MEMOIRS

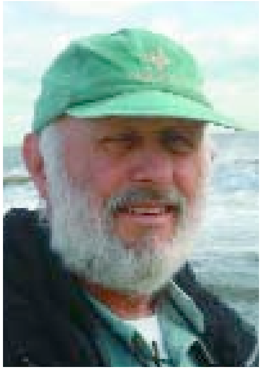
Memoirs of successful geophysicists

In this issue we feature memoirs of Bill Ostrander, a geophysicist well known in the international geophysical community for his pioneering work on AVO. Bill made several technical contributions throughout his career and worked in data processing and exploration geophysics. He also carried out research in geophysics and has several patents to his credit. Bill has been a noteworthy teacher, both at Chevron, where he served most of his professional life, as well as at many universities, where he taught courses.

In recognition of his outstanding accomplishment in the development of the AVO methodlogy, SEG awarded him the Virgil Kauffman Gold Medal in 1985. Bill now leads a retired and an enjoyable life.

William (Bill) J. Ostrander
Benicia, CA


1965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My Early Years

I was born in 1943 in the small rural town of Woodsville, New Hampshire. My dad was a man of many skills, and would attempt almost anything before asking for help. I tended to follow in his footsteps because he did many things with me. I really enjoyed finding out how things worked. Dad was a forester and was often reassigned to various locations in New Hampshire, Kentucky, New York, and finally Pennsylvania (Figure 1). It seemed like the first ten years of my life were spent moving and changing schools. I attended several one-room schoolhouses. In one case, the sixth graders taught reading to the lower classes - not a good beginning to my formal education. By high school I was ready to call it quits. Luckily my dad had other ideas. In my senior year, he persuaded me to apply for college. At the time, Penn State automatically accepted any Pennsylvania resident who graduated in the top two-fifths of their class. I barely made the cut. In the fall of 1961, I was off to college.


Figure 1. 1951 – Family gathering in New Hampshire. Bill is on far left.

College would become a whole new experience for me. I'd be leaving my comfortable world of four siblings and two great parents to enter a world of independence. I had to decide what to do with my life. My two favorite subjects in high school were math and science. I had little interest in the arts and humanities. So I considered forestry, or maybe geology. Following my father into forestry would have been natural. When I was twelve years old, I spent summers with my uncle in New Hampshire. There, I would go to work with him every day, unless it rained. My uncle was as an independent lumberjack working with my grandfather. My job was limbing up fallen trees with a broad ax, and later, driving logging horses. This would be unheard of today for a twelve year old, because of the dangers.

My interest in geology came during these same summers in New Hampshire. At times, the logging business went sour and my uncle turned to other means to provide for the family. This included mica mining. In the fifties, vacuum tubes were still the in-thing in electronics and high quality mica was used for insulation between the conductors inside a vacuum tube. The federal government subsidized the mica mining business and offered $10 to $70 a pound for high quality cut mica depending upon size. Thus with jack hammer, dynamite, and rock packs, my uncle and I would head off into the White Mountains of New Hampshire in search of pegmatite veins, the primary host rock for mica. New Hampshire, the Granite State, has plenty of pegmatites, but finding them takes some knowledge of geology and the glaciers that covered much of New England 12,000 years ago. My uncle taught me how to read the geologic clues to find pegmatite veins. These summers were my introduction to the earth sciences.

College Days

My freshman year at college was a great year for me. I took the calculus, physics and chemistry that I liked, with a required sprinkling of the arts plus ROTC, which was then required at Penn State. I enjoyed learning, and excelled, and by my sophomore year I was firmly on the way to an earth science career. However, coming from a family of five kids, money was tight and I started to look for financial aid. I was pretty much an all A student and found that industry sponsored scholarships were fairly easy to get, particularly in geophysics. For the next three years, I had scholarships: two from Chevron, one from the SEG, and a NASA traineeship, which financed my Master's Degree.

During my junior and senior years, Bob Watson was a visiting professor at Penn State. Bob had graduated from Penn State in 1957 with a Ph.D. in geophysics and had then hired on with Mobil in Dallas, Texas. During those early years at Mobil, Bob entered the digital world of exploration geophysics. He returned

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to Penn State and turned the focus of geophysics from earthquakes to exploration. Most of his classes were taught at the graduate level, but I was able to take several before he returned to Mobil in the summer of 1965. Bob encouraged me to take other courses covering Fourier series, communication theory, and numerical analysis. What an eye opener for me to see high-powered calculus at work. It was no longer hypothetical cases, but real world applications.

During the summer of 1965 I accepted a research position under Ken Waters at Conoco in Ponca City, Oklahoma. While there, I worked with Dale Miller, Paul Mathieu, and Pierre Goupillaud to name a few. At the time, GSI had a proprietary minimum-phase deconvolution algorithm and Conoco wanted to know what their digital operators looked like. Conoco would send seismic data off to GSI and receive back deconvolved data. My job was to find the transfer function between the "input" and the "output". It was a simple application of least-squares matrix algebra - and a whole lot of fun! That summer I learned where exploration geophysics was headed and I wanted to go there.

In the fall of 1965, I returned to Penn State with some great thesis ideas for my Masters Degree. With nobody in the department knowing much about current exploration geophysical data processing techniques, I was basically on my own. My thesis adviser was Shelton Alexander, an earthquake seismologist. Luckily, Shelton was pretty current on digital processing as applied to earthquake data, although he had little idea about what the oil industry was doing with it. I chose as my thesis project to estimate frequency dependent signal-to-noise ratios for reflection seismic traces. I got some live seismic data from Rolando Lara of Chevron in San Francisco. The work went fast and I finished my Masters Degree by the summer of 1966. I presented my results at the annual SEG meeting in Houston, Texas. Boy, was I nervous.

During my Masters' year at Penn State I was undecided whether to pursue a Ph.D. or get a job. I only had one formal job interview and that was with Gulf out of Pittsburgh, PA. They encouraged me to get a doctorate. However, several months later after returning from classes, my office roommate told me that a guy named Pete Diamond from Chevron had just been there looking for me. I rushed after him and moments later found him walking down the street. We had an interview over lunch and two months later I accepted a position at Chevron's exploration office in Seattle, WA. Pete became a great mentor, following my career until his passing in 1996. One cannot over estimate the value of mentors for the young inquisitive mind. I was very lucky to have many.

Off to Chevron

Beside myself, there were only two other geophysicists in Chevron's Seattle office: Jack Richgels and my boss, Jim Foster. I started interpreting seismic data from the Bristol Bay, followed by a reinterpretation of some newly processed data from offshore Oregon. My first big project was in the eastern Straits of Juan de Fuca. Here, I laid out a seismic program, recorded and processed the data, and finally interpreted the results ending with a subsurface contour map. My first map. I showed it to my office roommate, John Galloway, and he said, "What, no closures? Lets take a look at it". John was a veteran explorationist and knew what a prospect map should look like. It was then that I learned a few important things about oil exploration. You only find oil by drilling and you need prospects to drill. Therefore, when contouring subsurface data, you need to be as optimistic as possible. John and I worked on the map, and within an hour or so, four prospects appeared out of the blue. I made many maps after that, always considering the competition I was in for exploration budget dollars. Any slight reversal seen on a seismic section was embellished to the maximum that the data would allow.

In the summer of 1968, the Seattle office closed. Pete Diamond recommended that I go to Chevron's seismic data processing center in Houston, TX. I took his advice and started working in a data processing group and was soon made a supervisor of about twenty technicians and geophysicists. I had always been somewhat of a loner and perfectionist. With twenty people working for me, I was constantly correcting errors late into the evening to make sure that everything was perfect. I hated the job and actually considered quitting. My mentor Pete came to the rescue and I was moved into the Seismic Application Section. Fun was at hand once again.

My job became multi-faceted. One week I would be out visiting Chevron's exploration operations around the country seeking out their needs, and the next I would be testing out new seismic application programs. In addition, I began coding seismic data processing algorithms for the computer. It was here that I met a long-term co-worker, Fred Herkenhoff. Fred was coding up a new statics algorithm envisioned by Roger Judson, and I was testing his program on live seismic data. Fred and I thought the same way and communicated easily. For the next decade, we worked together on countless projects and co-authored many Inter Company Geophysical Conference (ICGC) papers. The ICGC was Chevron's in-house technical meeting. Every fall, a hundred or so of Chevron's geophysicists would gather at some exotic spot and present new geophysical ideas to each other. In 1969, I presented my first paper, a new seismic algorithm based on my M.Sc. thesis work. Over the next twenty years I authored or co-authored over twenty ICGC papers.

Figure 2. 1973 – At the SEG Annual Meeting in Mexico City.

In the spring of 1970 I was transferred to Chevron's exploration office in Anchorage, AK. After two years of seismic data processing I was back interpreting seismic data. However, my boss and Division Geophysicist, Jim Foster allowed me to "play" on the computer in addition to my interpretation duties. Soon, Jack Richgels and I convinced management that we needed an on-site computer for geophysical analysis. In a short time, an IBM 1130 was installed.

Much of my work in Anchorage involved velocity analysis and modeling for seismic depth conversion. It had been noticed that depth conversion on the North Slope of Alaska using seismic NMO velocities gave errors related to permafrost thicknesses. The thicker the permafrost, the greater the error. Analysis showed that permafrost velocities were anisotropic, with the horizontal velocities being considerably faster than the vertical velocities. But how did that affect seismic NMO velocities? I again teamed up with Fred Herkenhoff and after some research we found that seismic NMO velocities tend to measure the horizontal component of velocity in an anisotropic material. The results were presented at the ICGC and later at the annual SEG meeting in Mexico City in 1973 (Figure 2).

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The Beginning of AVO

In the summer of 1971, Chevron's exploration office in Anchorage was closed and relocated to San Francisco. After another year working on Alaska data in the San Francisco office, I was moved into the West Coast Division. My duties were again seismic interpretation with a bit of research as time permitted. The early 70's brought with it "bright spot" analysis and direct hydrocarbon detection. Gas exploration in the Cretaceous sands of the Sacramento Valley boomed. High amplitude seismic events were being drilled everywhere and the success rate for exploration wells was high. However, some bright spots were not associated with hydrocarbons. In the fall of 1974, Chevron drilled a well on a very high amplitude seismic event in the Fallon Basin of Nevada. It turned out to be a high velocity basalt layer and not hydrocarbons. My boss, Jim Foster, asked me to see if there might be a way to distinguish between bright spots related to hydrocarbons and those associated with other geologic layers.

My research on bright spot analysis took me up multiple paths. First, I looked into the various tuning effects and short path multiples associated with thin beds and their relationship to angles of incidence for both low and high velocity beds. Then, sometime in early 1975, I ran across a reference pointing me to a 1955 article in Geophysical Prospecting by Otto Koefoed on the effects of Poisson's ratio on plane wave reflection coefficients. Poisson's ratio is a direct function of P and S wave seismic velocities. At the time, I was aware that Don Thompson in Chevron's research group in La Habra, CA had been measuring both P and S wave velocities for various sediments in his lab. He found some surprising results for gas sands. Replacing brine with gas in high porosity sandstones caused the P wave velocity to decrease sharply as suspected; however, the S wave velocity hardly changed. The result was that gas sands might be expected to have very low Poisson's ratios. He also found that shales had much higher Poisson's ratios. I sent him samples of Cretaceous sands and shales found in the Sacramento Valley. He found the same results: very low Poisson's ratios for gas sands as compared to brine saturated sands and shales. Coupling Don's results with Koefoed's computations indicated that seismic reflections from gas sands might show anomalous amplitude behavior in angle of incidence or shot-to-group offset.

Now that I had a hypothesis, it was time to test it. One of the best examples of a gas related bright spot in the Sacramento Valley was the Putah Sink gas field, discovered in 1972 by Shell. Chevron had recorded multifold seismic data over the field in 1973. My initial look at CDP gathers over the field showed little amplitude change in offset, but that was because of automatic gain control commonly in use at the time. "True amplitude" processing and display were needed. After several weeks, I created a processing flow which maintained relative seismic amplitudes. The final results were sets of single fold CDP gathered traces that did show hints of amplitude buildup with offset, as predicted from the theory. But it wasn't until I began to do some partial trace summing in CDP and offset that the signal-to-noise ratios improved enough to see with confidence that seismic reflection amplitude increased with offset, by a factor of 2 or more. I looked at other gas fields in the Sacramento Valley, the Gulf Coast, and other areas of Chevron's holdings and found similar results. I looked at CDP gathers over the basalt related Fallen Basin bright spot and saw no such amplitude buildup with offset. The idea that seismic amplitude variation with offset (AVO) might be used to weed out false bright spots seemed to prove valuable. In 1976, Chevron drilled its first well in the Sacramento Valley based on this theory. It was a gas discovery.

I presented my theory and results to the Chevron world at the annual ICGC meeting in the fall of 1975. However, it wasn't until 1982, that Chevron allowed me to present the theory and results to the geophysical world at large at the annual SEG meeting in Dallas, TX. I published the paper in Geophysics in October of 1984. In 1985, the SEG awarded me, the Virgil Kauffman Gold Medal Award for this work. Since that time, AVO has seen extensive use in geophysical exploration.

Research Staff: La Habra and the Bay Area

By the mid-70's I had worked my way into a geophysical staff position and no longer did seismic interpretation. I was free to work on any project that I felt would benefit the exploration effort. In late 1976, after a bit of arm-twisting by management, Fred Herkenhoff and I were transferred to Chevron's research center in La Habra, CA. We, along with two other geophysicists, were to head up a newly formed Applied Geophysics Group. It was felt that we could peddle some of the ideas and work done by the research group to Chevron's operating companies. However, we soon went about developing our own ideas to sell to the op-co's. Our main project involved developing a seismogram inversion technique including wavelet extraction and processing algorithms. In addition, we developed other processing techniques, which filled some of the needs of the op-co's. Frequent contact with other Chevron geophysicists in La Habra, including Dan Tudor, Alan Trorey, Don Riley and Francis Muir, aided development of these techniques (Figure 3). After two years, I was transferred back to San Francisco and the Alaskan Division. During the next few years I applied many of the seismogram inversion techniques to North Slope seismic data.

In 1979 Fred Herkenhoff returned to San Francisco with Chevron Overseas. He and I could again have lunch together in the park and discuss geophysics. We started talking about how to improve AVO analysis. One idea was to do some form of least-squares fitting of

Figure 3. 1978 – Teaching with Don Riley at La Habra.

Figure 4. 1982 – On the North Slope of Alaska.

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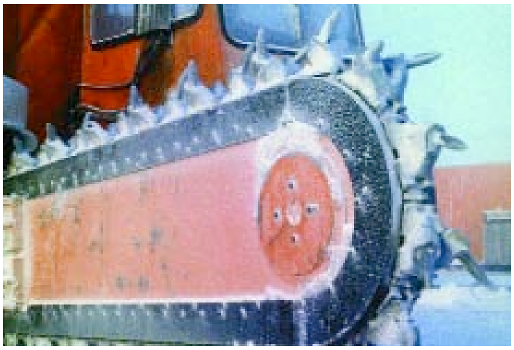

Figure 5. 1984 – GSI's Ice Saw on the Beaufort Sea, Alaska.

seismic reflection amplitudes versus offset. In applying this technique, we found that least-squares fitting of seismic amplitudes in offset equated to a simple trace weighting. Thus, a weighted stack could estimate both a zero offset trace and a projected far offset trace. Comparing these two traces in sectional form would become a great aid in AVO analysis. Result: another ICGC paper in 1980. G. C. Smith and P. M. Gidlow introduced similar trace weighting schemes in Geophysical Prospecting (1987), which are the basis for most AVO displays in use to this day.

In the early 80's I started to get more involved in seismic operations on the North Slope of Alaska (Figure 4). Each winter I would venture north and oversee our seismic recording operations. At the time, most of the operations were on the ice of the Beaufort Sea using Vibroseis. A big noise problem in seismic data recorded on the ice was flexural waves. However, I noticed that if the Vibroseis sources were separated from the geophone receivers by a lead or crack in the ice, the recorded flexural waves were reduced. I came up with the idea to search out leads and cracks in the ice, and program seismic lines which would straddle these ice cracks, with the sources on one side of the crack and the receivers on the other. It was a great idea but it wasn't practical. Two years later, GSI designed a vehicle mounted eight foot ice saw which could cut long lines in the ice, making man-made cracks similar to the natural ice leads (Figure 5). The Vibroseis units were placed on one side of the saw cut and the geophones on the other. The result was better quality seismic data. We used this technique with GSI for several years on the North Slope.

In addition to my career spent in improving seismic processing and interpretation techniques, I became involved in teaching at several venues. In 1983, I was solicited to teach a class at Stanford University. For the next ten years, while employed at Chevron and in retirement, I taught a course in reflection seismic acquisition and processing. I also did in-house teaching, having particularly to do with wavelet processing, seismogram inversion, statics and AVO analysis. I taught some general geophysical exploration courses overseas in Indonesia, Nigeria, Australia, and Norway. And, I was involved in teaching an SEG Continuing Education course on AVO analysis with Mike Graul and Fred Hilterman.

Towards the end of my Chevron career, I was transferred to Chevron Overseas as a geophysical consultant. There I continued working in applied research looking into the geophysical needs of Chevron worldwide. I developed a spatial prediction-filtering algorithm that was widely used within Chevron to improve seismic data quality. Later, I was one of the first earth scientists to receive Chevron's Chairman's Award for work I did on common-mid-point stacking of refraction data.

Retirement

In 1990 all of Chevron's earth scientists were offered a retirement package. Both my wife Janice (also a geophysicist at Chevron) and I accepted the package and retired at the end of the year. I continued to teach at Stanford and consult with Chevron for a few years immediately after retirement. But since then I have basically left geophysics behind me.

The past fifteen years of retirement have enabled me to travel and spend more time pursuing my other interests. Amateur astronomy has always excited me and since 1991, Janice and I have witnessed six total solar eclipses worldwide and spent over seventeen minutes standing in the shadow of the moon. In addition to our foreign travels we have a small camper for travel in North America. Our favorite places are the American Southwest with its many Anasazi ruins and rock art (Figure 6), Western Europe and the British Isles and its standing stones, and America's Oregon and Lewis and Clark Trails. We also enjoy the arts, live theater, and music festivals. We have recently taken up birding, which has been incorporated into our world travels.

As a kid, I had always wanted to build a house from the ground up (Figure 7). This desire has been fulfilled by recent major modifications and additions to our Bay Area home. I did all the work myself, from blueprints to painting. I also spend several days a month building and repairing structures at a nearby wildlife rehabilitation center. Never a dull moment. I sometimes miss geophysics but retirement has its many rewards. R

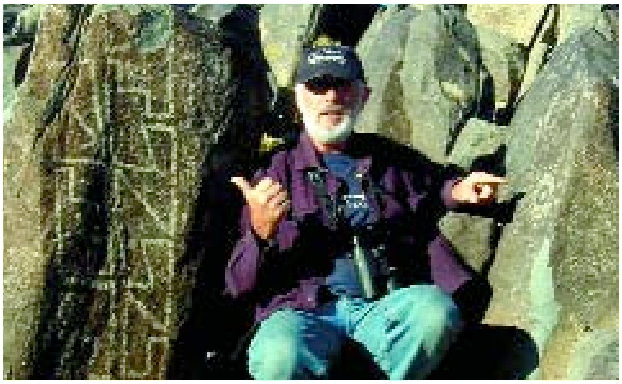

Figure 6. 2005 – At an Anasazi rock art site in New Mexico.

Figure 7. 1954 – Early training in house building.