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Interviewee: Graebner, Robert "Bob" J.
Interview Date: June 13, 2002

MMS OFFSHORE GOLF OF MEXICO

ORAL HISTORY PROJECT

Interviewee: BOB GRAEBNER

Date: June 13, 2002

Place: Dallas, Texas

Interviewers: Tyler Priest
Dr. Joseph Pratt

Side A:

TP: This is an interview with Bob Graebner. Today is June 13, 2002. The interviewer is Tyler Priest. We are at Bob's home in Dallas. Why don't we just start off with a little background on yourself?

BG: O.K. I went to the University of Colorado. I started at about the middle of World War II.

TP: Where did you grow up?

BG: Well, high school, Colorado Springs. And that was still the Depression in those days. And so, I did get a scholarship at the university and I did enlist there. So, there is the World War II experience. Then, I came back to University of Colorado and got a bachelors and a masters in physics. And in those days, there were not very many universities that offered geophysics; we had never heard of it, actually. There was class 1 geophysics like where Mike Forrest went to at Washington University, I guess, in st. Louis, and there was the Colorado School of Mines.

I was interested in classical physics. When I graduated, you know, there were no jobs in Colorado to speak of;

there was no high tech industry. The geophysical industry employed physicists and double E's and all those kinds. And, in fact, industry came from two sides: it came from the geology side where people had degree in geology, and from people who had degrees in the hard sciences. And so that is where I came from in the industry. And so, as a planned career, it zilch! But there were opportunities for employment for physicists in the geophysical business, and you can find all kinds of them in there now. That is when I started out, in 1949.

TP: You went from Colorado School of Mines to GSI?

BG: No, University of Colorado. The Colorado School of Mines is the big geophysics school just down the road from the University of Colorado. But I never heard of geophysics, particularly, at that time. And so, I went to work for GSI. We were on crews for a while. That is where you start out. And then, a few years after I joined them, they started a research department and Mark Smith was the head of that. I was one of the few guys in there that was not from MIT!

TP: There was a pretty large clique there!

BG: Yes. Of course, that is where I met Milo and that group

of people . . . Bill Snyder.

TP: Yes, Milo talked about him.

BG: He was one of the prime movers in technology in this industry, and in GSI, and in 3D. He was at this meeting in Santa Fe that we just returned from. And there were other people from MIT there that have gone on to other places. Some of them went to Scripps. Gilbert has become famous in the work he has done there. Stan Lasp. Well, Stan finally got a Ph.D. from MIT. So that was the crowd doing research in those days.

When we first started, it was more general kinds of research. I mean, we did not start out with 3D of course. As that research department grew, then one of the executives, Bob Dunlap, came up with the idea of, you know, what are we going to do with this research? How can you spend money if you cannot sell it? So, he's the guy that started in the company the idea of having an area geophysicist to work between out clients and the resource department. And I was the first area geophysicist they had. And so, it was me and the world!

That concept worked out pretty nice because we spent a lot of money on research. You know, we could sell it in

those days. You cannot sell it now. And so, that grew into a pretty big organization. We had a university for area geophysicists in GSI at that time. That was even the pre-digital days.

TP: Are you talking about a training program?

BG: Well, no. I am talking about the area geophysicists concept. We started the in-house university after the digital when there was more technology that people had to learn. Of course, with the digital thing came all the computer technology and all the software development. And so, they included that in my responsibility and I was in charge of data processing worldwide. In those days, IT was not yet invented as two words: information and technology. And so, we had this computer . . . I had l the programmers. Obviously, you had to work hand-in-glove with research which was basically Mark Smith. He headed up overall research but, you know, Mark left after the digital area, I guess, before 3D. So people think in terms of Milo being the head and he was basically the guy that I interfaced with. And, as time went on, I also became in charge of research in addition to data process and area geophysics. And then, pretty soon, Mark headed the nonoperational part of the company for a while.

Many years later, in 1988, Haliburton purchased GSI from TI.

TP: So, when you became area geophysicist, how many crews was GSI running worldwide? Where were most of their operations concentrated?

BG: North America in general, but the industry was moving around the world then.

JP: So, GSI had crews all over . . .

BG: Everywhere. Yes. So, we had a big office in London and, of course, Saudi Arabia is always a big deal. Indonesia was a big deal. Pretty soon, Australia, so we had a big office in Perth. I do not know how many crews we had. We had maybe 25 or so, but they were spread pretty much around Latin America -- Venezuela, Brazil. So, it was an interesting way to live!

TP: That would be fantastic.

BG: All this was based on that you were going to put a lot of money in research and develop something and that you could sell it. And then, you had to educate people internally and your clients. You know, in my lifetime,

I look at the technology in 3D that had three major discontinuities. There were lots of big developments, but I am talking about bigger than that. The first one, I was not around for, was in 1930, that went from refraction to reflection . . . a major change to industry. So, that is where we heard Dr. Kirchner and all those people. Cecil Green, I think he had crew *#3* in GSI in those days. He went to work in 1930 or 1931 - something like that. So, that is the first major discontinuity.

The second one was going from analog to digital in the early 1960s. A major change. And, of course, that what makes this jump from here to here. This is a semilog scale, so that is a big jump. And it changed the nature of the industry.

The third one that I lived through is 3D. That also has changed the nature of the industry. The way I look at it, we are headed for a fourth one, and that is multicomponent. Multicomponent has two pieces in it: one of them is it does provide more petrophysical data than you get from P-wave data that the industry uses 99% these days. The aim is to get a lot more petrophysical data. When you get more petrophysical data, you work hand-in-glove with the petroleum engineers which we do not do

TP: Or maybe before we do that, can you talk a little bit about the evolution of GSI in the 1950s? I am also interested in the relationship between GSI and TI, from your perspective.

BG: Well, the 1950s was when a different relationship started between GSI and TI. Really, it was the decision of TI to invest more money in GSI and invest money in research. GSI had joined this industry gag group, the MIT group. That was a GSI endeavor. The two key guys in that were Mark Smith and Robertson. What is his first name? I cannot think of it.

TP: Is it Enders?

BG: Enders Robertson. And, of course, before he graduated, we hired Mark Smith in GSI. But that was the stimulus for getting, finally, all the single processing technology, double E stuff that had been sitting on a shelf, developed probably by Norbert Weiner and a bunch of people at MIT. So, there was a whole host of things which nobody realized but you could transform the existing concept of processing into seismic signals. I think the connection with the gag group made the industry, in particular, at TI believe that it was a worthwhile investment to do research along these lines.

now.

TP: Are you talking about synthetic seismograms?

BG: Well, that is the early part of it. I am talking about getting all the properties of the rocks in making maps of it; the one the engineers start out with when they get their well data. So, the big contribution there that geophysicists and geologists will now be forced hand-in-glove in an integrated exploration with petroleum engineers. It has not happened yet. There is a big chasm, in my opinion, between geologists, geophysicists and petroleum engineering. Well, so those are the three discontinuities. Within that are major developments that we can talk about.

TP: Well, maybe we could start with the second discontinuity.

BG: Analog to digital.

TP: Yes, analog to digital. We know a lot about the shift from refraction . . .

BG: Oh, yes. I know. It is just a fact, not particularly interesting.

So Mark Smith really was hired and that is the first research group that there was in GSI. Of course, he got other members of that gag group. Milo, I do not think, was a member of that gag group, but they kind of spread around. Spen Tritel went to Amoco. They kind of spread around the industry, but there was a new wave of incipient technology sitting out there that those guys worked on.

To get further into the TI/GSI relationship . . . TI was trying to figure out ways to exploit new technology. The semiconductors were not that big a thing at that time. GSI was asked to come up. . . this was in the analog days … with some ideas on what does this industry need? And so, within TI, Mark Smith put together a big proposition for TI in finding stratigraphic traps. If we could find stratigraphic traps, we would make a lot of money. I would say he was the main driver on putting that together. There were a lot of different contributors like Milo and lots of people around who contributed to that thing and, of course, how do you find stratigraphic traps? Well, what is a stratigraphic trap? You know, there are degrees of grey that will not quit! But as a general title, it is nonstructural. That is sort of the origin of the digital program in TI. Well, there were two things. . . I am getting ahead of myself

here.

TI did a survey of the industry to see if they would be interested in digital concept - recording and processing answers. The answer was no. The oil industry is a very tradition-bound business, I can tell you that.

TP: The early 1950s?

BG: Yes, the early 1950s. I mean, this is a tradition-bound industry. In the semiconductor industry which developed .. .we were involved in the knowledge of what was going on but not participating in that. But that semiconductor industry turns on a dime; the oil industry turns gradually every decade! So, it is very tradition-bound. At that time magnetic tape was around and you could do all kinds of things with magnetic. Pure Oil Company had a lab in Chicago that would not quit with magnetic tape where they could take shifts . . . you know, it looked like a textile mill! And so they invested a huge amount of money about the time it became obsolete.

A couple of executives finally talked Mobil and Texaco into a one year deal. I think it was a one year deal in which they would put up. . . I think they put up something like $150,OOO apiece, and TI put up $5 million,

but it was really a marketing ploy from TI's side, to develop a computer in the field system. Developing signal processing software was not part of the deal. I mean, each company had their own research department and they were going to do that. So that got a much stronger relationship between GSI and TI. TI was putting up the money, and essentially we got folded as a department. The parent became a small department within TI.

TP: This was around 1961?

BG: Well, yes. Of course, we were doing the research before that. But one of the big things in TI . . . they saw all the marine work we were doing in the Persian Gulf and Lake Maracaibo, and it looked like a huge amount of data. I mean, by our standards now, it is nothing, but to TI . . . I remember the research guy they had in charge . . • the justification for the digital program was that it would save the number of people it took to interpret the data. You know, that turned out to be a nothing deal. What really came out of that research effort was the use of all of that signal processing technology that was out there and developed during World War II by double E's.

The chieftain within our company who actually did the development was Milo, Bill Snyder, and a bunch of others. But they were swimming upstream on the digital; it took this long before anybody paid attention to it – Five years. This is how the system developed.

TP: From 1961 to 1965.

BG: So, by the 1960s, we were pretty well folded into TI as a management group. A business is a business, and all that kind of philosophy that you portray it just the way we do it in semiconductors and everything else. We had all of those controversies going on. And we had to justify all our expenditures. So, we were really just a division of TI then by the time we got to the 1960s. Of course, digital made a lot of money for GSI, and therefore TI, in the 1960s. So I was made a vice-president of TI for 8 years until they reorganized and decided they wanted to do it differently.

They became disenchanted in this time period. The corporate forecasts were that you were not going to make any money, and so in the 1990s the investment in GSI went down, down, down, and then they finally sold it off to Haliburton.

I wanted to make the point that TI had a vision on the

stratigraphic trap that turned out to be right. I mean, it did justify the digital program but not in ways in which they anticipated. My experience is that you go out, invest and do something, and you find out you want to go that way instead of that way. But I give TI management the credit for pushing us to do something. If you could solve whatever problem you came up with, what kind of money could you make out of that?

TP: Who in TI management?

BG: Well, Ed Veder is probably the lead individual. Actually, the lead guy was Pat Haggerty; he was chairman of the board. He is the guy that really inspired me. He was a terrific guy. So, there is no question about it - Pat Haggerty had the fundamental concept. Ed Veder who had just come to us from Chevron, knew more about the oil industry. He was an old industry man and he was a good negotiator, so he came up. But essentially, TI was swimming upstream.

It was the same deal on 3D; the industry did not want 3D.

TP: Before we move on, let's go back to the digital period when you were trying to get the company to move to digital recording. Were you involved in trying to sell

all this?

BG: Well, of course, I was an area geophysicist, and this was a new technology, so I was right in the middle of that.

TP: Can you talk about some of the challenges and stor about that period?

BG: Yes. This is where the company characters sort of depart. Iwas much younger in those days and I was still an area geophysicist but I was in the middle of trying to sell this and you had to sell it with data, you know, and speculation, but not too much speculation and more data. A lot of these companies had major management locations in New York City - Shell included. So, I went to New York and was somewhat intimidated by this Shell guy that was running . . . well, he was way up in Shell management. Jerry Persig. Do you know him?

TP: Oh, sure. He is a legend!

BG: Oh, yeah? He is a big guy!

TP: He is an incredibly smart guy.

BG: He was smart, yes. So I spent a morning with Jerry

Persig, just Jerry and I. I was vastly impressed with Jerry. That afternoon I flew on a plane back to Dallas and we had a crew contract for two years on digital that Jerry phoned down and said, "We're going to test this out right now." I mean, Shell was a leader. Of course, Shell was right down in here at the very first, and they expanded more rapidly than anybody else.

The company that drug its feet the most was Exxon.

TP: Really?

BG: Yes. They just came out with a burning drum. They were absolutely against the digital program. So I had to go down to the chief geophysicist; he was then in New Orleans with Exxon. So, I am at two ends of the spectrum here. I was trying to set up a deal where I could bring all of our technical people down and have a day long discussion about what this thing does. So first of all, I had to give this pitch to the chief geophysicist to see if he would consider it. Well, he did consider it and we finally did make some presentations. And they were very slow on the takeup. But he told me that if this thing were as good as I said it was, Exxon would have already done it!

TP: That sounds like Exxon!

BG: sure it does! So, as a company, they were the slowest. And another aggressive company, of course, was Chevron. And in the role as area geophysicist, I got acquainted with Chevron managers at higher and higher levels. That is just the way history worked out.

TP: And Veder came from Chevron . . .

BG: Yes, he came from Chevron, so of course that helped.

Somewhere in the middle was Texaco. Of course, the independents cost too much money at the onset. There were a lot more companies around then. There was Tidewater, General Petroleum, and all of those people. It was an exciting time.

The people I knew most, which were the district geophysicists in these things, as on 3D, when it came around, it cost way too much. We did not even budget that much for the year, you know, and you are talking about us doing one survey.

TP: How quickly did digital recording make an impact? How and when did it really begin to change exploration

strategy?

BG: I would say that in 6 or 7 years it began having an impact. I mean, there were some really outstanding problems like water reverberation in the Marine… it was just obscure whenever we had those kinds of things. And, of course, Milo invented a process for GSI called the multiple analyzer eliminator which was an analog device with electrical filters that could delay things.

TP: He called it an analog digital filter or something like that.

BG: Yes, I mean, he could digitally delay these things. It was before we did it on the digital computer. It was a big, analog device. It was just a wonderful theory and it worked out really good. That was really my first fort before digital in getting acquainted with all the industry; but, of course, I got acquainted with them on the Marine side. I had some gorgeous examples of stuff processed through the may process that I got rid of a lot of reverberations. But, of course, when we went into the digital era, that was just one of many signal processing techniques then.

TP: There was an article that you wrote, "Seismic Data

Enhancement: A Case History."

BG: That is an article I wrote.

TP: In 1960?

BG: Well, that was really analog!

TP: Is this partly what you are talking about?

BG: No, I am talking specifically about this may process, analyzer and eliminator. I was talking about that. That was what Milo put together. It had a major impact on the water reverberation problem. But someone had to buy all this analog equipment. It was not like when it later became to be on the computer when you could writes a software program and it was just one of many. That is probably the first major impact that Milo had on GSI.

Similarly, when we went to 3D, there was a halfhearted attempt at a market analysis of whether that would be accepted in the industry. And the answer was not only hell no, but it is way too expensive, it is just totally impractical. And if you just looked at it, just surviving up there, it was. So, you had talk at the NP level and not just the E level. So, I give credit to TI

for swimming upstream on the two major discontinuities that I have participated in.

The early major developments within these, 1ike CDP ... CDP is one of those that, like Milo's may processor, was an analog system, but it did not come into its own until you could do it digitally.

Another case I will make here that a lot of people will not agree with, especially if you talk to Exxon and some of the others, is that at least two discontinuities and most major developments were made by contractors, not by oil companies in the 1950s, 1960s, 1970s, and 1980s. One exception is the vibracize which Conoco introduced. Now, name me another one that the companies did? I mean, the contractors put a lot of money in research and it paid off and the industry benefited; so did the contractors, of course. There were periods of time when we made a lot of money. We just saw at this meeting in Santa Fe that in the last five years the contract industry lost money over this.

TP: Well, the 1960s is an incredibly fertile period.

BG: The late 1950s is when the may process came out and we could get an audience with any oil company that was doing

marine work. So it started then and then the 1960s were incredible. Certainly by 1965 there was a major effect in the oil industry. That is not what it shows, but it shows much more usage of the digital system. And, of course, they would not pick it up on that kind of curve until.. .

TP: Are we talking still about digital recording or digital recording and processing? The oil companies did a lot of their own processing, too, right?

BG: That is right.

TP: But GSI also . . .

BG: We started out doing most of it; all companies had major, major computer palaces.

TP: Yes. I know the one that Shell had down at Old Spanish Trail.

BG: These were palaces! Amoco had one in Tulsa. We were glad they had those things . . . you are getting a very parochial contractors point of view here, but Amoco had good business practices where management controls all these things. So, they were early on the IT idea. They

had this palace in Tulsa that processed seismic data and also credit cards and everything else. And those exploration people just hated it! I mean, those fundamentally do not mix and, of course, everybody knows that now.

TP: I know that Shell was just the opposite: the exploration people got all the computer money and the other parts of the company were jealous.

BG: Well, Shell is one of the companies that I most admire. I certainly admired them unilaterally in those days. They have gotten too big into holding since then, but Shell US and Royal Dutch Shell . . . I used to visit Royal Dutch Shell maybe once a month for a couple of decades. They were a huge buyer of technology and they would work with you on it. And then, when you would get something done, they would give you a fair price for it. Of course, that has all changed.

TP: You started out doing recording processing and then . . .

BG: There was a big area . . . I mean, it did not last very long, but the recommended way to go, and IBM strongly recommended it, was to record magnetically in the field and then turn the tapes over to them and they will

digitize and process them. And then people can buy IBM computers and process it. So, IBM thought the whole thing was about data processing and not recording. In fact, I gave a paper at the National Convention in LA at that main old hotel down there… it is a big, classy hotel. But I was giving a paper on some new signal processes. Just in front of me, IBM gave their paper, and it was really an arrogant paper, on how this whole thing should have been done. And they showed a picture, I remember, of a field system and a hammer hitting it. Digital field systems cannot stand this kind of environment. You do not make it dig, you just keep your analog stuff, which appealed to a lot of people because they already had analog stuff. And then you buy an IBM computer and just take the stuff and digitize

TP: There was not a lot of self-interest involved in that!

BG: I will tell you this: initially, TI did not want to get into making computers. I mean, that was not their idea on this thing. So they wanted to make a deal with IBM where they would have some kind of joint program. I almost forgot this in the early stages of the digital thing, and IBM did not think there would ever be a big enough market to justify their participation. As history came out, the seismic part of the oil industry is the

second largest user of computers in the United States following the government. So, business judgement varies! I mean, just like that. My Exxon story is probably not printable, but . . .

TP: Can you talk about how it evolved in the 1960s from the digital recording and processing to how you started to move toward 30?

BG: Yes. By then, when that came around, Milo and I were kind of senior managers in GSI. He certainly was the manager of research and ran all that stuff. So we made presentations to the TI board on what is the next technology that we are going to do? Milo -- I will give him 98% of the credit -- was the conceiver of 30. If you want to identify any one individual that led 30, that Milo. After Milo, there were a bunch of people who did that.

TP: This is mid 1960s you are talking about?

BG: No . . . well, when we made these presentations, it was still following the digital revolution. Where it was the next problem you are going to tackle?

TP: so, it is the early 1960s when you are making

presentations about 3D?

BG: Yes, early 1960s. About 3D. A single theme that we had was that you need a large computer. If you were going to have three orders of magnitude, increase in data volume . . . up to then, TI made very successful _____ Computer and then A70A computer. They completed with the IBM product very successfully. So they thought, "well, that is nothing. We will make one of these parallel computers. So, TI was one of the ones who made the first vector computers. And they were going to sell it.

The idea of a vector computer as opposed to a scaler computer came out of all of this. TI called it the advanced scientific computer. Well, that turned out to be a monstrosity of a project for TI. I am sure they lost money on all of the money they put into that. But after you build the hardware, the software looms beyond your imagination in complexity! Certainly in their forecast of what it would take to make it work, because they were going to use it for the Weather Bureau. Australia wanted one for their government.

So part of my life involved there, I guess that was in the 1970s, was trying to make use of the ASC for 3D.

Royal Dutch Shell bought one and put it in Amster ---------- which is adjacent to a piece of Amsterdam. They probably sold one half dozen of them, but by then there were too many people working on computers who knew what they were doing. I cannot think of them all now, but Andall; not just IBM. CDC. Successor. Parallel computers all of a sudden hit the . . . it was another brilliant idea that the people latched onto. And, of course, for seismic processing, you need it as a minimum. Computers have gone on beyond that now, but . . .

Throughout my career and Milo's, there were more by geophysicists on what to do with it than you could afford to do. I mean, computers were always the limiting thing out there.

When we first came out with a price list on digital processing in the very early days, one of the things you do is design a deconvolution filter on every third trace. People nowadays think that you can do it just like that. So the development of computer technology was a major facilitating happening for this industry.

TP: And Ken Berg?

BG: Ken Berg was really the technical head of GSI when I went

there.

TP: He was associated with most of the work . . . or was it his son?

BG: His son. John Berg. I mean, Ken was above Mark Smith. Ken, I think, probably hired Mark Smith. And John – if I had to name a name for deconvolution, John Berg … after that, a zillion people were involved in it. I mean, there were some people who I think were first. GSI came out with one process after another, which really more engineering than it is fundamental research because we were using ideas from other people which John did, too.

TP: I am sorry I interrupted you. You were talking about computers as the limiting factor.

BG: And, you know, it was then and it still is now. The big thing now is prestack migration. Well, that costs a lot of money and people try to be clever in cost reduction, so they are still fighting how to use computers very efficiently when you do prestack migration. That is just the same story that it has been forever. Pretty soon, that will be a nothing. I mean, the price has gone down so low for doing it . . . you can process an incredible

amount of data for a couple of pennies.

So, I would say, if we are talking about 30, that TI swam upstream on that one. That was harder to sell than digital.

TP: What about your competitors? Were they working on 30 and pushing it by the late 1960s like you were?

BG: Well, first of all, then we will go back to digital on that. Amoco was independent in spirit in those days, so about that far down the curve they decided that they would make their own. So they had a model 1, model 2, model 3 - all the different formats. And pretty soon, they were in the soup. People discovered that you do not want to change digital formats. TI came out with the first 21 track, one inch tape, and that was the standard format for industry for 9 months. And then, the SEG standard format came out the industry could side on. And I think there are 240 variations of that. So that the problem.

Amoco got Western Geophysical involved in making field instruments. They made a few, but they did not go anywhere. So there was no competition for a few years on digital instruments. And if you go this far, these are

all TI/GSI, other manufacturers got involved in here.

TP: So you are talking about the growth of seismic digital data.

BG: Yes. For 10 years, I would say that TI had the market. And that was not a part of GSI, but TI. And the 9,000 switch were vacuum tube things and then they went to the lO,OOO's. That was a standard thing for around the world.

TP: So, was GSI selling those instruments to the oil companies or was TI selling directly?

BG: TI directly. That is another point that I think was part of the success of those instruments. They could have made it for GSI in-house and we would have had an exclusive on it, and there were those arguments. I argued that we ought to sell independently to all the oil companies and contractors because, boy it makes . .. you get a lot better response from other people besides an in-house division wants something. I am for a competitive atmosphere in that thing, and it helped TI out tremendously. GSI did not make any of these instruments. So, when you say a competitor, I think that we were working jointly with TI . . .

TP: I was just reading about the relationship between TI and GSI and how, over time, the contribution of GSI as a division to TI's overall revenues was declining. But, in this case, it was linked to the geophysical business.

BG: From TI's point of view, it was all one piece. From GSI, actually, we did not make any instruments. We bought them all from TI at market price. And if they would have made them available only internally, market price would have been three times higher! But, on the other hand, TI made a lot of money building instruments. But from their point of view, that was one business. The fact that it was made in a different division did not make any difference. That is an important point on the link between TI and GSI.

TP: so, did you go through the same song and dance trying to sell 3D?

BG: Yes, I would say it was a great deal harder.

TP: It took a much longer period of time; it did not catch on. 3D goes back to the late 1960s, but it does not really …

BG: Well, the first production was done in 1972, so it

is back here somewhere.

TP: Yes, but right about here, you really see the jump in 1987.

BG: It is pervasive in 1986 and 1987. And these were various places in the world, or two places. I have grafts on others, but this is really how it came. So, Gulf of Mexico went faster than the rest of the world. These are very accurate. I could count them. After some point here, it became so that there were so many of them that you cannot . . .

TP: This is a chart on 3D growth patterns from 1983 to 1992.

BG: And this is square kilometers, not money. Money is not a very good indicator. I mean, you have got inflation, you have got all those good things; so money is out of this thing.

TP: That is an interesting graph.

BG: This point here which is 5 years out, 15 years out on that one . . . the 1972 is the first one that was done out here.

TP: The first 3D shot in the Gulf was 1972?

BG: The first 3D which was land in west Texas, Lee County, New Mexico . . . we sold it to a group of 6 oil companies that were going to evaluate . . . it is what I call a first production technology, a demonstration of it. The first 3D in the Gulf of Mexico, I believe, was in 1975. Well, I know it was - it was Sun Oil Company.

TP: And GSI built it?

BG: Oh, yes. We did that. We did them all for a while.

TP: For how long before others started getting into it?

BG: I would say something like 5 years. You know, I am also on these circuits where you give papers at professional societies and Western was there also. They developed a kilocise, which is 1,000 traces in a streamer. And we appeared on the same show, you know, in which they were arguing that the way to do this thing in marine is to kilocise. I was saying that you have got to do it 3D. Well, to kilocise, you know, you are just pulling a cable with 1,000 traces in it, so they not 3D. It is just a bunch of baloney.! You had a lot more strength in a CDP kind of analysis, but it had nothing to do with 3D. That

just part of marketing.

TP: So why this jump in 1986-87?

BG: Well, it took that long to . . . we did save a lot of money. So, we are back to this thing here.

TP: This is the business plan for 3D.

BG: We took this to E&P. By that time, I had gotten acquainted and other people in the company with E and P managers. Well, some of them came out of geophys and they got promoted.

TP: It was probably easier to work with companies who promoted geology and geophysicists to top ranks!

BG: Exactly. But this is what got Chevron and Texaco . . .

End of Side 1

Tape #1, Side 2

BG: So, these are just actions with and without 3D . . . you crash the time, you drill less wells; so, time is money. You save delineation wells at $5 million apiece. Then you cannot find the cost of 3D; it is the roundoff. And so, here are a bunch of different actions . . . if you do them separately, it is the time value of money. If you do them all together . . . you know, various scenarios here. . . And just those simple ones there really are what…

I showed this to Larry Funkhauser when he was head of E&P for Chevron. He called their New Orleans group and told them he was going to be there in two weeks and he wanted to see five 3D surveys planned out. Of course, I had already been to New Orleans and got kicked out th very expensive, ridiculous idea!

TP: With Chevron?

BG: I will think of the guy's name. You probably know him. He came from Gulf.

TP: Galvan?

BG: Galvan is one of them, but a guy under Ray Galvan even. I am sure you know this guy. Before he retired, he was the head of Chevron domestic, you know, the only exploration company they had left. He was a very outspoken Aggie geologist. He was going to have nothing to do with it and then he was just mad as hell at me one month. Then we kissed and made up! But you have to be careful when you go around somebody to promote something. But, of course, I knew Larry Funkhauser very well.

And so, this kind of argument is what you had to make. And then, pretty soon, we had case history data. I mean, case history eclipses of everything. I had four of them in that book, and one of them is Exxon and therefore, it a fairly recent one! Exxon gave us, then in those days, a lot of credit for Exxon eventually doing it . I remember they came by our organization twice in Houston. They thought so much of it that they put five Ph.D.s on it that wrote the papers, you know, and they went around the world giving this thing. That is after . . . well, it was digital, not 3D but their initial response was just about the same.

Exxon continued that as a project on 3D. They analyzed everything out to the Nth detail. Those guys had to

figure out how much less data you could have recorded in the field and gotten the same answer - a really stupid thing to do. You should always overshoot because as time and technology move on, overshooting becomes undershooting. So that is another Exxon story.

Shell was one of the first to pick this thing up. In fact, I think Shell claims they did it in some way in Libya in the 1960s.

TP: You are talking about Royal Dutch Shell?

BG: Royal Dutch Shell, yes. our first land project was with Royal Dutch Shell in Holland. Their local chief geophysicist and I worked out this program. I do not have that book here, but they laid it out six square miles and it was too expensive, so they cut it back. Then, they cut it back and they cut it back. I think we shot three square miles or four square miles or something like that. And it turned out to be really spectacular, so they enlarged it, reshot it again, six square miles or something like that. And it looked even more spectacular so they reshot the whole damned thing! Six times. Talk about saving money!

Shell was the leader in promoting 3D in the oil industry.

There is a leading edge book; if you are interested, I can even give that to you. It shows… well, essentially, this guy's paper.

TP: A leading edge paper?

BG: Yes. Let me see if it is in there. This is one of the first ones they ever did in Nam but it is just Shell's view of it around the world and why you need to do 3D. So, they had a corporate policy. They had Woody Nestfull give this thing around the world because they were having trouble in their partnership deals of getting the partners to agree to the cost of 3D in a marine survey. I mean, Shell would have done about 95%.

TP: They would shoot 3D for 95% of their . . .

BG: Yes, I mean, if they could, but they could not; with a lot of acreage in the North Sea, there were joint partners or multiple partners.

TP: I always thought that 3D was used initially, not so much for exploration but because it was more cost effective to use to develop or explore fields . . .

BG: Yes. In fact, this was an argument ... I mean, our

pitch was built around field development, not exploration.

TP: But were people using it for exploration or not until later?

BG: To the extent that anybody used it more than somebody else, Shell did. I mean, certainly maybe in the first 10 years as mostly field development. So you had to trade off the cost of 30 versus saving wells. One of them made umpteen trips out to LA to convince Unocal that they ought to do a 30 in the Gulf of Thailand.

TP: Milo told me to ask you about this story.

BG: It did not happen this trivially but he said if he did one 30 would I quit pestering him? It is a bigger deal than that but . . . he had two locations in the Gulf of Thailand that he wanted us to do the 30 on. O.K., so we bid on it and won the job and were going to do a 30 on it. He said, "Well, can you do it immediately?" That just not the way to mobilize something because it moving two rigs on these two big anticlines in the Gulf of Thailand. So we had to get in there and shoot 30 real quick. I think it was 12 square miles or something like that; not real big. And they shoved these two wells in

there with no information from seismic whatsoever. These were mapped but by McNaughton and Unocal on vast amounts of 2D data that they had in there. And the first well off each location was a dry hole!

This is Hal Leon. I knew I would remember his name. He was really a nice guy, a famous geologist. He did not want to see too many faults there. So, we finished this thing finally and it looked like an egg shell had been thrown against the wall -- it had just faulted all to pieces. So they started drilling on what we told them were sands in between the faults and they hit it right on the button. The last time I left the scene, they had several hundred wells drilled without a noncommercia1 well . . . I mean, they also learned how to drill. It was an amazing success story.

About the same time, we were doing the Gulf of Thailand with Texas Pacific.

TP: I think this is a different story.

BG: Yes, it is different, but it was about the same time. This is the story with. . . .

TP: the name of Dr. Dom. Milo mentioned someone by

BG: Dr. Dom, yes. He was their chief geophysicist and Rubitz was the boss. Actually, I sold it to Al Rubitz. Dr. Dom thought it was too expensive. We sold 20 square miles and Al Rubitz kept cutting it down. I think we shot 12 square miles finally in the Gulf of Thailand. It looked like reasonable data and we processed that stuff. I had to run down in one main place where they had their office there to show the latest stuff to Dr. Dom. He was a good friend; he is dead now. He was a pretty harsh critic. He thought we did a terrible job of processing that data. Throughout history, we had done a lot of work for Hunt. Dom was very critical. He said, "You guys do not even know how to process this data. Look at all this crap, this stuff is shallow." So, we got it in a 3D cube and the revolutionist would be able to take horizontal slices through there. I have a paper . . . well, there it right there. That is the paper on the Gulf of Thailand, Texas Pacific. Dom and I wrote this thing. Actually, I wrote it, but in those days we tried to get the client to coauthor everything. Look at all the faults you see in this thing. I mean, it is just amazing. He complained bitterly whenhe looked at these vertical sections through here that were all crapped up. Well actually, we were shooting all through these channels . . . until you take a horizontal slice, you know, and can really see what is going on. There is just one reproduced here, but

you take it every five milliseconds and get a different picture, a different channel running in different directions. So it is full of channels – shallow and deep.

so, it gave a totally different picture of the image of the subsurface. All that crap you process in shallow was geologic; it was all channels. And as you went down the section, it was just full of channels going in different directions. That was just how it was deposited. And so, that made us famous. We showed that in papers around. Royce Nelson of University of Houston, do you remember him?

TP: Royce Nelson? No.

BG: He was professor there. He asked me if he could borrow a bunch of those things. He and a couple of other guys formed Landmark Geophysical. They used our Gulf of Thailand stuff . . . this was all done on an interactive.

TP: This book, Landmark Graphics?

BG: Yes, Landmark Graphics. That is how Landmark Graphics got started. He borrowed these pictures from me. Well actually, TI had developed a workstation. That is what

all this stuff was done on, a TI workstation. He got some investors, he and a couple of other guys, to make it a business; whereas, it was just part of our interpretation system. We were, again, not building a product.

It is interesting . . . part of the story on 3D that I did not mention was that, in the Gulf of Mexico, the whole industry is organized to interpret 2D data. So, you get a record section along a table like this and get your color crayons out and draw these horizons in. I can remember when we first sold Amoco a 3D survey in the Gulf of Mexico -- it was maybe 20 square miles, it was pretty big -- we made some terrible enemies in their interpretation crew because they had so much paper. If you have it every 50 meters instead of every 2 miles the paper is overwhelming. So they took this 3D data and interpreted every 50th line. So, what is the point of shooting 3D? But 3D would have almost died on the mind if we would have had to deliver the product on that.

TP: If you had to do the interpretation . . .

BG: anybody had to do it that way. You built a system where nobody could produce a product. And so, Marion Bone was another guy that worked with GSI at that time.

He worked for me. We had a few bucks in those days to spend on worthless ventures, and so I gave him some bucks to spend on what I thought looked like a worthless venture. But he came up with a table like this with a glass top on it and a way of projecting this data up on this glass. So we would take these horizontal slices of the section and follow the same pick as you go down on there. So in a few minutes, you have a map. I mean, you do not pick individual records anymore. You do not have to post and plot. In real time, you develop a map, draw in the faults. So that was a revolution.

TP: His name was Marion Bone?

BG: Yes. In my opinion, it saved the 3D industry. It made it economic to do it then because workstations came after that. Workstations as a product came after this se crop table, we called it.

TP: So, it projected . . .

BG: Today, you could project anything you want, but then we were taking horizontal slices. So, if you have an event that you follow in time through this projection, well, as you have followed it, you have made a map and that represents a contour. So we made three of those. The

third one was 100 times as good as the first one, I guess, but we finally made 12. We thought that was the market for these things. They were around the world.

We were able to shut down that product. We made 75. And by then, the electronic workstations were . . .

TP: About what year was the seis crop?

BG: That was in the early 1970s as a product.

TP: So, right when you really started . . .

BG: Oh, yes. I mean, it would have killed marine 3D in the Gulf of Mexico. Amoco or any other company did not have enough room to store the paper, let alone the guy with the colored crayons! They were going to follow these vertical sections. You would get a piece of paper for one, you would get a piece of paper for 50 meters on to try to . . . it was impossible. I mean, it was not a product having to do that.

TP: The workstations came along how soon after that?

BG: Well, the Gulf of Thailand that we did was on a workstation. TI should have gone into that business.

In fact, they did but they went into it too late; TI as opposed to GSI. You know, the first commercial really effective workstation was Landmark Graphics. I do not know whether Royce would admit to that or not, but he was interested in that at the University of Houston, so he came out . . . the chief hardware developer out of that thing came out of the TI workstation project. I will think of his name in a minute. So, we all steal from each other!

TP: Well, it is the nature of the . . .

BG: It is the nature of the business.

TP: Yes, in a technologically innovative business, it is hard to keep control.

BG: You do not. We had this ongoing argument all the time. My argument about patents was that you pursued patents for defensive measures, but a patent does not do anything for you. If you have got a technology you want to live, you have to keep pouring money into it and keep changing it.

TP: What was the patent position of GSI? They must have had thousands.

BG: Well, you could not patent software in those days. That was the big deal. We could have had a patent on deconvolution. We had hundreds of patents submitted on signal processing things. You can do that now, but you couldn not then. So, TI had a lot of patents on the field system and that sort of thing. You know, semiconductor technology changed so fast that it was not really a patent issue too much. TI was not, in my opinion, an aggressive patenter. They did what was right, I think, but Amoco, for example, or Philips, they had a patent department full of patent lawyers and they went around and beat everybody in the head to come up with a patent. That is how the lawyers got paid. TI did not do that. I mean, they got a lot of patents and they got semiconductor patents. They had the solid state circuit patent along with Fairchild.

TP: So, the technology gets out. You have people who leave.

BG: Yes, they start new companies!

TP: That is what has happened to the research organizations of the major oil companies. There are virtually none left.

BG: And some of them come out of universities. Royce, for

example, came out of the University of Houston.

TP: GSI seemed to be sort of a feeding ground for the whole geophysical industry.

BG: Western came out of GSI . . . everybody did until later in time. United did not. United was Herbert Hoover's son.

TP: How about CGG?

BG: CGG was certainly not out of GSI; that came out of Elf and Total. There was a raging argument about CGG in the early years because Larry Funkhauser, for example, head of E&P of California would not let his guys use CGG even though they wanted to sometimes because he figured you were giving it to the French government. This was when exploration was around the world. People were trying to shut out the French, actually.

TP: I was reading that there was quite a bit of attrition at GSI of talented people who went elsewhere and started their own . . .

BG: Like Marian Bone. He worked for me at GSI. He went to Sohio and then BP and became a senior manager. He quit

them and started his own company called Time Slice. He is the guy who invented the Time Slice. He is given credit for that somewhere in here in this paper.

TP: So you lost a lot of people to the oil company themselves?

BG: Yes, lots. The people you used to whip in shape, pretty soon, those were the guys you were begging for a contract!

It has been an interesting life.

TP: Well, what interests me about GSI are the links between industry and academia.

BG: It was strong. I talked to you about the geophysicists university, but what you are probably talking about is the co-op program. I mean, that was really a good deal that co-op program. Cecil Green is the guy that put that together and industry participated in Cecil's co-op program. You would get senior executives from oil companies to come down for that week and spend a few days. I went to that co-op program and Milo did, too. That was a source of major inspiration. I mean, all of a sudden you see all these other industry people around,

not just the outfit. I had already promised to go to work for GSI by the time I went to the co-op program. Everybody believes they cannot afford it anymore, but that was very successful.

TP: How long did it last?

BG: About 10 years, I guess.

TP: The co-op program?

BG: Yes. Before the cost cutters got into TI!

TP: I saw something mentioned in the Lloyd and Bates book about employee training at GSI. The Ed Stulkins College of G-Function and Knowledge?

BG: That is another big program. It was a correspondence course, basically, that Ed Stulkin had. It was very useful when we got into the digital era. It was more fundamental than just how you process data, but that was a very successful program for a couple of decades. It was very useful to GSI when we got into the digital era. So, Ed wrote programs relating to signal processing to geophysics and geology and made the connection.

TP: This is for GSI?

BG: For GSI around the world. So, our people in Singapore, you know, could send stuff into Dallas which they did. There was heavy participation in that program. So that was a major program. There was a need to disseminate the stuff if you were going to sell to somebody.

TP: What about some of the individuals? You talked about Milo a little bit … just about their personality about their role in the company. Cecil Green, did you know him very well?

BG: Oh, very well.

TP: Can you talk a little bit about him? He is too old to interview right now.

BG: You cannot interview Cecil. In fact, we became li long friends. The last few years, not the last three years but when he went to La Jolla . . . you know, he would come back to Dallas for a week every month. And Cecil always wanted us to set up something for him at the Petroleum Club. So, we would see him . . . he would talk to my wife on the phone. A great gentleman. That is sort of how I remember him in the company.

More than a few years ago, I had to go through one of these kinds of interviews, except I was videotaped by some outfit that came out and wanted to talk about Cecil Green. That day lasted 12 hours, I think!

TP: Was this for the SEG?

BG: The Chamber of Commerce or somebody gave him a business award or something like that; a great big deal down here at the hotel. That was another one of the millions of awards that Cecil got. They were videotaping a lot of different people, but I was one of them. The initial view was that he was a terrific scientist and was really into the details of things. He was a smart guy and a good scientist, but that is not where he made his major impact; his major impact was putting people together. He was a people emphasizer.

When I was president of the SEG in 1987, Esther and I, we took him to China with us. And, of course, they revere elders there. The way to travel China is behind Cecil Green! We stayed an extra two weeks for Cecil following him around China. He got a lot of respect from those people. And, of course, he had to give a speech wherever he went, to universities. They thought they would get a great technical speech, but they got a speech on the

importance of people in the business and one thing or another. It turned out that the Chinese liked that because they did not get that from their culture in those days.

So, his emphasis was on people. He put the co-op program together. He got people from industry. Only Cecil could have done that.

When I came down to be interviewed, I guess, in maybe 1949, I did not have very many pennies in those days, but I came from Colorado Springs to Dallas on whatever railroad was going in those days. It was an overnight trip. I went to be interviewed at GSI and stayed there for a day and a half, but what impressed me was that when I had to go back to the railroad station, Cecil took me there in his Cadillac.

Many, many years later, but still in the early times, GSI had gone on the board as Texas Instruments, and I just happened to be one of many standing with Cecil in the hallway there on Lemon Avenue in that building, and TI had reached 7 books. And he told us that it had reached higher heights than he had ever dreamed of. And this is before any splits, of course! And, of course, we made such little money in those days that if we would have

bought the stock we would have missed a meal or two, but God! Amazing!

Cecil was a prime mover in GSI in a people orientation kind of way besides of the contributions he made to the industry.

TP: He could recognize talent.

GB: Oh, yes. And he thought it was very important.

TP: And who worked well together.

GB: He made a good area geophysicist out of me. He liked that sort of thing where everybody is in contact and you do something in concert.

TP: That is good. What about some other people? Mark Smith?

GB: Well, of course, I knew Mark real well. He was hired by Ken Berg to start the research department and hired a lot of excellent people. He hired that tribe from MIT. He hired a bunch of others from Colorado School of Mines. I had to decide what tee shirt to wear to work: School of Mines or MIT. But nobody had ever heard of the University of Colorado!

Mark and I turned out to be good friends over the years. He was president of the company and ran it for several years. After head of research, he went on to become president of GSI. He aggressively supported my career. He got too wealthy, I guess! He is in Vermont.

TP: He went off to write short stories.

BG: I asked him what he was doing, he said, "Well, I'm just clipping coupons."[11] It was a long time ago when he clipped coupons. He absorbed the Cecil Green ethic. He was not an outgoing person like Cecil, but he recognized talent and supported it. And so, I give him a lot of credit for … well, he was the lead in putting together the stratigraphic thing that led to the digital program. He was certainly the lead on that.

The unquestioned leader in GSI that made big changes, both in digital but certainly in 3D, was Milo. He is the number one guy, unquestioned, about 3D. I mean, you can question number two and three and four, but not number one.

TP: He was the guy with the vision.

BG: Yes. He and I went around the world at different times

and he gave fantastic presentations and always got people interested in it. He did not have to tell them how much it cost in those days, I did!

TP: Well, it sounds like a good team.

BG: Yes, we were a good team, and Milo is a good personal friend. And Bill Snyder is another great one. And Bill French who started Tensor. Of course, that has been sold some time ago to PGS. So, Bill French did a physical model at Gulf Research Labs which were published and we made big use of that.

One thing that annoys me is that Exxon finally bulldozed their way to getting SEG to recognize that they invented 3D! I mean, GSI had gotten an award for it umpteen years ago on 3D - the proper award which is commercializing an idea. There is no such thing as inventing unless you want to go back and forth with something. How do you invent gravity? How do you invent 3D? But it is in the Exxon annual report. Lee Raymond is saying, look what great things we have done; we invented 3D. And that is just the craziest thing I ever heard of.

TP: How could they take credit for that?

BG: They published a paper in the analog days. Bill French and I were discussing that at this at this meeting. They were having a fiberoptics thing where they could simulate these waves coming down, so you know, in a way, you were getting a time slice when you looked at that stuff, but two things are wrong with that: That was one interesting paper that did not have any bearing on what anybody did subsequent to that. So, that is their basis for it, but there is no basis for saying that that is 3D. And number two, Exxon, to the best of their ability, keeps everything secret. I mean, what can you say . . . Exxon contributed towards the industry. They do not 1ike the word "contributed."

TP: Well, I heard the story that in the Friendswood field, there was a story . . . I think Tom Barrow may have told it to us, where they hung the seismic sections from the ceiling and looked at it in 3D.

BG: Oh, that is O.K. Number one, that is not 3D. I mean, the image was not obtained in a 3D sense. It is a 3D presentation … you can go to northern China, which I did and they have a great big building of their reservoir. It is all 3D, all made from gravity and wells incidentally. It is a 3D presentation, but that is not what 3D is. You cannot talk about 3D unless you are

going to talk about migration. And what Tom Barrow has, it has nothing to do with migration. He built that model from wells and 2D seismic in Friendswood. I am sure he is doing it as he sees it, but it absolutely is not what we call 3D technology. A presentation of 3D from 2D images or how you think it is or extrapolation from wells is not the 3D process at all.

Well, the Chinese showed us how they did this 50 years ago or something like that! And that is a problem I have with Exxon's claim that they invented 3D. The paper they did publish which was probably in the 1950s . . very clever, very expensive, but no migration involved. I mean, 3D involves gathering data in a spatial sense so that you can put together that data wherever it reflected from with another piece that came from that same spot. As you know, when you shoot a 2D line across a structure, it comes from over there or over there, depending on what the structure is. 3D is the process of finding those depth points that actually did the reflection and projects them into a plane. There are many things about 3D images, but the heart of 3D images is 3D migration. And if you do not have that, you are not talking about it.

TP: And you said Milo is the visionary in this part?

BG: Oh, absolutely. In my presentations, I argue that anything that the industry does in imaging the subsurface is always 3D. When you drill, you are going to drill in three dimensions. So, all we are talking about is how do you get that product? How do you image it? 3D imaging is totally different than just taking 2D samples and assuming they are in the plane when, in fact, they are way out of the plane in the general case -- and then making a 3D structure out of it. But, every contour map that anybody ever used is 3D. But I do not think you can use the word [11] invent!" Otherwise, I have no opinions!

Can you talk a little bit about the Gulf of Mexico and its importance in the history of GSI and the hashish of 3D? I can see from this 3D growth pattern that it probably was all around the world, but the Gulf of Mexico

TP: is the place . . .

Yes, this is where we developed the systems, in the Gulf of Mexico. I do not know how to begin on that because there is so much published in the literature on it.

BG: Well, I do not want you to waste your time on things I can find elsewhere.

TP: I can remember an SEG convention . . . the floor of our

BG:

booth, and there is a picture of Milo on the front page of our Grapevine, walking across our time slice magnified maybe in these two rooms here that shows just fabulous structures in the Gulf of Mexico. And this is when it first came out, 5,800 square miles of spec data we had. People began to shoot . . . it was called exploration 3D, in which the lines were far apart than what you do if you are paying any attention to get any detail. But that was the cost issue in those days. And so, it gave you a grosser image and a grosser image is lower frequency. As you go up in frequency, you have to pull in your spatial sampling or get all of this A leasing. One of the major parameters that anybody comes up with is what kind of structure are you trying to image and at what frequency do you want it? That determines your spatial parameters.

In those days, we had 5,800 square kilometers of 3D laid out as a rug. That was really an attention getter in the industry, in the Gulf of Mexico.

TP: This was all spec, right?

BG: All spec, yes.

TP: About what year was that?

BG: I do not know. It might have been the late 1960s. It was early enough to get a lot of attention. Today, you would thumb your nose at it because it is too crude and too low in frequency. People do much better work. I guess one could research that figure, but I would say it quadrupled the reserves in the Gulf of Mexico. 3D. It is a major factor in 3D exploration and field development in the Gulf of Mexico; and continues to be that way. It is very important when you get into deep water where a well costs $30 million. However expensive 3D is, it gets to be in the roundoff.

TP: I was talking with Milo about this. He thought the real value of 3D is in allowing you to exploit smaller and smaller fields.

BG: That is what I am saying, in doubling the reserves. I mean, the economics . . . you saved 47% of the costs, you have doubled your reserves.

TP: And then when you get into deep water, it also saves dry hole costs.

BG: Then you have got the risk element, big time. Big time. So, it is just as essential now as it ever was.

What is becoming important in deep water now, though, is multicomponent. The early history has not even been written on that yet. We are all making projections on how valuable it is going to be, but the jury is out. But that is coming to the forefront and there are some companies . . . one, Milo might have talked to you about - Aim, in which we are involved, Barrow is . . . are recording 20 sheer wave stuff in deep water. With sheer waves, you can sort out what the fluid is in the layer which gets to be pretty important in deep water.

TP: What about 40, the time lapse?

BG: The time lapse? Of course, I was promoting that.

TP: Right. I read about that.

BG: And we did some really good work for . . . I quit my career on that. That really has not taken off yet.

TP: It is all in the technical literature but . . .

BG: Yes. When I say "take off," I am talking about . . . it has not hit this curve, that is for damned sure! What I say is that you are not going to get this curve until you get to be multicomponent on time lapse, time elapse.

Well, Milo says time lapse. I correct him all the time. My argument is why invent a new word when one already exists that is precise. I mean, lapse is a technical word, but if you are using nontechnical words, it is a pejorative word, isn't it? I mean, lapse in memory, lapse in this. So, I do not think time elapsed technology is going to be a big deal before multicomponent is accepted because what you are trying to do on a time elapse is predict where the fluids have gone or where they are going or what is happening in fluids. You need to compare sheer and P-wave responses if you are going to address fluid content and fluid changes. So I am big on time elapse, but it has got to wait until people accept multicomponent.

TP: When did you present the paper and start talking about this?

BG: I guess it was in 1989, somewhere in there is when I started. It was a several year period. That was part of my distinguished lecture. And, of course, I made extravagant claims and all those good things! That was in the Osenberg field in the North Sea. It was really a good result. And since then, the Osenberg is a time elapsed case history. Well, I guess it is; I mean, they would not publish it. I know that they have had multiple

repeat surveys . . .

TP: Who is the company?

BG: North Sea Drill. We did three, but I am sure they started over because our first one . well, they get too old, and you have a problem matching technology. And since we started, the ability to locate where those streamers are has gone up by order of magnitude. GPS now is down to a few feet versus a kilometer or something like that, probably, when we started out. So, we had to do location adjustments through data processing. And you do not have to do that anymore.

End of Tape #1, Side 2

Tape #2, Side 1

BG: . . . multicomponent is happening in the Gulf of Mexico. Some in the North Sea, but . . .

TP: You explained a little bit before but can you explain again what you mean by multicomponent?

BG: O.K. What we tell everybody is we are trying to image the subsurface using the full vector wave field. The P-wave is not a vector, it is a scaler. That is what 99% of the work that has been done with and is still being done with. When you initiate some energy and it goes down to one plane interface, it already splits up into P-wave, sheer waves, andall kinds of stuff … refractions. So far, signal processing technology has been honed in on and targeted on getting the P-wave and knocking out all these other things. So, there are two big industry consortia. Well, there one big one now, I guess. The Colorado School of Mines under Tom Davis where the industry is trying to prod . . . well, they are doing experiments in various places in the country on how you interpret and what can you get out of comparing P and S wave.

A gas is a fluid. And, of course, sheer waves do not

propagate in a fluid, and P-waves do. So you have got a comparison right off the bat. I could show you some data here that I could bring out. It is a totally different reflection; you can get a totally different reflection sequence depending on what the fluid parameters are. Water even breathes different than gas. What you are trying to do on time elapsed is, what are the changes in this reflectivity sequence that you can say is due to fluids or other kinds of lithology? So with sheer waves you get two orthogonal sheer waves propagating a vertical 1 and a horizontal sheer wave, and those are vectors. So, the full vector wave field includes those along with the P-wave. And up to this point, we try to attenuate them and call them noise.

Now, since you cannot initiate a sheer wave in water, where it is being used now in water, shallow water or deep water, is under probably more difficult conditions because what you have to do ... this initiation that you have in the water hits a layer and there is a converted P-wave that comes out of it. So you are trying to map a P/S, pressure sheer, and on land you call it nine component because you initiate the P-wave and the two orthogonal sheer waves. In marine, of course, you cannot do that, so you are depending on this converted . . . the P converts to S and comes back up as an S, that

Is tougher, a lot tougher.

There are two or three people out there shooting spec as contractors in shallow water. The business model is based on the fact they will sell their P-wave spec, but they are waiting for the technology to come out to process it where they have recorded three component, not nine component. So, they have got the three components of sheer wave information and there are some really interesting results on it. The most obvious application is where they have these ... people call them gas Chimneys ... where gas comes up from a deeper layer and spreads out through the layer. Well, that completely obscures the P-wave and the sheer wave goes right through it. And so, you can map structures with sheer waves, P*1*s waves in the case of marine, that you cannot see with P-waves.

TP: But it is very hard to process sheer waves?

BG: Well, I am saying not anywhere near as much practical experience in processing sheer waves. We do not know everything about it, or very much about it. We probably know a lot about it. There is plenty of theory.

TP: But you have the computing power to do it?

BG: Yes. But, of course, computing power is a little bit of a cost issue because there is three times or nine times as much data to process. But, in my opinion, the computing power is not a major issue. Even in the six or seven years it has been out there as 3D, computing power has gone up like that again, so it keeps saving the technology.

The bigger issue is how, particularly in land, you get an image on a horizontal sheer wave, you get one on the vertical sheer wave, you get the P-wave. How do you relate all these things? Economically. I mean, it is kind of back to my Amoco example. On 3D, where do you get all these paper records? I mean, you are overwhelmed with results.

TP: I am sure there are a lot of people working out the problems.

BG: Oh, there are lots of people working on the problem. Tom Smith has this whole family of seismic processes on a PC. He has been at the Bureau trying to figure out what kind of processes do we think we need to process this data because they would like to build those processes. I know of several companies that are doing that. What is different than several decades ago is that the oil companies are not doing that research.

TP: Just independent geophysical companies and the universities? Colorado School of Mines?

BG: Yes, exactly. If you look at the last 10 years, oil company investment in upstream and research, it goes down like this.

TP: Why is it? Is it because it is just too costly?

BG: I do not know whether they are going to purchase reserves until the purchase opportunity runs out. Then they will have to explore again. I ought to ask you that, I guess! I mean, it is a different business model we are operating off of right now. The amount of exploration that is done has gone way down. Exxon puts billions in Sockland Island. They have big structures. That is their game, of course. And Exxon, of all the companies, is the one that thinks they should do a lot of research. So, this is another side to Exxon. And they do. But also, by corporate design, that is all confidential. In recent years, they have even shut down the number of people who can go to geophysical conventions and give papers.

BP says they are going to outsource it all. I mean, they are not going to do any in house, but they have yet to pay somebody to do it outside! So they are consolidating. BP is looking for deep water. They are doing the high risk thing. But nobody does it quite like

Exxon does . . . doing this thing in the Sockland Islands which is extremely expensive.

TP: Well, they have some of the hot areas, I guess, they are looking for big fields. They do not need this kind of technology.

BG: That is right. You cannot even see the exploration problem and priority list. There is a political problem and a pipeline problem!

TP: Well, it will come back.

BG: It will come back. Yes, it has got to come back. I mean, pretty soon, you have brought up all that has been found.

TP: I would think that the smaller companies, especially in the Gulf of Mexico, who are looking for the smaller fields, make money off the smaller fields. And the way the majors are, they do not consider anything less than 100 billion barrels. But they must be very interested in

it.

BG: They are. And that is, I guess, where the lion's share of the work is being done. Certainly on the shelf. The majors move it off the shelf. On the shelf, a typical field is 14,000 feet, or something like that. There is a lot of interest now in calling the shelf a new frontier, where you are looking at 20,000 feet. And so, there is an outfit doing spec and imaging stuff at 20,000 feet. Why not? If you can find it in deep water . . . well, it is just untapped, the shelf, which is a very mature province. It is hard to say it is untapped, but it is below 14,000 feet.

TP: This may be getting off the subject a bit. What interests me . . . I cannot remember when it started; I think it was in the late 1960s or the 1970s, but the move to spec data in companies like GSI and Western. Oil companies . . . doing their own seismic work.

BG: That is a good point. You know, it is a totally different model these days. I think the company, the pioneer of spec is Western. I mean, GSI was a follower. If a contractor is not in spec today, you lose even more money. The big spec players are Western Chiefco and probably even more than that is PGS. And they have got

a tremendous amount of spec offshore Brazil. That where their boats are. Now, deep water.

Boy, I will tell you - the jury is out on that. They have got a huge amount invested. In GSI, because of TI, we had to write off spec as an expense. That made our spec more costly in those days. But that is written off as a capital cost now. Spec ages; it does not keep on a shelf. Technology changes too fast. PGS stock has been falling for that reason. They were going to merge with Veritas and Veritas said, 'oh, wait a minute now. Our stock trade has got to be different. Your stock has gone down so fast! And so, they are quibbling over that at the moment. It must involve spec, but Veritas does some exclusive, but really their profitability is spec based, PGS totally. In fact, the only company I know of that does not do any spec is Dawson Geophysical. They have five land crews which run regularly but Principal Decker Dawson does not want to shoot spec.

The contracting industry right now is in terrible shape. They lost money for 5 years.

TP: When did Western begin moving to spec? I guess they did a bunch of shooting for a group of companies.

BG: Well, they used to be group shoots. We used to bid on group shoots. But I think, in addition to group shoots, they pioneered spec data probably in the mid 1950s.

TP: When did it become routine . . .

BG: Well, it has been routine for at least one decade. I would say two decades. I mean, in the last decade, it is a must. Two decades ago, you could blend your spec and exclusive. But the amount of exclusive has just gone way down.

TP: So, the real competition is in interpreting the data?

BG: That is not a competitive aspect for contractors because the oil companies figure that anybody can shoot and process this data, but only we can interpret it. They are getting interpretation from contractors but that is dirt cheap. Some of the oil people will tell you that they trash what they get from contractors and interpret it ... they want the data.And if even at that, some companies reprocess the spec data, but nobody wants to acquire it. And if you are pulling 16 streamers out there in the Gulf and getting good data and getting the location of the data, there is no point in shooting an exclusive survey if somebody will shoot spec.

TP: One question I have: before GPS, it must have been difficult to determine where the streamers were when you are doing marine shoots.

BG: Yes.

TP: How did you do that?

BG: The technology developed over time, but we started with World War II with _____and sea, where you had different stations. And that was the standard way for shooting a marine survey, located on the _____ and sea stations in North Slope and in the Bullford Sea. It was a big, big deal, a big problem. When it worked swell, it was good enough, but not by today's standards. And so, those distance ranging devices got better and better. But they were not good enough to do time elapsed or anything like that. So GPS has revolutionized what is possible. It helped spec out because people know they can trust the locations.

TP: That is interesting.

BG: These boats pulling 16 streamers are just

electronic marvels . . . software technology . . . and they cannot break even on it! It is probably the most sophisticated

stuff I have ever seen . . . and good people.

TP: There is just too much competition?

BG: I think fundamentally, the companies are not in the data gathering interpretation mood. They are buying each other and buying reserves. I think there is a different oil company model out there right now.

TP: Oh, yes. Certainly. I have seen that with Shell, which was one of the last companies to move to that model.

The geophysical industry has been in terrible shape.

BG: Well, the piece of pie you are fighting over got awful small. I am amazed at the optimism of investors that want to put up … still, there is a thing about putting out a boat. I mean, they are not geophysicists, they are not old industry people. But here high technology stuff and they will probably make a lot of money on that!

TP: I do not want to keep you too long. This has been very helpful.

BG: It does not take me long to tell you everything I know!

TP: The end of GSI; the purchase by Haliburton … is there anything you want to say about that? It certainly was the end of an era.

BG: Well, it made sense to me. I thought it was a good deal. I was a loyal employee all those many years, so loyalty was not an issue with me. But clearly TI had too much stuff to invest in. They were not investing in GSI. They did not invest in the seismic instrument, the next generation of these things. So they were interested, obviously, in the oil industry. And I thought it was a good deal. Haliburton, of course, was in the oil industry, a big company, and they were trying to broaden their bandwidth of capabilities, which I thought was a good idea.

In 1988, February 16 or something like that, they bought GSI. They bought them for a song. Then, the market continued to go to hell! And later in the year, they bought Geosource, which is a combination of a whole bunch of other companies in front of it. And for two weeks, they were the largest geophysical company in the world.

TP: For two weeks?

BG: Yes, for two weeks! I mean, just buying things and adding them up arithmetically, it does not work out that way. It never does. Even in banking where Bank of America bought all these other banks. Bigness does not make greatness. And Geosource was vastly underfunded and so was GSI. So here are two underfunded companies that they thought they would make a lot of money on. As the market was going ... 1988 was a terrible year for the market. It fell out of bed in 1986.

TP: Was GSI combined with Landmark Graphics?

BG: No. Landmark is very recent. This is 1988 that this happened. In that year, they bought two geophysical companies. Two broken down, I say, geophysical companies which when you add up, do not make . . . their corporate view was well show us you can make money and then we will invest in you! They had their own idea of the chicken and the egg conundrum. So, it did not work out chiefly because the market kept going down. Their timing was just bloody awful! They wanted out of the geophysical business, you know, "God, we have got to get out of it."

So they sold us Western. And Baker Hughes, well, Western was part of Atlas prior to that. And Baker Hughes bought Atlas, so they got in the geophysical business and they

were going to make big time money in the geophysical business. I think one year or two after they got in the business, they wanted to back out again. So they sold a deal just like TI and Haliburton. This was Baker Hughes of Schlumberget, Western Geco. That was mostly Schlumberget and part Baker Hughes yet, but sti11 the deal is that Schlumberget will own more every year. And, of course, Schlumberget is kind of like an Exxon in the service business . . . they do everything themselves.

TP: It is hard to keep track of. Things change every two weeks.

BG: Exactly! On both sides - contractors and oil companies. It is just a phenomena, not a reason why it exists, but one problem the contractors have is that there so much turmoil in the oil business thing, and whether they have a different model or not … I guess they do. But all the people you know, all the contacts, everything has gone asunder. And when you talk to those people they are more concerned about merging than they are about activity. They are going to get the alleged cost benefits that the merger was supposed to make and for that you have got to fire so many people. So, it is a mess right this minute and has been for five years.

TP: That is for sure. Is there anything else you would like to add?

BG: Oh, probably not. If you would like copies of this stuff, why do not I send it to you?

TP: That would be fantastic. Let me turn off the tape here.

THE END