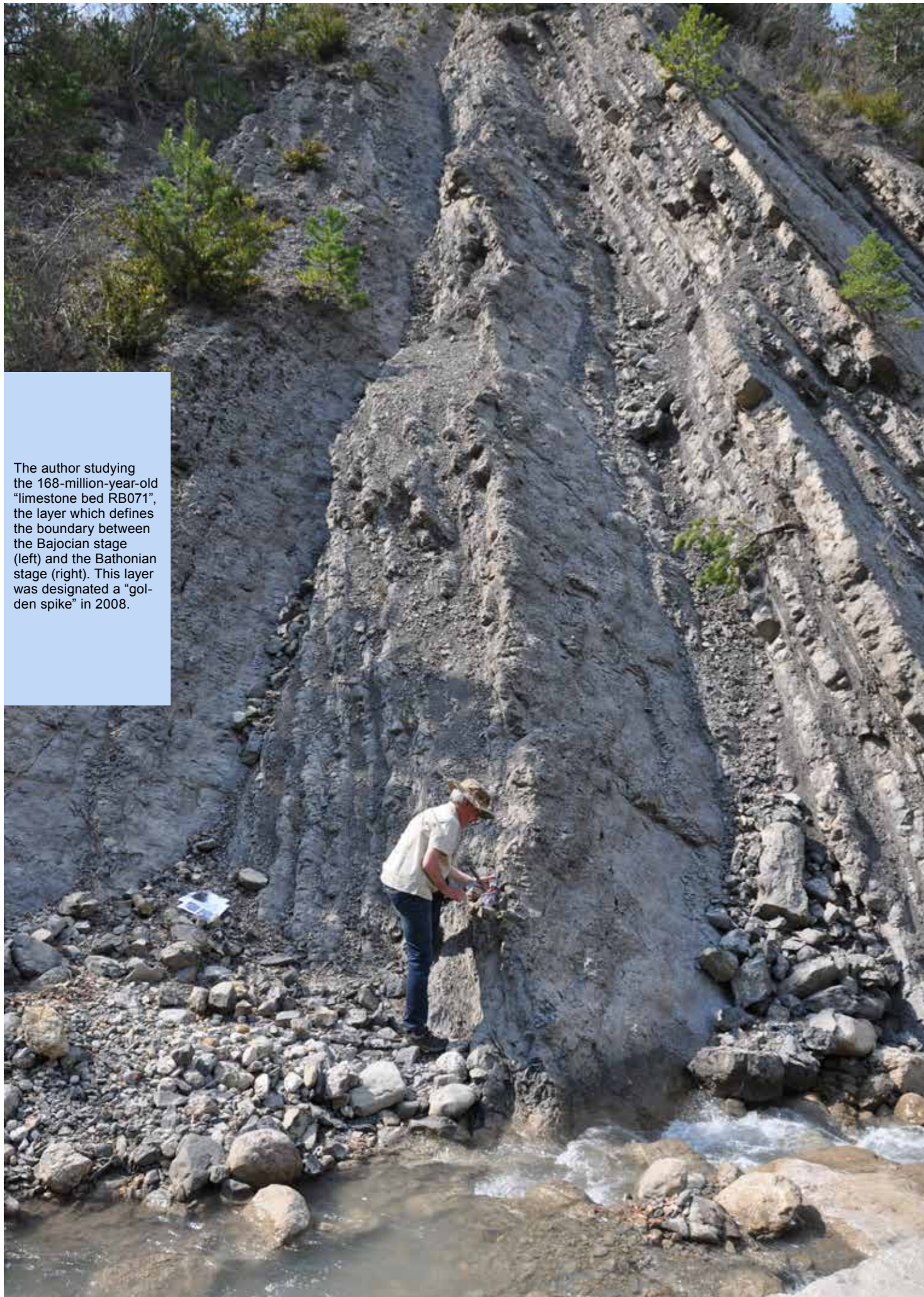
"There's a pressure to study here, and we must keep up from the start. Although most assignments are tackled individually, we do collaborate – either via the web and Facebook or in groups.

"We're good at helping each other to progress. Everyone knows that the only thing which matters is to do well, and to work steadily and proficiently throughout the year."

Seeing the connections

Distance need not be a barrier in geological interpretation. This point is borne out by a thin layer of rock in south-east France, which marks an important point in geological time on the NCS.

| Robert W Williams and Bjørn Rasen (photos)



The author studying the 168-million-year-old "limestone bed RB071", the layer which defines the boundary between the Bajocian stage (left) and the Bathonian stage (right). This layer was designated a "golden spike" in 2008.

This is the fourth article in a series on global boundary stratotype sections and points, informally called "golden spikes". These define boundaries in the geological time scale, which is divided into roughly 100 sections.

Previous articles are available at www.npd.no/publications:

Spiking the strata (*Norwegian Continental Shelf*, no 1, 2005)

Water world (*Norwegian Continental Shelf*, no 2, 2008)

Going green (*Norwegian Continental Shelf*, no 2, 2012)

How could the fossil content of rocks in the French region of Provence have anything to say about the way geologists interpret a particular depositional stage off Norway?

Moreover, why is this special point in time named not after the village where it is defined but for the city of Bath in the UK?

Curiously, the answers have to do with the slow northward drift of Africa and the birth of geology as a field of scientific inquiry.

The excruciatingly slow collision of the African and European continents created the Alps, and exposed an extraordinary record of Europe's geological past.

That in turn was crucial to the development of geology in the 19th century. These mountains lay bare a vast expanse of the Earth's history in the form of folded, buckled and fractured strata.

Some of the rocks forming magnificent Alpine vistas from the Gorenjska region of Slovenia

to the Provence Alps of France were once soft mud on the floor of an ocean now squeezed into oblivion.

The colossal energy of a continental mash-up has compressed crystalline basement rocks and overlying sediments like an accordion, and thereby given birth to a mountain chain.

Sun-washed

The Asse de Clumanc and Asse de Blioux waterways in south-east France merge to form the river Asse. At their confluence stands Barrême, a quiet Provençal village of centuries-old buildings built of pastel masonry with a sun-washed patina.

A curious feature of Barrême's public spaces is decorative displays of C-shaped, horn-like fossils almost a metre tall. They were once ammonites, shelled octopi which gradually died out toward the end of the Cretaceous.

Fifty-nine million years before

the ammonites went extinct, this C-shaped species was common when the Alpes-de-Haute-Provence region was a flat, muddy sea floor.

The rocks under Barrême received international recognition 140 years ago, because these fossils showed that the layers there were a previously unknown section of the Lower Cretaceous.

That is why the name of this medieval town is familiar worldwide to geologists in its adjectival form of "barremian".

Le Barrémien is a group of strata defined in 1873 by the French geologist Henry Coquand, and ranks as the fourth of six stages in the Lower Cretaceous series.

Set

To a geologist, a stage is a set of rock beds which contain specific fossil species, while a series represents a group of such stages.

This classification scheme



Rising landscape. The Provence Alps of France were once soft mud on the floor of an ocean.

began when early 19th-century geologists showed that the vertical and horizontal distribution of fossil species and rock types was the key to unlocking Earth's history.

Geological mapping proved an essential tool, which transformed geology into a mainstream science.

But 19th-century geologists employed only the relative ages of rocks to decipher deep time. There was no knowledge about or technology available to measure absolute ages.

Early stratigraphic nomenclature dealt with rock characteristics and the chronologic succession of fossil species – parameters which geologists could observe in the field.

Erathems, systems, series and stages became standard terms for discussing sedimentary rocks. The first to discover and define new rock intervals such as series and stages also had the honour of

naming them.

These designations were often derived from geographical regions, or even from cities and villages which lay near the rock sections.

The 20th century's advances in nuclear physics would provide the technology to measure the ages of rocks in millions of years. Absolute age dating opened a window to Earth history which allowed more detailed mapping.

Geological time units (eras, periods, epochs and ages) became meaningful units as geophysicists steadily improved the accuracy of radioisotope age dating.

Enhanced data quality over the past 50 years prompted a revision of the nomenclature used for rock and time subdivisions. This process became the mandate of the International Commission on Stratigraphy (ICS).

Through specialist subcommittees, the ICS refines global

rock units (systems, series and stages) to make them applicable over the entire Earth.

To define a stage boundary, geologists nominate several candidate sedimentary sections to an ICS subcommittee. The requirements are stringent.

For the ICS to approve a section, the defining layer must hold at least one fossil event (for example, the oldest appearance of a particular microfossil) which occurs at the same time in deposits worldwide.

The transition to the older stage below must also have no missing layers, and volcanic ash must be present because it contains unstable elements which permit absolute ages to be determined for the fossils.

Finally, the candidate section must lie in an area which has political stability and infrastructure, and which allows access to the rocks.

Defining

The ICS calls the defining layer a global stratotype section and point (GSSP). A geologist once described a GSSP as a “golden spike” because it is metaphorically like a nail hammered into the rock to mark a boundary between two geological units.

With their definitions based on global fossil events and absolute dates, these spikes provide geoscientists with a global standard for geological mapping.

Previously, for example, geologists working on the NCS used the definition of both the Volgian and the Portlandian stages to denote the uppermost section of the Jurassic.

Fossil ammonites found in northern Europe and Asia prove effective markers for local Volgian beds. Unfortunately, these ammonite species are absent in southern latitudes.

In the UK, the Portlandian stage covers almost the same interval as the Volgian, but the definition is based on ammonites which did not mix with their contemporaries in other realms.

Ammonites which preferred the southern Jurassic ocean (later eliminated by the collision between Africa and Europe) define the Tithonian stage in low latitudes.

In Europe alone, therefore, the Volgian, Portlandian and Tithonian stages are overlapping but not identical intervals of rock and time. To make matters worse, the European stages overlap with others throughout the world.

So what happened to Henry Coquand's Le Barrémien after the advent of golden spikes? His strata near the village actually fails to satisfy all the criteria for a GSSP.

While the Barremian stage will retain its name, however, the ICS will probably award the golden spike to a rock outcrop in the Spanish province of Murcia.

But its rich Provençal geology has nevertheless ensured that the village of Barrême won gold after all – but just not for the Barremian stage.

In 2008, the ICS awarded it a completely unrelated GSSP locat-



Ancient decor. Public spaces in Barrême are ornamented with fossil ammonites (extinct shelled octopi) around 127 million years old.

ed in the nearby Ravin du Bès, where the steep cliffs comprise thin layers of light and dark marl.

These alternating shades of grey form a parallel striped pattern which resembles a gigantic geological bar code, and the golden spike layer is 168 million years old.

Thirty-nine million years older than the Barremian stage, it defines the base of the Bathonian stage in the Middle Jurassic.

Belgian geologist d'Omalius d'Halloy proposed the name Bathonian in 1843 after the "Bath Oolite" limestone near the city of that name in south-west England.

This 167-million-year old limestone gives the local buildings their characteristic warm colour. It represents a group of marine beds containing a characteristic fossil fauna.

The Bathonian stage plays an important role on the NCS, since it lies in the middle of the very sandy series called the Middle Jurassic.

These sands contain more than 60 per cent of Norway's petroleum reserves, and it is fascinating to think that this stage was discovered as far back as 1843.

Originally identified in the UK, it is now defined officially by a thin layer of marl in a rugged ravine five kilometres downstream from Barrême.

Because of its wide-ranging geology, France has been awarded six GSSPs by the ICS, including two in the Cretaceous (with the ICS currently assessing three additional candidates there).

In addition come one in the Jurassic (with two additional candidates), one at the Devonian-Carboniferous boundary and two more for the uppermost stages of the Devonian.

If all the candidate sections are also accepted, France will rank alongside Italy and the UK as the leading countries for accommodating golden spikes.

Many charming names

Geological mapping became a tool of scientific knowledge and economic expansion in Europe at the end of the 18th century. So it is not surprising that early geologists named some rock units after towns, mountains and peoples in Alpine regions where sediments were well exposed.

For example, the Jurassic system is named after the Jura Mountains of Switzerland. The Ladinian stage (Middle Triassic) honours the Ladin people of south Tyrol.

In addition, the Aptian stage (Lower Cretaceous) is named after the village of Apt, in the Provence-Alpes-Côte d'Azur region of south-east France.

Civilisation on the edge

The puzzle-pieces of crustal plates even affected the birth of civilisation. Eleven of the 13 most important civilisations of the ancient world were located along boundaries between the African, Arabian and European plates.

Crustal movements in these earthquake-prone regions repeatedly destroyed ancient cities, and the question is then why early civilisation was attracted to these danger zones.

The answer could be that giant aquifers and rich deposits of metals are concentrated in fault zones along plate boundaries. These resources formed the foundations for commerce and power.

Of time and rock

Ages and stages – what is the difference? In the field of chronostratigraphy, the first involves time and the other rocks in the hierarchy of units.

The Phanerozoic eonothem consists of all the rocks deposited during the Phanerozoic eon, which includes the Mesozoic erathem (all the rocks formed during the Mesozoic era).

Part of the latter is in turn the Jurassic system (all the rocks formed during that period), including the Middle Jurassic series (all the rocks formed during this epoch).

And the Middle Jurassic incorporates the Bathonian stage, which consists of all the rocks formed during the age of that name.



Valuable. Fossil ammonite on the boundary between Bajocian and Bathonian.



Belgian geologist Jean Baptiste Julien d'Omalius d'Halloy (1783-1875) named the Bathonian stage in 1843 after the UK city of Bath. (Photo: Wikipedia Commons)

Figuring the forecasts

One of the most important inputs to Norway's national planning budget comes from the NPD. But Tom Andersen and his colleagues must first analyse huge volumes of oil company data.

| Bjørn Rasen and Emile Ashley (photos)



Independent. "The operators report their view of the position," observes Tom Andersen. "We make our own assessments of what the future will look like."



“ I thought I’d never be producing another forecast about growing oil production. ‘Johan Sverdrup’ certainly overturned that expectation elegantly. ”

Administration. One of the most important jobs for the NPD, and for Tom Andersen, is to maintain an overall view of petroleum resources on the NCS. The goal is to administer these assets in the best possible way for society.

The oil and gas sector accounts for a third of the Norwegian economy, and offshore revenues are highly significant for national prosperity.

Staggering sums flow from Norway’s energy-intensive resources. Inputs based on conditions in this industry weigh heavily in the national planning budget.

But somebody has to do the far-reaching job of collecting and analysing the figures from various activities related to the NCS – and develop forecasts from them.

“Many people know a lot about the NCS, but want to know everything,” says Andersen, a reservoir engineer who has long played a key role in this work.

Joining the NPD’s development department 22 years ago, he subsequently followed up companies

with chalk fields, such as Ekofisk and Eldfisk.

“During the decade I worked on that, the reserves increased by 100 million cubic metres [625 million barrels] of oil. Those were exciting times.”

The NPD collects and analyses data from operators on the NCS and compares this material with its own information and forecasts.

Andersen notes that these data represent an important management tool for the oil industry and a significant input to the government’s budgets and petroleum policies.

He is surprised over the lack of public debate about the forecasts for developments on the NCS, given that “these are important figures for the Norwegian economy”.

Autumn

All the operators on the NCS submit information and forecasts every autumn for their fields, discoveries and transport systems.

This includes reserves, both in place and recoverable, in each field and discovery as well as high and low estimates for these assets.

Recoverable petroleum resources are classified in accordance with the NPD’s system, which sorts them by maturity or status in relation to decisions by the relevant licensees.

With the companies also reporting predictions for production, costs and emissions/discharges to the environment, all this material is reviewed with a critical eye by the NPD.

Company and government forecasts differ. As Andersen says, “com-

pany attention is focused on projects, and their views are based on their own goals and plans.

“These are often a little optimistic. That’s probably inevitable in the nature of things, but we make our own adjustments.”

He nevertheless emphasises that a trusting relationship exists between the companies and the NPD, which means “that we get good data from them.”

“We don’t release any figures for individual projects. We publish resource estimates for fields and discoveries, but no further details.”

Pessimistic

Oil production forecasts are the NPD’s oldest series of figures, starting in the 1970s when the agency was over-optimistic about how fast output would rise and too pessimistic in the long term.

During the two subsequent decades, the predictions were both too low and too high. In recent years, the short-term forecasts have been accurate to within plus/minus five per cent.

But the surprises are never far away. The biggest is called “Johan Sverdrup” and is a coming field in the North Sea.

“I thought I’d never be producing another forecast about growing oil production,” says Andersen. “Johan Sverdrup’ certainly overturned that expectation elegantly.”

“As things look today, we could see a small increase in output around 2020. In the shorter term, next year’s production curve may also turn a little upwards.”

But he nevertheless believes that peak oil has passed on the NCS – although when that point was reached is a recurring topic of discussion.

Andersen has the answer.

Production reached its highest level in 2000 – a leap year, which meant the biggest output in a single day fell in 2001.

“Only a few barrels separated those two years, so the extra day in 2000 made the difference.”

However, Andersen is not ready to express either confidence in or doubts about oil prices. “Many people think a lot about the oil price, but we don’t produce any forecasts on that subject.”

The companies had a reporting deadline of 15 October, while the NPD’s contribution to the revised national planning budget is due no later than 31 December. So Andersen and his colleagues face the usual hectic Christmas period.

“ Many people know a lot about the NCS, but want to know everything. ”

Pumping down. Operator Jan Renzelmann ensures that the liquid is pumped into the facility.



Thicker than water

Fungi can have so many uses. They include helping to improve oil recovery, if the German company pioneering this method is to be believed.

| Astri Sivertsen and Christian Burkert (photos)



The drive from Wintershall's Barnstorf office in Lower Saxony passes fields which are full of rape in the summer, but now mostly feature sunflowers and various cereals. Nodding donkeys also stand here and there in the flat landscape.

We arrive at a fenced-off area of gleaming steel piping, with three tanks standing on what looks like a lorry trailer and a handful of temporary buildings.

Here, in the midst of sleepy farms, an experiment is under way which could – if successful – have positive consequences for oil operations on the NCS.

Beneath us lies the Bockstedt oil field, which has been on stream since the 1950s. This part of the reservoir began producing in 1959, and is a mature field in its tail phase.

Most of the output – some 95-97 per cent – is in the form of water, reports Alexander Steigerwald, who heads Wintershall's oil and gas production in northern Germany.

But we are not here because of what comes up, but for what goes down. The three tanks contain a liquid which – after blending and injection below ground –

could boost oil recovery by 10 per cent. If everything goes according to plan.

This magic substance is called schizophyllan, but has nothing to do with mental health problems. Its name derives from a fungus known as *Schizophyllum commune*, or split gill.

Agents

Growing on rotten wood, this species of mushroom produces biopolymers – gelatine-like fillers which have long been used in toothpastes and cosmetics, for example.

They are also interesting for the petroleum industry as a thickening agent in the waterflooding used as the most important improved oil recovery (IOR) method on most Norwegian fields.

Since oil is usually more viscous than water, however, the latter flows more easily through the rock pores in the reservoir. That means it may go its own way rather than driving out crude.

Adding polymers thickens the water and allows it to push more oil ahead of it. Both synthetic and biological polymers are available, but Wintershall has opted for the latter.

Split gill, a frugal organism which subsists on air and starch, is cultivated at laboratories in Ludwigshafen belonging to chemical giant BASF, which also owns the oil company.

The fungus is supplied with sugar and oxygen while it ripens in tanks similar to those used by breweries, but the end product is biopolymers rather than beer.

This output is cleaned and thoroughly filtered to leave an orange fluid which can be shipped by train and specially designed lorries to the pilot facility on the Bockstedt field.

The liquid delivered from BASF contains just under one per cent of schizophyllan, with water accounting for the remainder.

It is further diluted with treated formation water at the test site, kept under a nitrogen atmosphere to keep oxygen at bay and dosed with preservative to prevent bacterial damage.

When injected, the schizophyllan content is just 0.035 per cent. But that is enough to make the water 25 times more viscous, chemical engineer and project manager Burkhard Ernst tells me.



“Preliminary results suggest that both injectivity and the injection rate are good.”

Facility. Two types of oil are produced here in Lower Saxony.

Tests

Wintershall has been researching various thickening agents since the 1980s, he adds. The schizophyllan project began in 2006, and the fungus has been through many lab tests.

Biopolymers are preferred by the company to the synthetic alternatives because they have many superior properties – including the ability to function in temperatures up to 130°C.

Synthetic polymers are less stable and disintegrate once it gets hotter than 90°C. The biological types can also cope with very saline conditions – 186 000 parts per million (ppm) of salt, as is the case in Bockstedt, presents no problem.

Finally, and not least important, Ernst emphasises that they are completely biodegradable and therefore pose no risk to the environment.

That aspect should be particularly interesting for Norway, he adds, given the strict discharge

restrictions it imposes on offshore operations.

Wintershall also has a Norwegian subsidiary, which began life in Oslo during 2006 but moved to Stavanger three years later when it acquired local oil company Revus.

It secured its first operatorship on the NCS this year when it took over from Statoil on the Brage field in the North Sea on 1 October.

The two companies also have a collaboration agreement on technology development, which includes joint research on the use of schizophyllan.

Opportunities

When I ask whether Wintershall might apply the biopolymer method on Brage, the response is that it remains too early to say. Various opportunities are under consideration.

But the Bockstedt trial must be completed first. It began in December 2012, when the first

dose containing the additive was injected into a brine reservoir 1 250 metres below ground.

The injection well is located 70 and 230 metres respectively from two production and observation wells. Roughly eight months are needed for the injection solution to reach the first production well. That timetable has so far proved correct.

The second producer will not be reached until end of next year, which will be two years after the field test has begun.

“Preliminary results suggest that both injectivity and the injection rate are good,” says Steigerwald. The mixture of biopolymer and formation water appears to flood the reservoir outside the established water channels, and behaves as expected.

The Bockstedt reservoir consists of unconsolidated sandstone at a temperature of 50-55°C, and its oil has a high paraffin content.

But the schizophyllan has not

Polymers in brief

These are natural or synthetic substances which comprise molecular chains built up from repeated structural elements formed of smaller molecules.

Examples of synthetic polymers include polyethylene, polyvinylchloride and polyamide. Among natural types are cellulose, proteins and natural rubber (caoutchouc).

Most polymers are organic, but inorganic kinds also exist – such as many natural silicates, glass, plastic sulphur and so forth.

From salt to oil

Wintershall was established in 1894 to mine salt. One of its founders was called Carl Julius Winter, and “hall” is an old German word for salt. Oil was accidentally discovered in 1930 in one of the salt mines, with gas also found in the early 1950s.

The company is now a wholly owned subsidiary of BASF, and production head Alv Bjørn Solheim in its Norwegian arm says that it accounts for 30 per cent of earnings by the chemical group.

Wintershall has identified Norway and Russia as its most important priority areas for oil and gas production, and Solheim reports that half its exploration budget is allocated to Norway.

Testing. Project manager Burkhard Ernst with a sample.



been specially formulated for this specific reservoir, Steigerwald tells me. It can be used anywhere.

The additive can also be combined with other methods for enhanced oil recovery (EOR) – the industry’s term for advanced, and often chemical, ways of getting more out of reservoirs.

At the moment, some 250 litres of the liquid are being injected every hour, and another production well is scheduled for November. The test is due to last until the end of next year.

“This trial should provide answers to the basic questions of whether the method works as we want,” says Steigerwald. “The next step is to see how much extra oil we can recover.”

Interesting

Jannicke Nilsson, senior vice president for technology at Wintershall’s partner Statoil, confirms that the biopolymer method is interesting.

“We’ve recently defined polymers as strategically significant

for us, and think that flooding with these substances has a potential both on the NCS and elsewhere.”

Statoil has earlier studied polymer use on the Grane field in the North Sea. But that project ended in 2011 because its profitability was undermined by higher costs and smaller-than-expected reserves.

At the moment, both Heidrun in the Norwegian Sea and the “Johan Sverdrup” discovery in the North Sea are regarded as possible NCS targets for the method. Other candidates could be Brazil’s Peregrino field and Dalia off Angola.

Nilsson says work on the method has come so far that it is closer to commercial adoption than other untested EOR techniques. But making it profitable could be a challenge.

“The reservoir bit is one part, but in addition comes a big package in terms of logistics, transport and emissions,” she observes.

“We must be sure that adopt-

ing biopolymers will be acceptable, and that we can do this in such a way that we’re continuing to operate safely.”

The collaboration agreement with Wintershall was entered into more than a year ago, and applies both to specific field projects and to general cooperation between the two company research teams.

A test does not mean that the method works everywhere, Nilsson adds. Since all reservoirs are different, tests must be conducted for each field.

And it is questionable how much uncertainty the companies can accept if laboratory trials represent the only support available to them.

“We must find a tool which means that we dare to take this out into the field on the basis of lab tests,” says Nilsson. “We haven’t found that yet.”

Squeezing more out

It would be possible to improve the overall recovery factor on the NCS from 50 to 60 per cent, according to Statoil. But that depends on whether such an effort can pay off.

| Astri Sivertsen (text and photo)



Purposeful. Jannicke Nilsson and Kjetil Hove have key roles in improving recovery on the NCS.

Norway's oil production has been in inexorable decline from its peak in 2001, despite the large additional discoveries made in subsequent years.

Nevertheless, Statoil's ambition is to maintain output from the fields it operates on the NCS at today's level of 1.3 million barrels of oil equivalent per day (boe/d) at least until 2020.

"New discoveries are important if we're going to reach this target over the next few years," says Kjetil Hove, vice president for North Sea east. "But recovery will also need to improve."

Statoil defines improved oil recovery (IOR) as all planned activities and measures to get more oil and gas out of fields in a profitable manner than has been forecast at any given time.

Hove's responsibilities include Oseberg and Troll, which have both won the IOR prize presented by the NPD in recognition of an extra commitment in this area.

Hydro received the award as Troll operator in 1998 for drilling horizontal wells to produce the thin oil zones in this field.

Statoil as operator won in 2012 for measures on Oseberg which included the adoption of gas injection to maintain production from the field.

When the company announced a year ago that it was aiming at a recovery factor of 60 per cent for the fields it operates, no timetable was specified for achieving this.

Whether and when it breaks the finishing tape will depend in part on the financial parameters and the price of oil and gas, says

Jannicke Nilsson, senior vice president for technology.

Since its foundation, Statoil has boosted the recovery factor from 30 per cent to more than 50 on the NCS, and by one percentage point between 2011 and 2012 alone for the fields it operates.

The company reports that this single percentage point represented 327 million boe, worth more than NOK 200 billion at an oil price of USD 100 per barrel.

But both Hove and Nilsson emphasise that economics represent the big stumbling block when seeking to improve recovery even further.

Methods

"We can certainly find methods from a technological and reservoir perspective which make it possible to achieve this," says Hove. "Reaching the final barrels profitably will be the big challenge."

Oil prices are also an important factor, Nilsson adds. If they fall to USD 60 per barrel, recovering 60 per cent of the reserves will be impossible. Costs cannot be cut enough to compensate.

"The tax regime plays a key role, too," she says. "Amendments to the rules announced earlier this year were unquestionably unfavourable for IOR. Many projects will not be as profitable as they perhaps were two years ago."

Getting more wells drilled faster on the older fields is essential for extracting their final reserves and extending their producing life, Nilsson points out.

So cost cuts are one of the

three most important measures she and Hove identify when asked how Statoil is to reach its IOR target.

This calls for more rigs, enhanced efficiency on both fixed and floating facilities, extracting more from each well and drilling more cheaply.

Expanding rig capacity has been the premier IOR measure, and Statoil has made substantial investments in new units and upgrading old drilling facilities.

The second approach involves achieving more intelligent and advanced wells through the development and testing of new technology. And cost cuts are the third, as noted above.

Initiative

Drilling and wells account for the biggest expenditure in petroleum production, so Statoil has launched an initiative to bring down costs in that area by 25 per cent.

Launched six months ago, this goal is to be reached by 2015 – primarily through simplification and standardisation.

Subsea technology currently provides an example of overly expensive solutions, says Nilsson. "We must help our suppliers to minimise tailor-made products."

"They must come up instead with standard answers so that we can get good solutions while keeping down prices. We must think simplification to cut the time taken. Simpler subsea solutions could contribute to improved recovery on many fields."

Statoil recently reviewed its technology strategy, she reports, and has changed its priorities with regard to subsea facilities.

The company will concentrate in future on technical solutions which can help to get more out of fields currently in production rather than on what it thinks may be needed 15-20 years ahead.

A great deal of work is moreover being devoted to understanding the sub-surface better by developing the mapping and modelling tools used on the fields.

Statoil will be opening a large new IOR centre in Trondheim next spring. Costing NOK 240 million, this will include an industrial computerised tomography (CT) scanner.

A hundred times more powerful than a corresponding medical machine, the latter is intended precisely to enhance knowledge of reservoir change.

"Good mapping of the sub-surface is crucial for all IOR projects," explains Hove. "Four-dimensional seismic on Troll and Oseberg, for example, has allowed us to optimise well positions."

Nilsson says that Statoil intends to adopt less traditional recovery methods – such as adding chemicals to injection water and similar approaches, often called enhanced oil recovery (EOR).

"We're currently using a great deal of produced water for injection, but other types of water could permit substantially greater utilisation of the reservoirs," she explains.

Statoil is cooperating with universities worldwide to explore such opportunities, and resolved this autumn to do more research on polymer flooding.

That technique has a great potential both on the NCS and internationally, as noted in the article entitled "Thicker than water" on page 25.

Nilsson emphasises that EOR is a small part of Statoil's IOR package, accounting for only three per cent of the additional resources it hopes to secure from all improved recovery measures.

Pilots

The company runs 60-70 pilot projects every year on new technology and methods. Some are halted before being implemented, while others continue. This can be a time-consuming process.

Statoil began research on subsea compression in the early 1990s, for example, but a plan for development and operation of such a system on Åsgard in the Norwegian Sea was only submitted in August 2012.

Much of the job involves deciding which tools are to be used and where, and the company is currently introducing a new internal method for this work.

It takes the form of a database of all existing types of equipment and technical solutions, providing a systematic overview in place of information which may be hidden away on local drives.

Statoil establishes a task force of experienced specialists for new development projects which can assess the challenges faced and

propose technology to optimise recovery from the reservoirs.

A recent example of this approach is provided with what will be the "Johan Sverdrup" development operated by the company in the North Sea.

"These specialists are highly experienced personnel who do not belong to the project team, but who can identify the challenges and the technology to overcome them," says Nilsson.

The "Johan Sverdrup" task force has already come up with several technologies which could be used on the field, including ones Statoil has not used before.

Plan

New approaches have also been adopted on existing producers, and Hove reports that an IOR plan is drawn up for every field operated by Statoil during the annual well planning process.

"The whole industry depends on keeping alive what we've got on the NCS," Nilsson adds. "To be able to tie in new discoveries, it's important that all the transport pipelines are good quality. A whole infrastructure can't be based on small developments."

Although no schedule has been set for reaching the 60 per cent target, this must clearly be achieved within the producing life of the existing facilities, Hove emphasises.

"This isn't a matter of a century, or of a decade. It's somewhere or the other between them," he notes.



Broad range. Testing the principle of a wind turbine. Fifteen-year-olds are introduced over two days to electricity generation from renewable and non-renewable energy sources as well as the formation of fossil fuels.

Room for learning

All 15-year-olds in Stavanger will now be spending two days of their school year studying energy-related science in a new facility opened at the city's Norwegian Petroleum Museum (NPM).

| Bente Bergøy and Emile Ashley (photos)

"It's taken us about a year to plan, build, outfit and equip this Newton Room – but we've also ended up with a good solution," says exhibitions head Geir Mosseige Johannesen at the NPM.

He is very pleased with the learning space, where white-coated pupils from class 9b at Tastaveden secondary school are deeply involved in practical experiments on the day I visit.

"It's not always as peaceful as this," admits Jan Kåre Rafoss, who regularly takes the class for science studies and who is now present as an observer and source of support.

"The equipment here's tip-top," he adds, looking around this addition to Norway's network of special facilities for science teaching. "I'd really like to have the same in our own school."

In addition to cupboards holding most of the requirements for practical physics experiments, the NPM's Newton Room features such advanced technical aids as an interactive whiteboard system.

Collaboration

This facility is a collaboration between the NPM, the City of Stavanger and Statoil, with the museum's own three educators responsible for the teaching.

Statoil has financed the room as part of a larger sponsorship package at the NPM, while the city is paying the salary of one of the education staff.

Norway now has more than 30 of the special Newton Rooms, a concept originally dreamt up by the First Scandinavia charitable foundation.

It aims to boost interest

among children and young people in technology, design and science through programmes driven by the youngsters themselves.

In addition to the foundation, the Newton scheme has been developed over a number of years by teachers and personnel from the industrial community.

Pupils using these facilities take a "Newton module", a multidisciplinary educational programme with the emphasis on science and technology.

"We're right at the start here, and are now testing a two-day module the museum has developed in cooperation with First Scandinavia," explains Johannesen.

"However, what the pupils learn falls within the curriculum for Norway's knowledge promotion programme in secondary

Newton



Active. Elin Rosnes in action. She is one of three museum educators who run the Newton energy room courses.



Concentrated. Pupils in experiment mode. First theory, then practice.



Educational. Emma Lysanne Bruin and Ivar Dahl have learnt about energy in the Newton Room at the Norwegian Petroleum Museum in Stavanger.

schools – in other words, what they'd learn anyway in Year 9."

They are taught, for example, about renewable energy and the formation and use of fossil fuels. The module consists of preparations at school, practical activities and teaching at the NPM, and concluding work back in the classroom.

Equipment

"This is very different from school," says Emma Lysanne Bruin from 9b, and fellow pupil Ivar Dahl agrees: "There's masses of equipment here and lots to do."

In their view, they learn better when allowed to test theoretical learning through practical assignments.

"It's also fun to work in groups,"

adds Dahl, who is not sure whether he will be continuing to study science. Bruin wants to become a researcher or an architect.

The content of the module being tried out in Stavanger is linked to a special exhibition currently being shown at the NPM under the title *Energy - problem or solution?*

"That includes asking the pupils to come up with proposals for overcoming energy problems, and then to present these to the whole class," explains Johannesen.

After a year-long pilot phase, the module will be evaluated before possible adjustments and final approval by the Norwegian Centre for Science Education at the University of Oslo.

Source site

Approved educational packages developed in the Newton network are posted in Norwegian to the www.newton.no website, allowing good solutions to be passed on to the other facilities.



Where fractions really count

Inspection tour at the Dornum gas terminal in Germany. (Photo: Emile Ashley)

The NPD's metering team can celebrate its 40th anniversary this autumn, having conducted its first formal inspection on the Ekofisk field's temporary *Gulftide* platform in October 1973.

All oil and gas output on and exports from the NCS are metered for the amount produced, the amount sold and the volume of gas yielding carbon dioxide and nitrogen oxide emissions.

These measurements form the basis for oil company revenues – and for the government's collection

of income and environmental taxes. The team's five members inspect installations offshore and terminals on land to ensure that their metering stations are within the tolerances prescribed by the regulations.

Small errors in such equipment can represent a great deal of money, and the NPD monitors 64 facilities spread between 14 operators of both Norwegian and shared fields.

These include seven satellites tied back to installations with other

owners on the UK and Danish continental shelves, and 12 land-based plants in Norway, the UK, France, Belgium and Germany.

The metering team is the driving force for national expertise development under the auspices of the Norwegian Society for Oil and Gas Measurement (NFOGM).

In addition, the NPD was one of the founders of the North Sea Flow Measurement Workshop (NSFMW), which began in 1993 with 50 participants and now regularly attracts 350 people.



Force aims to squeeze more out of the NCS. (Illustration: Anette Moi)

Chasing the residue

Two enhanced oil recovery (EOR) seminars organised by the Force collaboration have allowed petroleum engineers to share experience from field projects as well as ideas and new knowledge.

The EOR competence-building workshop during November was followed by a one-day meeting on late life – max recovery later the same month. Both took place in Stavanger.

No less than 44 companies working on the NCS belong to Force, which stands for the forum for reservoir characterisation, reservoir engineering and exploration technology cooperation.

With the NPD as its secretariat, this collaboration wants to strengthen expertise on EOR and build a professional network across the companies represented. See www.force.org.

Experience from the foam-assisted water alternating gas and silicate field pilot on Snorre in the

North Sea was presented at the first seminar. Speakers included research director Arne Skage from the University of Bergen and Tore Blaker from Statoil.

The second meeting built on a Force network which focuses on maximising recovery from mature NCS fields. It discussed where remaining oil is to be found, and which methods are needed to get out these reserves.

"We regard EOR as a very important issue," says Arne Holhjem, director of technology and the environment at the NPD. "We must collaborate better both with the industry and with research bodies to get it implemented on the NCS."

"Good discussions and exchange of knowledge through such seminars are important for optimum oil recovery from both mature fields and new developments."



Experimenting. PhD students Bergit Brattekås, Marianne Steinsbø, Jarand Gauteplass and Lars Petter Hauge spend a lot of time in the lab.

Staying the course

Many promising Norwegian petroleum students drop out to take well-paid jobs in the industry. Universities cannot compete on pay – but they can make it more attractive to study.

| Astri Sivertsen. Photos: Monica Larsen (Stavanger) and Marit Hommedal (Bergen)

Advanced arena

The four-year-old Petroleum Research School of Norway is not actually a physical facility, but a network funded by the Ministry of Petroleum and Energy, Statoil and BP.

Covering all five of the Norwegian universities which offer PhD studies in petroleum-related subjects, it offers discussion fora for these students along with seminars and courses.

A total of 360 students have so far taken advantage of the opportunities through 15 courses and meetings, and 153 of them received travel and accommodation grants to participate in 2012.

The annual seminar at the Petroleum Research School of Norway (NFIP) is aimed primarily at PhD students. But this year's event – the fourth – was also attended by people studying for an MSc.

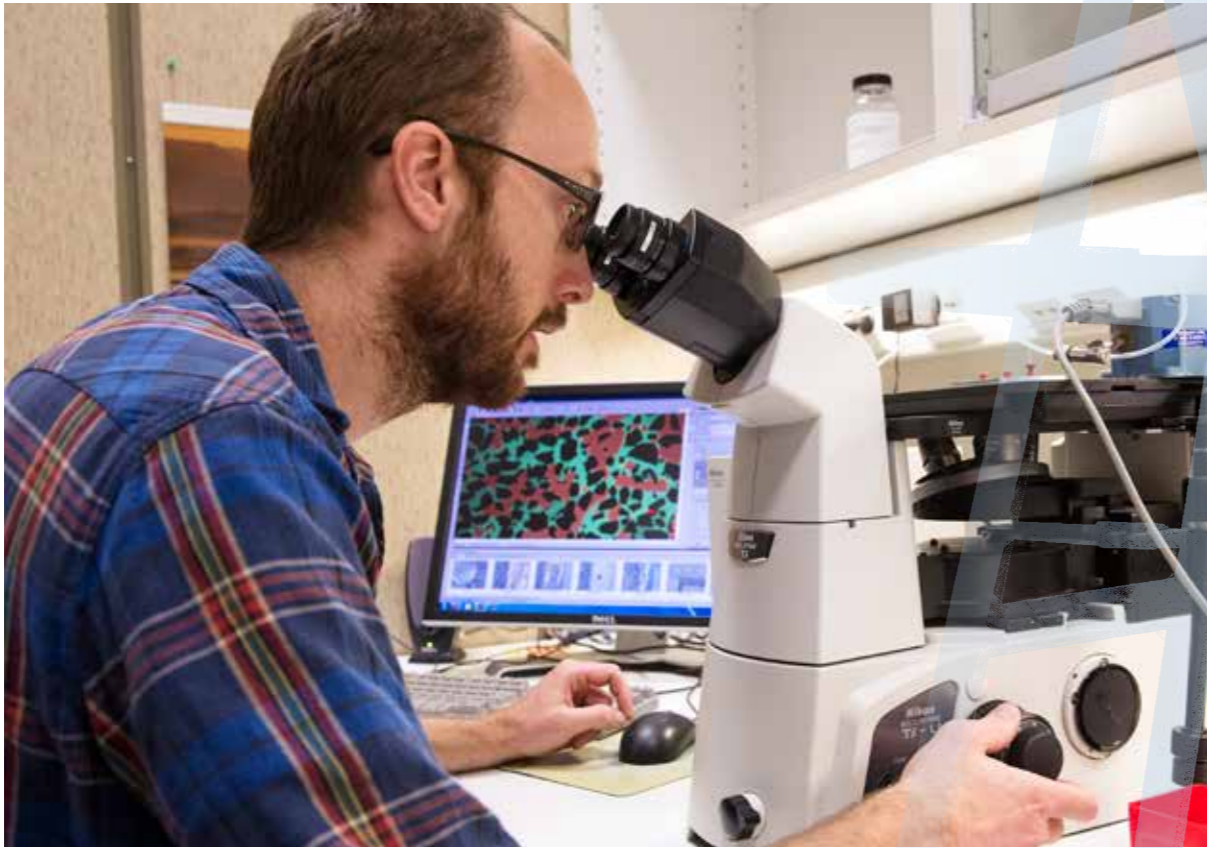
"Many students go no further than a master's, particularly in petroleum subjects, since they get job offers from the industry," explains NFIP secretariat head Martin Fernø.

An associate professor at the University of Bergen, one of the NFIP participants, he takes time out from the presentations to explain that graduates are lured away by high pay rates.

So MSc students have been invited to the October session in order to boost their interest in remaining in academia, and they make up half the 61 attending.

The other half comprises PhD students, with both groups drawn from the Universities of Tromsø, Trondheim, Stavanger and Oslo as well as Bergen.

They have joined academics, industrialists and civil servants



Tempting. Martin Fernø, associate professor in reservoir physics, says pay levels in the petroleum industry are so high that they draw students out of Norway's universities.

for the seminar at the Norwegian Petroleum Museum in Stavanger to discuss improved recovery from mature fields.

"PhD students get to see what the industry demands of them, and what terms the government sets," explains Fernø. "They encounter the whole value chain in one and the same place."

Each of them must apply to their university to include the NFIP's course in their studies. Depending on university, they get credits for attending the meetings. Writing reports and oral reviews also secures credits, Fernø says.

Useful

The seminar is useful for keeping abreast of both technological progress and industrial/economic developments, agrees Vera Iversen, one of three participants from the University of Tromsø.

Forging new contacts is naturally also important, she adds. Her everyday work involves analysing drill cores to study changes in climate and map seabed stability.

She wants to move on to a PhD when her MSc in marine geology has been completed next year, and could well imagine working on mapping for somebody like the Geological Survey of Norway.

"The whole country rests on ancient seabed, after all," Iversen points out. "And good mapping is necessary for building roads and tunnels."

Statoil does not employ applicants with just a BSc but is looking for people with doctorates, reports Øivind Fevang, one of the company's chief researchers and himself a PhD.

Education is valuable not only for working in research but also for those involved in developing new discoveries or operating producing fields, he tells the seminar audience.

"A PhD is not compulsory, but it's very advantageous," he adds. "It's essential for becoming a chief researcher, engineer or adviser."

Present

Fevang is followed by various

PhD students who present their work. They include Sirikarn Narongsirikul, due to complete her thesis on petroleum geophysics at the University of Oslo next year.

She has seven years of experience from Chevron in her native Thailand, and hopes to land a job with a major oil company after graduating.

This is her second time at the NFIP seminar, but she had not made sufficient progress with her degree work last year to be able to present it to others.

Narongsirikul is interested in four-dimensional seismic surveying, reservoir monitoring and rock physics, and is using well logs from the south-western Barents Sea in her thesis.

She finds the seminar very useful, both for training in presenting her work and in order to get acquainted with other students working on different topics with alternative approaches.

"I always get valuable feedback from people who ask whether I've tried to do it in this way or



Seriously. "We take students seriously as researchers," says professor Arne Graue.

that," she comments.

John Emeka Udegbumam, originally from Nigeria and now a doctoral research fellow at the University of Stavanger, is another of the seminar speakers.

His presentation is based on a course organised by the NFIP at the Norwegian University of Science and Technology (NTNU) in Trondheim on reservoir porosity.

This will form part of his thesis on better well design. He has participated in three of the NFIP's courses and published four articles in Society of Petroleum Engineers (SPE) journals.

According to Udegbumam, many PhD students are fed up with their studies. But meeting colleagues from other universities and having the opportunity to travel makes their lives more interesting and rewarding.

"Thanks to the NFIP, I'm working more, and more efficiently, than somebody who sits in the same place quite alone or with nobody else but their adviser," he says.

"Time goes much faster when you meet others and attend conferences, and you suddenly find yourself wishing that you had even more years available to work on your thesis."

Once he has secured his PhD, he could well imagine a career in research. But he would also like to spend a few years in the industry to see how his discipline is applied in practice.

Big demand

According to NFIP head Arne Graue, demand for places to study petroleum subjects in the department of physics and technology at the University of Bergen is high.

A professor of petroleum and process technology there, he reports that these courses attracted 268 applicants for the 60 places available this year.

"We take our students seriously as researchers," he responds when asked to explain this, and notes that all of them are able to spend time in the oil industry as part of their studies.

They can also work with equipment which the universities can only dream about, and with scientists hand-picked by the oil industry.

Finally, they are sent around the world – including to US universities, where they can stay for weeks and months.

Flexibility

During a chat with four PhD students in one of the department's labs, the two women – both mothers of small children – highlight flexibility as one of the advantages of studying there.

They both expect to be finished next year and one of them, Bergit Brattekkås, could imagine being a full-time researcher once she is qualified.

"We see that the research work we do gets used," she comments. "And what we lack here in the way of equipment and expertise can be found elsewhere."

All four emphasise the benefit of contact with the industry and other universities, and of acquiring a good network during their



studies. They also like the combination of theory and practice, and the opportunity to do experiments in the labs.

Based in one of the department's offices, four MSc students in reservoir technology estimate that they devote half their time to lab work. And three have been in the USA during their studies.

Six laboratories in the Bergen department range from a starter facility where students get an introduction to lab work, to the "experiment shop" in the basement.

The latter makes it possible to look inside rock samples using microphysics methods. To see how oil, water and gas flow through porous rocks, scientists here can study samples both to the smallest micro level and in large blocks.

At the levels in between, magnetic resonance and positron emission tomography (PET) imaging equipment at Bergen's Haukeland University Hospital can be utilised at night and on week-ends.

Describing what happens at micro, nuclear and block levels makes it possible to develop numerical tools for understanding what happens in fields, says associate professor Geir Ersland.

The equipment is specially constructed to study high-pressure storage of carbon dioxide and the use of this greenhouse gas to improve oil recovery, he adds.

Permeability

In one of the department's lecture rooms, 64 undergraduates taking a BSc in petroleum and process technology have gathered to hear Graue talk about capillary pressure and reservoir permeability.

Tilde Sørstrand Haugen from Flora in Sogn og Fjordane, Mari Gjerde Christiansen from Vinje in Telemark and Anne Cleo Styrmø from Oslo are seated side-by-side in the back row.

All agree that the course is very good. "It offers lots of opportunities, and is very varied," says Hauge, before Graue starts to draw curves on the blackboard.

Simple tools are sometimes the best.

Secondment. "PhD students get to see what the industry demands of them, and what terms the government sets," says Martin Fernø. "They encounter the whole value chain in one and the same place."

ROCKSHOT



Motion picture

| Terje Solbakk (Text and photo)

Faulting is a normal term in structural geology, and means that rock has been subject to such substantial mechanical loads that it rips apart. Movement along this fracture zone is what creates a fault – if no shift occurs, it remains a crack.

The angle of faulting can vary from vertical to almost horizontal. Moreover, special names have been given to the rock on either side of a fault. The part on top is called the *hanging wall* and that below is the *footwall*.

A normal fault is one where the hanging wall has been thrust

down in relation to the footwall (as in the photograph above). If it has been thrust up, the term is a reverse fault. And displacement to one side is a strike-slip fault.

The movement in itself may be small, and the term "fault displacement" is used to describe the amount involved. It could be anything from a few millimetres to kilometres.

A fault seldom occurs alone, and the movement between hanging wall and footwall could be distributed between several faults which occur together in a fault zone.

Fault displacement can occur very quickly, and several times over geological time – with each movement often separated by many millions of years.

Mapping and understanding faulting is crucial for petroleum production on the NCS. Several of its oil and gas fields are found in structures created by faults.

Faulting within reservoirs can influence productivity, either by being open so that oil and gas pass through or because fine-grained rocks create a seal and prevent flow.

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Carbon stores mapped

The NPD has completed its mapping of possible storage locations for carbon dioxide on the NCS, and has issued an atlas of such sites in the southern part of Norway's Barents Sea sector.

Produced for the Ministry of Petroleum and Energy, this is the third in a series which began with the Norwegian North Sea in 2011 and continued for the Norwegian Sea earlier this year.

The atlas covers that part of the Norwegian Barents Sea which has been opened for petroleum activities and shows that it could theoretically hold up to 7.2 gigatonnes of the greenhouse gas.

However, the sites thought most certain have a capacity of 0.1 gigatonnes. The North Sea is thought to offer 70 gigatonnes, while the Norwegian Sea could have a mature capacity of 5.5 gigatonnes.

The atlases build on information provided by seismic surveys plus offshore well and production data, but the Barents Sea is less explored than the North and Norwegian Seas.

During its work on the atlases, the NPD mapped brine-filled formations (aquifers) and other sub-surface structures before assessing whether they are suitable for long-term secure storage.

One criterion in these evaluations is that carbon storage should have no negative impact on oil and gas operations, either now or in the future.

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