'GEO-SCIENTISTS, not *computer* scientists'

POWERFUL AS UNIX, EASY TO USE AS WINDOWS, EARTHWORKS EVEN DOES PRE-STACK ANALYSIS BY PAT ROCHE

WORKING AT SUNCOR ENERGY INC. IN THE 1980s, MARK SUN WAS frustrated with the tools he had to use as a seismic interpreter. A computer whiz who wrote his own software as a teenager, the young geophysicist believed he could build a better workstation.

So he quit his job, sold his house and became a software developer. The result is the EarthWorks Exploration System, an interpretative workstation offering just about every tool a geophysicist could imagine — including pre-stack analysis.

Everything is in one integrated package, so a user never has to import or export data. There are no enigmatic icons — everything is in plain English. And a user never has to type in strings of arcane commands; instead, the system works with the point-and-click ease of an Apple Macintosh computer. With a small but loyal following, EarthWorks has drawn praise from some top geophysicists. A few clients work at big companies; others are immersed in sophisticated geophysical research.

GETTING STARTED. So how did one man come to build an entire exploration system, single-handedly?

It all began at Suncor about 20 years ago. A lot of the technology that geophysicists were using was designed by people who were programmers, but not necessarily oil and gas finders. And the results sometimes left working geoscientists scratching their heads.

"There were lots of times when we said, 'Well, why is it doing this when it doesn't make sense for it to do that?' Or, 'Why is it so difficult to do this very common thing that we do all the time?'" recalls Sun.

During an oilpatch slowdown in the mid-1980s, Sun found himself with extra time on his hands. He asked his boss if he could write software. Drawing on his oil and gas exploration knowledge as well as his years of programming experience, Sun felt he could write a basic pick-and-post application for geophysicists.

He was told that it couldn't interfere with his interpretation duties and that he couldn't buy any hardware or software — but to go ahead. He was assigned a computer systems person and they spent more than a year on the project.

"And I really got into it," he says. "I was writing software at two in the morning." He would work as a seismic interpreter by day, go home to grab a bite to eat, then come back to the office with his dog and work into the wee hours of the morning.

Then one day some R&D types from Dallas were in the office, saw his application and deemed it a good product. "And that made me think that maybe I do have the ability to write professional-grade software," Sun remembers. In addition, amid the layoffs and downsizings of the mid-1980s, the prospect of life as a seismic interpreter didn't seem likely. Plus, he wanted a creative outlet and a chance to do something entrepreneurial.

Six months later, he decided to take the plunge. But first he had to cough up the cash for a workstation. So he sold his house and used the $75,000 in equity to buy a state-of-the-art workstation. Houseless and facing a prolonged period without income, he phoned his parents in Vancouver.

"I called back home and I said, 'Look, mom and dad, I sold my house and bought a computer with it and I need a place to live to develop this software, which is going to sustain me for the rest of my life,'" he recalls, laughing. "Although they didn't quite understand what I was doing selling the house for a box, they were great parents and they said, 'Sure. Come on in.'" So as the rest of the world was pouring into Calgary for the 1988 Olympics, Sun headed west with a U-Haul in tow.

About three years earlier, Easton Wren, a Calgary geophysicist and geoscience educator, was asked to do an assessment of Suncor's exploration technology. One of the people he interviewed was Mark Sun. The veteran geoscientist was mightily impressed with the personable young geophysicist's intelligence, his commitment and his honesty.

A few years later, "somebody told me, 'Did you hear about Mark Sun? He's gone off to Vancouver to build a workstation,'" Wren recounts. "I thought, 'Nobody can do that!'" No one person, he thought, could produce an entire seismic interpretation system on his own — an undertaking that occupies teams of developers. But do it he did. In 1990 — after two years of labouring away quietly at home — Sun sold his first EarthWorks workstation.

Wren is among EarthWorks' biggest fans. "It's got so much power as well as software capabilities," he says, "that it makes everything else seem like a horse and cart." About five years ago, at the request of the Canadian Society of Petroleum Geologists, Wren and Sun developed a three-day course on seismic interpretation and workstations for geologists. They've repeated the course, which uses EarthWorks, several times. Because of space and hardware limitations — there are two people to a workstation — the number of attendees is limited to about a dozen. The courses are always oversubscribed.

While geologists aren't known as computer geeks, Wren says their response to EarthWorks has been positive. "Nobody who has attended this has come away without an understanding of how to do it and [without concluding], 'That was easy!'" He says the response is equally enthusiastic when EarthWorks is demonstrated on the final afternoon of his five-day flagship course, Geophysics for Geologists.

In Houston, geologists routinely sit at workstations to do seismic interpretation, notes Wren, who sees no reason why the same couldn't happen in Calgary — especially with an easy-to-use system such as EarthWorks.

WORKSTATION FEATURES. So what makes EarthWorks easy to use? For one thing, the menus are straightforward, the responses instantaneous. For example, if you want to do spectral analysis, just click "analyze" and choose "spectrum." Then you drag out a window. EarthWorks generates the spectrum inside the window. It may show, for instance, an average frequency spectrum with energy ranging from highs of 100 hertz down to lows of 15 hertz.

You click to turn on a frequency filter. As you adjust sliders with the mouse, the data changes in real time — all without touching the keyboard. At a certain frequency, a river channel appears in the subsurface. At other frequencies, you see a stratigraphic pinch-out.

Now that you've identified a channel, let's say you want to pick it. You choose "analyze" and "pick horizon." You pick the event — but the channel isn't continuous in that area. So you ask for the spectral analysis window again. But this time you change the frequency content in an attempt to clarify what's happening to the reflector in question. You find it, you change one of the mouse buttons to "pick" and

point to the reflector. And — voila! — EarthWorks has picked your channel continuously.

Again, everything is done without typing in a string of numbers. "It's like focusing a camera," says Sun, who strives to make EarthWorks as intuitive, or natural, as possible. "If you had to focus a camera by digital means — which is how a lot of [seismic interpretation] systems work — you'd have to say, 'OK, rotate the lens back 10 degrees,' and then go through the focus point, and then say, 'Now go forward five degrees' … it'd take forever."

His philosophy is that if something can be done quickly and easily, geoscientists will use it more than if it's slow and clumsy. EarthWorks' frequency filtering makes it easy to hunt for things, Sun says during a demo. "I can see the channel shows up really clearly at this frequency. Now let's look for more of these channels [or] let's look for a pinch-out," he says. "[EarthWorks] allows you to very quickly go through hundreds of filters and see the response change on the fly," he says, noting his workstation has had this capability for at least 10 years.

Sun's central message is that geoscientists should be doing more with their seismic data. But because of unwieldy systems, geophysicists spend most of their time picking, posting and mapping. This is where a geoscientist sitting at a workstation tracks a seismic event and picks it, or measures the reflection time to it, then posts the numbers on a database map to prepare for contouring. Says Sun: "That is probably the lowest common denominator of what we should be doing with seismic data."

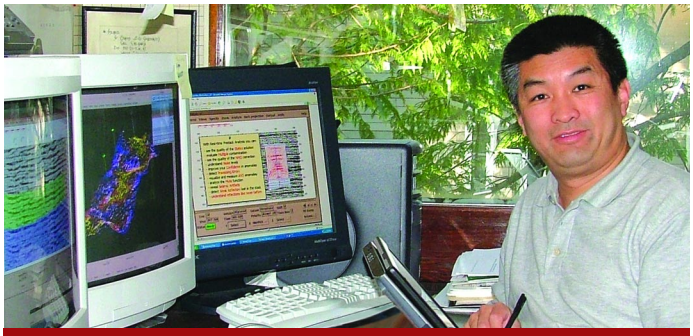
With about four times as many geologists as geophysicists in the industry, geophysicists are under constant pressure to produce. So the more time something takes, the less likely it is to get done. And that's the trouble with most workstations, says Wren. "You take something, you save it, you export it, you bring it back, you do something, you export, you save — you're in and out of the system repeatedly," he says. "And that makes it clumsy. And frustrating."

Seismic interpreters who wanted the widest range of capabilities have traditionally used the hefty Unix-based workstations. But despite their breadth of capabilities, the big Unix-based systems are often used just to pick, post and map, says Sun. "You ask why and [the answer is], 'Well, it's difficult to do these other things with the workload that I have.' So then management says, 'Why do we have these very expensive Unix-based workstations that require a large support team? Why don't we go to a very inexpensive pick, post and map application?'"

And that, he says, explains the migration to Microsoft Windows-based interpretation systems, which are cheaper and easier to use than the Unix-based workstations. Indeed, interpretation systems running on PCs have grabbed market share on the geophysical desktop in recent years. Geophysicists who switched say they prefer the click-and-point ease of Windows over unwieldy workstations running on Unix or its PC-based equivalent, Linux (Nickle's New Technology Magazine, January-February 2004). But Unix doesn't have to be hard to use. The Apple Mac, which set the standard for ease of use, runs on Unix (Nickle's New Technology Magazine, April/May 2004).

"So they are reduced to the pick-post-map approach — and as a result, you only get pick, post and map results," says Sun. But if everyone is looking at the data the same way, how do you gain a competitive advantage? "You're not going to be able to differentiate your prospect — and that could be a difficult thing when you're bidding on land," he says.

"There's two things that find oil and gas: There's people's brains and the technology. You need the technology to understand the seismic data. And if you're using the technology the same as everyone else, then the only differentiator is people — and sometimes that works. What we're saying is technology should help you, too."



SELF-STARTER **Dissatisfied with seismic interpretation tools, Mark Sun set out to build his own workstation.**

For technology to be helpful, it must be convenient. Many interpreters like to generate synthetic seismograms, but popular applications such as GeoSyn are Windows-based. If someone on a Unix-based workstation wants to use GeoSyn, he has to go to a Windows-based PC. (A synthetic seismogram is a model showing what the seismic reflection should look like, based solely on well data. These traces are called "synthetics" because they aren't real seismic data; they're fabricated from well logs. It is a way of calibrating, or checking the quality of, the actual seismic data.)

Creating synthetics on certain workstations is so clumsy that some users actually prefer to walk over to a Windows-based machine and fire up a separate application. Then they print out a hard copy, return to their workstation and hold the paper up to the screen to compare it to the seismic section. "It almost reminds me of the joke about the blonde — no offence to blondes — but the blonde with the Wite-Out on the screen," Sun laughs.

"In fact, we have some clients who have told me, 'We have this [interpretation] package, but creating synthetics is so hard to do, we just don't do it.' And it's such a loss not to create synthetics because you can learn so much about your data," he says on a more serious note.

Similarly, EarthWorks is a real-time mapping system. The workstation is usually configured with two monitors with the seismic data on the left and the mapping application on the right. As you're picking and posting seismic data displayed on the left-hand monitor, the map on the right automatically re-grids, re-displays, re-contours and re-images the data in 3-D perspective. Change the capture radius and you see the result instantaneously.

"So what this allows you to do is to learn the system much faster because you can see the results of what you do right away," Sun says. He contrasts this with systems where a user must select various parameters from an often-bewildering array of menu options and then click "apply" to see the result of his efforts. With EarthWorks, everything happens in real-time.

PRE-STACK DATA. EarthWorks' flagship feature is its ability to look at pre-stack data. (Stacking refers to the averaging of dozens of seismic traces into a single trace. A trace is the data recorded for one channel.) Stacking began about four decades ago when computers packed only a tiny fraction of the power of today's machines. So seismic data processors would average as many as 120 seismic traces into a single trace to make the entire volume more manageable.

But the problem with stacked traces is you can't see the original data. If an anomaly appears on a processed seismic section, you can't tell if it is a result of geology or just an "artifact" — something caused by poor data processing or poor field acquisition. By looking at the pre-stack data, or gathers, geoscientists can distinguish between geology and artifacts. This reduces the risk of drilling dry holes.

"There are published examples of wells where the post-stack interpretation was exactly the same between a bad well and a good well, but the pre-stack was different," says Ron Hinds, a textbook co-author and course instructor for the Society of Exploration Geophysicists (SEG). He notes that most junior geophysicists coming into the industry today have had limited or no access to the analysis of the pre-stack gather. EarthWorks takes the explorer to the next level of geophysics, allowing the seismic interpreter to inspect the quality of the data processing.

But even if the processor did an excellent job — as most do — there's still another reason to look at pre-stack data, says Hinds, who works as a senior geophysicist at Talisman Energy Inc. Pre-stack data can provide some insights into the presence of natural gas.

Seismic data processors provide post-stack data to clients and the major interpretation workstations only use post-stack data. "So you're really limited as to seeing if there's any effect caused by gas," says Hinds. That effect is called AVO. Often the response factor of gas has been averaged out by the stacking process. To describe the potential lost opportunities of interpreting only post-stack seismic, Hinds coined the phrase "bypassed geophysics."

Wren says the ability to offer insights into the presence of gas has implications for the exploitation of coalbed methane, shale gas and tight-sands gas. He believes EarthWorks' ability to investigate fracture patterns could aid in the development of unconventional resources.

Indeed, EarthWorks is already being used for sophisticated fracture characterization work. Heloise Lynn and her husband, Walter Lynn — both of whom hold PhDs in geophysics from Stanford University — specialize in the use of P-wave and shear-wave seismic anisotropy for detection and characterization of fractured reservoirs. Their Houston-based consultancy, Lynn Incorporated, does applied R&D and data analysis for large oil companies.

EarthWorks enables the consulting firm to evaluate the pre-stack data signal by azimuth and offset, and to do frequency, phase and spectra analysis. "That's one of the unique edges that [EarthWorks] has over all the other platforms," Heloise Lynn says of the ability to look at the pre-stack data by azimuth.

"That's really important to me because I work in anisotropy. My clients wish to characterize aligned vertical fractures that transmit fluids," she says. She adds EarthWorks also has excellent AVO with azimuth capability.

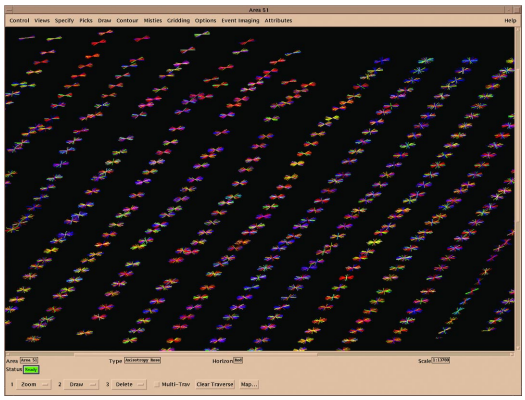
Sun is constantly adding new features to his workstation at the request of clients. For Lynn Incorporated, "he's added quite a bit of the azimuthal analysis functionality — for example, [the ability to look] at amplitudes by azimuth," says Heloise Lynn. He's also looking at adding multi-component, multi-azimuth capability.

The veteran geophysicist, who served last fall as a distinguished lecturer for the SEG and the American Association of Petroleum Geologists (AAPG), believes other workstations will eventually be forced to add azimuthal capability. She expects that eventually every geophysicist will be interested in vertical aligned fractures — in other words, aligned-connected porosity that flows fluids. "If you're trying to find reservoirs, then finding an aligned-connected porosity that flows fluids is pretty important," she says.

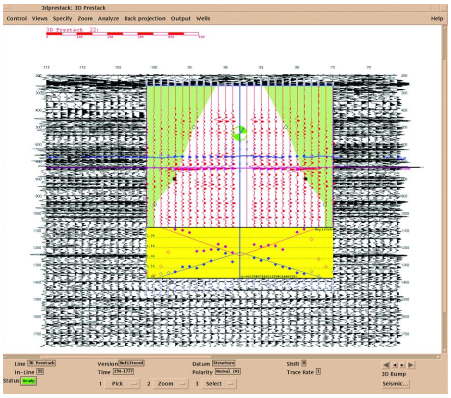
Lynn, who has been using EarthWorks for about a year, previously used a Windows-based system. She says EarthWorks compares favourably with PC-based systems for user-friendliness, but has far more features.

WORKSTATION DESIGN. So if the EarthWorks platform isn't Unix or Windows, what is it? A user can't tell — and that's no accident. Sun passionately believes a computer's operating system should be like the engine in your car. "You don't have to open up the hood every time you go drive around. Yet a lot of the software developers have made the operating system an integral part of the end-user experience.

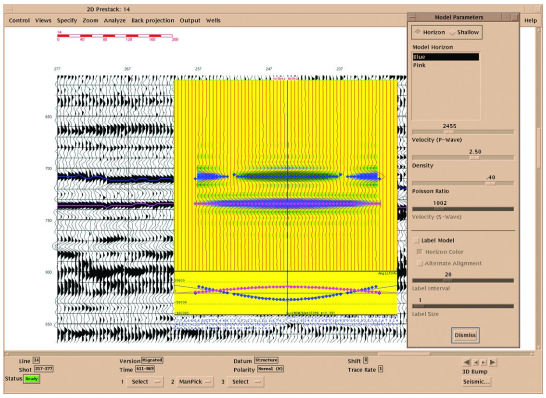
"As a software developer, I think that's a big no-no," he says with a laugh. "The user is supposed to talk to the application. The application is supposed to talk to the operating system. And the operating system is supposed to talk to the hardware. And if you short-circuit that, then you are causing a lot



ANISOTROPY **Anisotropy rose diagrams can help geoscientists understand azimuthal energy distribution.**



PRE-STACK DATA **EarthWorks integrates pre-stack data into normal interpretation workflow. Unmuted gathers are displayed overlaying regular stacked seismic data. AVO attributes are extracted and plotted below the gather. The green rose dial indicates azimuthal energy separation in real-time for anisotropy analysis.**



ON-THE-FLY **Real-time modelling while interpreting seismic data enables instant pre-stack data assessment. The model parameters can be adjusted while watching the seismic response change in real-time. Velocities, frequency, Poisson ratios and thickness can all be modified on-the-fly.**

more hardship on the end user." An example would be a Unix-based seismic interpretation system that forces a geoscientist to learn about Unix. "He shouldn't have to learn about Unix," says Sun.

This goes to the heart of his philosophy as a software developer. "We studied to be geoscientists, not computer scientists," he says. "And yet a lot of the work that we're doing is computer science. It's computer clerk-type work — moving data around. We shouldn't be moving data around; we should be visualizing the subsurface and coming up with play concepts and things like that. Letting the data speak to us."

As he sees it, the problem with the traditional workstation is users were constantly having to interrupt their work to import or export data, or they were expected to know strings of arcane commands. If geoscientists weren't proficient as computer technicians, they had to call IT support.

"We have clients that have no IT department at all," says Sun. "Everything that you do in EarthWorks, you go through the EarthWorks interface…. We try to put it all into one complete package." For this reason he won't sell EarthWorks components separately. "Some people say, 'I just want the pre-stack.' Sorry, it's everything or nothing," he says. "The power of EarthWorks is that everything is integrated. So make use of that."

In case you're wondering what's under the hood, EarthWorks runs on an operating system called OpenVMS powered by a 64-bit HP Alpha processor. Sun chose the Alpha because it was the most powerful workstation available. The Alpha chip was developed by Digital Equipment Corporation (DEC), a pioneering maker of powerful workstations and servers. DEC was selling 64-bit machines in 1992 and it took years for competitors to catch up, says Sun.

Most consumer PCs have 32-bit processors. Most technical workstations now have 64-bit processors, which are potentially much faster and can handle bigger chunks of data. But the real gain in performance occurs only if software is rewritten to capitalize on the 64-bit technology — and that hasn't been a widespread trend. "There are 32-bit software solutions overlaid on a 64-bit machine, which doesn't buy you much," says Sun. "There are very few native 64-bit-designed applications like ours."

EarthWorks runs on OpenVMS because that was the operating system for the Alpha hardware. Hewlett-Packard Company, which now owns the Alpha technology, says OpenVMS has 10 million users. Typically not used on desktops, OpenVMS is used in applications such as finance, defence and health care where lives or large sums of money could be lost if the system fails. As well, Sun says EarthWorks will soon be able to run on the 64-bit Itanium, a powerful chip developed jointly by Hewlett-Packard and Intel Corporation.

Sun's goal was to build the "next generation" seismic workstation. "That's the whole point," he says. "It's not a clone of any system." His philosophy is to approach each problem fresh from the geoscientist's perspective rather than trying to copy existing solutions. "What I'll try to do is to build a new real-time solution that gives us the shortest point from A to B," he says. "That's what turns me on. That's the thrill."

Every line of code in the software was written specifically for EarthWorks. Hinds says the absence of "legacy code" is one of the system's non-geophysical advantages. (Legacy code refers to the tendency of long-established software packages to retain heaps of original code as successive generations of developers continue to layer on new components, sometimes in different programming languages. But the old code lives on within increasingly bloated applications on the assumption that adding to an existing package is cheaper than starting from scratch.)

MINIMIZING RISK. Whether it's due to hardware or software, EarthWorks wins kudos from users. Hinds says it's "blindingly fast." Wren calls it the "screaming machine." Lynn says she would "thoroughly recommend" the workstation to other geoscientists. So why isn't EarthWorks dominating the geophysical desktop? For one thing, it costs more than the smaller interpretation packages running on Windows-based PCs. Depending on the configuration, the workstation sells for about $50,000-$120,000 (US), plus a maintenance fee, which covers all software updates and technical support.

Sun, whose company is called Genetek Earth Research Corporation, won't say how many systems he has installed, citing competitive reasons. But he has a loyal following in Calgary. "He's certainly penetrated the market," says Wren, who believes EarthWorks' market share would be much bigger if it didn't need the approval of information technology (IT) bureaucrats who have the final say over which systems companies install.

"The geophysical folks get all excited," Wren says. "But then the IT people say, 'We're not bringing in another system.'" He says the concern is understandable — IT people already have complex systems to manage — but not supported by the actual experience where EarthWorks has been installed. "The geophysicists want it. IT says no. That's what it boils down to."

Sun describes a typical exchange during an EarthWorks demo at an oil and gas company.

"The geoscientists go, 'Wow, this is like the system of my dream,'" Sun says. "And then there's an IT guy back there and he says, 'Yeah, well, I don't know anything about VMS. I don't know anything about Alpha. And that's a lot of disk you're asking for — because you're going to do pre-stack data. Well, that's big!'"

Sun's response: "Disk is really cheap these days. Load'em up!"

And the IT guy will say, "It's still a lot of disk, I don't know how we can handle that," Sun recalls.

"And I say, 'But you're drilling wells worth $30 million. You're spending $10 million on seismic and you're acquiring land worth another $10 million. And you're worried about 20 grand worth of disk?'"

Thus IT's quest for commonality thwarts the geoscientists' desire for competitive advantage. As for IT people not knowing the OpenVMS operating system or Alpha hardware, Sun says Genetek provides full technical support to its clients, some of whom have no IT departments.

Another concern: What if Sun gets hit by a bus? EarthWorks' sole developer, who says he leads a low-risk lifestyle, responds: "The chance of me surviving is probably better than [the chance of] your current software vendor getting bought out by someone else and having the product languish or die." Noting that he has been writing EarthWorks code for 17 years, Sun says he has no intention of selling out. As a privately funded enterprise, he doesn't have to worry about venture capitalists breathing down his neck, impatient to cash in.

Meanwhile, as long as he's healthy, clients are getting updates about once a week and brand-new software every three to six months, says John Card, an oilpatch veteran who provides technical support for EarthWorks in Calgary.

Hinds isn't particularly worried about the single-developer risk. "It's not a multimillion-dollar system," he says. "It's not something which only the top countries in the world can use. It's something the individual geophysicist, sitting in his office or at home, can [use to] do the job of interpreting." Meantime, he says, "If [EarthWorks] helps me minimize risk by five or 10% and maybe out of four dry holes we only drill three, it's paid for itself several times over. Several times over." ntm

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