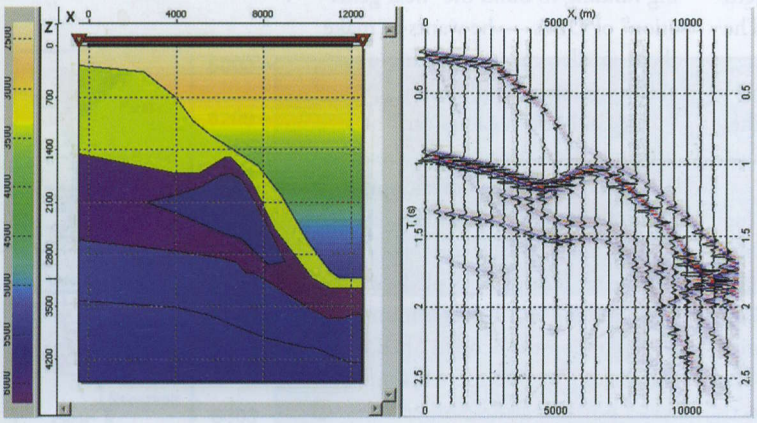
Wave Of The Future

Seismic Wave Modelling Software Runs On PCs

Chalk up another victory for the personal computer over mainframes.

Seismic full-wave modelling has traditionally required powerful computers that only big companies and universities could afford. Now, a Calgary company with roots in the Ukraine has developed software that does the job on a PC.

After working as a postdoctoral fellow at the University of Alberta in 1993, Dr. Alexendar Kostyukevych, a senior research associate at the Ukrainian Institute of Geophysics in Kiev, developed the algorithms that enable full-wave modelling to be done efficiently on a PC. He recently formed Tesseral Technologies Inc. in Calgary to commercialize the software.



Tesseral's software allows seismic full-wave modelling to be done on a PC.

"It brings a very high-powered tool down to the level of the average guy who doesn't have a major corporation behind him," says Norm Cooper, president of Mustagh Resources Ltd., a geophysical consulting firm that provides training and plans surveys. Cooper has used Tesseral's software.

Knowing how seismic waves will propagate in an area helps determine the density of sources and geophones. One of the big variables is how far a receiver can be from a source point and still provide useful information about a geologic target. The more sparsely placed the geophones are, the cheaper the survey. But if the geophones are too far from the source, the result will be a poor image.

"So there's a tricky balance between trying to get the optimum costs and optimum imaging," says Cooper. "And in order to walk that fine line, you really need to understand what the reflections will look like."

The product can be used in seismic survey design, data processing and interpretation, says Keith Edwards, a geophysicist who is evaluating the software at Boyd Exploration Consultants Ltd.

"It models the Earth so accurately that it's a bit like interpreting real data. And as a result you get model data back that is just as complicated as real data," Edwards says. This can be challenging, he adds with a laugh, but it results in greater accuracy. "You can basically mimic what's going on — in the real Earth — on the computer. And that's helpful every stage of the way."

Seismic modelling methods are usually fairly simple, which makes model data easy to interpret, says Edwards. Tesseral's software, on the other hand, models all the variations that could occur as seismic waves bounce around within the subsurface.

Edwards believes the software will be "extremely helpful" in the Foothills because of complex tectonics and extreme differences in elevation. "It's very difficult to process real data in a setting like that," he explains. Tesseral's software allows different concepts to be tested on known cases and then applied to real data.

Other applications include searching for reefs, amplitude versus offset analysis and enhanced oil recovery, says Ivan Iantsevitch, Tesseral's Calgary-based marketing manager. "We can model effects of the steam zone," he says about EOR monitoring for heavy-oil projects. "As soon as they know the layer has been saturated, they can stop pumping steam."

Given the software's ability to test various expected scenarios, it could also aid the University of Alberta's research into 4-D seismology, says Dr. Doug Schmitt, a U of A geophysics professor. "One can quickly change the rock properties over certain zones of the reservoir. One could use this to see if there is any noticeable change in the character of the seismic reflections that one could associate with the evolution of the reservoir as it is produced," Schmitt says. "This could be used to feasibility-test whether a certain type of response might be detected, or be compared to real data in order to update an existing model." He also likes the program's user-friendliness. "It makes building the model almost like a computer game. It runs very well on my 800-megahertz laptop."

Kostyukevych's algorithms help make this possible. But the explosive growth in PC power is also a factor. "When we came to Canada in 1995, we bought a Pentium 60," says Iantsevitch. "It would take 24 hours to calculate a model that was one kilometre by one kilometre. Now it would take one minute on a 1.7-gigahertz Pentium."

A traditional alternative to full-wave modelling is ray-tracing — →

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simpler software that runs faster but generates less-precise models. This method works in simpler geology — a few flat horizontal layers, for example — but is less effective in complex structures.

Unlike ray tracing, full-wave modelling uses no approximations. It gives all the possible seismic waves, but traditionally has required too much computing horsepower to run efficiently on a PC.

Cooper, one of the first commercial users of the new software, used it to plan 3-D surveys of complex and relatively unfamiliar reservoirs. "It has really helped me a couple of times in convincing a client that we knew what we were talking about," he says. In one case, he used it on a project in Iran where limited information was available and it was necessary to visualize what the seismic would look like.

In another case, he used it on a Northwest Territories reservoir with unusually complex geology. The challenge was to design a seismic program to effectively image a structure that was complicated by a salt feature with large vertical dips. He used Tesseral's software to understand how the seismic would behave. This helped determine the optimum placement of sources and receivers.

Cooper says the software is useful wherever there's uncertainty about how seismic waves will propagate. Even in the case of the simplest reservoirs that geophysicists believe they understand with simple ray-tracing models, he says, it can be "very enlightening" to build full-wave models because the latter are more realistic.

Full-wave modelling is "about the closest thing we can do theoretically to predicting what Mother Nature and reality really will offer," he says. "It just helps the geophysicist understand what he's seen in the seismic and why, and where it comes from. And I think that leads to better planning of surveys and I think it could lead to better interpretation."

Northern Cross Energy Limited, a privately held Calgary-based explorer, wanted to know why it was getting poor seismic response on a play in southern Ontario. So the exploration team prepared a model that had a karsted carbonate surface underneath Pleistocene gravels, which are prevalent in the area where Northern Cross operates.

"And when we ran that model we found that we wouldn't see any seismic response because of diffusion and dispersion caused by fracturing, erosion and cutouts due to karst dissolution of carbonates," recalls Peter

Moignard, senior geologist.

So Northern Cross avoided spending money on acquiring seismic data in areas where it "shouldn't and wouldn't" show much, says Moignard. "The other problem is that we do get data — but where the model suggests that we shouldn't get data," he says. This raises another question. "What is the data we're getting? We know we've had a lot of trouble processing it. And now we kind of wonder if it's real data or not."

Tesseral's package retails for $9,000 (Cdn.) for one work station. The cost is much lower than would be possible if development work was done in North America, Iantsevitch says. He says Tesseral's programming is done in the Ukraine, where an experienced programmer costs $600 (U.S.) a month.

Sixty per cent of Tesseral's costs in the Ukraine are paid by Ottawa through the Canadian International Development Agency.

Kostyukevych divides his time evenly between Calgary and Kiev, where Tesseral employs three programmers and six geophysicists and geologists at the Science and Technology Centre of the Ukraine. Established under an agreement between Canada, Sweden, the United States and the Ukraine, the centre funds technology projects "that engage the former Soviet weapons science community in Ukraine in peaceful activities," the centre's 1997 annual report explains.

Tesseral also received a $10,000 grant from the Industrial Research Assistance Program of Canada's National Research Council.

Iantsevitch says Tesseral serves a specialized niche — PC-based full-wave seismic modelling — and isn't competing with existing commercial products. "Our philosophy is try to do only one thing but do it well," he says. The company also plans to provide processing and interpretation expertise and Iantsevitch says clients will be able to have their processing done in the Ukraine to save money.

Cooper describes Tesseral's full-wave modelling software as another tool that the ever-increasing power of the PC has placed on the geophysicist's desktop. "To model an interpreted result and compare that result back to the original source data is another quality-control step that we should be doing," he says. "Up until now we really haven't been because we've had the excuse that it wasn't accessible. Now that it's accessible we really should be doing it."

— *Pat Roche (E-mail comments to NewTechnology@smenergy.com)* ■