MMS OFFSHORE GULF OF MEXICO

ORAL HISTORY PROJECT

Interviewee: DAVID WORK

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Bio

Work was a top exploration manager for Amoco for many years and then with BP-Amoco after the merger. Received his M.S. in geology from UC-Santa Cruz and hired on as a geologist with Amoco in 1970. He retired from BP-Amoco in 2000 as regional president responsible for the Gulf Coast, Southwest, and Rocky Mountain states. His direct influence over activities in the Gulf started in the late 1980s.

Summary

Insightful discussion of exploration and exploration technology in the 1970s and 1980s. Touches on many topics, including bright spots, risk management, bidding strategies, turbidite reservoirs and the move to deepwater, and 3-D seismic.

Side A

TP: This is an interview with David Work by Tyler Priest, June 4, 2002, at Energy Virtual Partners in Houston.

DW: Well, Ty, I appreciate the opportunity to talk to you about this subject. My familiarity is probably about as great as you might find in some of the other Amoco employees or ex-Amoco employees that you can run down, but certainly well within the macro picture, in many respects.

My direct influence over activities in the Gulf started in 1987 when I transferred or was rehired by Amoco to run Texas offshore in the Texas Gulf Coast for exploration. Prior to that, I was an independent, and for four years prior to that, I was the regional exploration manager for Alaska and California. And, in that sense, competed for funds with those people who were on the Gulf Coast in the offshore, trying to obviously take advantage of new technologies that were developing for those plays.

When I look back at technology, and I started my career in 1970, the first breakthrough I was party to come through the bright spot technology. Shell probably had us by two years on that, Exxon was a quick follower, and Amoco probably third. We had to high grade the sales and the tracts that we wanted to buy, so Shell probably had a two-year lead on buying the good stuff. But with respect to activity, we were very active in the lease sales in the late 1970s/early 1980s.

One of the things I think that is remarkable is how fast the bonus prices escalated, and that was because the bright spot technology allowed us to reduce our risk. And you knew about hydrocarbons, you knew how big the potential pool was; you may not know absolute thickness, but all of a sudden, you were not going to drill a dry hole. It was just a question of how much pay you were going to have.

TP: Yes, it was all of a sudden. I cannot remember who told me the story, but I think it was maybe one of the 1972 sales, but all of a sudden Mobil and Shell had these bids that were way out of whack with other companies and people starting thinking, well, they have got something . . .

DW: They have got something that reduces the risk so they can put more on the bid. If it started that early, I would have guessed 1973 . . .

TP: Maybe it was 1973.

DW: It was pretty early on. And, of course, this is not even 3D. This is still just bright spot off the 2D.

TP: So, you think that it had that big an impact?

DW: Oh, absolutely. It had a huge impact because all of a sudden you took out of the equation what I call the dry hole. So, if the potential for a dry hole went from 10% to let's say 50%, then on a risk weighted basis, you had a lot more money to buy the tract with. And, of course, I think the late 1980s and 1990s have shown us that most amplitude work today has gotten the failure down in the 10-20% range for an exploratory well. We just do not fail. It is a question of how much you might find but you do not fail. And so, the industry just went crazy.

TP: There were a lot of phony bright spots, too. This technology was not perfected.

DW: Well, it was not foolproof. People were chasing . . . corals give you a wonderful bright spot, fizzy gas gives you a wonderful bright spot, which mislead a lot of us in Alaska. They had a lot of fizzy gas in Alaska. But the technology had to obviously be perfected and the people who were doing that were the people who had the research departments: the Exxons, the Shells, the Mobils, and the Amocos. And what transpired was that no secret could be kept in a major oil company; if somebody comes up with a good idea, they can see how to make money and quickly become an independent, so no one could hold on to this technology for more than two or three years before it was out on the street and everybody had it. And that has been the cycle of all of our technological breakthroughs. And is probably one of the reasons today that there are not very many research departments left in major oil companies except in Exxon!

But be that as it may, I think the interesting thing was that probably prior to my career there had been 20-30 years of looking for structural closures or pinch outs or fault closures in the Gulf Coast, hoping that you would find hydrocarbons. Well, now with amplitudes, there was just no question whether the hydrocarbons existed or what your targets were. The question was whether or not it was big enough and could come out of the ground fast enough. And, of course, even in the 1970s, gas was not the preferred discovery; you were looking for oil.

TP: How reliable was bright spots for detecting oil?

DW: Well, it was the same phenomenon. What you were seeing was basically oil/water contact and a lower density zone in the reservoir, and a contrast between the density displayed with water. And basically, with the processing, you could make this contrast jump off the map and most companies mapped it and tweaked their computers to make it yellow. But it showed up in most black and white sections; in the old days it showed up as a dim spot. And what happened is as you lost the big reflection because of the velocity contrast that it would have had if the reservoir contained water. And so, people got good at it. Successes went way up . . . buying a lot of easy hydrocarbons. By the same token, as I mentioned to you earlier, I think the bonuses got crazy, especially by the early 1980s. The bonuses were just ridiculously high, if not in the late 1970s.

TP: Was Amoco active in advocating a new system in leasing? I know Shell was always lobbying the Department of the Interior to revise the way they offered leases.

DW: Well, we had talked about this with Joe before but one of the barometers was that each of the majors had their own idea of how the other man should do their job. And API was extremely ineffective in having any impact because the industry could not agree on what to do next and how to do it. And that is where I think we had zero influence on the MMS.

In fact, I was a lobbyist in Washington from about 1976 to 1978 with the Department of the Interior on leasing systems. Those dates are fresh in my mind. That was really when some of the crazy things were happening offshore, and people were saying, “let's change the equation, let's increase their royalty, let's do something else, sliding scale royalty” - all these different systems that would potentially take the bonus pain out of the system and make the government equally rich out of production, not out of bonus. And all of these failed because there was no ruling consensus in the API, and without consensus the MMS did not have to do anything. And they loved what they were doing! I mean, they thought it was phenomenal when they had a couple of sales and they had one billion dollars worth of revenue! They liked the system as it was. As things got a little tougher with respect to when we get to the deep water story, I think lease terms had to be modified, extensions had to be reconsidered, and certainly some of the royalty relief had to be reconsidered to stimulate the deep water exploration. But that is another chapter.

TP: And more tracts had to be put up.

DW: And more tracts had to be put up and bigger tracts. Certainly one of the problems in the early sales was that as these new anomalies were being recognized, especially as we moved into 500-600 feet of water, then off the shelf . . . they now started getting larger and you were not going to be happy unless you had three or four conventional tracts . . .

TP: Shell was always complaining about checkerboarding. Some of the adjoining tracts were never put up on the structures that they were interested in.

DW: Well, either it was checkerboarding, or a company came in and said, 'I can't get it all. I am going to put all my money on the top tract or side tract. And then, I'll get carried. In fact, it was common to see the independents play "flank the major oil company." Let the majors take the top, let the majors take the risk, let them run it; and then, they had the flank for that free ride. And they would get pooled in after all the exploratory work was done. But those were the games we all played.

The lease sales were very exciting events. My counterpart, Tony Benson, and I, we would have whole teams. We divided the Gulf up into three segments and they would work all year in preparation for a sale. And Tony would take the sale package up to Chicago, get one billion dollars or three quarters of a million, $750 million worth of authority, and then go those sales. It was just a wild time! The parties that would occur the night before the sale after all the bids were turned in were just . . .

TP: There was a lot of secrecy about who knew what.

DW: Oh, yes. Well, there were very few people who saw the final bid cut. There had to be a check in that envelope, too. Well, that was a bunch of cloak and dagger. In fact, there was always the question of who could sign the check, and you always had to have corporate authority. Checks were getting so big. A bonus on a tract would be $200 million, $150 million. The average vice-president could not sign that check! So, it was really wild at times.

Technology obviously has continued to play a very, very important role . . . but now, some of the majors (BP) claim that one of the largest resources still undeveloped and undiscovered in the world is the deep water. So, we worked with bright spots. We then moved into the 3D and some of the things surrounding 3D migration, and also depth migration, moving into deep water, the drilling technologies. In the early 1970s we would have never thought of the drillship being stable enough to drill off of. Now, we have dynamic positioning of the drill string. The idead that the drill string can move and does not hurt anything if it moves has just revolutionized how deep we can drill.

In early 1970, I came down to the Gulf Coast from Denver, and the thing that jumped into my lap was the development of Ram Powell, which was Shell, Exxon and Amoco.

TP: That was one of the earlier ones; it came after Auger and Mars.

DW: Yes, it came after Auger and Mars. One of the big things that was different about Ram Powell was that it was not a continuous sand. These sands were off the shelf type turbidites. And so, they were coming off the shelf in sheets that are fine-grained, high porosity loosely consolidated; a very fine grain. But early on we could only map them to cover anywhere from 600 to a couple of thousand acres in size. But they are stacked. I think we had seven wells down before we actually decided we had to take a drill stem test. We were out there with the *Discovery Seven Seas*, which was the biggest drillship that the industry had produced so far. We were out there and we said, "We have to have a drill stem test. We have to understand how these reservoirs will perform. And we have to establish that this is a stable drill stem test. And so, Amoco took the lead. It was our well. We had yet to pool the structure. Amoco took the lead and performed the first deepwater drill stem test. That was about one-half year just in preparation of how do you take a drill stem test from a floating drill ship and all the safety things that you would have to do to test this formation? So that was really one of the first confirmations that these gas-bearing, turbidite sands could be very, very productive.

TP: How did the theory develop about turbidite sands and their productivity?

DW: Well, the turbidite story was one that is not a necessarily new story because a lot of California deposits are turbidites. But, it was new to the Gulf of Mexico, where we had previously been seeing sheet sands, beach sands, dune sand all being played all the way out on the shelf. Once we went over the shelf edge, we had these basically turbidite deposits being played. It was the first time we had done it on a large scale in the United States. Turbidites are productive in other parts of the world; other areas have turbidites, North Sea has turbidite deposits. And as I said, it was a start in the Gulf of Mexico. And the recognition was that these were very valuable potential reservoirs.

TP: So, there was no big secret.

DW: Oh, yes, I could recognize it. But nobody had explored them because they just thought, based on the outcrop and based on everything they knew, such as the discontinuous sands, you could not get the reservoir continuity. They were potentially fine grained and dirty and therefore they could be great reservoirs. But these things were stacked, they were unconsolidated, so they had high porosity even though they were dirty, and, of course, with lack of porosity, and potentially high pressure, you worry about producing the formation as well as the formation content. So the question was will these things produce a lot of sand and will we have problems producing the well?

But anyway, so 1970 was my first experience in the Gulf of Mexico firsthand and we did the drill stem test. And after the drill stem test, then it was decided we should pool Exxon, Amoco and Shell. The real question was who was going to take the lead in development? Shell was busy with Mars and Auger and really did not want to take the lead, but Exxon's and Amoco's interests were exactly the same. You would have to go back to the records but Exxon was 34 or 36 and Exxon and Amoco were, in that case, 32 and 32. There was not a whole lot of difference between all of us.

I can remember Phil Carroll and myself being on a boat as a guest of one of the construction companies down in the Gulf Coast. And we were sitting there and saying, "Who is going to operate this damned thing?" And it always got to a flip of the coin because Shell did not want to operate and we were sitting there deciding whether it was going to be Exxon or Amoco, and both of us wanted to operate it but we could not. As I said, when we got to Phil Carroll, he said, "Let's flip a coin."

But be that as it may, we obviously pooled out and development went forward. Of course, there were all kinds of engineering things that had to be considered. No one that had built platforms in that kind of water knew what that would really take. Obviously, we all wanted to learn from Shell, so we actually put teams in the Shell office and they took the lead and learned that technology.

And then, of course, the next thing that came around was planning production facilities which really revolutionized how much deeper we could go. And one of the things that really challenged Amoco was a discovery that was very close to Ram Powell we called Marlin. And we knew Marlin was not big enough to sustain its own production facility. We had to either tie it back or we had to float. We had to have some mechanism for getting the capital cost down on that sucker. Drilled it, it was a discovery, and it sat idle for I do not know how many years - I would have to go back and see the records - before we finally got that thing hooked up.

When I was working as exploration manager from 1992 to 1996 with Scott Urban and whoever was in charge of the Gulf Coast at that time, King's Peak came along. It had big, huge turbidites. We had some acreage Shell farmed out to us and I think there are sever different distinct discoveries around King's Peak. There were some which were in about 600 feet of water. King's Peak was in about 700 feet of water. And there were subsequently three or four more discovers around it. And now, I think that is all part of Canyon Express; that is the modern name for it. And then, subsequent to that, there is another farm out from Shell that we took, even going further off the shelf, Na Kika, and those all worked. As I say, we knew we were going to find hydrocarbons. The question was were you going to find enough to justify setting these tremendously expensive platforms?

In lieu of all of this, when I was still running the shelf, was the subsalt play. That was on the edge of the shelf. Everybody thought that the subsalt had not been adequately explored. We actually took a farm out from . . . I forgot who it was. Anyway, Anadarko was in the play and everybody thought it was going to be huge, but it was very difficult to image below the salt. It is still very difficult to image below the salt.

TP: In recent years, you hear a lot about subsalt. But do not really understand what the challenge is . . .

DW: Well, the subsalt is just a sponge; salt is a sponge as far as trying to get energy into it. It just soaks it all up so you do not get anything back. And the other thing, it is not laid down ubiquitously; it is not tabular, it flowed. You take a foam insulation cannister, you know those things you buy at the hardware store and you can spray foam out of it? Just think, if you just stood someplace and you squirted that, all the crazy shapes, contorsions, air spaces . . . if you sprayed that into a bunch of mud, what would happen? The mud would be encapsulated. So, there was just no way to accurately model its shape. If you could model its shape and its velocity, then you could correct for the structure underneath and put everything back in the right place because obviously, if you had real thick salt, it would slowly urge you down and the reflections underneath it would be pushed down. It would just take more time for the reflection to come back. If the salt were thin, that same reflection would be pulled way up because it took less time for that noise to come back. So, all of a sudden, on the thin side, you would have, it would look like a high in time, but in depth, and really flat, sometimes it might even have been reversed. And so, the challenge was correcting some of the velocity of the salt and you cannot correct for the velocity of the salt unless you actually pile a hole in it and you know how fast it is and how thick it is. But when you are exploring, you do not have a hole in it.

So, still a problem, but not nearly as serious as it was because we could do a better job modeling the bottoms of the salt. If you could figure out where the bottom of the salt is, you can figure out where the top is; figuring out where the bottom is, is the trick. And then giving it a velocity.

Before we really went offshore, we were starting to drill in deepwater but there was a subsalt play that ran pretty hard. Anadarko thought they had the world by the tail. We had drilled the first discovery, Mahogany, with Anadarko. Who did we take the farm out from? They were certainly embarrassed when we took it from down here at this plant. In fact, this guy right here saw it at the farm out there and said, "We've got to have that," because he saw a bright spot under the salts. "We've got to do that." You should talk to those guys because if you want to know the story about the history of the geophysical prospecting in the Gulf over the last ten years, those guys are on top of the game.

TP: With Emerald Geoscience Research?

DW: Exxon - Amoco Gas would get a good idea and then leave. One of the things we had was a technology called coherency cubes, coherency technology. We had that proprietary for about two or three years and then a bunch of our guys left. Coherency stacks.

TP: What are those?

DW: The computer was actually doing the correlation for you. You could cross a fault. One of the problems in the Gulf of Mexico is that when you cross a fault you cannot correlate from one side to the other. This is Sand A, but where is sand A on the other side of the fault? And basically, the computer would take its characteristics and it would basically say, well, A, B, C, D. You know, the sequence has to be A, B, C, D. There may be one missing, but they are a little bit thicker on the other side of the fault because they are growth faults. And now, what are the characteristics here and the characteristics here? How do they best fit together? And the computer would do it for you. It was really a revolution in mapping sands and sand distributions.

TP: So, it is called coherency?

DW: Coherency. Coherency stacking. After prestack migration it was what you could do with the data that would even enhance it more.

Well, of course, then I came back from London and we were in the middle of the deepwater, there were big breakthroughs, such as Crazy Horse, in exploring deeper off the shelf into the Miocene which, of course, is what everybody is excited about now, because it is oil again.

TP: In the Mississippi canyon that everyone is talking about?

DW: Yes. Jim Farnsworth at BP would be the guy to talk with about all of that. He was the exploration manager for North America. Jack Golden is the regional vice-president here for BP. He was the exploration manager working with what I call superdeep, 6,000 foot . . .

TP: Well, BP is soon to surpass Shell in production in the Gulf if they have not already.

DW: Well, it will not take long. With the acquisition, BP got all the . . . they had good acreage to start with, but our acreage was pretty good, too, so between the two of them. And then, Arco had some stuff out there or Vastar had some stuff out there, so they are sitting on all the best.

TP: Yes, it is amazing. How about the evolution of 3D? It was something that had been around for a long time but really did not come into its own until the 1980s, right?

DW: Yes, absolutely not until the 1980s. Obviously, labs were experimenting with it. When you get a chance to talk to Peebler, he can even tell you a little bit more about it, but all these technologies have grown with computing capacity. The early 2D . . . when you look at 2D data, it was a wild record that was really interpreted by hand. Guys got their slide rules out, converted the things to depth, and it would take a week to do one seismic line . . . five seismic lines, five weeks . . . a basin in two years, just to get raw data interpreted. And, of course, we can do that all with computers now and you can do it very, very quickly. It is Moore's Law in spades. Anything you could last year, you can do twice as fast the next year, if not 10 times faster. And, of course, Moore's Law is 10 times faster every year or exponentially faster every year. And so, the computers made the huge difference.

So, we went from 2D, and then the logical step was to go to 3D and put the 3D data set together and it took the extra computing horsepower. It also took a huge amount of extra computing to even record the data. Instead of having in the way of 600 geophones out there in line where you are recording 600 different signals, you had 6,000 potential geophones out there and you had to record that data. So, it just took a massive amount of recording capability.

I can remember the early days in the thrust belt that we invented something called the seismic group recorderk which made it very easy for 3Ds because you did not have to lay the cables out. You actually had a box that would pick up three or four geophones. One of the other things about 3D is logistics. The early 3Ds were done on shore because you could lay the cables out, know where they were, and record the data. Each line had a truck, basically, recording. And you would take it back to the lab and you would process the data together. Basically, with the data set, with the lines laid out like this, you could obviously interpret this line, interpret this line, just like you could in 2D. But with the computer you could then take and create a line of a data point here, a data point there, a data point here, a data point there and a data point there. So you could artificially create a line. Well, that was what you were doing initially at depth; you did not know what the dip of the beds were, which direction they were dipping. So, these beds were dipping this way or this way or this way. And so, let's just say you made a mistake, you were trying to shoot the dip line. So, what you wanted to do was have the beds dipping this way or this way. But you will not always know ahead of time. So, with a 3D data set, well, if we made a mistake, the beds are actually dipping this way. So you could take the data point here, data point here, data point here, data point here, and you can create a dip line. And you can make the interpretation. There is very little that is really done until we got to visualization that was actually done in 3D. It was actually taking the data, creating the right 2D section and getting the dips right. Obviously, if this were the surface and you had these lines going across it, these lines are not truly going down the steepest dip; only this line is going down the steepest dip. And these lines are not seeing the flat line. You have got a little bit of dip. So that is what made the big difference, is we could take this cube of data and slice it so we could create the line that had the flat beds and we could create the line that had the maximum dip beds and make the structure map.

TP: There is the old story about . . . I think Joe talked to Tom Barrow about this . . . the first 3D was in the Friendswood field down here and they hung the seismic profiles from the ceiling and tried to do . . .

DW: Oh, to do a spatial imaging?

TP: I guess so.

DW: Yes, hanging 2D lines in a 3D sense, trying to make the correlations. Yes.

TP: When did visualization really come about?

DW: Well, I think we probably all had some form of visualization of small data sets in the early 1980s; but basically, huge computing nightmares. Your computer people would be up all night to show you five images, just compositing the data. And, of course, today it is instantaneous. You have got the data set and you can play it back and forth. Have you been in the visualization room yet?

TP: No

DW: They are just out of sight in what you can do with the data. I can remember our researchers playing with this in the early 1980s, if not the late 1970s. But it certainly made all the difference, again, in defining accurately where the objectives were. Of course, the problem in the marine world was you had to put this all on a boat, and more important than that you had to know what these lines were, what you were towing. And, of course, with the currents and everything else, they would get big bends in them like that. So, the real challenges in the marine world were positioning these and knowing where the cable was. And, of course, all kinds of technologies were developed around that.

TP: By independent sources?

DW: Yes, the independent contractors. The oil companies were out of that game. We gave up acquisition. There were very few company boats after the mid 1970s. They were all gone.

TP: On spec data?

DW: Well, no, it was not all spec data. It was a lot of contract, but a lot of spec data. The challenge for the contractor in getting an accurate record or an accurate picture was to get an accurate line. Sometimes a line would come over there and foul them up, but today it is all done with GPS. It is very easy today, but in the old days it was tough.

TP: It must have had a great impact on the industry as a whole. How did it affect the industry, this digital fire hose of data and everyone being able to acquire these massive reams of data?

DW: Well, it had two things: it had a very detrimental effect on the number of employees you had because, all of a sudden, one employee could interpret what it used to take 10 to interpret. So, it had a direct effect on our sizing of organizations. So, the downsizing in the early 1980s, the downsizing in the late 1980s, are all reflective of how many people it took to interpret data.

TP: Exploration data?

DW: Right, and on how you created a competitive advantage. When the spec data became widespread, especially in the Gulf of Mexico, then the competitive advantages were really reprocessing the data and identifying things that are more subtle than what you might see in the contract boom stack. So, it became a processing breakthrough. And then, the high tech processors were out there, too. These guys here will take any group shoot data and reprocess it for you with the latest, "Gee, wow, whiz!" and you will see things you have never seen before. So, if you have got money, anybody can do it.

TP: It opened up things for the smaller independent companies?

DW: It really did. Not to say they were not out on the shelf in the first place, but it kept them viable. The only way it kept them out of the game in the middle 1970s and early 1980s were the bonuses. They could not compete with the majors on bonus.

And so they were out either picking up the smaller tracts or playing flank oil, and then when the majors left the shelf, they have been then the recipients and the purveyors of the new higher, more sophisticated technology, and basically filled in behind the big companies who were not plying anymore, and using the higher technologies to lower their risk and find smaller targets. There is no major that is going to go after a 20 BCF anomaly. But the independents think that is great. So, that is the game that is going on in the shelf.

TP: And 3D has benefited production as much as exploration these days, right?

DW: 3D is a phenomenal tool for exploration. You know where the field goes, where the highs are, where the faults are, and it is very valuable in exploitation mode. Now, 4D, which is, in the fourth dimension, is time, it really has not caught on as some people might have thought it would.

I would be happy to help you with anything specific about Amoco that might come up that you need some clarity on.

TP: Well, you have talked to Joe about that history.

DW: He can probably pull it out from the other book.

TP: How about this company?

DW: The late 1970s and the early 1980s was such an exciting time because the 1950s and the 1960s had been a quiescence in the industry. Joe has got this in the records, but I was hired as one of the geologists in 1970. And by 1980, we were hiring 60 a year! It is the technology. Absolutely it is the technology that let us see things we could not see before; either deeper, clearer, of greater definition. Of course, the thrust belt was my story. I can remember George Galloway, who was our president, told us it was a driller's graveyard. I wrote an article about that that everybody would love. One hundred dry holes in the thrust belt until modern technology came along, and then we got 18 straight discoveries or something like that. And the same thing for the Gulf Coast.

Amoco, in its prime, was one of the first companies to have a posted barge operation out in the open water. I mean, there are lots of people on barges fooling around in the coastal zones of Louisiana, but we were out in the open water. I guess Kerr-McGee was actually the first company. But we were right behind Kerr-McGee going out into 20 feet of water and drilling a well. So, the drilling technology got us into the water, but I think it was the seismic that really made the huge differences and it was basically the ability to acquire data and accurately figure out where in the subsurface that was, and then drill to it. And it just got better and better. And, quite candidly, I never thought we would improve on 3D. I mean, I was sitting there saying, "we can't improve on 3D." And then came along pre-stacked depth migration where we basically could take all the velocity problems away and actually put these things into a depth section and more accurately predict where to drill; and then, things like coherency cubes came along, bigger spreads.

We were talking about 4D. Well, one of the things that is out there now, one of the things we have known for a long time is if you acquire shear wave . . . P-waves basically are compression waves and then you have shear waves. And shear waves eliminate a lot of the velocity problems associated with gas and salt. And you have got shear wave technology coming along now; very difficult to acquire, very expensive to acquire. Now, some of the shear wave technologies are coming, so there is another whole breakthrough in my mind that is going to make its way on the scene here in the next three to four years that will cause everybody to go back and relook at their fields and their data. It will let us see deeper around the salt domes, under the salt domes, will let you penetrate the salt. So there is another wave of exciting opportunity coming in the next four to five years because of shear wave. We have known about shear wave, we have known what it is, we have used it, but we have not been able to afford it.

TP: It was the same way with 3D for a long time.

DW: Absolutely. Yes. And, of course, the computer horsepower made it prohibitively expensive in the long run. I can remember 3D sets when we had to have one year to process the data.

I can remember the Gulf of Suez, when I was managing there, we used 3D through the whole Gulf. And I said, our exploration license could expire before you come up with the first prospect. It did. It actually expired before we came up with the first prospect because it took so long to process the data! But that obviously is not the case today.

TP: How intensively is this kind of technology being applied worldwide as it is in the United States?

DW: Equally intensive.

TP: Now?

DW: Yes. Well, the Mexicans do not need it. They can use basic technology and still, if they are good at it, hit 100 percent of the time.

Brazil does not need it. Hydrocarbons jump off the map and there are bright spots everywhere. I mean, they shoot in 3D. But, you know, they do not need to worry about pre-stack depth migration. They just find a bright spot that is ten miles long and three miles wide and you can not miss it.

TP: So, the fields off Brazil are that big?

DW: Oh, huge! It is huge. But, as these things get drilled out, Nigeria requires it. Angola requires it. Obviously, the North Sea is extremely sophisticated. Kazakhastan and the other "stan's," very simple stuff. Very simple stuff.

The Gulf of Mexico and the North Sea have led the technology development just because of the need and quite candidly the lease terms are so attractive in the Gulf of Mexico that this is the place where you can take your greatest risk. Everywhere else in the world, the terms are much more risky.

TP: That is interesting. Now the Gulf has been pronounced dead many times.

DW: Yes, well that would be a history itself!

TP: That is part of the history.

DW: There are people that would say you can not explore in water. And you go back there, so you cannot get your feet wet.

TP: Beau Dykstra, the guy who got Shell into the shallow water, said beyond 60 feet . . .

DW: . . . you cannot operate . . .

TP: . . . it is too costly. There was a battle between the New Orleans office and the guys in the head office in 1960-61 about this.

DW: I can remember George Geller saying, "you can't find oil below 10,000 feet. You can't find oil below 10,000 feet. Just forget it."

TP: It is a great story. It is going to be difficult for us, as nontechnical people to make sense of this.

DW: Well, Joe did a great job of that in the last book so I do not have the slightest bit of concern. I do think you are going to have to probably put some . . . because you have nontechnical people reading it, too, so I think you have got to put some illustrations in to explain what you are talking about.

TP: Yes, we want to make this story accessible to the nontechnical reader. People hear about the offshore and they think production and platforms and it is all a matter of drilling technology, but they do not understand the years of exploration wor and data acquisition that have gone into it.

DW: Well, I would be glad to give you more references, but I do think that Benson can give you a lot of detail if you want it. He is in Taos, New Mexico. Let me see if I can get his telephone number for you.

THE END