H. Roice Nelson Jr.: Quixotic geophysics

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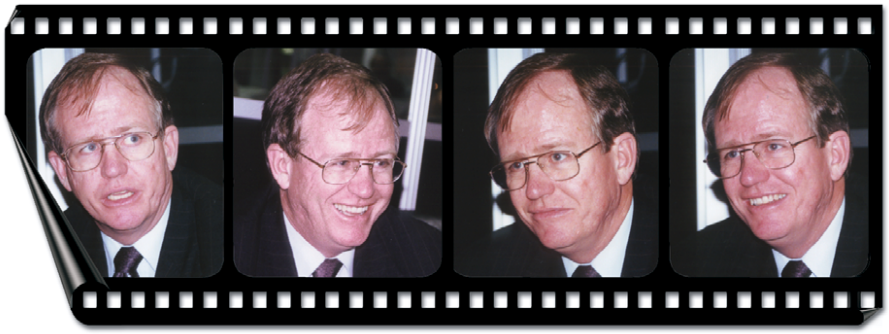


"When it comes down to what wisdom is all about, it is about the stories and the transfer of experiences. We are not capturing these stories, and they will dissipate. We've got this great big bubble of experience that's moving into retirement, we are not replacing it, and what we're going to end up with is horrendous gaps of knowledge because we are not taking advantage of the previous generation's vast experience."

Howard Roice Nelson Jr. grew up on a farm flanked by stratigraphic and metamorphic geology in southern Utah. After school and chores, rather than play he would explore the land on horseback or build things. Music provided a social outlet for the shy youngster. On 24 February 1964, inspired by The Beatles' debut on American television, Roice and four other junior high schoolers gathered in that hotbed of rock 'n' roll, a garage, from which they emerged as "The KeyNotes," with Roice the lead and rhythm guitarist.

Normal teenage behavior notwithstanding, Roice was marching to the tune of a different drummer, thinking "outside the box" before the term was coined. Futurist, visionary, dreamer, always planning 30-40 years out, risking it all but his integrity to stand behind his ideas, Roice Nelson would, to a large degree, cause a paradigm shift in geophysics. The now familiar sight of workstations cranking 3D seismic data is the result of his ability to look into the future as early as 1973, when 3D surveys were still a novelty, computers ponderous mainframes, and workstations in their infancy. Around this idea, Landmark Graphics Corporation, a geophysical service industry phenomenon, was born … But back to the beginning.

Roice was studying mathematics at the University of Utah when his fraternity big brother, Bob Otis, introduced him to geophysics, a profession that fused his three loves: science, nature, and service to humankind.

A little knowledge, to paraphrase the adage, makes undergrads a dangerous breed, but there are exceptions. While working for Pan American (later Amoco) in the summers of 1970 and 1973, Roice began to challenge conventional wisdom. "After my first summer job with Amoco, I couldn't understand why they spent so much time doing things the way they did. It seemed as though they should be looking at the data three-dimensionally relative to where they come from. When I went back to school in 1973, I did a study in Yellowstone Lake, and it was a turning point in my life."

Nelson took a conventional 2D-sparker seismic survey in Yellowstone Lake, digitized the resulting map, put it in an Evans & Sutherland Line-Drawing System-1, and produced a 3D map of the base of the Quaternary sediments in Yellowstone Lake. "I believe it was the first of its kind in geology using seismic," he says, "and became convinced that the technology was there to revolutionize seismic data interpretation."

This was the topic of his senior thesis at the University of Utah in preparation for graduate work, which he would have pursued had it not been for the 1973 Arab oil embargo. The internship at Amoco firmed up Nelson's resolution to work in the oil industry some day. It arrived sooner than expected because the U.S. oil industry was throwing money at young graduates to lure them into their ranks. Nelson, holding a brilliant idea under his hat, simply couldn't resist the offer of Mobil in Dallas.

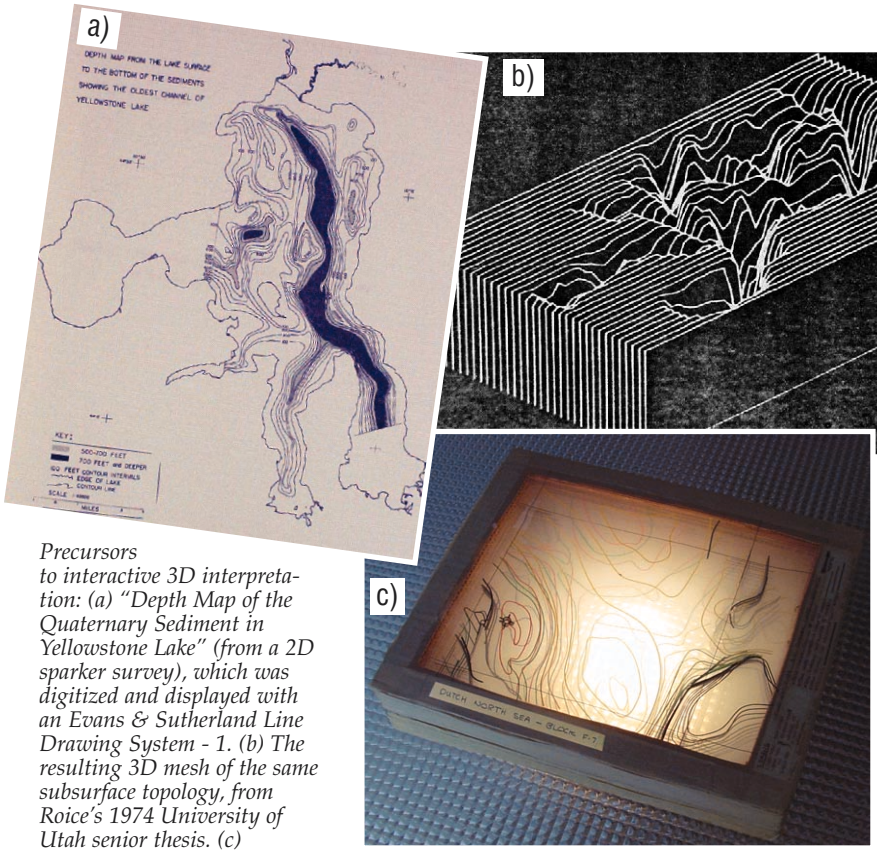
Yet no one, he soon found out, was overeager to trade in the colored pencils for a workstation when it came to seismic interpretation. Nelson went from one manager to another, and ended up talking to one of Mobil's key men, Bob Peacock, who simply advised that he keep trying to implement his idea in house, "… and if you don't succeed here in five years, go do it somewhere else."

Nelson, who expected to work for Mobil the rest of his life, "didn't know that people would actually quit a company. I decided to stay and try even harder to get Mobil to build the first 3D seismic interpretation workstation. I finally gave up after an emotional encounter, following which my boss sent me to a seismic crew in Wyoming to cool off."

Nelson's old alma mater was near the Utah/Wyoming border and Nelson decided to go check out a medical imaging device he had read about. It was built around a vibrating mirror that would produce a 3D volume of data. The developer of the equipment recommended he visit Evans & Sutherland—small world—manufacturer of the system used for the seminal Yellowstone 3D mesh.

"I went to E&S and took the VP of marketing out to lunch. I explained that it made sense to have their technology represented at the 1979 SEG Exposition in New Orleans. It was almost too late, but E&S went for it. For the next six weeks they flew me up to Salt Lake on Friday afternoon to work straight through on our project until the last plane left for Dallas on Sunday. We built deviated well plans, multiple horizon maps, fault plane maps … We basically built prototypes that Landmark would finally deliver in 1992, and showed them in New Orleans in 1979. I wasn't there, except for set up and to train demonstrators; I was in Dallas working at the Mobil office. Some of my friends later told me, 'Roice, you should have been at the SEG … there was this neat demonstration showing stuff you had talked about.'"

Having proven to his satisfaction that the giant corporation wasn't about to embrace interactive interpretation, in 1979 Nelson changed course when, at the first SEG Continuing Education course on "3D Seismic Technology" he met a former Mobil man, Fred Hilterman (Geophysical Development Corp.), who was cofounder and principal investigator of the Seismic Acoustics Laboratory (SAL) for theoretical and physical 3D modeling at the University of Houston. Hilterman remembers the exchange that was to favorably impact both their careers: "This young man from



Precursors to interactive 3D interpretation: (a) "Depth Map of the Quaternary Sediment in Yellowstone Lake" (from a 2D sparker survey), which was digitized and displayed with an Evans & Sutherland Line Drawing System - 1. (b) The resulting 3D mesh of the same subsurface topology, from Roice's 1974 University of Utah senior thesis. (c) Interpretation of 2D data from the Dutch North Sea, in which each contour was placed at its own depth on transparency sheets separated by hand cut cardboard windows. Created in the fall of 1974 as part of Mobil's interpretation training program.

Mobil approached me and without beating around the bush said, 'I want to manage the Seismic Acoustics Lab and allow you to concentrate on the scientific aspects of the consortium's objectives.' He wanted to deal with the drudgery associated with approximately 30 companies and I had to ask, 'Why!?'

"Roice opened his briefcase and removed a cardboard 3D interpretation display [see Figure c above]. Then he candidly said, 'I want to become known in the industry, and after three years with you I will build a company that will provide a hardware and software system to interpret 3D data.' Soon after this conversation he left Mobil and joined SAL, where he handled magnificently the daily operations of the lab, published papers and a book [*New Technologies in Exploration Geophysics*], and presented papers at technical meetings."

SAL consisted of 16 people when Nelson joined. In three short years he showed his knack for implementing institutions. He recalls, "We formed four new research labs and the Allied Geophysical Lab as an umbrella organization, which still exists. We had 85 people working, we had gone from 30 to 46 sponsors … It was a boom time in the industry and I was at the right place."

The consortium also profited from Nelson's frontal approach to fundraising. "He was like a pit bull," says Hilterman. "One day in the lab, I passed Roice as he was showing the modeling facility to the president of a startup oil company. The visitor was explaining that he currently had no technical employees to review SAL's progress … Leaving no escape route open, Roice interrupted: 'I can help you there! Just donate $15 000 and this will relieve the burden from your staff.' The president thought that was a great idea, and he gave Roice a check."

At SAL, Nelson "got to really understand where seismic energy is coming from." And having obtained what he was after, as he forewarned, Nelson left the University of Houston in November 1982.

"Late in 1981 I had been approached by Kevin Kinsella, a venture capitalist broker, to form a new company he registered as Geographix—which became Landmark Graphics. We approached several people to become cofounders, but we were turned down for a variety of reasons, mainly that it was too risky. I invited Bob Limbaugh to quit his job at Digicon, take a pay cut, and be my boss, because I was deemed too young by Kinsella to be the CEO. Bob accepted and we agreed we needed the best hardware and the best software people in the industry. Limbaugh knew them and that's how John Mouton and Andy Hildebrand came on board and we became the four employed founders. Our first employee was Terry Smith, one of the people who turned us down for being a cofounder."

A lot has been written about Landmark. But perhaps what was lost in the huge success story is that the company that changed geophysical interpretation and eventually sold for more than half-a-billion dollars was the methodical execution of a college student's realization that things could be done differently. Roice Nelson never let go of the idea nor the intellectual property, relentlessly gathering the knowledge until he was ready to turn the concept into a product—a David to the Goliath of conventional practice.

"In Roice's view, we make all sorts of assumptions about the world and why we can or cannot do something," says long-time friend Tracy Stark (Stark Reality, Inc.), remembering a conversation on a cold New England morning near Walden Pond, a place Nelson holds dear. "In reality, Roice said, if you only think outside the box you've put yourself in, you will find a solution to the problem."

Only nine months after being capitalized in December 1982, Landmark introduced workstations at the 53rd SEG Annual International Meeting and Exposition in Las Vegas. Even before the show, the company boldly announced in THE LEADING EDGE, "[our] revolutionary new graphics interpretation workstation … will make our brand new company one of the best in the oil exploration industry." And they delivered: There were three microcomputer-based workstations running—one in the Landmark booth, one in the Control Data Corporation booth connected by a yellow Ethernet cable, and one for backup and private demonstrations. Conspicuously absent were any anaconda-girth cables snaking from their workstation displays to a tractor trailer with mainframe computers hidden outside the exhibit floor.

Nelson beamed at this unveiling in September 1983, which for him meant the true birth of Landmark; his long-nurtured idea had changed 3D seismic interpretation forever. However, "success has many fathers," cautioned Nelson when, inevitably, someone claimed paternity of a

similar concept. "There were dozens of people at Gulf, Exxon, Shell, ARCO, GSI, Geco, Western Geophysical, Seiscom Delta, and other places working on ideas very similar to the one I got credit for; their contributions were all part of the *Zeitgeist*. That's why I'm uncomfortable taking credit, because I acknowledge there are smarter people than me working toward the same goals. Not only that, but I owe my own ideas to countless other people. Some time ago I began to make a list of all who helped me—Bob Otis, who collected the Yellowstone data and took my map over to the secret government project to create the 3D images for me; Bob Smith, my advisor; Robert Kalweit, Alex Benton, and Craig Hanson at Amoco … I have yet to finish writing acknowledgements because there are so many."

Some of his mentors may have recognized that Nelson's hyperactive mind was as much a liability as a gift. To Nelson the present may as well be the past; it's done. He works on long-term projects faster than companies can, worries little about short-term revenues, and gives up control of his enterprises to others in order to be free to think about the next step.

In 1989 Nelson created Walden 3D Inc. (W3D) as a general contractor for the city of the future. *If a man does not keep pace with his companions, perhaps it is because he hears a different drummer. Let him step to the music which he hears, however measured or far away*, wrote Henry David Thoreau on Walden Pond. A friend once remarked that Nelson is among the few who "have built a rocket and ridden it to the moon." This sort of high can be habit forming.

Landmark's public offering made Nelson a rich man and he decided that "it was time to go full gun." Walden 3D, "Designing Responsive Environments," had long been Nelson's quest: To design and build a prototype city of the future, no less. The company was not only to be the general contractor for the model city, but the incubator for other companies that followed in quick succession to support the goals of W3D (the curious should check *http://www.walden3D.com*). One of them, Walden Visualization Systems, intended to provide a virtual prototype of the new city, was merged with Energy Innovations by Kjell Finstad in 1999 and fused into Continuum Resources. Nelson, who had retained intellectual property of the visualization technology he had developed, transferred it into Continuum, which would build software tools to create immersive representations of reservoir environments.

But, according to Stark, "Continuum's concept of globally distributed visualization centers was too far ahead of the rest of the crowd. New software and industry acceptance could not be built fast with the available funds. The fact that so many companies now have multiple visualization centers shows that Roice was headed in the right direction. He has given me some good advice to start my own company. The first is 'never lose control.' I take this as don't lose control of the company's direction and goals. Another is, 'be willing to pay others more than you pay yourself,' and also, 'use other people's money; it provides you more leverage and you are investing your time to make their investment grow.'"

Standing by his ideas and promoting his companies' product and mission with unwavering enthusiasm is Nelson's trademark. "The first time I saw Roice in action was in May 1986," remembers SEG president-elect Peter Duncan (MicroSeismic, Inc.). "He was presenting, or more correctly evangelizing about computer assisted exploration, CAEX, in general, and his own Landmark brand in particular. From the beginning, perhaps more than any of his contemporaries, Roice has seen how we can use computers to turn G&G data into practical knowledge. I was moved by his vision, his enthusiasm, his focus, and his energy. These have been the hallmarks of Roice's career."

A year before Continuum shut its doors, Nelson returned to his incubator, W3D, where he now juggles present needs and future dreams. And if that were not enough, his passion for work comes a distant second to his devotion to family, his faith, and his commitment to an impeccable reputation. H. Roice Nelson Jr. is a man of strong convictions, although not inflexible he assures, as can be appreciated from the following interview at the 2002 SEG Annual Meeting in Salt Lake City. And one more thing: He still plays a mean guitar.

What makes geophysics unique for you?

The data is what makes us unique. If we don't collect the data right, if we don't do our best in the field, we won't have anything we can use; we don't get results. As an interpreter, I've spent a lot of time tying loops and coming up with pictures of the subsurface. I don't believe people can do it if they lack integrity. The data force us to have a lot of integrity in everything we do, and I think this is why geophysics is such a unique and special profession.

Geophysicists love the outdoors and enjoy solving puzzles—working through what I call n-dimensional problems. In geophysics the numbers we work with are quite phenomenal; the only other industry that surpasses the computing done in geophysics is the U.S. military, and this has been so since the Geophysical Analysis Group at MIT in the 1950s. Back then they were using one third of the cycles at MIT in the time-series stuff and the military was using the other two thirds deciphering codes and things like that. Today with business and personal computing there are a lot of cycles used in a different way, but in terms of actual data processing and data handling it is phenomenal the amount of data geophysicists run through.

Like it or not, money is how you measure everything, even in geophysics. That's why in the last three years, I've been moving to the other side of the business—putting deals together to get them drilled as Dynamic Resources Corporation.

The problem with money is that it's transitory; it causes a vast majority of the people who have it to change and to lose integrity—the edge of our profession. It has been an interesting transformation for me to work more in the exploration side—raising money to buy leases, getting a well drilled. Yet, although I'm moving in a somewhat different environment, I always come back to interpretation. And that's what I enjoy most in my new business: I do my own interpretations and maps for my own deals.

You have made millions and yet you are not rich. Do you choose to live on the edge?

Everybody has to decide—consciously decide—how much risk they are willing to take. I know that I'm more comfortable with risk than many people. Today there is no longer the security in working for larger companies as in the past, so everyone is exposed to more risk anyway. Entrepreneurship, starting things, on the other hand, has always been risky, but because I feel reasonably competent technically, I always feel we can find a solution when we come up against the wall. And this has been a problem. I've been involved in several start ups; I think I can make a case that each one has been a technical success, but Landmark is the only one that was also a financial success. I guess I haven't used my MBA knowledge as much as I should have.

To date, what have been your professional high and low points?

The highest points have to do with SEG and being recognized by my peers—the Enterprise Award in 1999 was something I didn't expect. Another highlight was the fact that I had the opportunity, with others, to build Landmark up.

What is exciting to me about Landmark is not the fact that I made a bunch of money, or that we created many jobs, or that it was sold to Halliburton for $550 million—maybe because I was long gone and I had already lost all the money I had made. What matters is the fact that Landmark changed the way every oil company in the world looks for oil and gas. By doing this, we had a major impact on petroleum usage and availability. This affects my kids and my grandkids and everybody else's. To me this is the real highlight.

Low point? HyperMedia, one of the companies created to support W3D, was not a happy time, although technically it was great stuff. We had developed some technology at Landmark to help people capture their interpretation projects and also to correlate those interpretation projects against analogs, like outcrop examples (*www.walden3d.com/abbott*). I had put everything I had earned at Landmark, which was a lot, into HyperMedia. We built a UNIX, X-Windows, Motif, and Client-Server hypertext engine in 1988, about five years before Mosaic and Netscape. It's still better technology than the HTML-based browsers for geologists because it allows us to display a cross-section or a map, then draw the geology, fill it with geologic symbols, and build hyperlinks connecting these arbitrary shapes to other pieces of data. Once again, I delegated too much power and was not totally informed about what was going on at HyperMedia. We started on the down spiral when Netscape came to market for free.

What's important to me is to use the talents I've got the best I can. I am comfortable with risk, although no one likes to fail at projects. I keep learning, and I have learned more business best practices in failed businesses than by getting an MBA or at Landmark.

Does the fact that your planning horizon is 30-40 years out tend to complicate your life?

If you look way out over the horizon, you don't look down, and so you stumble. The solution is to surround yourself with good people. I don't have the money to hire them now, yet I have the ability to attract them. I have an extensive network of people I can count on when I need help with a problem.

In 1972, when I was serving my mission [for the Church of Jesus Christ of Latter-day Saints] in England, the first place I was assigned was White City, a suburb of London. After looking at those government Council Housing units, my friend Ray Gardner (erstwhile KeyNotes' drummer) and I started thinking how the city of the future would not be built around the automobile, but around people. We'd build them so that natural environment would be part of the built form. The basic idea is that you can walk to the doctor or to the store; that you can have a sense of community. We had also been talking about massive parallelization of personal computers in the city to solve complex geophysical problems since the 1980s.

As soon as Landmark succeeded, I started funding projects designing the way cities could be, collecting information, and putting it all together. My role in designing the new city, as a geophysicist, is to understand the framework, the geology we are going to build on, and the source of energy.

If we redesigned the cities around people, so that people could walk from place to place, it would be better for our health and for the environment, and free all this valuable petroleum for better uses. Petroleum use is pervasive in our society—fertilizers, medicines, synthetics, paints … One of the main uses of petroleum is to drive our cars and the reason for this is the way we've designed our cities. My desire to see if we can encourage a more efficient way of living is a pretty simple thing. I tend to complicate it because I tend to think about geology and I ask, "Why can't you grow a city out of the rock formations? The technology is available, but it takes a lot of money. It'll take a while to get enough money to prototype this type of city.

[Roice Nelson pauses, grins impishly, and adds] I'm as crazy as the Man of La Mancha.

What are the obstacles standing in the way of small business start ups?

Nine out of 10 companies fail, and every one that fails, fails for a new and unique reason. Now you can classify those reasons and there is a large percentage of those that fail for lack of enough business sense, while others fail because they are undercapitalized—certainly the latter has been one of my problems. So when someone is ready to start a new business, there is a lot of tools available from various sources, like universities, and it is worthwhile accessing them.

While I was working for Mobil, I earned an MBA with emphasis in entrepreneurship from Southern Methodist University. This program has been created with the specific purpose of generating new businesses in Texas, and they had people flying into Dallas from everywhere—Houston, Tulsa, Midland, you name it—to attend the class and then catch a flight back home in the evening. People looking at starting a business should take advantage of these resources, learn from the experiences of others, and best practices. I have a friend who follows the model of Landmark with the companies he has started and then sold, and has done very well.

The business model you favor has no use for lawyers, right?

Ed Rogers, my attorney, has looked over every deal I've done since he did the Landmark Graphics investment paperwork. However, I don't base my business model around legal constraints. Geophysicists have a culture that's unique—we are well traveled, we've been to tough places, and there is a trust. Given this context, we can show society doesn't have to be litigious; we can do things differently. Too often there are problems when the bean counters and the lawyers get involved. They are the reason why when big companies take over smaller ones, research is the first thing to go. Look at what happened to Gulf—one of the best research labs, that invented 3D seismic, that invented depth migration, that invented many of the things we take for granted. Cities Service, Amoco, ARCO, Mobil … all shut down. The bottom line is that the long-term thinking of our industry has been shut down.

Talk to people in any of the remaining research labs: They are frustrated to death, because they are now responsible to clients. They now have, instead of a five- or 10- or certainly 20- or 30-year planning horizon, a six-month planning horizon. What made oil companies great didn't come within a six-month timeframe.

There is an opportunity for geophysicists—who trust each other and have common experiences and backgrounds—to work together using a new business model. A model where people are putting all their intellectual property into a common pool because they know the others are not going to take advantage of them. They will be rewarded

for their contribution, and it all comes down to trust.

It is difficult for most people, yes, but geophysicists are unique; no other science has created the kind of interaction that we have within our community. It's almost like we live back in the 1930s, before the financial people and lawyers got so involved in business.

What advice do you have for young people interested in geophysics?

I was told to buckle down and learn it. I agree, it takes time, and the best way to learn it is to do the most basic, most menial jobs. Having grown up at the back end of a shovel, I didn't mind planting geophones, but that's not true for all kids.

The point is this: There is an apprenticeship process you can't rush. You need to take the time to work on different projects. And if you can buckle down and learn as much as you can, it will most likely happen that after 5-10 years, suddenly you are one of the leaders in the industry and you didn't even know it happened.

And never stop learning. Just because some new hires make good money, it doesn't mean that they understand the complicated nature of this industry. It doesn't need to take 10 years, especially in this age of electronic best practices, where there are ready references, examples, and where new best practices are being added constantly to online data bases. It's like having a tutor wherever you are. But if there is excessive pride, the learning process can suffer.

Who will succeed in becoming a "complete" geophysicist? Kids who are in school need to get a quantitative science background as an undergraduate. You must first learn the value of measurement and monitoring and the ability to pull the right kind of answers out of data.

In *Human Capability*, Jacques and Cason describe "planning horizons" which they correlate to complexity of thought. The book provides a test that any of us can take and allows us to determine what our planning horizon is. Some people have an inherent ability or talent for certain types of things. There are some quantitative measurements that we can draw from to determine for what type of activity we are best suited: geology, geophysics, engineering, acquisition, processing, interpretation, etc. Students who are looking at this industry, if they understand where they are coming from and what's important to them; if they read some good books about it and especially talk to somebody who's been around the block, they'll be able to find the right direction for their career.

What are some of the books that have influenced your thinking and/or you would recommend to others?

Everyone who knows me will tell you that I study the scriptures of the LDS Church, and that they are a guiding force in my life. Other books that have made a positive impact are *Oil is First Found in the Mind*, an excellent summary of the philosophy of oil and gas discovery, the role of the geoscientist, and the scientific method; *The Prize*, by Daniel Yergin, provides an overarching historical context for geophysicists and others in the oil industry to place their own experience, contributions, successes, and failures. I especially enjoy personal accounts like *The Memoirs of Lewis G. Weeks, Geologist*; Paul Walton's candid account of the trials and discovery of large oil fields in Saudi Arabia, Kuwait, and the Rockies in *From Prospect to Prosperity*; and books of a more local flavor like *A Trial Furnace, Southern Utah's Iron Mission*, written by Andrea's (my wife) father and sister-in-law (married to the KeyNote's accordionist) about the settlement of Cedar City, my hometown, specifically because it provides context of the struggle often needed in mineral exploration and exploitation.

I would also be very interested in the books yet to be written by my friends and colleagues with accounts of their own unique experiences in exploration and science, which otherwise will go untold. I have identified three working titles I hope to write over the next few years: *Success Has Many Parents*, my perspective on Landmark Graphics, *Failure is My Responsibility*, reflections on HyperMedia and Continuum Resources, and *An Open Mind—Thoughts About Science and Religion*.

You are bent, it seems, on capturing individual knowledge and experience for future reference.

It is very important. All over the world, there are countless man-years of experience that have walked out of the oil industry over the last decade or two. Those minds are still fertile, viable, and the experience they have is invaluable. Universities could set up programs to find out people in their area of influence who have this experience, and get them in front of students to explain what a wonderful industry this is, despite its boom-and-bust cycles. At the same time, use that opportunity to capture the knowledge, the experience, the background of the individuals they bring in to create a series of industry best practices they can share and make available using the Internet. That's something that can be done immediately, would give fulfillment to people who have had a good career, would mentor and teach students, and give them an opportunity to experience things they won't otherwise.

We are not going to go into Saudi Arabia again for the first time; and yet there are people who saw the initial reports. I talk to them on a regular basis. Reports saying: From the geophysical standpoint there's nothing but flat layers here; from the drilling standpoint, there are no hydrocarbons in the section; from a surface geochemistry, magnetic anomaly, gravity … no opportunities whatsoever. And the driller said "I'm going to drill this well because there are oil seeps on the surface." People now retired did that. When it comes down to what wisdom is all about, it is about the stories and the transfer of experiences. We are not capturing these stories, and they will dissipate. We've got this great big bubble of experience that's moving into retirement, we are not replacing it, and what we're going to end up with is horrendous gaps of knowledge because we are not taking advantage of the previous generation's vast experience.

I think SEG could do more about it too. With the Web the way it is, SEG could set up a way an individual could either type or talk to their Web server about some of the most important career experiences. And the key thing you'd need to do in order to make it useful to the earth science community is to classify it spatially, which ties it to geology, and by activity. And if you index these kinds of activities (which can be set up so that the narrators do it themselves) you end up with a tremendous resource. Say you've got problems working on any given formation, you get plugged into this resource and find out what others have done there; how obstacles were overcome. SEG should be expanding on this tremendously, and universities should too. After all, everyone is smarter than anyone.

Is the Web the best repository for knowledge?

There is the problem with froth. We have too much information, too many data, and we can't get to the things we need. In the early days I described interactive interpretation this way: "Interpretation is interactive if the interpreter can ask a question, do a series of steps in the workstation,

and get an answer before they forget the original question." Speed is important. Now we have all of this froth on the Web and so we do a search for *stripper wells* and guess what we get. Where if we had a reasonable classification system, then as long as we are looking for a series of key words or an activity, we will be able to find exactly what we are looking for.

How does one go about establishing a proper classification system for the earth sciences?

I've been trying to sell a best practice classification mechanism since HyperMedia first developed it in 1996 for Fletcher Challenge Petroleum. We used a bunch of the best minds we could find in Houston—everything from drill stem testing, geochemistry, seismic acquisition, processing and interpretation, and so forth. We modeled the entire upstream oil and gas industry. The system we used creates a checklist from a formal modeling language developed by the U.S. Air Force for modeling complex systems. It's an extensible modeling language. And many people in major oil companies became excited about it. However, the cost of implementing it within a company made it seem too big a project—unless you can break it down into small pieces. I believe we will be able to demonstrate it within the next five years and then it will become the way that every oil company will want to handle their knowledge management. We call it the *Knowledge Backbone*.

Science is based on categorization. If you generalize to the most basic level, there are four classifications particular to the geosciences: location, time, activity, and geologic parameters. This is what we have developed. It helps to identify patterns, creating a best-practice "prospect machine." Imagine how many hydrocarbons can be found using a creative and collaborative network of minds.

In your opinion, what is the future of the petroleum upstream?

The first thing that comes to mind is technology. I anticipate that the upstream is going to become dominated by all kinds of new sensors. We'll be listening to instrumented fields as they produce, and as the fluids move in the subsurface we will come up with tomographic pictures of the subsurface telling us exactly where we stand. And, as friends like Albert Boulanger help me see, the pictures of the subsurface will be completely different from anything we've seen so far. Real Options will provide bottoms-up financial planning based on micro-options developed on the sensors.

The technology perspective is exciting, but what happens from the business standpoint? Technology is developing much faster than our integrity and so there will be people who will misuse the technology, like for instance, tapping into someone else's sensors. Lean management, metric thermostats, reinforced learning, supervised and unsupervised clustering, and other disruptive technologies will create an exciting future. In my opinion, the faster we can get the technology out there, the better, because technology creates a transparency and this is good for the industry.

The next 20 years are going to be very exciting. We will see tremendous declines in all the big fields and we've got to find new reserves. Ideas, like dynamic replenishment of oil fields, which Roger Anderson, at Columbia University, and I have been pursuing for over a decade, will become very important. If we can find these fields that are replenishing and tap into the sources, this will have a major impact on world energy needs.

You are saying that petroleum is a renewable resource?

There are certain geologic environments in which fields are replenishing from sources deeper than we can drill to with the present technology, e.g., Eugene Island 330, offshore Louisiana. There are certain things that we can do as we are exploiting these fields to help the earth send petroleum faster to where we can recover it.

The *Bible* gives the command, "Multiply and replenish the earth." With 10 kids I understand multiply. W3D's urban plan, dynamic replenishment, digital hypertext libraries, and some other projects I'm working on are intended to demonstrate stewardship, sufficiency, sustainability, and replenishment.

Finally, what's your leading professional goal?

My goal is to continue to make a positive difference. I have many ideas which others consider outside the box; ideas that will take considerable money to implement. There are various funding schemes, but it seems to me that there are always too many strings attached. So the simplest thing is to go and find a bunch of oil and gas and use the income to fund those things which seem obvious to me and yet have proven to be so hard to sell. TLE