MAURICE DUSSEAULT

Date and place of birth (if available):

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Name of interviewer: Robert Bott

Name of videographer:

Full names (spelled out) of all others present: N/A

Consent form signed: Yes ☐ ☐

Initials of Interviewer: BB

Last name of subject: DUSSEAULT

BB: This is an interview in White Rock, B.C., on July 12th with Maurice Dusseault, D-U-S-S-E-A-U-L-T, and maybe you could just give your title, or your professional designation.

DUSSEAULT: I'm a professional engineer in Alberta and Ontario, both registered in both Provinces, and I completed a PhD in engineering from the University of Alberta in 1977.

BB: And you're currently Professor at University of Waterloo?

DUSSEAULT: Yes, Professor of Geological Engineering at the University of Waterloo, yes.

BB: And consultant on what...

DUSSEAULT: Yes.

BB: Reservoir Engineering, is that sort of the...

DUSSEAULT: I consult in three areas, one a term called Petroleum Geo-Mechanics, that's kind of the rock mechanics aspect of all types of petroleum work, including conventional and heavy oil, the second area that I do a lot of teaching in and advisory work is in production techniques for heavy oil, and the third area is deep waste disposal, so solid and liquid disposal, deep into sedimentary basins or into salt caverns, through methods of injections.

BB: Does that include things like carbon dioxide injection or is this mainly more conventional materials?

DUSSEAULT: Well up to now, it has been focused on the deep disposal of solid waste which by no means conventional. We've been doing deep well injection of liquid, pure liquids for generations, two generations now, but the advent of solid wastes injection is novel and the first project in Canada started in 1988, with Mobil Oil Canada and I actually did advisory work on that project, back in 1989 and more recently of course, my research work has been in the direction of carbon dioxide sequestration and some new ideas I hope and some new patent applications in that area, so yeah, its an emerging area very exciting, I don't know if it will ever happen big time technologically, I mean economically, but if it does, we're working on ways of doing it better.

BB: Now I think maybe the first section of the interview will go chronologically and I was interested in your little reference to flunking out in 1965 and working as a rough-neck and stuff like that, maybe just a brief bit about your pre-academic, pre-industry experience. You grew up in Alberta?

DUSSEAULT: Alberta and the Northwest Territories, yes. In fact, I suppose the links go back even farther, in 1937, a decade before I was born, my father was in the Peace River country and unemployed and he heard there was jobs to be had with Northern Transportation, in Fort McMurray, because there was already a railway up to Fort McMurray in those days, it was the jumping off point for all of the transportation to the north. So my dad and a friend got three dogs and a sledge, they had their 22's and they decided to go across country in February to go to Fort McMurray, because they didn't even have enough money to buy a train ticket down to Edmonton and then another train ticket to Fort McMurray, and it almost ended in disaster because there was an early break up that spring and they lost the sledge and the dogs, they managed to save one dog, but after a few days when they started looking at the dog kind of hungrily, the dog kind of got the message and disappeared. So dad had to take this fellow who developed elephantitis, swelling of the legs, you know in the Muskegs and stuff, he had to almost carry him out of the high lands, west of the Athabasca River there and they reached the mouth of the Ells River by floating down the raft, and the guy was on the raft because my father was taking care of him, he was delirious, so then the next day, the day after they got there, May 24, 1937, the channel marking boat from Northern Transportation came up for the first time and rescued them, so my dad became a bartender in the Oil Sands Hotel in 1937, and he bartendered for awhile, then got a job on the barges, you know on the tugs, for awhile, and then went back down south after he made some money and got married, did gold-mining up in the Northwest Territories, all kinds of things.

So I was raised six years in the Northwest Territories and the rest of the time in St. Albert, which was a town of 800 people when we moved there and then I went to university, too young, I started university when I was 16 years old in 1963 and I was way too immature and fortunately, I flunked out, and I say fortunately because if I had been limping on through, I never would have continued. I went to work in the oil industry. I went to my uncle, Frank Dusseault, drilling superintendant for Jennings Drilling Corporation at the time, Jennings Drilling Company and asked them for a job and he said, damn, he says, we don't hire city boys and he went on in a big...and I was just crushed you know, I was 18 years old, just 18. Finally, he says, alright but you take what they give you and if I ever hear that there's a problem, he says, you're gone just like that. So I worked as a rough-neck for a year and my uncle said to my dad that he was kind of proud of what I did so, I didn't know very

much but at least I didn't have to be told three times, you know, I learned fairly quickly. And then I went to work as drilling mining engineer, you know that kind of a job they call them engineers but they're really just drilling salesman, you know, a little bit of technology and then I met my wife, she was working in the summer as a waitress in Whitecourt and...I can't remember, but its the motel in between the two rivers there at Whitecourt and we kind of hit it off and she wanted me to go back school, so I went back to school and ended with a Doctorate.

BB: Was it in geology, what did you do...

DUSSEAULT: No, it was civil engineering.

BB: ...you're BA was...

DUSSEAULT: Civil engineering.

BB: Okay. Or, BSA?

DUSSEAULT: My BSE, yes. Yeah my BSE was Civil Engineering and during that time, I started to work as a summer student at the Alberta Research Council, so I got to fly all around Alberta doing mapping with the Maurice Cariggy and Barry Melon, who used to be the Assistant Deputy Minister of the...the Senior Assistant Deputy Minister of the Government of Alberta...

BB: I think he's on our list.

DUSSEAULT: Yeah. When the conservatives came in, they plucked him out the Alberta Research Council right away. And I did a lot of hard rock geology mapping, so I got a real interest in geology and saw the mechanics and rock mechanics so that I when I decided to go on for a PhD I went into, what we call, geotechnical engineering and after about four months, I went to one of the professors to, I had a scholarship, I went to one of the professors there and said I'd like to do my research work on the Athabasca Oil Sands and he said that sounded like a fine idea, Syncrude wasn't... they were just starting to do things like digging the pit, the first pit, the first trial pit.

BB: That was around what '75? '74?

DUSSEAULT: Well they started in '77, so the trial pit was probably '73, '74, '75 and I ended up doing my doctorate on the oil sands, geology mechanics and a little bit about the mining and the stability of slopes in the oil sands; and one summer, I spent a few remarkably enjoyable weeks canoeing up and down the Clear Water River and the Athabasca River and visiting all these slopes and taking measurements and trying to understand why they were steep, which I finally understood and that was part of my thesis, yeah. So I graduated in '77 and my supervisor had encouraged, in fact, almost sponsored me I suppose to apply for a position funded by AOSTRA, Alberta Oil Sands Technology and Research Authority. The chairman at the time was Clem Bowman and his vice-chairman was Maurice Cariggy, well I had worked for Mr. Cariggy as a summer student about six years, seven years before that, so they offered me, or they gave me a five-year chair in the University

of Alberta, which I spent partly in civil engineering and then partly in mineral engineering, which was a different department at that time. And I was doing things on tailings behaviour, slope stability, hydraulic fracturing in the oil sands, I started to understand about steam injection and how it affects the behaviour of the rock and became and more and more implicated the in situ production side as time went on, rather than the mining side.

BB: Let's go back a second, why are the slopes so steep?

DUSSEAULT: The slopes are steep because the quartz grains are...it's not like a loose sand, the quartz grains are actually much denser than loose sand, they're about 29% porosity whereas a loose sand is about 35-36% porosity, so the course grains are somewhat interlocked, but on the slopes, the bitumen holds the sand grains together so that interlocking stays in place, if you didn't have the bitumen then the rain fall, you know, other things would tend to effect things, tend to make it flatter and one of the discoveries, you might say, was that as long as you keep you this kind of inter-granular fabric intact the slopes tend to stay quite high, quite steep, so if you go up the Clear Water River and visit some outcrops, you'll find some places there where the sand is free of bitumen but it still stands up, because it's still well drained, so it's kind of like a, you might say, a jigsaw puzzle, you know and that's the reason why the slopes are so steep along the river, now the slopes are not so steep in the mining area because they mine very rapidly and there's gas in the oil sands, it tends to destabilize the slopes, so that was a bit of a disappointment actually for Syncrude, is that they couldn't maintain slopes as deep as they had hoped and that effect their mining quite a bit, that's a different problem though, that's the gas coming out of solution. On the natural slopes on the Athabasca River, the gas came out of solution very, very slowly over thousands of years so that it didn't make the slopes unstable. So that's what I wrote my PhD about is those kind of issues, yeah.

BB: This AOSTRA chair, were you mainly doing research or teaching, what was the kind of the mix?

DUSSEAULT: The agreement with the University was that AOSTRA would pick up 100% of the salary and, incidentally, AOSTRA originally had the idea of funding distinguished scientists with 20, 30 years experience and I was the first person to hold a "young person's chair", after that there were several others that held "young person's chairs" but my supervisor had the insight to see that AOSTRA should be interested in that and convinced them, so I when I said he sponsored me, it was indeed, he talked to AOSTRA and suggested that they should look at funding not only old people, but also young people. Maybe you remember the name Otto Strauss?

BB: Vaguely.

DUSSEAULT: Vaguely. He was one of the old people, a distinguished chemist. Oh, Harry...my mind is failing here but a number of older people at the University of Alberta in Calgary were funded by AOSTRA, and I was about three or four and I was the first young person, so the idea was 50% teaching, I was supposed to only have a half teaching load, and the other 50% of time would be spent on research.

BB: You mentioned your supervisor, who was that?

DUSSEAULT: Norbert Morgenstern.

BB: Rings some bells.

DUSSEAULT: Oh yes, he's been a very distinguished person in the area of geo-mechanics in Alberta.

BB: Okay you were just saying it was 50% teaching and 50% research and what was the...did AOSTRA give you research assignments or did you, how did that work, what was the relationship?

DUSSEAULT: No, I have to say that AOSTRA was remarkably liberal in these matters; they allowed me to pursue the research directions that I felt were important. That of course, I had to send in occasionally a research plan, but there was no insistence that I adhere, you know, explicitly to the plan, I was able pursue those research subjects that I felt were important and, as an engineer, of course, I've always been interested in those subjects that have practical interest so I was pursuing subjects in mining and hydraulic fracturing and in situ processes that were of practical interest. But I must say that AOSTRA was a remarkably beneficial force for a better part of a generation in Alberta, one outcome of the AOSTRA programs is a very large number of people, highly trained, who basically are the major, some of them are the major technically well-positioned people in Alberta today, for example the Vice President Cenovus, Harbir Chhina, is a graduate, you might say of a graduate of AOSTRA programs, as well as many, many others, I could go on and on.

BB: How do you spell Chhina?

DUSSEAULT: C-H-H-I-N-A.

BB: C-H-H-I-N-A.

DUSSEAULT: Harbeer.

BB: What's the first name?

DUSSEAULT: H-A-R-B-I-R. Very, very smart guy and he was an AOSTRA employee for a few years, so this is all of a, kind of a building up a body of highly qualified people. I was part of that strategy. My students of course, were part of that strategy and some of my students have gone on to do some interesting things, Chris Fordham of Suncor is maybe their Chief Environmental Office.

BB: It's F-O-R-D-H-A-M?

DUSSEAULT: Yes, that's right. And he graduated from Waterloo but I'm very proud of Chris and what he's done at Suncor team, lives in Fort McMurray, you know three boys in his family, they've been raised as canoeist and outdoor people up there, you know, it's good stuff. And a number of other students of mine have gone on to work in Alberta. But AOSTRA supported me and let me the research that I thought was important, so I was at the University of Alberta for five years. Then an

opportunity came to go to the University of Waterloo, which in those days it had a reputation of being extremely dynamic, so at the end of my professorship, these were five-year terms, at the end of my professorship in 1982, I took a position at Waterloo in geological engineering and I tried for a few years to change my research area and move out of oil, into hydro-geology or other subjects, but after about five, six years, I just saw that my fate was sealed in bitumen and I just went back in the late 80's to doing research, pretty well exclusively on areas related to heavy oil and bitumen, working also on some other things, like salt, salt mechanics, storage of liquids in salt caverns, storage of solid waste in salt caverns, disposal of salt wastes by deep injection, this is a technology that I've been implicated in developing and as time goes on its going to become more and more used because it's so environmentally favourable to put the waste down a kilometre deep than storing them in, you know, at the surface in landfills and things, these are solid waste like sand contaminated with a little bit of oil.

BB: Produce sand.

DUSSEAULT: Exactly, produce sand, yeah.

BB: Any other materials, radioactive wastes, anything like that?

DUSSEAULT: Well the problem with radioactive waste, two problems, the regulatory, it's very, very heavily regulated and secondly, in radioactive wastes, they have spent not millions but billions of dollars in pursuing mining type repositories and even though I believe they could dispose of radioactive waste much, literally at one-twentieth of the cost, by deep injection, that's not going to happen for a long, long time because of the sunk costs already in the deep mining tap repositories and also because of a regulation insisting that the radioactive, the high level radioactive like the fuel rods be retrievable, so if you take the fuel rods and grind them up, dilute them 50 to 1 with shale and other wastes and inject them, you can certainly dispute of the material absolutely safely, but it's not retrievable anymore, so as long as they operate on the basis of retrieve-ability, but I think in the next ten, fifteen years, we're going to see the possibility of, we're going to see that deep injection is going to be considered for low-level radioactive wastes, the wastes that they don't have to put into repository, it's just a good way of doing it.

BB: Now you did mention the three broad areas of your research, chronologically, I took a brief look at the hundreds of titles you've published, to a laymen there's a lot of Greek in there, which was petroleum geo-mechanics production technology, which sort of came first, or if you just want to deal with them as separate topics.

DUSSEAULT: Sure. Well first of all when I was at the University of Alberta, I was doing work on tailings, on the mechanical properties of the oil sands and some of the strata associated with the oil sands, like the clays at the base of the oil sands, some of the shales on top of the oil sands, the overburden in the clear water formation. So I was studying the properties of these materials and of course, engineers need properties in order to do design. And there's a little bit of more fundamental science there, I was developing some equations to help describe things, nothing too profound. In

1980, we started doing a lot of work on tailings and this was along with Professor Don Scott, J. Don Scott, who's retired but still at the University of Alberta, even though he's 76 or 77, I believe he still goes in, he's certainly worthy of interviewing, he's a great guy. And we developed some test techniques which are quite novel and I was reviewing some of the tailings work recently and I think we did pretty good back then, you know, there hasn't been a whole heck of a lot that made our results irrelevant, in fact, our results are still quite relevant to the long term behaviour of tailings.

BB: We were talking specifically about the clay.

DUSSEAULT: The fine grain.

BB: Montmorillonite.

DUSSEAULT: Yeah, the sand is not a problem, the problem is the fine grain part of the tailings and the fact that they have oil in them, because when the oil is there with the clay, its keep the clay from settling and consolidating into a solid, it just stays as something of the consistency of chocolate pudding, indefinitely.

BB: I've heard chocolate pudding, yogurt, buttermilk...

DUSSEAULT: So yes indeed, it's the fine grain tailings that represent the problem, because they occupy a lot of volume, very high water content and they're not a solid so you can't walk on them, and all of the technologies that the oil companies are now pursuing, under increased pressure from the Alberta Government, because the Alberta Government didn't really push things too hard for a generation, but starting a few years ago they said, the time has come to start solving this problem, so now various companies have gotten together in a consortia and they're testing out various techniques for making these fine grain tailings disappear one way or another, or turning them into solid material, which they can then reclaim. But if you'll allow me to diverge a little bit, you know, we've come under very, very bad press in the last few years in the oil sands because of the large scale of mining tailings ponds. Well I would like to put this in some context; I've been working on this area off and on for many, many years. The entire area of oil sands that can be surface mined, is actually only two-thirds the area of the city of Los Angeles, now you tell me which is the most serious environmental blight on the surface on the Earth, the oil sands or Los Angeles, the second point is that, we will reclaim the land.

If you look at the German brown coal development in the rural valley that was being mined since well in the last century, but now is no longer being mined. All of that land has been successfully reclaimed, there is still some mining going on, but they've done a fine job in reclaiming it, we can do a fine job reclaiming it. It's not a technically impossible problem, it's just that it's a regulatory issue, the government has to make sure that the companies are properly regulated and working towards the reclamation and now that they've put them under increased pressure, the companies are responding. This will be solved. And the landscape that will be created, is likely going to be a lot more productive than the landscape that was there before, because it will be better drained, better topography and it'll be maybe three or four times more productive in terms of the amount of

vegetation per square kilometre that can be grown, so if all goes well, and I'm an optimist on these matters, if all goes well, we're going to create a lot more moose fodder than existed there before, yeah so. But of course these things take time, the German brown coal industry has been going on for a 125 years and reclamation doesn't happen the day after you mine, it happens decades after you mine and that's going to happen in our oil sands, the government has the will, the companies have the money, the society has the demand that it be done, so it's going to be done.

BB: Forester friend of mine compares it with the retreat of the glaciers, that we know that after glacier retreats, that eventually forest and vegetation establishes itself, but it does take quite awhile, you have to have a build up of sediment, and you can speed that along a little bit but some of its just...

DUSSEAULT: It's a decade's thing, and remember, we've only been mining seriously since, well, since the first GCOS started mining in about 1965, '68?

BB: '67 or '68, yeah.

DUSSEAULT: And then Syncrude started mining in '77, so I mean, this is just the beginning, really very short time. So I have worked on tailings, fine grain tailings and then starting at about the middle 80's I started getting interested in the rock mechanics aspects of steam injection and later on, coal production with sands, which we call CHOPS, Coal Heavy Oil Production of Sand, I did a lot of publications in that area, trying to understand how the formations respond, mechanically, when you put steam in under high pressure. And starting about ten years ago, well pardon me, during that era, starting in 1982, I also started doing a lot of work on salt, much of our oil sands area, in fact, is underlaying by salt, not the mining area, but south, Cold Lake and Lloydminster and these salt beds represent a major resource in simple ways, not as you might think for salt, but as repositories and storage areas for solid wastes and storage of natural gas, we have many natural gas storage cabinets in Alberta and Saskatchewan and these are very important because if you're going to produce something like natural gas, which is used mostly in winter, to heat homes, in Ontario in Quebec and everywhere west of that, well you have to have a place to store it, so you need bottles, so you make bottles in salt, essentially because salt is impermeable.

And I did work in salt mining, the stability of salt mines, so I've worked for companies as a consultant and also doing research in salt properties and for mines in Louisiana, New Brunswick, Ontario, New York, Brazil and in fact, the hottest I've ever been in my life was 44 degrees Celsius, 600 meters underground in Brazil in a potash mine. 44 degrees Celsius and in that mine, it's so hot in that mine, that all the workers are required by law to take eight litres of water down with them in the morning, they have to, they're not allowed on the elevator if they don't and at noon, or halfway during their shift, they have to take a salt tablet to restore some of the salts that they sweat off, they're not working at 44, they're working about 32, but even so, at 32, its very, very sweaty work. So the salt is also important to Alberta in a sense that it represents this resource for waste and for storage of liquids and I also did research work on the temporary, that was like hundred year storage of carbon dioxide in salt caverns, because again, if you're going to have any degraded carbon dioxide

disposal economy, we need bottles to store carbon dioxide in during transit, it's just like a tank, so we have these underground tanks, so I've done research into the behaviour of salt caverns for carbon dioxide storage as well.

BB: Why wouldn't they be permanent storage for CO_2?

DUSSEAULT: Because salt slowly, slowly creeps, it moves very slowly and that means the pressure inside these bottles, if they were sealed, would build up to a dangerous level. So you can use them for short-term storage you know. In the natural gas business we kind of, you know, fill them up and empty annually, maybe even more frequently, in the carbon dioxide storage it might be the same thing, or you might put them there for say a decade or two, until you have an underground repository or until you have a need for the carbon dioxide as an enhanced oil recovery agent or something like that and I would say that, since the 1990's I've been working largely on in situ oil sands methods. Trying to understand things like coal production and cyclic steam, but again, from the rock mechanics point of view, not so much from the reservoir engineering point of view, and I went on half time in 1998 and I would say that the majority of my outside work since that time, has actually been teaching around the world, so I've become fairly well known as an instructor in heavy oil production technologies and also in petroleum geo-mechanics issues and that's how I sustain my income after I went on half time, because half time means half salary too of course, so I do a lot of advisory work of a teaching nature and of a, I would say, kind of like a high level evaluator of properties or technologies for companies.

Like for example, right now in my email I have to answer a query as to whether or not I can do an assessment, a technological assessment of a deep, heavy oil reservoir in Kazakhstan and make some recommendations as to which areas they should focus on as opposed to them just, you know, so it would save them time and money if I can give them some advice on that matter, so I do a lot of that too.

BB: Now, when you're talking about rock mechanics, what is sort of the main question you're trying to answer?

DUSSEAULT: Well rock behaviour, for example if you're doing hydraulic fracturing with a high pressure steam injection, how does the rock behave, is the rock above the reservoir going to form a genuine seal, or are we going to have a break through, like happened in the Joslyn Project with Total, back about three or four years ago. When we put in very hot steam into reservoirs we build up a lot of local stresses and these stresses can cause shearing of the formations, and this shearing has very good benefits for us because it makes the permeability higher and it makes it easier to extract the oil, but also, if you have say, vertical wells, these casings can be sheared off at the top of the formation and for example, Imperial Oil has, over the years, had maybe 400 or 500 wells shear off from this high stress induced shearing.

BB: The rock moves and cuts the pipe.

DUSSEAULT: Exactly, exactly and that's a rock mechanics problem, right. And then another big issues in heavy oil is the co-production of sand, we found out about 25 years ago that if you encourage sand production, you could produce heavy oil a lot more rapidly but only in a certain type of reservoirs, the reservoirs are a little missive? for example, I'm pretty good for that, and we call that CHOPS, which stands for Coal Heavy Oil Production of Sand and that's again a mechanical process because we have the strength of the sand and the pressure from the oil, from the gas in the oil that expands and CHOPS is an non-thermal process, no steam involved, so the destabilization and production of the sand along with the oil, like maybe 1% sand by volume, turns out to have a remarkable beneficial effect on oil production and that has been a major sustaining component of heavy oil industry in western Canada ever since the late 1980's, say 1990's for the last 20 years and now that we see the emergence of SAGD and more mines, people forget that for about 20 years, the real fundamental basis of the heavy oil industry was really coal production using this sand production, so I wrote quite a few papers on that, trying to understand it and trying to analyze it and...

BB: Now how do you separate out the sand from the oil once it's up?

DUSSEAULT: They just use gravity, they put all the produced fluids, which is oil, sand some water of course and natural gas, they put into tanks, these tanks are about ten meters high and some of the natural gas that is produced along with the oil they use that to heat up the tanks, so the tanks are about 90 or 95 degrees Celsius and that reduces the viscosity of the oil tremendously, so the sand drops out and goes to the bottom of the tank and then there's a layer of water, because it has a density of about 1.03 or 1.04, its salty water, then on top of that is the layer of oil which has a density of about 0.96, 0.98, so it's kind of a density, stratified, vertical, separation I guess would be a good way of describing it.

BB: And then what do you do with the sand and water?

DUSSEAULT: Well the water is withdrawn, cleaned up and then injected in deep well injection, that's a technology that's been around for 50 years of course, but interestingly, the sand, it used to be just spread onto farmland or spread onto roads, but the sand now, more and more is being injected as well, so you mix the sand up with water, waste water and co-inject the waste water and the sand deep into aquifer that doesn't have oil in it. But probably most of the sand still is disposed of by land filling and there continues to be debate as to whether or not that is a good thing to do in the long term, because although the oil is not toxic in any way, it does have a very distinctive flavour, so when it washes into ground water, and it will eventually, it will give the ground water a distinctive flavour, in fact many farmers in the Lloydminster area who have shallow wells adjacent to these roads that at one time were...the waste sand was put on there, their well water is no longer really drinkable because it tastes too strongly of the heavy oil, again, not toxic but certainly unpleasant. So the injection of solids and liquids has been a big part of research, starting in about 1990, I've done a lot of research in that area, and I helped start a company called Terralog Technologies in Calgary, which is...

BB: How do you spell that?

DUSSEAULT: Terralog. T-E-R-R-A-L-O-G. Terralog Technologies Inc. And that company now does solids waste injection in Indonesia and they give advice on solids waste injection in the North Sea and they have projects that are now being initiated in the middle east, where, instead of the solid wastes being treated chemically, which is very expensive, the solid waste will be, you know, slurried and then injected down maybe a thousand meters deep, where basically we're taking the sand and the oil and putting it back where it came from, really, so it's kind of in a sense, environmentally it's pretty straight forward. So that company, I helped start the company about 20 years ago and it seems to be doing okay now. Along with some other colleagues I helped develop a new production technology called Pressure Pulsing and helped start up another company which is in Edmonton, it's called Wavefront, one word, it's actually listed on the stock exchange, and its technology basically is the use of very amplitude and low frequency pulsing of pressure as an aid to production. It has proven to be fairly effective for helping clean up all the contaminants from ground waters and is now being slowly, slowly adopted by the oil industry as an enhanced oil recovery method, as a way of getting oil out of the ground, more of it, more quickly. So these are commercialized technologies that I started basically, not alone of course, these are all this, there is always other people involved.

BB: I know some of your papers seem to have minimum of about three, sometimes great long lists go all through some [talk over].

DUSSEAULT: Sure I mean, you know, it's the students and the people in the industry that I work with that enable a lot of these things, you know, the idea that a researcher, you know, sits there and cogitates and comes up with brilliant ideas alone is rarely the case, most of these things are worked out in discussions with other people. For example, the deep solids waste injection for sand, I had the conversation in an airport in 1987 with Don Best, who was an AOSTRA person but he went to work for Mobil after AOSTRA, 1987, yes that's right, and he mentioned to me the problem of produced sand and I said well why don't we re-inject it, and then we sat over a drink and worked it out and then Mobil started doing it that year in Saskatchewan and then after that I kind of adopted that as a research subject and developed it further and further, to try to understand the mechanics and how do you choose your reservoirs, how do you monitor, how do you do quality control, how do you analysis, those are the kind of things that have been involved. But I do think personally that that deep injection of solid waste was one of the more important things that I have done, because I think that's going to have very important environmental benefits for centuries and centuries to come as it becomes slowly adopted by industry and by other industries. For example now, since late 2008, the city of Los Angeles has been injecting bio-solid sledge from the sewage on a trial basis into an old reservoir, near Long Beach, California and that came directly out of the work that I've done, deep bio-solids injection and that's a much safer way of getting rid of bio-solids than spreading it on land and also, if you take the biological solids and put them down 1500 meters like in Los Angeles, 1300 meters, well a lot of methane is generated and about 15% of the mass of carbohydrates is turned into methane and that in principle is recoverable, I mean that's what you do with [unsure] right now, is you have these digesters, well this like a natural digester 1300 meters under the ground and of course, it also means that all of the heavy metals and all of the other things that are in bio-

solids are detoxified or simply stay there permanently and can't really interact with the biosphere and the third thing is, is that about 40% of the mass of the bio-solids stays behind permanently as solid carbon, I mean that's how coal is made, you bury tree trunks and it makes coal, or peat, well what we're doing is burying organic matter and its making coal in a sense, and that coal, or carbon, stays down there permanently sequestered and much, much safer than injecting CO_2 for example, so that's, I think the whole area of solids injection is going to have nothing but growth for the foreseeable future and I mean for generations, because, I mean I have about 20 years experience in doing it, we know what to do, we know how to do it, we know we can do it safely, we know where it can be done, we know what can disposed and as time goes on, that knowledge based experience base is going to mean that solids injection by, solids disposal, pardon me, by injection is going to become more and more adopted as a technology.

Not only in petroleum, but also in other areas, civil engineering wastes, mining processing wastes, industrial wastes, so far the technology has not been permitted for anything toxic, just for non, what we call non-hazardous wastes, but in the future, I think that it will be permitted for more toxic wastes with of course more safety built in.

BB: What would the concern be, type casing integrity or?

DUSSEAULT: Actually, that's really not a problem, because we can demonstrate casing integrity in real time by taking measurements all the time, so we have a breach in the casing, we know that within a few seconds of the breach happening, so the risks actually are fairly low. But whenever you start putting in something toxic underground, you go into another very, very different set of regulatory environments. For example in Alberta the oil field wastes are classified as hazardous or non-hazardous, so far we've only dealt with non-hazardous oil field wastes, there the permitting is relatively straight forward. But for hazardous wastes, it's much, much more difficult. And right now, you have to treat it chemically, usually at a cost that is thousands of dollars per cubic meters, where as the sand wastes, it can be disposed of for a hundred dollars a cubic meter, easily, maybe much less.

So I think in the future we might do things, like for example, taking a material that is classified as hazardous and adding it in small proportions to the non-hazardous wastes, because the non-hazardous wastes are many, many times the volume of the hazardous wastes of course, for example, when non-hazardous waste is tank bottom sledges, they're just ugly, they've got clay and bitumen and oil and water in a kind of emulsion but they're not toxic, they're not going to kill you if you put your hand in, but if you'd eat that waste, waste sand and you add say 5% or 10% of the toxic wastes, maybe only a few percent, then you have the toxic wastes dispersed and diluted an your also injecting it down maybe a kilometre deep, or a half a kilometre deep, it's going to stay there encapsulated and entombed in those other wastes, so I think that's going to be a technology that, maybe the one I'm going to be most proud of, you know, 25 years from now when somebody asks me, if my memory is still, I think that's the one that I think is going to have the biggest impact worldwide.

BB: The reason why I was smiling was because back in the 60's when the environment was just starting to become a concern, George Govier supposedly said, delusion is the solution to pollution and that was when they started ordering those great big stacks on the gas plants and Syncrude...

DUSSEAULT: Well they were just following the example of the nickel industry in Sudbury that put on the biggest stacks in the world in order to put out the sulphur dioxide at a higher level up. Well starting about the same time, technologies were developed to take the sulphur dioxide out of the smoke stacks and now the nickel industry is remarkably good at that.

BB: Yeah.

DUSSEAULT: But Dr. Govier, who I did meet when I was a young man.

BB: He's still around.

DUSSEAULT: Oh he must be 90!

BB: Yeah!

DUSSEAULT: Oh wow, I never would have thought, hmm. But Dr. Govier was, I think, a little bit too optimistic, I mean we now realize that the atmosphere and the oceans are not infinite but, if you take solid waste and you put them back down deep in the ground, in a slurry, most of the water leaks off and then you've got the whole weight of the overburden that is holding those solids in place down there five hundred meters deep, or a thousand meters deep and the rocks are 120 million years old, so I mean, those wastes aren't going to go anywhere, they're being held in very, very solidly, the only concern is, really, is the interaction with the ground water and we can demonstrate that the probability of that is incredibly, incredibly low because of a number of good geological reasons. Again, that's an area where I've been publishing in over the years.

BB: Now looking back, what are your thoughts on the relationship between government, academia and industry for advancing science and technology?

DUSSEAULT: Well, I think that they all have an important role to play, I look upon the government as having several roles, one of the establishment of an appropriate regulatory regime and that means they have to be sensitive to the needs of the population, classic example is in the area of the environmental protection, the government has to be very proactive and let me again, take the example of the fine grain tailings, I don't know what they call them, mature tailings, mature fine grain tailings, MFT, Mature Fine Tailings, I think that's the term they use nowadays. Well the government has not been pushing the mining companies aggressively to cope with this issue until the last few years, for whatever reasons, but as more and more negative publicity became directed toward the oil sands, they Alberta Government has responded, perhaps a little slowly, but they have responded by putting billions of dollars into carbon dioxide sequestration, for example, to try to reduce the carbon dioxide footprint of our industries and into more and better programs to encourage the companies to do some research on tailings, because we knew it was a problem, we

knew tailings were going to be a problem back in the late 70's, early 80's, this is nothing new, but the government did not put into place a strong regulatory enforcement and regulatory environment to force companies to do reclamation more quickly.

So when they were caught in the headlights, you might say, in about 2005, 2006 by the sudden emergence by an anti-oil sands lobby, in Europe and the United States, mainly California and Europe, would be the central locations for this, they were a bit shocked and their response I think was appropriate and maybe not fast enough, so that's one of the important things the government has to do. The government also has to, in our western societies fund some basic research, corporation are not going to fund basic research. And sometimes, not always, but sometimes it's appropriate to let the researcher go and do the research that the researcher wants to do as opposed to doing the research that the corporations want the researcher to do. So in my case I mentioned earlier, that AOSTRA gave me a great deal of freedom in pursuing the subjects I chose to pursue, this is a great privilege. You have the Federal Government and the Alberta Government, who fund, and of course, the Alberta Government has always funded academics in Alberta very generously in terms of oil sands and energy related research. For industry, the big companies like Exxon, Imperial Oil and BP, they have enough cash flow and size to be able to establish and maintain centers in excellence in research, so Shell in Holland, in Texas; Exxon in Houston; and BP, particularly in England; Statoil in Norway, these companies maintain large research groups to pursue subjects, but even they do not pursue the long-term issues, they tend to pursue issues that are more geared towards patent, processes, business profits, so it's very much more applied research.

So there's no problem in taking that research commercial, it happens quite easily, but the more fundamental research that the governments fund, or that some academics almost do on their own sometimes, or if we get some funding from industry, we of course, try to meet our contractual obligations, but you know, some of that work also ends up being fundamental too. So the fundamental ideas move along from, you might say, the academia, in academia, and you get to a certain point where you have to go to the next scale, call it the pilot scale, or the pre-commercial scale. So from in between here we have something that we call the Valley of Death, we actually call it that, and that's the leap from having something that you have demonstrated works in the laboratory, to go to a pilot operation which might be anywhere from a million to maybe a couple hundred million dollars for a very large pilot operation and making that leap, from the academic and just the beginning of the applied research, into the actual pre-commercial pilot project, that requires a lot of money, and that requires a capital to come together with academics and thinkers and often good ideas die.

So industry needs or has claimed that they need incentives to be able to go into that Valley of Death area, so they have convinced the Government of Alberta to give them royalty rebates, so we have the program where they will put in the proposal to the government and the government will say, okay, we will give you a royalty rebate of ten million dollars, you put in another ten million dollars and you know, you will write reports for us, or send us your annual reports and report to us but, you know, you have the full right to patent everything and to implement it, you know.

BB: Well the figure that's often thrown around is that it took a billion dollars of Alberta Government money and a billion dollars of industry money to create the modern oil sands industry.

DUSSEAULT: That's not a bad statement; it's not a bad statement. I would agree that it is a partnership, yes.

BB: Yeah.

DUSSEAULT: The industry is much more field oriented, pilot-project oriented, commercialization, but at the moment, the people that do the research in the industry and do commercialization, these are PhD's and Masters graduates from academia, so a huge role in academia is creating highly qualified persons that go into mainly industry and carry forward this process of commercialization, so these are vital, vital elements, we could not do without that input of highly qualified people. I remember a Texaco president, or vice-president of Texaco had a reputation for not doing any research and a Texaco president saying cynically, he says, we don't do research, we do commercial things he says, if we need any research, we'll buy it, or we'll buy the method. Well that is a very, very Polly Anna approach, because how to do the ideas get generated and how do the highly qualified people get generated, you know, that's academia, and Alberta for example, the governments, they can't look at the next year's stock price and what dividend to the shareholders, that's not what, the government has to do is look at what the dividend is to the citizens over a period of generations.

So right now Alberta is setting the plan, a flexible plan for a strategic research plan, that will probably be established early next year, once it goes through all the necessary stages and this will be a kind of a program providing high level guidance as to the directions for research for the next generation in Alberta, of course, the plan is flexible in the sense that it's not tied into specifics but it basically comes down to identifying what your strengths and the issues are and building upon those, for example, it doesn't make sense for the Alberta Government to fund research on growing of bananas in Honduras, or growing of bananas in tropical soils, that's not going to benefit the people of Alberta and the government has to spend the money in ways that benefit the people in Alberta. So what's the biggest thing that Alberta has going for it, the largest oil reserves in the world.

It's very technologically challenging, in order to access those reserves, you need ideas and people, methods, capabilities, infrastructure, and that's what the government is, they have a role to support that, that means funding academics, funding technical schools, NAIT and SAIT, you know, we need those types of graduates very, very much, not just engineers and scientists, the Alberta Research Council which is now is called Technology Futures, a branch of Alberta Innovates. I used to work for them as a summer student back when it was called the Research Council of Alberta, so its undergone a couple of name changes since then, so now it's called Technology Futures of Alberta Innovates, and they are encouraged strongly to work with industry and they tend to, the idea there is that maybe that's an organization that can help bridge that gap, between the more academic based research and the pre-commercial research.

So whether or not they've been highly successful in bridging that gap, that's for others to decide, they've done quite a reasonable job in some areas, in other areas, you know, methods that seem to have promise have not really, you know, come out, but they do a lot more research now and jointly with industry where three or four companies will put together and a lot of that research we don't see in the public domain, and to me, as an academic, that's unfortunate, I do think that government funded research should end up in the public domain, at least the knowledge, somebody else can hold the patents like you, fine, but at least the results should be in the public domain because that helps guide us as academics as to understanding what the problems are so we can dedicate our energies to helping solve issues that are worthy of attacking as opposed to being told by some company, oh yeah, we solved that five years ago and we have all kinds of patents but we haven't published anything, you know, that's kind of a disturbing blow after you spend a year of your life working on a subject for example you know, so I hope that in the future, the Alberta Government is going to push for more openness and more access to this information of government funded research. So if the government funds an industrial research project, the idea, sure, let the company hold the patents, but at least the results should be in the public.

BB: Now in the U.S. isn't it always public?

DUSSEAULT: They are much better that way, Alberta Government in my view, has been too often convinced by industry that everything has to be confidential and I think that that's a mistake, yes, I mean after all, it's your tax dollar that is going to pay for this research, in part, and to have this research being perpetually confidential, is that the best use of your tax dollar, I suggest not.

BB: And the technologies, once they're developed, I think others could licence them but the...

DUSSEAULT: Well that's the old AOSTRA model, but the new model where the government is providing some royalty rebates to companies, I don't know the details and I don't know if there is a licence ability like there was with AOSTRA, perhaps not, perhaps not.

BB: Have to look into that.

DUSSEAULT: Yeah.

BB: Now in our chatting earlier, one of the things that struck me is you mentioned Venezuela and maybe you could just talk a little bit about Canada in the world picture and where we stand in terms of research and development.

DUSSEAULT: Sure, well...

BB: Would you like to take a break?

DUSSEAULT: No its fine. First let me talk a little bit about the reserves in Canada and Venezuela to give you an idea. Around the world there is, its estimated that there's about 14 to 15 trillion barrels of liquid petroleum and then the leaves the viscous stuff in Alberta and Venezuela, as well as

the conventional oil. Of that 14.5 trillion barrels, probably 9.5 or 65% roughly is viscous oil, so in other words for every barrel of conventional oil there's probably 2.2 barrels of viscous oil, you know, its a huge resource and remember, that the oil that we've used so far has been 98% or 97% of the oil we've used so far has always been conventional oil, or 93%, but you know, well over 90%. Okay, so we have 14.5 trillion barrels of liquid petroleum, Canada, mainly in Alberta and Saskatchewan of course, but mainly in Alberta has on the order of 2 trillion barrels, so that represents about 15% of the world's oil. Venezuela has between 1.5 and 1.7 trillion barrels, so its very close and that represents 13%, 14%. Canada and Venezuela together have maybe, you know, conceivably 26%-27% of the world's liquid petroleum.

BB: A quarter of the world's resource.

DUSSEAULT: More than a quarter, we figure. That doesn't count natural gas, that doesn't count methane hydrates, that doesn't count shale oil okay or oil shales rather, but it's just liquid petroleum So the Venezuelan resources, especially in the Oronoco belt are far easier to extract than ours, the reservoirs are of better quality, higher permeability, thicker. The oil is of a lower viscosity, at least 2-3; about 2-3 orders of magnitude lower viscosity generally than our Athabasca bitumen. For example our Athabasca bitumen in the fire-bag project and the Suncor Petro-Canada Project at MacKay River tends to be over a million centipoise, that's like peanut butter, whereas the Venezuelan, Oronoco tar belt has huge, most of it is less than 5000 centipoise, which is still thick but its much, much less viscous than the Athabasca deposit, so that means its more producible, much more producible. Means you have to use less steam for example.

Third point is that the climate in Venezuela is far more conducive to production, the temperature never drops below to minus 45, it never drops below 10 degrees Celsius. Well the additional costs imposed upon in our heavy oil industry, just talk to Suncor and Syncrude about how hard it is to keep a mine operating when its minus 45, and talk the in situ producers who, you know, when its minus 45 they have severe problems with their steam generation and transmission, in Venezuela all of that disappears. So if Venezuela had had over the last generation, a stable western-style democratic economy where people could rely on the rule of law and rely on contracts being honoured by the government, by far the majority of the investment dollars would have gone into Venezuela during that time, the only reason that all of the investment dollars have gone into Canada, basically, is that we are stable, we have an understanding of the stability of business, what business needs to be stable, we have an understanding of the spin-offs that industrial activity gives to our society and our politicians, although politicized, don't play, what I would call, silly bugger politics, such as happens all the time in South America and right now with Venezuela and Mr. Hugo Chavez. So he has been a, Mr. Chavez has been a great benefit to Canada because companies will not invest in Venezuela, the only way a company will invest in Venezuela is if 100% of the risk capital comes from say, the banks, or from some other source. Except for companies like the Chinese National Oil Company who are investing in Venezuela for trying to secure their own oil imports, secure an economic base, but you never know, maybe ten years from now the Venezuelan Government will be in the hands of another demigod? and they might say, oh well let's kick the Chinese out, because after all the Americans and the Western Europeans have been kicked out three times or two times

over the years, so if it wasn't for Hugo Chavez and the instability in Venezuela, there is where the oil would be produced. The reserves are huge. Second thing is the investment in research and in the development of high qualified people, the Alberta Government, and I believe this is a wise thing to do, is back in the late 60's and early 70's, realized that conventional oil had peaked, our peak in Canada was 1972-'73 and that the only way, realistically to sustain oil production was to foster the development from the oil sands, so they started spending a lot of money, as you said, a billion dollars from the government, a billion dollars from industry was spent over a 20 year period, 25 year period, on pilot projects, on the university research, training a cadre of highly educated people who now form the technical basis in the world for the heavy oil industry.

Before the advent of AOSTRA, there was little doubt that the heavy oil research and commercialization industry was centered in California, but over about five-six year period, I would say from 1970 to 1980, I would say a ten year period, that center of activity moved to Alberta and since then, for the last 30 years, there's no doubt Alberta has been the center of the heavy oil industry worldwide. I spend a lot of my time teaching these ideas and concepts that we've developed here in the field and in practice to other countries, like Argentina, and Columbia, Kazakhstan, Egypt.

BB: You've mentioned Canada and Venezuela are there other big heavy oil and bitumen resources around the world?

DUSSEAULT: Yes, Russia has a resource that is probably is about half the size of the Venezuelan or Canadian resource, roughly, maybe a little bit more than that. But it's very high viscosity oil and a lot of it is in fractured carbonates in the middle of Siberia, where the weather, if anything, is harsher than Canada and it is far, far away from the seacoast so there are transportation problems, there are infrastructure problems, fortunately in Alberta we have pretty good infrastructure, all things being said, and that has helped us greatly. So number three in the world probably is Russia, but we're also finding on the east side of the Andes Mountains, all the way down South America, we're also finding a lot of heavy oil in Columbia, new discoveries in Peru, new discoveries in Argentina, and these are new discoveries because they're were found in the shallower deposits that people were not so interested in for conventional oil, cause you don't find huge conventional oil fields, you know, 500 meters deep.

So in the sedimentary basins in Peru, Columbia, Ecuador, Argentina, we've been doing a lot more investigation and they've been finding a lot of heavy oil, so, but those are about an order of magnitude, each one of those countries is about an order of magnitude smaller than Venezuela, so for instance, Columbia, Peru they might look forward to 50 billion or a 100 billion barrels of heavy oil, very appreciable of course, but not the two trillion barrels in Canada or the 1.6 trillion barrels in Venezuela, so for me in my teachings there's been a lot of interest in South America, and I have another request to go down to South America and teach and I'm going to have to turn them down because I just don't have enough time in my life, but they desperately need the advice of Canadians and wherever, around the world you see large heavy oil projects, you always find Canadians, you know, because at the end of the day, and it's not just, you know, researchers like me, at the end of the day, you know somebody's got to know how to turn the valves and Canadian operators are

pretty good. So a lot of oil fields around the world in heavy oil, you'll see Canadian people working for four weeks in and four weeks out and flying back to Calgary and spending four weeks with their family and then leaving again, I seen that in Oman, in Kazakhstan, in Columbia, the Canadian companies are very active in Columbia.

BB: You know from about 1865 to about 1920, the Canadians from the Petrolia Fields in Ontario worked around the world...

DUSSEAULT: Indeed.

BB: ...in much the same way and they were called hard oilers, and so its a little bit of history repeating itself.

DUSSEAULT: Well, although the Americans will greatly debate the issue, the first flowing well in North America deliberately sunk in order to produce oil, predated the Drake Well in Pennsylvania by about eight months, only the well was not sunk with a...

BB: A drill.

DUSSEAULT: ...a drill, one of those hammer drills, or whatever you call them, that kind of, the name will come back, it was actually sunk by hand and lined by hand and it actually produced oil. So you know, we are not as nationalistic and arrogant as the Americans, so we don't we go around saying, you know, that the first well was drilled in Canada. Well, it was, but we're not very good at promoting ourselves in general, although in this heavy oil business we've done okay, I mean people around the world know where the expertise is, it's in Canada.

BB: You're doing a good job of covering your territory. Now what about the carbonates, the carbonate triangle in Alberta and elsewhere where the heavy oil and bitumen is in carbonates, have you done work in that field?

DUSSEAULT: Indeed I have, remember that figure of 14.5 trillion barrels?

BB: Yeah.

DUSSEAULT: Well just under five of that, about 4.6 maybe is conventional oil and by conventional oil I mean less than a 100 centipoise viscosity in the ground, so about 9.5 to 10 trillion barrels is more viscous oil, more than a 100 centipoise in the ground. So of that 9.8, about 2.2 probably is in fracture carbonates and the other 7.2 or something is in sands, mostly high porosity unconsolidated sands like in Venezuela and Canada of course. So that 2.2 trillion barrels in fractured carbonates, still represents about roughly, 15% of the world's resources of liquid petroleum, but there are problems. The first issue is that in these high porosity sands, the porosity is say 30% and that's about 80% film with the viscous oil, so let's say 30% x 8% that's about 80%, 80% of 30% is about 24% of the volume of the rock is actually oil. Now in the fractured carbonates, the porosity is only about 15% or 16% usually, so the amount of oil per cubic meter of rock is far less, so if you've got to for

example put in steam, you still got to heat up all that rock, but now there's less oil, so your steam/oil ratios all of a sudden go for a big poop, they start degrade pretty appreciably and therein lays a major problem, can you develop a technology that can get a significant portion of that heavy oil out of the fractured carbonates, economically, in Alberta alone there's probably 500, 450-500 billion barrels of our oil sand is actually in fractured carbonates, the rest of it is in the sands. So there's less of it per cubic meter and the viscosity is high.

Now in some areas of the world, like Oman, they have oil in-fractured carbonates and they're higher porosity than ours and the viscosity is much lower, only a few hundred centipoise and there they can produce quite nicely, so Oman has got some good heavy oil production from fractured carbonates, they're the biggest in the world in fractured carbonate production. We have nothing commercial and I don't think that we will see anything commercial for maybe the next generation even though of course there are companies that are trying to promote their technologies and their properties, but this promotion is not necessarily based upon a guarantee that it will be a commercialized project personally, I have my doubts. Unless the price of oil stays really high and the price of natural gas stays really low, I have my doubts if that will be commercially...you see, if you have free energy or very, very cheap energy, you can do anything, so historically, the price of natural and oil follow a similar pass up and down, but in the last few years, with this shale gas development in the United States, we have surfeit of natural gas, so the prices remain very low, so this is very cheap energy for the oil sands company, it's wonderful, burn cheap natural gas and make viscous bitumen.

That may not last, it's unlikely that it's going to last indefinitely and also governments are well aware that natural gas is a nice clean fuel, and burning a nice clean fuel to generate heat to produce a more tarry substance and then of course, using some more natural to create hydrogen to upgrade the tarry substance, that has to be looked up in terms of the whole context of the energy industry and also in terms of generations, do we want up vast amount of natural gas in order to produce all of our heavy oil sands, and this is why there is still continuing interest and there will continue to be in the possibility, for example, of using a nuclear energy in some safer form to generate heat needed for steam injection. Because you don't want to use electrical energy, because electrical energy is very valuable for other reasons and it's not fair to say that one unit of energy electrical is the same as one unit of energy from gas, it's not true because one unit of energy from natural gas or oil has a carbon penalty, the electrical energy may have been made with coal, but it may not, okay, so it doesn't necessarily the same carbon penalty, but also electrical energy in the home and everywhere else is clean, and you can use it for example in a heat pump, here in my house I have a heat pump for my furnace and one unit of energy actually produces about 2.2, 2.5 units of heating in the winter, so that's kind of a multiplication of the heat pump concept, can't do that with natural gas and oil, so they're not equivalent.

BB: It's the quality of the energy.

DUSSEAULT: Exactly and how you can use it.

BB: In forestry and land management, they talk about highest and best use.

DUSSEAULT: Yes.

BB: And if you have something that, like electrical energy that can do...is very high quality, you don't want really want to be using it to heat water to a 100 degrees.

DUSSEAULT: Right. So some people in the oil industry now, in the fractured carbonates, are talking about putting in horizontal wells and using electrical heat to heat...well, will that ever become commercialized, my view is that it will not. But that doesn't keep them from trying. Because trying technologies and trying to promote the commercialization of deposits is not simply a technological issue, it's also a business issue. If I am working hard to develop a technology, for may asset and other companies think that hey, these people are doing really well, then all of a sudden the value of my carbonate assets jumps up dramatically, so if I turn around and sell that asset for a billion dollars, having poured 200 million dollars of research in, then whether it or not it becomes commercialized has become irrelevant to me, it has become a market issue and a commercialization issue. It's like the price of diamonds.

If I can, well not quite, because diamonds don't have an inherent use really, at least the gem diamonds, but if I can convince people that my house here in White Rock is worth $200,000 more than the market value because of special assets, well that's fine and nobody would say that's wrong, so I'm not saying that what some promotion companies are doing, sorry, what some companies are doing to promote their land base is wrong, no, I would never say that, if they can get a client to pay more for it and run a profit, that's their privilege, it's up to the client to understand, the purchaser of the land to understand the nature of the technology, for example I have served as a consultant, I won't name the names, but I've served as consultant several times, as a third party consultant to a company who was looking at buying assets, in several cases in different countries actually, and they brought me in as a technical expert to make comments as to what could be done in order to render the deposits commercial, in both cases its fractured carbonates by the way, and I gave my opinion and even though I'm an optimist technically and then their reservoirs were better than our reservoirs here in Canada in some ways, in both cases the client declined to invest in the fractured carbonate, in that case the client said, hey, we don't think it's that easy to commercialize it even though you have done a lot of preliminary work.

When I was here in Canada we have a number of companies that are doing preliminary work in fractured carbonates but if they can develop a commercial technology, what they can do is maybe generate interest in other companies to buy their assets, and of course, buy their technology, that's part of the deal. Now some of these companies might buy assets not just for the oil in them, although in turning a profit, but for example I've advised the Chinese for years, and the Norwegians as well, I advised them for years to get involved in the viscous oil business in Alberta, because that's where the technology is and if they want to get that technology into their corporations, they've got to be on the ground in Alberta, it's not enough to have some academic lecturing, they have to on the ground and get their fingernails dirty, okay. Of course, I was saying that back when the price of oil was, you know, $15 or $20 dollars a barrel back in the middle of the 1990's and the companies kind of thought that was an amusing concept, because you know at $15 dollars a barrel, heavy oil isn't

going to economic, well of course these same companies bought in to the oil sands business when the price of oil is $80 or $100 a barrel, they were spending far, far more money, you know, but that's the way companies are, they can't, so we now have Statoil and the Chinese coming into Canada.

But the Chinese very much want to be the operators or want to be involved in the operations because they want to learn the technology hands-on and use that to apply to other assets that they have around the world, heavy oil in Sudan, heavy oil in several parts of China, heavy oil off-shore China in the bay in front of Zhejiang, Beijing it's called, in Bohai, in that area. So being here, in Canada, on the ground with your fingers implicated in a heavy oil project, is the learning process, and it brings value to the corporation. So there are many reasons to invest in heavy oil: to make oil, to make profits, to get knowledge and learning into your own company and training people on the job, in Alberta, where the technology centers are.

BB: Now in your view, is SAGD still the start performer amongst all the technologies?

DUSSEAULT: Yes, and it will continue to be so for several reasons, lower steam well ratios then the other technologies and higher recovery factors. But I think what is emerging more and more is the concept of a sequence of technologies. Many reservoirs are perhaps, not quite suitable enough for SAGD but are suitable for say, horizontal well steam injections, cyclic steam injections in horizontal wells. SAGD operates at a constant pressure whereas the cyclic steam operates at very high injection pressure, and then production, very high injection production, then production. But the very high injection pressure are very aggressive on the formation and they improve it, they break through the barriers, they cause the shearing, and dilation of the fabric of the sand which makes it more permeable and easier to produce the oil, so they turn reservoirs into better reservoirs, so what we're seeing now, more and more, are companies that are saying well look, we have our reservoir here, an asset, it maybe is not the best for SAGD right from day one, but let's use horizontal well cyclic steaming for two or three years, break up those shale barriers, create better vertical permeability and then after three or four years, we're going to convert it from a cyclic steam process, to a gravity drainage process and then be able to have a higher extraction ratio and lower steam costs.

Then once we're all done, we've got the whole, we still have oil in there that's hot, but we don't have easy ways of getting it out so now let's pump in an inert gas, like flue gas, carbon dioxide and injecting it into the reservoir and try to displace some of that hot oil towards the producing wells at the end of the project. So now we have three technologies, starting with say horizontal well cyclic steam, followed by steam assisted gravity drainage, followed by inert gas injection; so instead of looking at just looking at one technology, the idea nowadays, more and more, is to look at the evolution of the reservoir and use the appropriate technologies at the appropriate stage in the reservoir's life to minimize your costs and increase your chances of getting oil out. And this whole idea of sequencing is only five, six years old and people are talking about it now quite a lot, for example, we have many, many CHOPS wells, Cold Heavy Oil Production, but those wells area all drilled and installed as non-thermal wells and there's tens of thousands of them in Alberta and Saskatchewan, by the way, and in many of those reservoirs now, the oil companies will very much

like to put steam into those wells, but they can't because their non-thermal wells. Now if they had spent an additional 10%-12% back at where they drilled those wells, after the coal production phase, now they can move naturally, maybe into a cyclic steam phase, using the same steel to get more oil out, but they didn't. So they have re-drill the entire reservoir with thermally completed wells, because you can't go back in and recomplete a well thermally, its either a thermal well or it isn't.

BB: It's a matter of the casing or the...

DUSSEAULT: The casing, the quality, the coupling, the casing coupling grade, the cement. Those are the three major factors.

BB: Now...

DUSSEAULT: But yes, I'm going to answer your question more directly.

BB: Okay.

DUSSEAULT: SAGD is yes, it's a winner. High recovery factors, lower steam well ratios than cyclic steam for sure. But we have 1.6 trillion barrels of oil in Canada, okay. And it is deemed that only a fraction of that, say 30% could be amenable to SAGD, the way we look at it right now. But part of our on-going research over the next generations is going to be to optimize SAGD, find ways to improve its performance, for example, many companies are experimenting with SAGD combined with some kind of a hydro-carbon vapour.

BB: Yeah, it's all, of some sort.

DUSSEALT: And that seems to reduce the steam/oil ratios while maintaining relatively good recovery factors and that might mean that we can then use SAGD for more marginal cases, horizontal cyclic steam, as precursor to SAGD means it's going to open up more resources. Let me make a prediction, right now we have a hundred and sixty-seven billion barrels of resources in Alberta, in Canada, you know and that's the number we use right now. That can only grow and twenty years from now, we'll be talking about 300 billion barrels, 50 years from now we'll be talking about 500 billion barrels, technology moves on, it's never static. Who would ever...if you had told me back when I started out my academic career in 1977, if you had told me that gee, 35 years from Maurice we're going to be getting, you know, from good reservoirs, 80% recovery of highly viscous oil from a...I would have called you insane, and yet we're doing it with SAGD. Technology moves on. What's around the corner? Well, there are new approaches to nuclear power, but nuclear power, making electricity is one thing, nuclear power to make heat is much, much more appealing because there's no heat losses, see in nuclear power generation, you turn water into steam, pass it through a generator and then you have extra heat losses, all the way down the line.

BB: They only have about 30% efficiency.

DUSSEAULT: That's right and then you have to transmit this, you know, to Toronto or someplace else, now suppose you have small scale reactors and they're sitting right on top of the oil sands and you're generating heat now, steam, all of a sudden your efficiency almost doubles, you know, you don't have transmission issues, so you all of a sudden are looking at a very different set of economics, because you don't have the capital costs either because you don't have the generators for electricity, you're just generating steam, so it all starts looking very interesting. So supposing this technology does get developed and about a generation from now we might be using small-scale nuclear reactors, not CANDU's probably, but different types of reactors like what we call a pebble-bed reactor.

BB: Thorium cycle.

DUSSEAULT: A thorium cycle is really a possibility, which is really being looked at again.

BB: Yeah.

DUSSEAULT: And these might be again, small scale, safer, local and we're turning nuclear energy into heat, heat into steam, steam into bitumen and we're preserving the natural gas for the use of heating homes and cooking, for which it is very convenient.

BB: Not to mention chemicals and everything else.

DUSSEAULT: Sure. One thing you can say about technology, it will change, it will change. We're up to 350,000 barrels a day now from SAGD, maybe a bit more, and you know the latest figures from the ERCB are 3.5 million barrels total, per year, by 2020 of heavy oil, viscous oil from mining and in situ and what's going to happen is the following, from mining, it's going to level off, probably we'll never have more than seven mines, because we have a limited mining area, and these mines have to have land to continue mining. So this is going to level off and then decline after some time, whereas the in situ will potentially continue to climb for the foreseeable future. So right now we're here, so this is about 2011 where the amount of oil, the amount of heavy oil from mining is about a million barrels a day, and from in situ, it's about 600 and something, 650,000; 700,000, something like that. So that's where it is now. So these two curves are going to cross here in about another ten years where there will be about the same amount from in situ as mining and then after that, there will be more from in situ and then mining will taper off. So technology's changing, as we speak. And I don't know what the future holds, but I do know the key drivers, the key drivers are the cost of thermal energy, okay.

Environmental issues: water use, air quality, wastes; but again, I think all these problems in principle, solvable. Carbon footprint, right now our oil sands are, on average, about 10%-12% more carbon intensive than average conventional oil.

BB: Lifecycle.

DUSSEAULT: Lifecycle yes, wells to wheel, as they say. Can we reduce that to say 6%, 7% and then, or 5% or 6% and that means then that its only marginally more carbon intensive than conventional oil, it's unlikely we'll ever get down to the level of conventional oil just simply for physical limitations.

BB: Well when you say conventional oil, its actually, I think the figure that they use is the global average, or the average of U.S. imports, so what happens is if they import more Venezuelan and Mexican heavy crude they're...

DUSSEAULT: They're average.

BB: ...the comparison and that average will come down, so...

DUSSEAULT: Sure, that's right, it will go up, but for example, the Europeans import very little heavy oil compared the United States and the Europeans are taking a very holier than thou attitude, as they always do, a good example is what is happening on the carbon in the Europe. Europe in the 1960's, 70's and 80's was dependent upon coal fire power plants, then they started talking about Kyoto and of course, they took as the basis here, I can't remember...

BB: 1990.

DUSSEAULT: 1990, thank you. And they took that as the basis here in 1997, in other words, 1997, in other words in 1997 they said, let's just pick 1990, well as it turned out between 1990 and 2005 is when Europe got off of coal fire power plants and switched to natural gas, but the Europeans in 1997 knew very well that that was happening, so we got suckered in to make a climate change, pardon me, a carbon dioxide agreement with a very, very different economy than the Europeans because they knew they were going to be getting off of carbon coal fire power plants and we weren't, so we got kind of suckered into signing an agreement that we shouldn't have and the you know the Alberta Energy Minister at that time, who was in Kyoto was not...the Albertans were not allowed in the final negotiations, it was the feds that did it, and the feds went in with a mandate to offer 1% cuts and they came out having offered 4% cuts. I talked to the guy who was the Alberta Energy Minister at that time, whose name escapes me right now.

BB: Let's see, that was Norman wasn't it?

DUSSEAULT: I'm sorry it just escapes me...1997, '98.

BB: Was that, by then...Pat Nelson?

DUSSEAULT: He was from the Lloydminster area. That was way before Pat Nelson. He was from the Lloydminster area and region, yeah. In fact, he may have been the MLA for Lloydminster area. But anyway, he said to me at a dinner that I happened to sit beside him, many years, in Lloydminster, he said the Europeans just simply negotiated us completely out of our underpants, they just stole it from us and we should never, ever have agreed because our economies are so

different. So the Europeans take a holier than thou attitude in heavy oil, in viscous oil because they don't import any.

BB: Let's take a little break, I think we've covered a lot of stuff, and I want to think for a minute.

[END OF NO. 1]

BB: I wanted to ask you about some of the people who you've encountered in your work and how they interacted and contributed, starting I guess with Roger Butler, when did you first encounter him?

DUSSEAULT: I first encountered Roger Butler, oh when he was still the head of research at Imperial Oil, in Calgary and I was a young professor at the University of Alberta and we never worked together but we certainly worked for AOSTRA and he was funded by AOSTRA as I was and we have occasionally been working on the same project but on different sides of the project, but I guess I had met Roger back in the early 1980's, back in '81, '82 when he was just trying to get his SAGD concept off the ground and of course, as you know, he couldn't get it off the ground at Imperial Oil and he went to the Alberta Oil Sands Technology and Oil Sands Authority and they decided to go with it, but they couldn't get industry interested in this idea because industry generally had the concept that it was a pretty silly idea, and I think Imperial Oil also had some patents on it, I know they did, and that maybe scared off some other companies. Well, of course, the rest is history, the government almost single-handedly went in and did a full-scale pilot project for hundreds of millions dollars to try it out and turned out to be fabulous.

BB: That was the Underground Test Facility.

DUSSEAULT: That was the Underground Test Facility, yes. Although, its never been published in the archives of the AOSTRA, and by the way this is a big issue in my mind is that all of that stuff is there in the archives in AOSTRA but the government is not publishing it, and that bothers me quite a bit, but I know, although I didn't participate, I know from first-hand the description, back in 1985, roughly there was... AOSTRA funded about ten groups around the world, some oil company groups, some consulting companies to estimate how much oil recovery would happen in the UTF, in the Underground Test Facility where these two wells, you know, five hundred meters long, etc., then they paid all of these groups each quite a bit of money, something like $50,000 each, back in those days it was quite a bit, to do these simulations and to come up with a prediction of the recovery factor and the various predictions were like 12%, 22%, 30%, 17%, you know different numbers, but mostly in the range of 15%-20% recovery factor, well of course, once the UTF was phase one was finished in the early 90's, early to middle 90's, there was over a 90% recovery factor in the two central wells, totally completely unpredicted by the oil industry of course, who claimed, that they had all the best technology, when they absolutely, completely didn't understand it and they failed to appreciate it from the beginning and then when the UTF was such a success, then all of a sudden, it clicked in and then they started going full-speed towards the development of the implementation. On the second phase of the UTF, when AOSTRA again, went around to solicit

participation, my understanding is that they had to stop at 15 or 20 participants, they just didn't want to have anymore, I think it was 15, so on the first cycle they couldn't get anybody to participate, and then on the second cycle after the obvious success, it was just no problem and the industry around the world was beating a pass to AOSTRA's door saying let us participate please in phase two and then of course, we had the decade of development which was from 1991 to 2001 which is the pilot projects all over Saskatchewan and Alberta with CS Resources, Pan Canadian and all these other companies are defunct, you know Morgan Norsen, all of these companies, you know, trying SAGD out, and ELAN, and during the price collapse since the late 1990's all of these companies ended up going, having to sell their properties because they couldn't make production so they all went out of business, and of course the smart companies like Husky and others, you know, picked up these properties at bargain rates, back in those days.

So Encana which is a combination of the old Alberta Energy Company, AC and Pan Canadian and CS Resources were all folded in and became Encana. Encana took the lead in development of SAGD and the first commercial project, basically, the first commercialization, and by commercialization I mean, a single project producing ten thousand barrels a day, that's my own personal definition of commercialization, that occurred in late 2000, early 2001 with the Foster Creek Project with Encana, so that was the first commercialization, but even so it was still a few years before the second and third project became fully commercialized, and now of course, we have 350,000 barrels a day production from a number of projects.

BB: What about things like Amoco Primrose, was that a different?

DUSSEAULT: Yes, Amoco Primrose was predicated on cyclic steam injection actually.

BB: It was.

DUSSEAULT: Yes, they didn't start off with SAGD, now of course, a large part of that area is SAGD, but CNRL still does a lot of cyclic steam injection in horizontal wells, which I think is a far, far less, the recovery factors are more like 40% instead of 80%, the steam/oil ratios is much higher than SAGD, SAGD is a remarkable technology in terms of a very efficient use of heat. We don't lose as much heat, because you're not forcing it out long distances, its staying nearby by operating at the same pressure. So it's a very efficient use of heat, and of course, it is the cornerstone technology for in situ and it will remain so, but it is not suitable for all reservoirs, if you're less than 50 meters thick, you don't have enough oil you know, thickness, and you still have the same heat loses because the area on top is the same, so it doesn't look so good anymore at 15 meter or 14 meters or 13 meters, at 25 meters it looks great. And then there's some reservoirs that have too much shale in them, and for those we don't have any technology, or the reservoirs like I said are too thin, or other things, you know, but for example, the presence of mobile water, a water lake on the base of the reservoir that's problematic for any heavy oil technology, because cold water and steam chambers don't mix. Once you have a breakthrough, the steam chamber disappears in minutes, it just collapses and this has happened a number of times, at least three or four times that I'm aware of in our industry, but people never talk about it. Do you ever see a paper published on how I chose my

reservoir badly and everything kind of went for a great big poop and I lost the company $15 million dollars, no, you never see that. It's just like the Joslyn blowout, how many papers have you seen published on that? Not one.

BB: Yeah.

DUSSEAULT: Nobody likes to talk about their mistakes; that's just human nature. So we learn from our mistakes but we don't publish them unfortunately, and that's too bad because there are many things that we would have learned much faster in the industry had we had a need to publish our mistakes, but because we don't have to publish our mistakes, we tend not to, we all like to tell good stories. So all of the conference papers and the SPD papers and the Canadian Journal of Petroleum Technology are what I call sunshine stories. You know, they're good news, nobody a write a paper about how they screwed a project, or how a project was ill-conceived or whatever.

BB: One hears that from the medical field as well.

DUSSEAULT: Sure but in the medical field, you have to do pathology on people, people has to be made public, so we don't have that requirement in the petroleum industry so the corpse tends to get buried quite often, too bad.

BB: What are some of the other key personalities or champions?

DUSSEAULT: I think my supervisor Norbert Morgenstern was a key person, he has been sitting on the Syncrude Canada Technical Board for 30 years, he is still publishing and still working as a consultant even though he's been retired from academia for the last 12 years. On issues of tailings, and tailings dyke stability, and slope stability, a very wise man, he was my supervisor and my mentor. Maurice Cariggy, a very wise man, he was the person who acted kind of as my mentor at AOSTRA and I remember once, when I went into his office upset because some oil company had kind of led me down the path a little bit, promising that there was going a research grant for me, etc, etc, so I wrote a big proposal and he came and spent five hours with him and I was all enthusiastic and then I never heard anything from him. And then about 18 months or 14 months later, I saw a paper published in a journal and its exactly what I said too and he did it with another academic from Toronto and I was upset, so I stormed into Maurice Cariggy's office, and I said, this guy...and he calmly listened, you know, ranting and raving, after I was all done he said, Maurice he said, is this the only original idea you're going to have in your career and I said, I hope not, and he said well Maurice, he says don't worry about, just go and develop a few more ideas and that put everything into context, you know, that guy behaving dishonourably was small potatoes, these are the kinds of things that you just have to ignore and go on with life. There's a number of things that I've done and that I've suggest and that have been adopted and I feel that I have not got all the...as much credit, but am I going to sit in a dark, unlit room worrying about...no, I've done extremely well, I mean, I've got a huge amount credit, financially I've done well, the university system has been very good to me, I've had a fabulous life, so don't dwell on little things like that and that was a lesson that Maurice Cariggy taught me. I stuck to his advice ever since.

BB: Yeah, he also helped to internationalize the research, his UNITAR work and...

DUSSEAULT: Absolutely, he was one of the instrumental people in the UNITAR conferences which I've published in a number of them, and that gave Canada a reputation around the world, that helped Canada's reputation, he was the chairman of that division in UNITAR for a few years, before he retired, after AOSTRA, so yes, yes, he's never going to be a publisher but he's always been a very, very good administrator pursuing these things for the benefit of the people of Alberta, you know, one never, ever could doubt his ethics, his sincerity, his hard work, you know, on behest of the people who owned the resource, that was always behind his behaviour, great, very nice human-being too, just a wonderful guy, not a mean bone in his body, you know, a lot of people, including me I suppose, or many of us have a little bit of sarcastic or a mean streak in there but Maurice Cariggy didn't have mean bone in his body, he was always a gentleman, you know, very quiet, and soft-spoken and smart and I admire him greatly, yes.

BB: And Clem Bowman?

DUSSEAULT: Clem Bowman was never a mentor to me, he was the director of AOSTRA and I didn't interact with Clem, I interacted with his right hand man, which is Maurice Cariggy. And then of course, after a bit of mentorship in my AOSTRA professorship, then I went off on my own and didn't need mentors anymore, but my mentor is my supervisor, Maurice Cariggy, these were very good people to me.

BB: What about protégés, have you...

DUSSEAULT: Well Chris Fordham of Suncor is a graduate student of mine, I'm proud of what he's achieved, I haven't had as many top students that have gone on to great important positions like Norbert Morgenstern has, he educated a generation, fabulous, but I had a few students that have done quite well, I've worked with a lot of people that have done well, you know, co-published with them for example, you know, Grant Mossop and I exchanged a lot of information at one time, we didn't publish much together but we taught each other a lot.

BB: That was the Institute of Sedimentary and Petroleum Geology...

DUSSEAULT: That's right. Well he was actually with the Alberta Research Council before that.

BB: Oh okay.

DUSSEAULT: Yeah, but, yeah so I learned a lot from Grant and his geological work and I think I taught him a little bit about the rock mechanics side of it, I've had another student of mine, Roman Bilak, is the President of Terralog Technologies, that I mentioned earlier.

BB: How do you spell Bilak.

DUSSEAULT: B-I-L-A-K. Bilak, Roman. Another student of mine, or not really student, but a technologist of mine started this Wavefront that I was involved in. Another student of mine started a consulting company, he was from China and his consulting company does work, you know, large amount of work in China, he has a Beijing office and a Calgary office, you know, about 10 or 15 employees.

BB: What's his name?

DUSSEAULT: Yarlong. Y-A-R-L-O-N-G. Wang. W-A-N-G.

BB: W-A-N-G?

DUSSEAULT: W-A-N-G, yeah. Yarlong Wong. And he works out of Calgary and he's a consultant.

BB: Is that in heavy oil or is this just general petroleum?

DUSSEAULT: Petroleum Geo Mechanics, but focus on heavy oil. He has focused on heavy oil, yeah, and mathematical analysis. You know a couple of my students are professors in the United States and there's a sprinkling here and there but like I say, had I stayed in Alberta, at the Universities in Alberta, I think I would have had a better opportunities to graduate more students in this area, but I went to Waterloo and Waterloo, of course, is not an oil place. But nevertheless, I think I've been fortunate to have a bunch of the students. Another one of my students has become a very senior person, very, very rapidly at Hess in Houston, so he's become quite a guru in a very short time, in ten years he's become a guru at Hess, which is really remarkable, I'm not sure he's 45 yet and he's looked upon as one of the senior type of the people in the entire company, so that's good.

BB: Now there was a parallel to the science advancing newer technologies like horizontal drilling, coil tubing, 3D seismic; it always intrigues me this question of, you know, this sort of chicken and egg thing, whether the technologies enable the science or the science that...you're making a ladder effect.

DUSSEAULT: It's like parallel ladders, you know, and people, you know, the technology's climbing one ladder and science is climbing the other ladder and they are feeding off one another, they're helping each other climb the ladders, of course. I'll give you an example, the first horizontal well in Canada ever drilled was... Imperial Oil was trying to learn how to drill horizontal wells and they had drilled a horizontal well from the valley wall, north of Fort McMurray and I believe this i s1979, '78 and I think that about the same year, they tried to drill a horizontal well in Norman Wells, because the Norman Wells field...

BB: They wanted to get under the river.

DUSSEAULT: ...oh yes, that's right. And it's also a fractured carbonate and horizontal wells and fractured carbonates turned out to be good things, okay. But they drilled in the first horizontal well

in the oil sands 1979 or 1978, so I attended a conference in 1980 and I heard the Chief Engineer describe that, he never published it but he spoke at this conference, so he spoke for about 20 minutes, about this horizontal well and how they drilled it, and they used mining technology, okay, not oil field technology, and of course as you know, in the UTF they used mining technology to do the drilling and he said, after the talk, he said so horizontal wells, you know, la-de-la-de, unfortunately horizontal wells will always remain too expensive for us to use.

Wow, how times have changed you know. Because within a decade we would learn how to drill horizontal wells from the surface, with steering, geo-steering as we call it, and put them where we want, so now we can and hit a target anywhere, we can have wells that have any geometry you want virtually, for example in the oil shell work, shell oil work, pardon me, oil shell work in Colorado, one company there is drilling wells from the surface, going horizontal and then another well from maybe two kilometres away from the surface and going horizontal, the two wells intersect and they pull the casing all the way though, and then they circulate hot steam through the sealed casing, not injecting steam, but hot steam at like 400 degrees Celsius, why? To heat the oil, not by direct steam contact but to heat the shale oil, or pardon me, the carrageen, the solid stuff in the shale, to break it down into smaller molecules, so it's not really viscosity, it's what we call pyrolysis and who would have ever thought 30 years that you could do that?

I mean if you'd have stood up and said, you know, 30 years from now we're going to be drilling wells, two meters apart, three kilometres deep and people would look at you and they would have called for the men in the white ambulance to come and take you away. It's astounding, so yeah its building one on top of another. Solvents have never really been highly economical in heavy oil because of the solvent losses, but we now understand we can use solvents like Imperial Oil is doing and some other companies are doing, in combination with steam injection because as we continue the steam injection, we continue to recover more and more of the solvent, so that now our solvent loses are much less than they used to be, these are all advances, and there's many, many. Coil tubing.

BB: Yeah.

DUSSEAULT: You know, coil tubing is a good example, and by the way, many, many of these technologies have been perfected in Canada and then have gone around the world. The drilling of shallow horizontal wells, 500, 400 meters deep, this was in Canada in the early 1990's and then this technology was exported around the world, for example, in Venezuela, coil tubing drilling, coil drilling work-overs, this was developed for Canada, of course some American companies were implicated, but it was developed in Canada and now coil tubing, drilling and coil tubing units are being sold around the world, for work-overs and also for shallow drilling. Many, many innovations have been developed in Canada in the oil industry and gone around the world, all of these technologies like cyclic steam, SAGD, pressure pulsing, cold heavy oil production without sand, cold heavy oil production with sanding, all of these have been essentially perfected in Canada, and some of them exclusively in Canada, to this day virtually, like cold heavy oil production with sand, you know, everybody around the world is scared of sand, but in Alberta, hey, sand makes oil. So we're going to produce sand and oil is a fortunate bi-product.

You know, improving our steam generation capacity, heat recovery, because when you do steam generation you want to scavenge as much heat as possible so you don't...well its money in the bank. So our surface facilities have been perfected in Canada and now these improved surface facilities are being installed around world in heavy oil operations, in fact, in many cases you just simply order it from Canada, like for example, progressing cavity pumps. Progressing cavity pump existed for 30 years before heavy oil, but it was perfected for heavy oil in Alberta in the 1980's and then became used all around the world for heavy oil, coal production and now, in the last few years, a metal-metal version has been developed by French researchers and is now marketed but Koodoo, it's called Vulcan, V-U-L-C-A-N, its metal-metal progressing cavity pump that supposedly can operate at 300 degrees Celsius, you know, well gee whiz, now we can use progressing cavity pumps for SAGD, whereas five years ago we couldn't.

You know it just goes on and on and on. Better monitoring, we have 40 seismic, we have micro-seismic, we have surface deformation measurements so we can measure the surface deformation at the ground surface and that tells us what's going on in-depth, Shell oil for example has and their Peace River Project has tested all kinds of monitoring techniques and grid detail. The Alberta Government is even thinking of making it a requirement that the companies do surface deformation monitoring because there are small environmental issues as well. The ground might move up as much as a meter over the period of the exploitation, but the important thing is that these up and down movements during production, we can use them to analyze what's going on. So in combination with 40 seismic mixes gives us some eyes to look into the earth.

It's really interesting, by the way, that's another area that I made contributions to is the analysis of surface deformation data, you don't want to go there, that's a hairy area, but I made a few contributions to that, fortunately I got the privilege of working with some people that are mathematically far stronger than I am, so I got a pretty good understanding of the physics, but they understood the math, so the two of us together did a good job. So you're right, technology and science are, you know, partners. They walk arm-in-arm through history.

BB: Curious, conventional oil, 70% is left in the ground.

DUSSEAULT: On average, around that, yes.

BB: Is any of this work going to unlock some of that?

DUSSEAULT: Major, major impacts. If I was a young man and a betting man, I would be looking at redeveloping fields like east Texas with gravity drainage. I think I know how to do it and I think that there's going breakthroughs in the applications of the technologies that we've been developing in heavy oil. For example, Vapex, you've heard of Vapex, well Vapex has problems in the heavy oil because you need a lot of solvent in order to cut the heavy oil and lower the viscosity. But suppose you have oil that is medium oil, like 20 centipoise, 30 centipoise 80% of it is still in the reservoir and Vapex now starts to look really good, with conventional oil with horizontal wells. Just like SAGD only now we're using Vapex, but you've got to have the right reservoir. The pressure pulsing, which

was first tried out in heavy oil, in 1998 and 1999 and then as the price was very low back then, there wasn't much interest but now it's starting to come back.

Pressure pulsing was developed by myself and a professor at the University of Alberta and one of my, well my technician actually at Waterloo and that company now is doing this commercially out of Edmonton, and that's going to have a big impact, but it takes a lot of time. The oil industry is a very, very conservative industry. Especially when they have, it's funny on the expiration side, they understand how to take risks, on the production side, they're very, very risk adverse, but you know, we're bound to go back into many of those old reservoirs and get back and get out some of that oil, for sure, so we'll have a higher recovery factor. Already the recovery factor for conventional oil now is better than 30%, it's in new fields, it's much, much better, we have better methods of monitoring, better methods of doing polymer floods, better methods of doing all kinds of things to get more out, but the number you quote, 70% is still in the ground, that includes all of the bad jobs we did, or we didn't know better, back in the 1940's, and 50's and 60's, so that includes all of those cases, I mean, but now we're 30% recovery from the conventional oil field, that's not good enough, we're doing better.

BB: What about the heavy oil fields in Alberta, the Viking and Lloydminster and...

DUSSEAULT: Our big problem there is that they're too thin, for steam, your heat losses are too large, if you've only got five meters of oil, you'll never steam because your heat losses are the same because surface area is the same as if you have 25 meters, but there's only $1/5^{th}$ as much oil, so you're using the same amount of heat to produce $1/5^{th}$ as much oil, it's not going to work. So we generally perceive the lower thickness as somewhere in the order of ten to fifteen meters, if it's less than ten meters, you're probably not going to use steam, unless of course you have free energy, then you can do anything. So that means there's a lot of those reservoirs that we've only produced ten, fifteen percent of the oil in and they're just sitting there. What's going to happen? Well, right now there's work being done on the use of polymers and water injection in the heavy oil in the Lloydminster type reservoirs, that's a bit promising but that's not going to give us 30% recovery, that's only going to improve it a bit.

Pressure pulsing I think has some merit, if the price of oil stays high and the price of energy stays low, or the price of heat stays low, then maybe steam will be used, maybe some of other technology, maybe solvent technologies can be used in the right circumstances because then you don't have heat loses, but then you have to have a higher recovery factor for your solvent, you can't afford to put in expensive solvent and produce crappy oil you know, you've got to have an economic balance there and that has been the problem that has plagued all solvent projects to date, is a low solvent recovery factor which hurts the economics, but with Vapex concepts, maybe, maybe there's something there. Maybe we're going to start to use Vapex in these Lloydminster type reservoirs.

BB: Vapex just stands for vapour extraction?

DUSSEAULT: Vapour Assisted Petroleum Extraction.

BB: I don't know, are we running out of steam, so to speak?

DUSSEAULT: To coin a phrase. It's up to you, I mean.

BB: I think we've covered most of what I had in mind. Are those my notes?

DUSSEAULT: Yes.

BB: Well somebody said that you were exemplary of the addictive buzz the industry creates.

DUSSEAULT: Not sure what they meant, am I enthusiastic? You bet. Do I love it, I love my job, I love it so much I don't know what I'm going to do without...I hope to work until the day I die in this area. Am I enthusiastic? Yes. Am I optimistic? Yes. Do I communicate well? Fortunately I do and people are willing to listen, so yeah, I suppose that I helped create that buzz, it's not...you know, it's just because I'm having a heck of a lot of fun.

BB: You still do, would be considered pure science, or are you more into the overview kind of things?

DUSSEAULT: Well, like right now, I have a student who under my guidance, and but then don't get me wrong, largely himself, you know, let me read you his email okay, now this was not planned but let me read you his email that he sent me, he went to a conference in Australia presenting a paper this last week, so, then he sent me this email this morning and I was kind of, it made me feel good, so where are we here...okay, he said, "Maurice, the Due Process Conference was the first I've been ever at, you're so generous to support me to make it possible for me to attend and that was extremely valuable. For the last two and a half years that I was doing my PhD I was working somewhat in isolation, I had no real interaction with other students and professors about my work, the subject was very multi-disciplinarian, I was confused between geo-mechanics, which I studied in civil engineering and mass transferred from chemical classic engineering and fluid mechanics from mechanical engineering and I had to put these things together and most of the people that I discussed with were pessimistic about the future of my work and reluctant to participate, probably they felt a bit insecure about all this.

Academics prefer to avoid something completely new; that is what happens to you when you spend years and years in a limited area. All of this gave me the feeding over the last few years, that I'm doing something totally irrelevant to anything scientific or doable and probably would be no future for me in any of this. The 3-day conference has finally changed my mind and I see people from around the world doing exactly what I'm trying to do and what you've asked me to and they've tried to use the same understanding that I am trying to develop. I've learned how much background is related to carbon sequestration and capture, cyclic steam injection and other technologies and when I learn that these problems are important and realistic and how little of them is understood about the physics of them, and how naive is the mathematics to this area, my work is going to be applied in all of these sciences, I can say that this is the field that I want to be in, for my career, thank you." So there, after two year in the wilderness, he's kind of realized that what I've been asking him to do

has very, very profound implications, that is what being a professor is all about. That makes me feel great!

BB: That's addictive buzz!

DUSSEAULT: That's an addictive buzz, yeah.

BB: Well it exemplifies exactly what are, however put your name forward on this list was talking about.

DUSSEAULT: There have been so many new ideas generated in the last 30 years, if you had told me 30 years ago, we would be where we are today, again, I would have simply laughed. You know, it's been an incredible kick, and AOSTRA had a big part to play, Alberta Government has had a big part to play and I think Alberta Government is going to have a big part to play in the future, I think that there's a new, and I don't think I'm saying anything that they wouldn't want me to say, but I'm saying this on my own, you know, I'm a consultant to them, I think Alberta Government has a new appreciation of how necessary it is for governments to try to create an environment of technical innovations, scientific innovation and in part, promote that, even to the extent of working with industry to address specific problems at a scale that the government alone can't not achieve, the tailings, management is a good example of that. And I think for about a decade, after the end of AOSTRA, the Government of Alberta has not really kind of been as proactive as they should be and I think we're getting into another decade of proactive government, environmental questions. I think it's going to be a real fascinating decade, 20 years, 30 years, 50 years, it just seems to go on, there's us and downs but it's a great area to be in.

BB: The one other thing I meant to ask is about the Syncrude Research Center with their fairly large research staff, but mainly applied to their problems.

DUSSESAULT: Sure, its commercial research.

BB: But how do they fit in. Before we talked about academia, industry and so on, but they were a little bit more than your normal industry.

DUSSEAULT: Yeah, that's a kind of a difficult question for me to answer because many of their research issues that they address were very, very commercial, like for example, trying to reduce the water content of the whole tailings stream by a few percent but putting in a little bit of a nudge here, a little bit of a nudge there. This is not scientifically publishable research, a lot of it, but it's very important commercial research, so they did a huge amount of that okay, and of course, it wasn't just in rock mechanics or tailings, but in all areas extraction, transportation, for example Syncrude pioneered I believe the concept of slurry, pipeline transport of ore bodies.

BB: Yeah.

DUSSEAULT: They tried out one technology, that's the draglines and bucket wheel reclaimers and they have gone away from that because the bitumen oxidizes and that hurts the recovery process in the extraction plant, so now they have a much less residence time for the ore under the atmosphere so you that you have much, much lower level of oxidation and that improves the recovery in the extraction plant and actually makes the tailings better to handle too. Remember that that extraction plant is a multi-billion dollar refinery, is essentially what it is, an upgrader, so they've always been looking for ways to fine tune this, improve a little bit here. So that's what industrial research is all about. It's not basic, they haven't...and this is no criticism, they have not contributed to basic research, really, they've contributed to applied research and commercial research. And like I say, that's not a criticism, that's just the reality. I'm going to see if I can show you the...a document here, which contains a slide that I want to show you, okay where are we... no, this is just Alberta Innovates... hm. Darn, I'm having trouble, I'm sorry.

BB: Is this something you might email to me?

DUSSEAULT: Well yeah, this is the strategic research program that the Alberta Government is working on which I can't send to you because it hasn't been made public, but basically, the graph that I wanted to show you is something like...concept to commercial, fundamental, bench, applied field project, pre-commercial and then of course, infrastructure, decreasing risk but increasing cost, so commercialization is very, very low risk, but very, very high cost. Basic research is very high risk, but very low cost. Okay so you fund an academic and give him $100,000 a year and if it doesn't work out, it doesn't work out, but you can't build something out of a billion dollars a unit, unless your risk is extremely low, so we go from here to here, that's fine, but then there's a great big problem in breaching the gap. Companies handle the pre-commercial and the scale up and the infrastructure development, but they don't handle this jump from the lab and bench scale to the pre-commercial, that's a very difficult...

BB: That's that Valley of Death you were talking about.

DUSSEAULT: ...that's the Valley of Death, yeah.

BB: Hey what happened to Taciuk, the dry process?

DUSSEAULT: Well, here's the problem, you've got cubic meter of ore at the 30% porosity, basically it contains maybe a barrel of crude oil from the Taciuk process, so if you cook it in the Taciuk process you burn some of the energy in it and cook the rest, and then the Taciuk process of course has all this kind of heat exchange and you need to try to be thermally efficient, so you have a barrel of product, but then you have dry tailings, or not tailings, dry waste. But it's not a cubic meter anymore, it's about a 1.1 cubic meters, it's not 30% porosity, its higher porosity. How do you transport that and put it into place. Pipelining is extremely, extremely cheap. So like somebody said, well gee, you take the stuff, slurry it with water and then pipeline it, well now you have tailings again, or then its conveyer belt and that's, you know, like five times as expensive as pipeline. Furthermore, the high temperature process creates chemicals and residues in the sand that are less benign than the

residues that are in the tailings from the hot water extraction process. They're not as environmentally favourable. The next thing is Taciuk, can it be scaled up. A Taciuk reactor is, I don't know, a few tonnes, maybe 50 tonnes a day, maybe something like that, but we're talking scales that are 500,000 tonnes a day, 400,000 tonnes a day, so there's a huge scale-up issue and there's the handling of materials.

Okay like some people said, well look, you could just have a bunch of small reactors and have them, you know, just right where the ore is, put the ore in and get the...well, hmm...there's technological risk, so your Shell oil or say, another oil company coming into the oil sands, you're going to go to an unproven technology at a scale of 300,000 barrels a day, where you're going to have process 500,000 tonnes of ore, you're going to go to an unproven technology? No. You can't take the technological risk; your backers will not permit it. The backers will say use proven technology and hot water extraction is proven. And we're getting better and better at hot water extraction; remember when Syncrude started off with hot water extraction the temperature of the water of the water was like 85 to 90 degrees Celsius, now that they've reduced that to like 40 degrees Celsius.

BB: Yeah well a lot of the extraction is actually done in pipeline.

DUSSEAULT: Pipeline, exactly. Shell oil uses aliphatic hydrocarbons as their solvents, which are not as nice environmentally, aliphatic solvents are less environmentally damaging and that has benefit, okay.

BB: How do you spell aliphatic?

DUSSEAULT: A-L-I-P-H-A-T-I-C. That means thing like, just hexane and C6, C5, C7, you know the simple molecules, whereas the solvents used by Syncrude had a lot more aromatic molecules in them so they're not as environmentally friendly. Syncrude has increased the recovery from 90% or, 88% back in 1980, '85 up to 93%, 94%, these are improvements. And the same companies that say that we can take some of the residue and get another couple of percentages of the oil out, Titanium Corporation, for example, believes that. All these things are good developments and they're all commercial research but their all on the right hand side of that graph, low cost, sorry high cost, low risk. It's the academic like me, and that's why the government has to continue finding academics, now companies have trouble funding academics because the academics say well I want to pursue this odd idea and the company says, well that doesn't help us, well actually it does, but they can't justify that in the short-term that they think, okay, so it's a problem, the government has this important role, this very important role to play in funding basic research.

BB: What about some other things like PTAC, or is that more conventional, the Petroleum Technology...what is alliance or...

DUSSEAULT: Yeah, well PTAC is a good agent say to, kind of try to bring industry together, identify problems, define the problems, etc, this is...but PTAC also you know makes recommendations about basic research and things that have to be look at to their industrial clients and also the government, the government participates in PTAC and listens to PTAC as well, and of

course, other people there. So this is the, you know, you're not going to get a copy of this, but this is the strategic research plan that I've been working with the government and, you know, overall policy objectives and here is, the chart that I mentioned on energy density, so here we are, and this unfortunately a mega jewels per litre and this is mega jewels per kilogram, so this is density and volume, so here's hydrogen gas, way over here, in other words, huge volumes are needed. If you had hydrogen going down the highway, you'd have two trailers, one to carry the hydrogen, one to carry the load. We're never going to have hydrogen vehicles, except as what I call city vehicles, you know, short haul, but the other thing is, where do you get the hydrogen from?

BB: That to me is the bigger question because you could use hydrates or something to store it, but...yeah.

DUSSEAULT: That's right and we don't have the technology and hydrogen is notoriously challenging to put into a tank.

BB: Oh yeah, or through a pipeline.

DUSSEAULT: Or through pipeline, yeah. Now if you go up here, you'll see that here is ethanol, carrying some diesel, and if you look at ethanol and diesel in terms of energy per litre, you realize that ethanol compared to gasoline, ethanol has only 68% or 70% of the energy, no 60% of the energy as a litre of gasoline, so when you buy a litre of ethanol, they're charging you the same as a litre of gasoline but you're only getting 60% of the energy, your mileage drops off, and people say, aw but the pollution is less. That's not true, pollution is no better or worse than for gasoline, it's just that in the old days we measure pollutants that were typical of gasoline and now if you measure pollutants that are typical of ethanol, you find that oh gee, it's not that great after all. So what we want...is a very dense, the best thing that we can do for our environment right now is just to switch every vehicle over to high quality diesel, we would reduce our carbon footprint by about 20% in North America, its dieselization, that's the concept, the Europeans have done it, but the reason they're doing it is that they have different crude sources, our crudes are more aromatic and don't make as good diesel, on the other hand, our crudes are the best in the world for big, low, RPM engines like diesels, locomotives and ships and cats, and big heavy duty diesel equipment, that's where our diesels shine, but they're not so good in the high RPM, high compression, little engines that Europeans have on their cars.

BB: The new diesel standards are better.

DUSSEAULT: Ah, that's just on sulphur though, no, what I'm talking about is fundamental, something called the seitan number, our seitan numbers are weak, the European diesels are better quality, so that's another area we're going to go into is trying to, it's the carbon, west Texas intermediate, this is the kilogram per barrel, you've seen this from the CRA, okay, what is that? Okay, so here's the fundamental applied, applied field pilot pre-commercial infrastructure, that's the commercialization, and the universities, okay. And these are funding projects, okay, Department of Energy, they IETP, they're funding here, carbon capture and storage, funded again by the

Department of Energy and that's only on the demonstration side, and I'm just trying to see, shoot I'm sorry I missed it, I'm trying to see the Valley of Death, if I can show you the Valley of Death here. No, it's another slide from a different presentation, it's too bad I can't show it to you but, no, but basically the Valley of Death is right in here, going from you know, fundamental and basic and bench, up to pre-commercial demo.

That's where a lot of good technology now looks, at everyday, not every day, every month, the Department of Energy gets emails, presents, even people flying up from Atlanta, or Houston, or Europe to give a presentation because they found a new method to extract oil sands from the sand and mining operation and it's just great. No company is going to take the commercial risk of implementing an unproven technology that has not gone through the Valley of Death and build a plant around it, they will only touch proven technologies, the hot water process is absolutely well understood and proven and gradually improving, year by year. People say, well look, we need a hydras technology; I don't think it's going to happen in my lifetime.

BB: I think we'll turn it off for now.

[END OF RECORDING]