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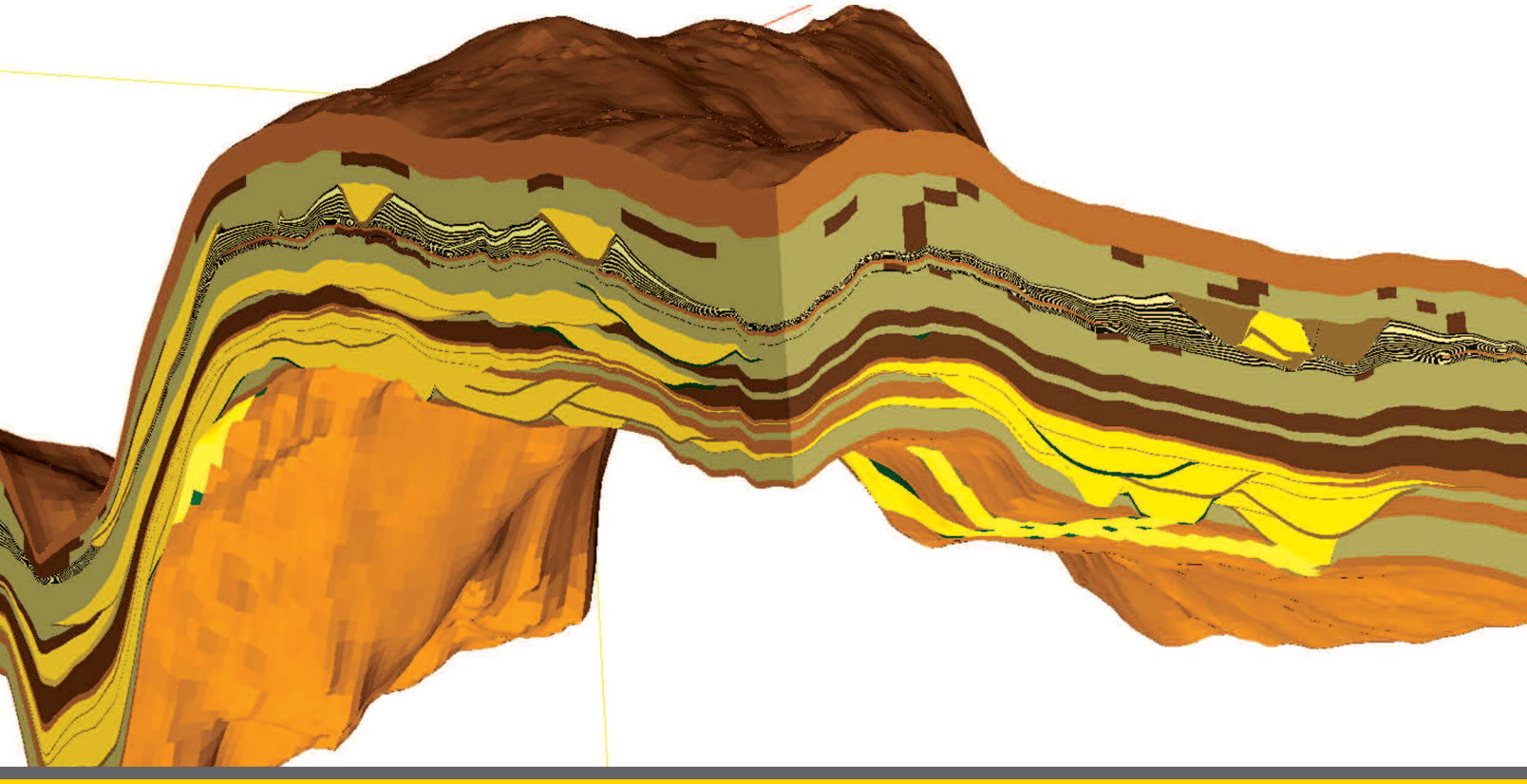


seeing the subsurface

Geomodeling Creates Groundbreaking Geological Modelling Software

seeing THE SUBSURFACE

REALISTIC RESERVOIR ARCHITECTURES AT THE PRESS OF A KEY BY MAURICE SMITH

GIVEN A CHOICE, OIL AND GAS GEOSCIENTISTS would surely love an opportunity to peel back the layers of earth covering their buried reservoirs to steal a peek at their inner workings. But given that's not feasible, a Calgary company is providing the next best thing.

Geomodeling Technology Corporation has created a ground-breaking geological modelling software that, by mimicking the way the geology was laid down millions of years ago, models fine-scale sedimentary details that impact large-scale reservoir performance. By integrating stratigraphic, lithofacies and petrophysical data, its software is able to build models for reservoir evaluation that are more geologically realistic than any seen before.

Developed over the last decade in collaboration with many of the largest E&P companies around the world, Geomodeling's SBED (Sedimentary Bedding Heterogeneity Modelling Tool for reservoir property upscaling) and SBEDStudio programs have now reached the commercialization stage. And if the enthusiasm from its early users is any indication, the products are bound to have a big impact on how companies understand and manage their assets. In June, Statoil's wholly-owned Offtech Invest AS injected 20 million Norwegian kroner ($2.5 million) into Geomodeling to accelerate the technology's commercialization.

Geomodeling was the brainchild of company president and CEO Renjun Wen, whose expertise with the new techniques dates back to the early 1990s, after completing his PhD in petroleum geology at the Norwegian University of Science and Technology in Trondheim. The original designer and programmer of SBED geological modelling technology, Wen founded Geomodeling in 1996.

He set out to bridge the "scale gap" in three-dimensional reservoir modelling — that which existed between core samples and well log data and geostatistical simulation grids. Core plug data is used to compute mean and standard deviation statistics for porosity and permeability, which are mapped to a geostatistical simulation of full-field models. The gap caused skewed results since core data is on a centimetre scale and the geostatistical simulation grid is on a metre to tens of metres scale.

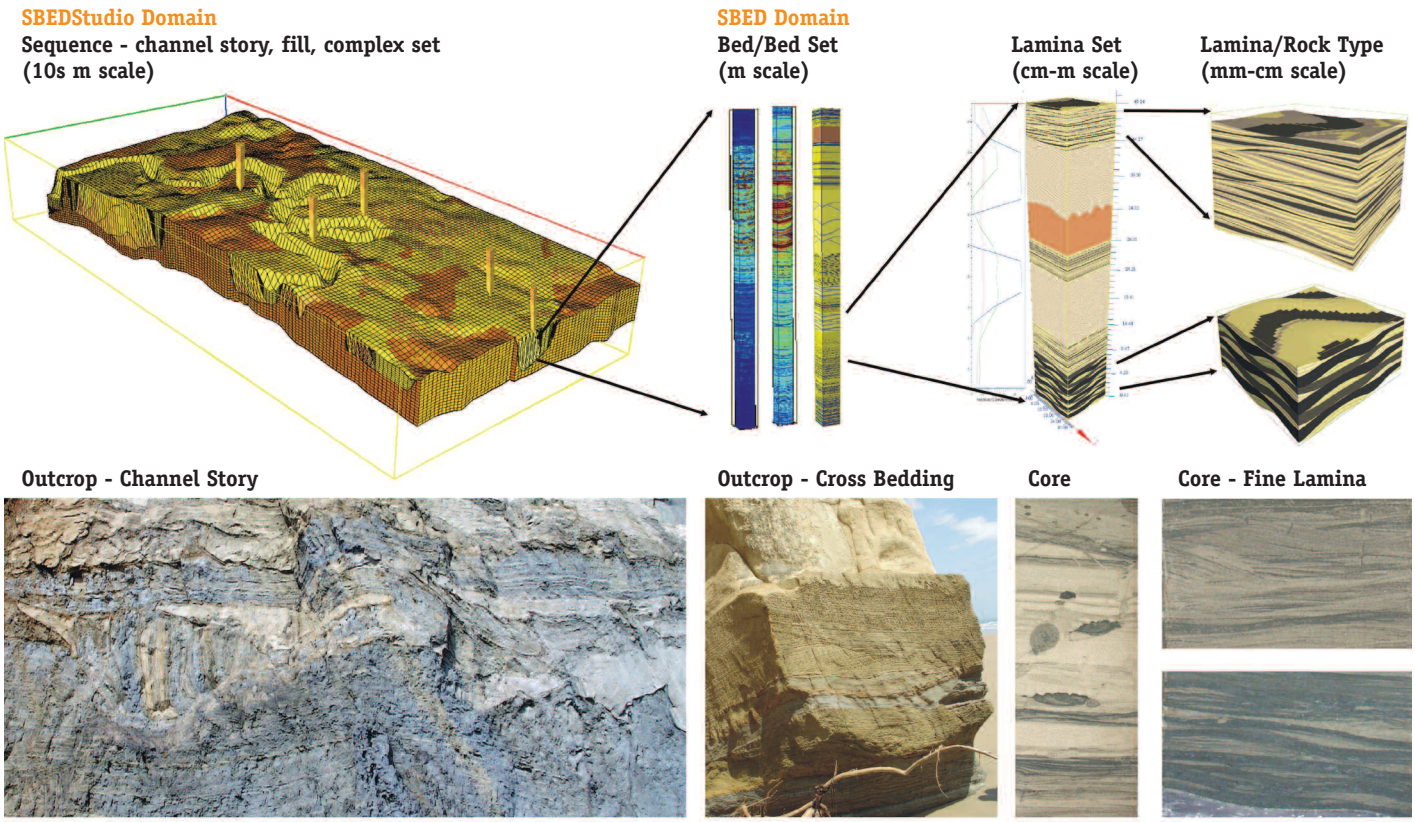
"To measure permeability, for example, companies actually go into the core and they flow fluid through the rock to understand permeability," says Murray Christie, Geomodeling's chief operating officer. "The problem is, the permeability is not the same at the centimetre scale as it is at the cell size that they simulate, which is maybe 30 metres by 30 metres — in fact, it changes dramatically. But you can't go down into the reservoir and take a 30 metre by 30 metre chunk of rock out and run flow tests on the entire volume in a core lab."

The problem was particularly acute in geologically complex and heterogeneous fields, such as Statoil's North Sea fields, says Christie. "The old technology really didn't have a good handle on the ability to understand the potential of thin-bedded reservoirs that had sand and shale layers which are finely interlayered. Initially Statoil recognized that this was a bigger problem than maybe they could handle. So they sponsored Renjun and they got some initial companies into a consortium. Wen came up with a methodology in which he could simulate the fabric of the rock at the scale at which you see a core."

MODEL BEHAVIOUR. Unlike conventional technology — which extrapolates small-scale core data to full-field scale without adequately taking into account the small-scale geological details, and are unable to reproduce stratigraphic heterogeneity patterns at sub-seismic scale — Geomodeling modelled detailed geological features based on their formation process to enable their 3-D structures to be accurately represented in the geological model. Wen developed programs based on process-orientated stochastic (probabilistic computer simulation) algorithms. The depositional process is formulated in a stochastic framework and petrophysical simulation is constrained by the bedding geometry.

SBED was designed for small-scale (centimetre to metre-scale) geological heterogeneity modelling and upscaling, while SBEDStudio integrates well log, seismic, stratigraphic, lithofacies and petrophysical data to create realistic models for forecasting reservoir production profiles and managing reservoir risk.

"There is a lot of traditional thought out there that says that these simple changes in models aren't going to make a difference, but what we have been finding is that they can make a tremendous difference," Christie says. Case studies using SBED indicate Geomodeling's methods can result in recovery factors which differ as much as 50% when compared to conventional models, the company says, due mainly to the fact SBEDStudio has modelled subseismic boundary surfaces that can be significant permeability barriers.



"What we found with these solutions is that we are able to tell companies a lot about what the real potential of the reservoir is. There are several cases, for example Statoil in an African project, where we have changed their take on a project from a no-go to a go because of this, and in other cases [we] have been able to give them a more realistic understanding of how to develop the reservoir.

"Compared to the traditional approaches out there, this is a real leap of technology because the traditional approaches primarily use statistics. What's unique about our software is that it mimics the way the geology was laid down in the first place, so we are going beyond a statistical approach. I think it's really important that the software create that exact geometry, because the essence of the flow depends on the geometry. And when you look at our models they actually look a lot like the outcrops or the core that you acquire from the field."

By actually using the process in which the geology was created as the main factor in its distribution, Geomodeling captures the essence of the permeability barriers, says Christie. "So we can capture, for example, barriers to flow that you have got to address — maybe there is a shale barrier between meandering channels, for example, or mud floods that have been dropped in a turbidite that are very important to how that reservoir performs."

NORTH SEA RESEARCH. As early as 1995, Statoil began using SBED software prototypes in a research project on remaining reserves in different Statoil fields, says Carsten Elfenbein, senior geologist, Statoil ASA, Research & Development. Early research also focused on tidal bedding, he says. "We looked at how to represent the sedimentary structures that the tides produce in the reservoir model on a very detailed scale."

Sandstone/mudstone alternations in tidally-deposited rock typical of many North Sea fields could only be measured from sporadic cores because the resolution of standard petrophysical well logs was too low to register them, according to Statoil, which sought a way to extrapolate the wealth of data provided by cores to similar intervals where wireline log data was available. SBED would allow the company to mimic depositional and burial processes, compute porosity and permeability, and upscale the data to well log responses.

Nobody was able to assign reservoir properties to tidal structures before, Elfenbein says. "There was no program to do this kind of modelling in such a great detail because other software packages look at much larger scales," he notes. "They describe reservoir properties and their distribution inside a whole sand body several tens of metres thick and hundreds of metres long, for example, whereas we are now able to investigate flow properties on a very detailed scale, from millimetre to centimetre scales, and those details are very important when it comes to flow of gas and oil through rocks."

Sedimentary structures deposited by tidal flows, for example, create complexities in the rock in a very fine scale, which are able to trap hydrocarbons on a very small scale, he says. A thorough description of those traps is necessary to be able to predict how the reservoir will behave when it starts producing.

"You produce your models in a way that is process-based, meaning that you mimic geological processes like erosion and deposition to create structures that are geologically meaningful. And, at the same time, you can use your experience about variability in various systems to give the model statistical com-

ponents, so that you can actually model a whole spectrum of possible geological situations and that will help you to describe uncertainties in your reservoir properties.

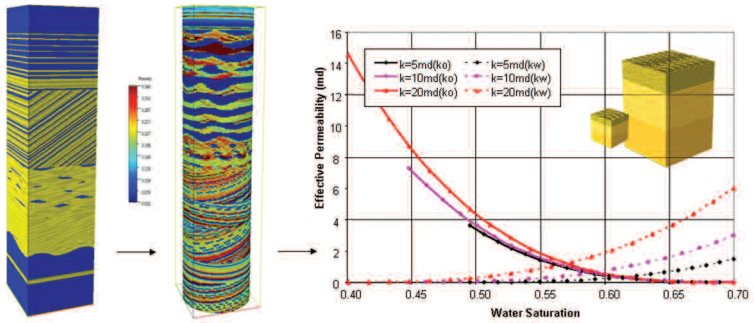
"The problem is you never see what's down there, but you have some experience about how natural systems work, and you need to catch as much as possible of the variations that might occur in your sedimentary structures, which then again gives you a whole range of possible flow situations. So with your models you aim at creating a realistic picture of your subsurface and at the same time assign an honest uncertainty to your reservoir description."

Statoil has found SBED particularly helpful in solving one classical problem in complex reservoirs — determining vertical permeability. "That is a very important parameter for flow simulation, but it is very difficult to estimate based on traditional data and software," Elfenbein says. "In the Norwegian Sea we are producing a lot from tidal reservoirs and the vertical permeability inside these tidal intervals was very often earlier based on 'guesstimates' of the reservoir engineer or simple averaging methods which we later found out weren't quite right. So we used SBED to derive functions to calculate vertical permeability based on more conventional data and we got several examples where SBED helped us to improve reservoir behaviour prediction based on these vertical permeability estimates."

SOFTWARE SOPHISTICATION. Within Statoil, SBED use is "really taking off right now," Elfenbein says. "We have just taken the step from a research-type of program to a real-world application, which is implemented in several of our production asset groups at the moment, so we are beginning to get value back from it. We are constantly increasing activity levels with SBED. We have a huge project going on right now reviewing reservoir models and reservoir characterization for a whole region and SBED plays a very central role in that whole project."

Last spring, SBED was also used by TRACS International, a petroleum consultancy based in Aberdeen, as part of a reservoir modelling study for an offshore U.K. operator. The project involved the rebuilding of a producing field simulation model, involving modelling across 40 years of permeability heterogeneity for a range of geological realizations, according to TRACS. Scaling issues were solved by capturing detailed reservoir heterogeneities implicitly using effective properties derived from SBED modelling, the company says.

Mark Bentley, principal geoscientist, says



MODEL ASSEMBLY **The SBED workflow proceeds from near-wellbore modelling, left, to petrophysical modelling, centre, to upscaling, right. Upscaled results are applied to large-scale reservoir simulations to evaluate reservoir characteristics.**

SBED allowed the modelling team to determine effective properties for intervals of complex sedimentology that would have been a much more time-consuming task with conventional modelling software. "These models fed onward to simulation and forecasting and we are confident that by using SBED we have generated static models which capture permeability architecture far better than the current industry standard," he says. "Moreover, we were able to do it quickly."

While it's using the technology to different ends — primarily to model channelized architectures — Shell has also found Geomodeling to have most refined the reservoir modelling process. "One of the gaps that SBED fills is it allows you to model very realistically so that when you make a model you are more confident with it. It gives us insight into what to expect," says Mark Barton, a reservoir geologist with Shell International Exploration and Production in Houston.

"A lot of times, you have to do a lot of modelling up front, where you try to forecast how the reservoir is going to perform. We think SBEDStudio is capable of generating very realistic architectures that other programs just can't do at this point. It's a great tool to look at the impact depositional architecture has on recovery. There is nothing out there at this point that can compare with it."

Shell has been using the software primarily for research purposes for about three years, Barton says. "We are looking at the impact that channel architecture has on reservoir performance," he says, declining to comment on specific projects.

Another one of the technology's main developers, Shell has provided feedback to the consortia that has helped to set the direction of research, Barton says. "It's worked out real well for us — we have been able to give them our concepts on what we would like the modelling program to be able to do and they have been able to go off and execute it in terms of the programming."

Widespread adoption of the technology, however, may be hampered by increasing resistance among the majors to take on any new software solution, no matter how highly recommended it may be, he says. "There has been a trend lately where all the oil companies want to standardize their software, so there is a real reluctance to bring in additional software packages unless it is absolutely necessary. If that wasn't part of the attitude, I think it would be more widely accepted. So for us, in the research part of it, we think it's absolutely necessary, but it's still hard to say whether it's going to be adopted in terms of the operational side of things. I think the program is quite easy to learn, but again, people always want to go with what they know."

Geomodeling's Christie does think SBED's ability to model channelized reservoirs provides ample opportunity in Alberta, where the McMurray formation contains typical examples of tidal-influenced channel systems. Since bounding surfaces and internal stratigraphic variations in channelized reservoirs are below the resolution of conventional seismic data, computer-based modelling based on knowledge of geological processes is the only way to reconstruct a realistic 3-D model capturing detailed stratigraphic features, the company says. "For reservoir settings such as thinly-bedded tight gas or heavy oil, such as those in Alberta, SBED has got big potential to address some of the need to understand those reservoirs and enhance oil recovery."

Besides Statoil and Shell, joint industry project partners that have contributed both funding and leading-edge technical expertise to the development phase of SBED are BG Group, BHP Billiton, ConocoPhillips, ENI-Agip Petroleum Co., ExxonMobil, Norsk Hydro and Total. ntm

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