
MAURICE DUSSEAULT

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2 **Date and place of birth (if available):**3 **Date and place of interview:** July 12, 2011 at White Rock, British Columbia4 **Name of interviewer:** Robert Bott5 **Name of videographer:**6 **Full names (spelled out) of all others present:** N/A7 **Consent form signed:** Yes

8 Initials of Interviewer: BB

9 Last name of subject: DUSSEAULT

10 BB: This is an interview in White Rock, B.C., on July 12th with Maurice Dusseault, D-U-S-S-E-A-U-
11 L-T, and maybe you could just give your title, or your professional designation.12 DUSSEAULT: I'm a professional engineer in Alberta and Ontario, both registered in both
13 Provinces, and I completed a PhD in engineering from the University of Alberta in 1977.

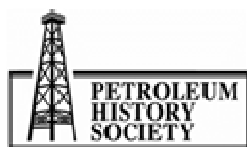
14 BB: And you're currently Professor at University of Waterloo?

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

16 BB: And consultant on what...

17 DUSSEAULT: Yes.

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

19 DUSSEAULT: I consult in three areas, one a term called Petroleum Geo-Mechanics, that's kind of
20 the rock mechanics aspect of all types of petroleum work, including conventional and heavy oil, the
21 second area that I do a lot of teaching in and advisory work is in production techniques for heavy
22 oil, and the third area is deep waste disposal, so solid and liquid disposal, deep into sedimentary
23 basins or into salt caverns, through methods of injections.24 BB: Does that include things like carbon dioxide injection or is this mainly more conventional
25 materials?

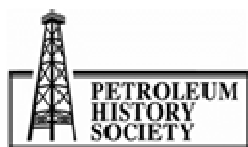
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26 DUSSEAULT: Well up to now, it has been focused on the deep disposal of solid waste which by no
 27 means conventional. We've been doing deep well injection of liquid, pure liquids for generations,
 28 two generations now, but the advent of solid wastes injection is novel and the first project in Canada
 29 started in 1988, with Mobil Oil Canada and I actually did advisory work on that project, back in
 30 1989 and more recently of course, my research work has been in the direction of carbon dioxide
 31 sequestration and some new ideas I hope and some new patent applications in that area, so yeah, its
 32 an emerging area very exciting, I don't know if it will ever happen big time technologically, I mean
 33 economically, but if it does, we're working on ways of doing it better.

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

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

56 So I was raised six years in the Northwest Territories and the rest of the time in St. Albert, which
 57 was a town of 800 people when we moved there and then I went to university, too young, I started
 58 university when I was 16 years old in 1963 and I was way too immature and fortunately, I flunked
 59 out, and I say fortunately because if I had been limping on through, I never would have continued. I
 60 went to work in the oil industry. I went to my uncle, Frank Dusseault, drilling superintendant for
 61 Jennings Drilling Corporation at the time, Jennings Drilling Company and asked them for a job and
 62 he said, damn, he says, we don't hire city boys and he went on in a big...and I was just crushed you
 63 know, I was 18 years old, just 18. Finally, he says, alright but you take what they give you and if I
 64 ever hear that there's a problem, he says, you're gone just like that. So I worked as a rough-neck for
 65 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



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

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

73 DUSSEAULT: No, it was civil engineering.

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

75 DUSSEAULT: Civil engineering.

76 BB: Okay. Or, BSA?

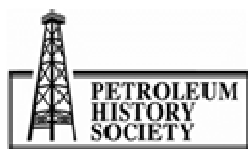
77 DUSSEAULT: My BSE, yes. Yeah my BSE was Civil Engineering and during that time, I started to
 78 work as a summer student at the Alberta Research Council, so I got to fly all around Alberta doing
 79 mapping with the Maurice Cariggy and Barry Melon, who used to be the Assistant Deputy Minister
 80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

81 BB: I think he's on our list.

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

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

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



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

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

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

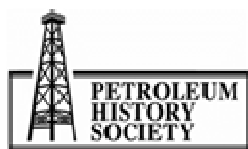
122 BB: This AOSTRA chair, were you mainly doing research or teaching, what was the kind of the mix?

123 DUSSEAULT: The agreement with the University was that AOSTRA would pick up 100% of the
 124 salary and, incidentally, AOSTRA originally had the idea of funding distinguished scientists with 20,
 125 30 years experience and I was the first person to hold a "young person's chair", after that there were
 126 several others that held "young person's chairs" but my supervisor had the insight to see that
 127 AOSTRA should be interested in that and convinced them, so I when I said he sponsored me, it was
 128 indeed, he talked to AOSTRA and suggested that they should look at funding not only old people,
 129 but also young people. Maybe you remember the name Otto Strauss?

130 BB: Vaguely.

131 DUSSEAULT: Vaguely. He was one of the old people, a distinguished chemist. Oh, Harry...my
 132 mind is failing here but a number of older people at the University of Alberta in Calgary were
 133 funded by AOSTRA, and I was about three or four and I was the first young person, so the idea was
 134 50% teaching, I was supposed to only have a half teaching load, and the other 50% of time would be
 135 spent on research.

136 BB: You mentioned your supervisor, who was that?



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137 DUSSEAULT: Norbert Morgenstern.

138 BB: Rings some bells.

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

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

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

154 BB: How do you spell Chhina?

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

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

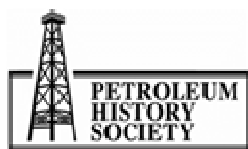
157 DUSSEAULT: Harbeer.

158 BB: What's the first name?

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

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

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



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

181 BB: Produce sand.

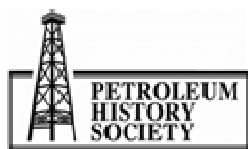
182 DUSSEAULT: Exactly, produce sand, yeah.

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

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

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

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



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206 1980, we started doing a lot of work on tailings and this was along with Professor Don Scott, J. Don
 207 Scott, who's retired but still at the University of Alberta, even though he's 76 or 77, I believe he still
 208 goes in, he's certainly worthy of interviewing, he's a great guy. And we developed some test
 209 techniques which are quite novel and I was reviewing some of the tailings work recently and I think
 210 we did pretty good back then, you know, there hasn't been a whole heck of a lot that made our
 211 results irrelevant, in fact, our results are still quite relevant to the long term behaviour of tailings.

212 BB: We were talking specifically about the clay.

213 DUSSEAULT: The fine grain.

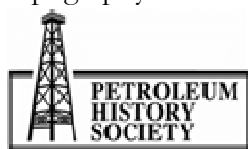
214 BB: Montmorillonite.

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

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

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

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



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

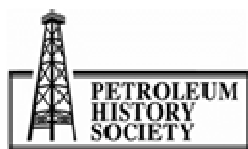
249 BB: Forester friend of mine compares it with the retreat of the glaciers, that we know that after
 250 glacier retreats, that eventually forest and vegetation establishes itself, but it does take quite awhile,
 251 you have to have a build up of sediment, and you can speed that along a little bit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

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

255 BB: '67 or '68, yeah.

256 DUSSEAULT: And then Syncrude started mining in '77, so I mean, this is just the beginning, really
 257 very short time. So I have worked on tailings, fine grain tailings and then starting at about the middle
 258 80's I started getting interested in the rock mechanics aspects of steam injection and later on, coal
 259 production with sands, which we call CHOPS, Coal Heavy Oil Production of Sand, I did a lot of
 260 publications in that area, trying to understand how the formations respond, mechanically, when you
 261 put steam in under high pressure. And starting about ten years ago, well pardon me, during that era,
 262 starting in 1982, I also started doing a lot of work on salt, much of our oil sands area, in fact, is
 263 underlaying by salt, not the mining area, but south, Cold Lake and Lloydminster and these salt beds
 264 represent a major resource in simple ways, not as you might think for salt, but as repositories and
 265 storage areas for solid wastes and storage of natural gas, we have many natural gas storage cabinets
 266 in Alberta and Saskatchewan and these are very important because if you're going to produce
 267 something like natural gas, which is used mostly in winter, to heat homes, in Ontario in Quebec and
 268 everywhere west of that, well you have to have a place to store it, so you need bottles, so you make
 269 bottles in salt, essentially because salt is impermeable.

270 And I did work in salt mining, the stability of salt mines, so I've worked for companies as a
 271 consultant and also doing research in salt properties and for mines in Louisiana, New Brunswick,
 272 Ontario, New York, Brazil and in fact, the hottest I've ever been in my life was 44 degrees Celsius,
 273 600 meters underground in Brazil in a potash mine. 44 degrees Celsius and in that mine, it's so hot
 274 in that mine, that all the workers are required by law to take eight litres of water down with them in
 275 the morning, they have to, they're not allowed on the elevator if they don't and at noon, or halfway
 276 during their shift, they have to take a salt tablet to restore some of the salts that they sweat off,
 277 they're not working at 44, they're working about 32, but even so, at 32, its very, very sweaty work. So
 278 the salt is also important to Alberta in a sense that it represents this resource for waste and for
 279 storage of liquids and I also did research work on the temporary, that was like hundred year storage
 280 of carbon dioxide in salt caverns, because again, if you're going to have any degraded carbon dioxide



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

284 BB: Why wouldn't they be permanent storage for CO₂?

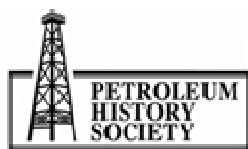
285 DUSSEAULT: Because salt slowly, slowly creeps, it moves very slowly and that means the pressure
 286 inside these bottles, if they were sealed, would build up to a dangerous level. So you can use them
 287 for short-term storage you know. In the natural gas business we kind of, you know, fill them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

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

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

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

316 BB: The rock moves and cuts the pipe.



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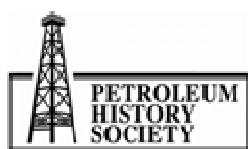
317 DUSSEAULT: Exactly, exactly and that's a rock mechanics problem, right. And then another big
318 issues in heavy oil is the co-production of sand, we found out about 25 years ago that if you
319 encourage sand production, you could produce heavy oil a lot more rapidly but only in a certain type
320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

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

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

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

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



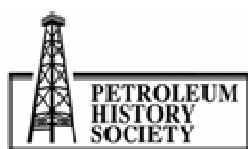
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355 BB: How do you spell that?

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

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

373 DUSSEAULT: Sure I mean, you know, it's the students and the people in the industry that I work
 374 with that enable a lot of these things, you know, the idea that a researcher, you know, sits there and
 375 cogitates and comes up with brilliant ideas alone is rarely the case, most of these things are worked
 376 out in discussions with other people. For example, the deep solids waste injection for sand, I had the
 377 conversation in an airport in 1987 with Don Best, who was an AOSTRA person but he went to
 378 work for Mobil after AOSTRA, 1987, yes that's right, and he mentioned to me the problem of
 379 produced sand and I said well why don't we re-inject it, and then we sat over a drink and worked it
 380 out and then Mobil started doing it that year in Saskatchewan and then after that I kind of adopted
 381 that as a research subject and developed it further and further, to try to understand the mechanics
 382 and how do you choose your reservoirs, how do you monitor, how do you do quality control, how
 383 do you analysis, those are the kind of things that have been involved. But I do think personally that
 384 that deep injection of solid waste was one of the more important things that I have done, because I
 385 think that's going to have very important environmental benefits for centuries and centuries to come
 386 as it becomes slowly adopted by industry and by other industries. For example now, since late 2008,
 387 the city of Los Angeles has been injecting bio-solid sledge from the sewage on a trial basis into an
 388 old reservoir, near Long Beach, California and that came directly out of the work that I've done,
 389 deep bio-solids injection and that's a much safer way of getting rid of bio-solids than spreading it on
 390 land and also, if you take the biological solids and put them down 1500 meters like in Los Angeles,
 391 1300 meters, well a lot of methane is generated and about 15% of the mass of carbohydrates is
 392 turned into methane and that in principle is recoverable, I mean that's what you do with [unsure]
 393 right now, is you have these digesters, well this like a natural digester 1300 meters under the ground
 394 and of course, it also means that all of the heavy metals and all of the other things that are in bio-



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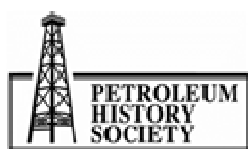
395 solids are detoxified or simply stay there permanently and can't really interact with the biosphere and
 396 the third thing is, is that about 40% of the mass of the bio-solids stays behind permanently as solid
 397 carbon, I mean that's how coal is made, you bury tree trunks and it makes coal, or peat, well what
 398 we're doing is burying organic matter and its making coal in a sense, and that coal, or carbon, stays
 399 down there permanently sequestered and much, much safer than injecting CO₂ for example, so
 400 that's, I think the whole area of solids injection is going to have nothing but growth for the
 401 foreseeable future and I mean for generations, because, I mean I have about 20 years experience in
 402 doing it, we know what to do, we know how to do it, we know we can do it safely, we know where it
 403 can be done, we know what can disposed and as time goes on, that knowledge based experience
 404 base is going to mean that solids injection by, solids disposal, pardon me, by injection is going to
 405 become more and more adopted as a technology.

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

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

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

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



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

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

440 BB: Yeah.

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

442 BB: He's still around.

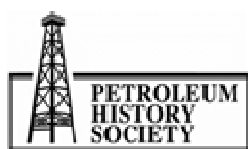
443 DUSSEAULT: Oh he must be 90!

444 BB: Yeah!

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

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

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



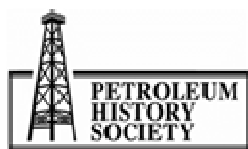
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468 knew tailings were going to be a problem back in the late 70's, early 80's, this is nothing new, but the
 469 government did not put into place a strong regulatory enforcement and regulatory environment to
 470 force companies to do reclamation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

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

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

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



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

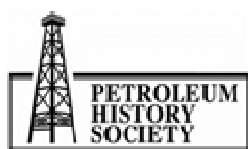
509 DUSSEAULT: That's not a bad statement; it's not a bad statement. I would agree that it is a
510 partnership, yes.

511 BB: Yeah.

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

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

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



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

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

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

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

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

567 BB: Have to look into that.

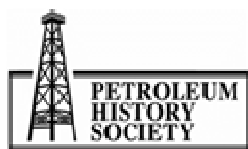
568 DUSSEAULT: Yeah.

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

572 DUSSEAULT: Sure, well...

573 BB: Would you like to take a break?

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



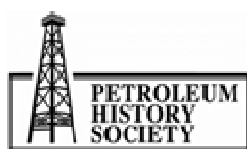
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577 the conventional oil. Of that 14.5 trillion barrels, probably 9.5 or 65% roughly is viscous oil, so in
 578 other words for every barrel of conventional oil there's probably 2.2 barrels of viscous oil, you
 579 know, its a huge resource and remember,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

586 BB: A quarter of the world's resource.

587 DUSSEAULT: More than a quarter, we figure. That doesn't count natural gas, that doesn't count
 588 methane hydrates, that doesn't count shale oil okay or oil shales rather, but it's just liquid petroleum
 589 So the Venezuelan resources, especially in the Oronoco belt are far easier to extract than ours, the
 590 reservoirs are of better quality, higher permeability, thicker. The oil is of a lower viscosity, at least 2-
 591 3; about 2-3 orders of magnitude lower viscosity generally than our Athabasca bitumen. For example
 592 our Athabasca bitumen in the fire-bag project and the Suncor Petro-Canada Project at MacKay
 593 River tends to be over a million centipoise, that's like peanut butter, whereas the Venezuelan,
 594 Oronoco tar belt has huge, most of it is less than 5000 centipoise, which is still thick but its much,
 595 much less viscous than the Athabasca deposit, so that means its more producible, much more
 596 producible. Means you have to use less steam for example.

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



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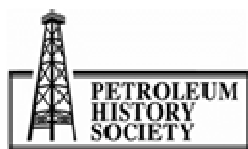
617 over the years, so if it wasn't for Hugo Chavez and the instability in Venezuela, there is where the oil
 618 would be produced. The reserves are huge. Second thing is the investment in research and in the
 619 development of high qualified people, the Alberta Government, and I believe this is a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

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

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

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

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



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

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

662 DUSSEAULT: Indeed.

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

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

668 BB: A drill.

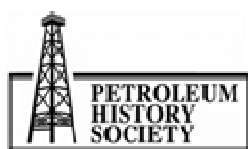
669 DUSSEAULT: ...a drill, one of those hammer drills, or whatever you call them, that kind of, the
 670 name will come back, it was actually sunk by hand and lined by hand and it actually produced oil. So
 671 you know, we are not as nationalistic and arrogant as the Americans, so we don't we go around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

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

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

679 BB: Yeah.

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



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

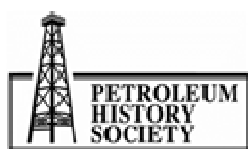
696 Now in some areas of the world, like Oman, they have oil in-fractured carbonates and they're higher
 697 porosity than ours and the viscosity is much lower, only a few hundred centipoise and there they can
 698 produce quite nicely, so Oman has got some good heavy oil production from fractured carbonates,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

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

725 BB: It's the quality of the energy.

726 DUSSEAULT: Exactly and how you can use it.

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



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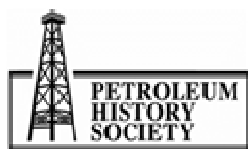
728 DUSSEAULT: Yes.

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

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

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

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



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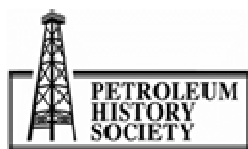
767 going to economic, well of course these same companies bought in to the oil sands business when
 768 the price of oil is \$80 or \$100 a barrel, they were spending far, far more money, you know, but that's
 769 the way companies are, they can't, so we now have Statoil and the Chinese coming into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

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

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

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

794 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
 795 easy ways of getting it out so now let's pump in an inert gas, like flue gas, carbon dioxide and
 796 injecting it into the reservoir and try to displace some of that hot oil towards the producing wells at
 797 the end of the project. So now we have three technologies, starting with say horizontal well cyclic
 798 steam, followed by steam assisted gravity drainage, followed by inert gas injection; so instead of
 799 looking at just looking at one technology, the idea nowadays, more and more, is to look at the
 800 evolution of the reservoir and use the appropriate technologies at the appropriate stage in the
 801 reservoir's life to minimize your costs and increase your chances of getting oil out. And this whole
 802 idea of sequencing is only five, six years old and people are talking about it now quite a lot, for
 803 example, we have many, many CHOPS wells, Cold Heavy Oil Production, but those wells area all
 804 drilled and installed as non-thermal wells and there's tens of thousands of them in Alberta and
 805 Saskatchewan, by the way, and in many of those reservoirs now, the oil companies will very much



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

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

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

814 BB: Now...

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

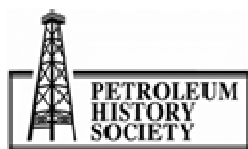
816 BB: Okay.

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

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

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

838 BB: They only have about 30% efficiency.



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

848 BB: Thorium cycle.

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

850 BB: Yeah.

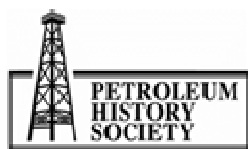
851 DUSSEAULT: And these might be again, small scale, safer, local and we're turning nuclear energy
 852 into heat, heat into steam, steam into bitumen and we're preserving the natural gas for the use of
 853 heating homes and cooking, for which it is very convenient.

854 BB: Not to mention chemicals and everything else.

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

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

872 BB: Lifecycle.



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

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

880 DUSSEAULT: They're average.

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

882 DUSSEAULT: Sure, that's right, it will go up, but for example, the Europeans import very little
 883 heavy oil compared the United States and the Europeans are taking a very holier than thou attitude,
 884 as they always do, a good example is what is happening on the carbon in the Europe. Europe in the
 885 1960's, 70's and 80's was dependent upon coal fire power plants, then they started talking about
 886 Kyoto and of course, they took as the basis here, I can't remember...

887 BB: 1990.

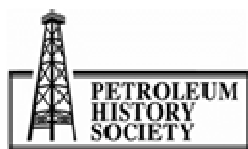
888 DUSSEAULT: 1990, thank you. And they took that as the basis here in 1997, in other words, 1997,
 889 in other words in 1997 they said, let's just pick 1990, well as it turned out between 1990 and 2005 is
 890 when Europe got off of coal fire power plants and switched to natural gas, but the Europeans in
 891 1997 knew very well that that was happening, so we got suckered in to make a climate change,
 892 pardon me, a carbon dioxide agreement with a very, very different economy than the Europeans
 893 because they knew they were going to be getting off of carbon coal fire power plants and we
 894 weren't, so we got kind of suckered into signing an agreement that we shouldn't have and the you
 895 know the Alberta Energy Minister at that time, who was in Kyoto was not...the Albertans were not
 896 allowed in the final negotiations, it was the feds that did it, and the feds went in with a mandate to
 897 offer 1% cuts and they came out having offered 4% cuts. I talked to the guy who was the Alberta
 898 Energy Minister at that time, whose name escapes me right now.

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

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

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

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



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

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

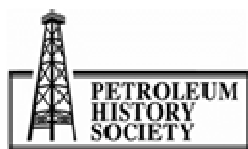
910 **[END OF NO. 1]**

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

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

926 BB: That was the Underground Test Facility.

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



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

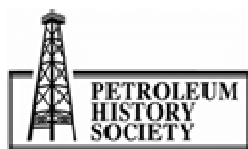
955 So Encana which is a combination of the old Alberta Energy Company, AC and Pan Canadian and
 956 CS Resources were all folded in and became Encana. Encana took the lead in development of
 957 SAGD and the first commercial project, basically, the first commercialization, and by
 958 commercialization I mean, a single project producing ten thousand barrels a day, that's my own
 959 personal definition of commercialization, that occurred in late 2000, early 2001 with the Foster
 960 Creek Project with Encana, so that was the first commercialization, but even so it was still a few
 961 years before the second and third project became fully commercialized, and now of course, we have
 962 350,000 barrels a day production from a number of projects.

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

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

965 BB: It was.

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



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

985 BB: Yeah.

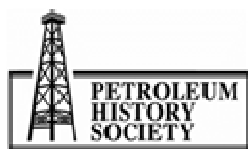
986 DUSSEAULT: Nobody likes to talk about their mistakes; that's just human nature. So we learn from
 987 our mistakes but we don't publish them unfortunately, and that's too bad because there are many
 988 things that we would have learned much faster in the industry had we had a need to publish our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

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

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

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

998 DUSSEAULT: I think my supervisor Norbert Morgenstern was a key person, he has been sitting
 999 on the Syncrude Canada Technical Board for 30 years, he is still publishing and still working as a
 1000 consultant even though he's been retired from academia for the last 12 years. On issues of tailings,
 1001 and tailings dyke stability, and slope stability, a very wise man, he was my supervisor and my mentor.
 1002 Maurice Cariggy, a very wise man, he was the person who acted kind of as my mentor at AOSTRA
 1003 and I remember once, when I went into his office upset because some oil company had kind of led
 1004 me down the path a little bit, promising that there was going a research grant for me, etc, etc, so I
 1005 wrote a big proposal and he came and spent five hours with him and I was all enthusiastic and then I
 1006 never heard anything from him. And then about 18 months or 14 months later, I saw a paper
 1007 published in a journal and its exactly what I said too and he did it with another academic from
 1008 Toronto and I was upset, so I stormed into Maurice Cariggy's office, and I said, this guy...and he
 1009 calmly listened, you know, ranting and raving, after I was all done he said, Maurice he said, is this the
 1010 only original idea you're going to have in your career and I said, I hope not, and he said well
 1011 Maurice, he says don't worry about, just go and develop a few more ideas and that put everything
 1012 into context, you know, that guy behaving dishonourably was small potatoes, these are the kinds of
 1013 things that you just have to ignore and go on with life. There's a number of things that I've done
 1014 and that I've suggest and that have been adopted and I feel that I have not got all the...as much
 1015 credit, but am I going to sit in a dark, unlit room worrying about...no, I've done extremely well, I
 1016 mean, I've got a huge amount credit, financially I've done well, the university system has been very
 1017 good to me, I've had a fabulous life, so don't dwell on little things like that and that was a lesson that
 1018 Maurice Cariggy taught me. I stuck to his advice ever since.



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1019 BB: Yeah, he also helped to internationalize the research, his UNITAR work and...

1020 DUSSEAULT: Absolutely, he was one of the instrumental people in the UNITAR conferences
 1021 which I've published in a number of them, and that gave Canada a reputation around the world, that
 1022 helped Canada's reputation, he was the chairman of that division in UNITAR for a few years, before
 1023 he retired, after AOSTRA, so yes, yes, he's never going to be a publisher but he's always been a very,
 1024 very good administrator pursuing these things for the benefit of the people of Alberta, you know,
 1025 one never, ever could doubt his ethics, his sincerity, his hard work, you know, on behalf of the
 1026 people who owned the resource, that was always behind his behaviour, great, very nice human-being
 1027 too, just a wonderful guy, not a mean bone in his body, you know, a lot of people, including me I
 1028 suppose, or many of us have a little bit of sarcastic or a mean streak in there but Maurice Cariggy
 1029 didn't have mean bone in his body, he was always a gentleman, you know, very quiet, and soft-
 1030 spoken and smart and I admire him greatly, yes.

1031 BB: And Clem Bowman?

1032 DUSSEAULT: Clem Bowman was never a mentor to me, he was the director of AOSTRA and I
 1033 didn't interact with Clem, I interacted with his right hand man, which is Maurice Cariggy. And then
 1034 of course, after a bit of mentorship in my AOSTRA professorship, then I went off on my own and
 1035 didn't need mentors anymore, but my mentor is my supervisor, Maurice Cariggy, these were very
 1036 good people to me.

1037 BB: What about protégés, have you...

1038 DUSSEAULT: Well Chris Fordham of Suncor is a graduate student of mine, I'm proud of what he's
 1039 achieved, I haven't had as many top students that have gone on to great important positions like
 1040 Norbert Morgenstern has, he educated a generation, fabulous, but I had a few students that have
 1041 done quite well, I've worked with a lot of people that have done well, you know, co-published with
 1042 them for example, you know, Grant Mossop and I exchanged a lot of information at one time, we
 1043 didn't publish much together but we taught each other a lot.

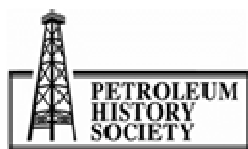
1044 BB: That was the Institute of Sedimentary and Petroleum Geology...

1045 DUSSEAULT: That's right. Well he was actually with the Alberta Research Council before that.

1046 BB: Oh okay.

1047 DUSSEAULT: Yeah, but, yeah so I learned a lot from Grant and his geological work and I think I
 1048 taught him a little bit about the rock mechanics side of it, I've had another student of mine, Roman
 1049 Bilak, is the President of Terralog Technologies, that I mentioned earlier.

1050 BB: How do you spell Bilak.



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1051 DUSSEAULT: B-I-L-A-K. Bilak, Roman. Another student of mine, or not really student, but a
1052 technologist of mine started this Wavefront that I was involved in. Another student of mine started
1053 a consulting company, he was from China and his consulting company does work, you know, large
1054 amount of work in China, he has a Beijing office and a Calgary office, you know, about 10 or 15
1055 employees.

1056 BB: What's his name?

1057 DUSSEAULT: Yarlong. Y-A-R-L-O-N-G. Wang. W-A-N-G.

1058 BB: W-A-N-G?

1059 DUSSEAULT: W-A-N-G, yeah. Yarlong Wong. And he works out of Calgary and he's a consultant.

1060 BB: Is that in heavy oil or is this just general petroleum?

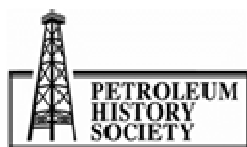
1061 DUSSEAULT: Petroleum Geo Mechanics, but focus on heavy oil. He has focused on heavy oil,
1062 yeah, and mathematical analysis. You know a couple of my students are professors in the United
1063 States and there's a sprinkling here and there but like I say, had I stayed in Alberta, at the
1064 Universities in Alberta, I think I would have had a better opportunities to graduate more students in
1065 this area, but I went to Waterloo and Waterloo, of course, is not an oil place. But nevertheless, I
1066 think I've been fortunate to have a bunch of the students. Another one of my students has become
1067 a very senior person, very, very rapidly at Hess in Houston, so he's become quite a guru in a very
1068 short time, in ten years he's become a guru at Hess, which is really remarkable, I'm not sure he's 45
1069 yet and he's looked upon as one of the senior type of the people in the entire company, so that's
1070 good.

1071 BB: Now there was a parallel to the science advancing newer technologies like horizontal drilling,
1072 coil tubing, 3D seismic; it always intrigues me this question of, you know, this sort of chicken and
1073 egg thing, whether the technologies enable the science or the science that...you're making a ladder
1074 effect.

1075 DUSSEAULT: It's like parallel ladders, you know, and people, you know, the technology's climbing
1076 one ladder and science is climbing the other ladder and they are feeding off one another, they're
1077 helping each other climb the ladders, of course. I'll give you an example, the first horizontal well in
1078 Canada ever drilled was... Imperial Oil was trying to learn how to drill horizontal wells and they had
1079 drilled a horizontal well from the valley wall, north of Fort McMurray and I believe this is 1979, '78
1080 and I think that about the same year, they tried to drill a horizontal well in Norman Wells, because
1081 the Norman Wells field...

1082 BB: They wanted to get under the river.

1083 DUSSEAULT: ...oh yes, that's right. And it's also a fractured carbonate and horizontal wells and
1084 fractured carbonates turned out to be good things, okay. But they drilled in the first horizontal well



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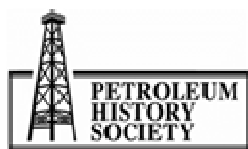
1085 in the oil sands 1979 or 1978, so I attended a conference in 1980 and I heard the Chief Engineer
 1086 describe that, he never published it but he spoke at this conference, so he spoke for about 20
 1087 minutes, about this horizontal well and how they drilled it, and they used mining technology, okay,
 1088 not oil field technology, and of course as you know, in the UTF they used mining technology to do
 1089 the drilling and he said, after the talk, he said so horizontal wells, you know, la-de-la-de,
 1090 unfortunately horizontal wells will always remain too expensive for us to use.

1091 Wow, how times have changed you know. Because within a decade we would learn how to drill
 1092 horizontal wells from the surface, with steering, geo-steering as we call it, and put them where we
 1093 want, so now we can and hit a target anywhere, we can have wells that have any geometry you want
 1094 virtually, for example in the oil shell work, shell oil work, pardon me, oil shell work in Colorado, one
 1095 company there is drilling wells from the surface, going horizontal and then another well from maybe
 1096 two kilometres away from the surface and going horizontal, the two wells intersect and they pull the
 1097 casing all the way though, and then they circulate hot steam through the sealed casing, not injecting
 1098 steam, but hot steam at like 400 degrees Celsius, why? To heat the oil, not by direct steam contact
 1099 but to heat the shale oil, or pardon me, the carrageen, the solid stuff in the shale, to break it down
 1100 into smaller molecules, so it's not really viscosity, it's what we call pyrolysis and who would have
 1101 ever thought 30 years that you could do that?

1102 I mean if you'd have stood up and said, you know, 30 years from now we're going to be drilling
 1103 wells, two meters apart, three kilometres deep and people would look at you and they would have
 1104 called for the men in the white ambulance to come and take you away. It's astounding, so yeah its
 1105 building one on top of another. Solvents have never really been highly economical in heavy oil
 1106 because of the solvent losses, but we now understand we can use solvents like Imperial Oil is doing
 1107 and some other companies are doing, in combination with steam injection because as we continue
 1108 the steam injection, we continue to recover more and more of the solvent, so that now our solvent
 1109 loses are much less than they used to be, these are all advances, and there's many, many. Coil tubing.

1110 BB: Yeah.

1111 DUSSEAULT: You know, coil tubing is a good example, and by the way, many, many of these
 1112 technologies have been perfected in Canada and then have gone around the world. The drilling of
 1113 shallow horizontal wells, 500, 400 meters deep, this was in Canada in the early 1990's and then this
 1114 technology was exported around the world, for example, in Venezuela, coil tubing drilling, coil
 1115 drilling work-overs, this was developed for Canada, of course some American companies were
 1116 implicated, but it was developed in Canada and now coil tubing, drilling and coil tubing units are
 1117 being sold around the world, for work-overs and also for shallow drilling. Many, many innovations
 1118 have been developed in Canada in the oil industry and gone around the world, all of these
 1119 technologies like cyclic steam, SAGD, pressure pulsing, cold heavy oil production without sand, cold
 1120 heavy oil production with sanding, all of these have been essentially perfected in Canada, and some
 1121 of them exclusively in Canada, to this day virtually, like cold heavy oil production with sand, you
 1122 know, everybody around the world is scared of sand, but in Alberta, hey, sand makes oil. So we're
 1123 going to produce sand and oil is a fortunate bi-product.



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1124 You know, improving our steam generation capacity, heat recovery, because when you do steam
 1125 generation you want to scavenge as much heat as possible so you don't...well its money in the bank.
 1126 So our surface facilities have been perfected in Canada and now these improved surface facilities are
 1127 being installed around world in heavy oil operations, in fact, in many cases you just simply order it
 1128 from Canada, like for example, progressing cavity pumps. Progressing cavity pump existed for 30
 1129 years before heavy oil, but it was perfected for heavy oil in Alberta in the 1980's and then became
 1130 used all around the world for heavy oil, coal production and now, in the last few years, a metal-metal
 1131 version has been developed by French researchers and is now marketed but **Koodoo**, it's called
 1132 Vulcan, V-U-L-C-A-N, its metal-metal progressing cavity pump that supposedly can operate at 300
 1133 degrees Celsius, you know, well gee whiz, now we can use progressing cavity pumps for SAGD,
 1134 whereas five years ago we couldn't.

1135 You know it just goes on and on and on. Better monitoring, we have 40 seismic, we have micro-
 1136 seismic, we have surface deformation measurements so we can measure the surface deformation at
 1137 the ground surface and that tells us what's going on in-depth, Shell oil for example has and their
 1138 Peace River Project has tested all kinds of monitoring techniques and grid detail. The Alberta
 1139 Government is even thinking of making it a requirement that the companies do surface deformation
 1140 monitoring because there are small environmental issues as well. The ground might move up as
 1141 much as a meter over the period of the exploitation, but the important thing is that these up and
 1142 down movements during production, we can use them to analyze what's going on. So in
 1143 combination with 40 seismic mixes gives us some eyes to look into the earth.

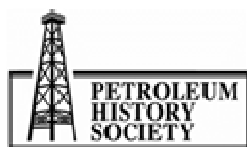
1144 It's really interesting, by the way, that's another area that I made contributions to is the analysis of
 1145 surface deformation data, you don't want to go there, that's a hairy area, but I made a few
 1146 contributions to that, fortunately I got the privilege of working with some people that are
 1147 mathematically far stronger than I am, so I got a pretty good understanding of the physics, but they
 1148 understood the math, so the two of us together did a good job. So you're right, technology and
 1149 science are, you know, partners. They walk arm-in-arm through history.

1150 BB: Curious, conventional oil, 70% is left in the ground.

1151 DUSSEAULT: On average, around that, yes.

1152 BB: Is any of this work going to unlock some of that?

1153 DUSSEAULT: Major, major impacts. If I was a young man and a betting man, I would be looking
 1154 at redeveloping fields like east Texas with gravity drainage. I think I know how to do it and I think
 1155 that there's going breakthroughs in the applications of the technologies that we've been developing
 1156 in heavy oil. For example, Vapex, you've heard of Vapex, well Vapex has problems in the heavy oil
 1157 because you need a lot of solvent in order to cut the heavy oil and lower the viscosity. But suppose
 1158 you have oil that is medium oil, like 20 centipoise, 30 centipoise 80% of it is still in the reservoir and
 1159 Vapex now starts to look really good, with conventional oil with horizontal wells. Just like SAGD
 1160 only now we're using Vapex, but you've got to have the right reservoir. The pressure pulsing, which



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1161 was first tried out in heavy oil, in 1998 and 1999 and then as the price was very low back then, there
1162 wasn't much interest but now it's starting to come back.

1163 Pressure pulsing was developed by myself and a professor at the University of Alberta and one of
1164 my, well my technician actually at Waterloo and that company now is doing this commercially out of
1165 Edmonton, and that's going to have a big impact, but it takes a lot of time. The oil industry is a very,
1166 very conservative industry. Especially when they have, it's funny on the expiration side, they
1167 understand how to take risks, on the production side, they're very, very risk adverse, but you know,
1168 we're bound to go back into many of those old reservoirs and get back and get out some of that oil,
1169 for sure, so we'll have a higher recovery factor. Already the recovery factor for conventional oil now
1170 is better than 30%, it's in new fields, it's much, much better, we have better methods of monitoring,
1171 better methods of doing polymer floods, better methods of doing all kinds of things to get more
1172 out, but the number you quote, 70% is still in the ground, that includes all of the bad jobs we did, or
1173 we didn't know better, back in the 1940's, and 50's and 60's, so that includes all of those cases, I
1174 mean, but now we're 30% recovery from the conventional oil field, that's not good enough, we're
1175 doing better.

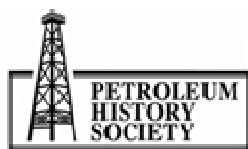
1176 BB: What about the heavy oil fields in Alberta, the Viking and Lloydminster and...

1177 DUSSEAULT: Our big problem there is that they're too thin, for steam, your heat losses are too
1178 large, if you've only got five meters of oil, you'll never steam because your heat losses are the same
1179 because surface area is the same as if you have 25 meters, but there's only 1/5th as much oil, so
1180 you're using the same amount of heat to produce 1/5th as much oil, it's not going to work. So we
1181 generally perceive the lower thickness as somewhere in the order of ten to fifteen meters, if it's less
1182 than ten meters, you're probably not going to use steam, unless of course you have free energy, then
1183 you can do anything. So that means there's a lot of those reservoirs that we've only produced ten,
1184 fifteen percent of the oil in and they're just sitting there. What's going to happen? Well, right now
1185 there's work being done on the use of polymers and water injection in the heavy oil in the
1186 Lloydminster type reservoirs, that's a bit promising but that's not going to give us 30% recovery,
1187 that's only going to improve it a bit.

1188 Pressure pulsing I think has some merit, if the price of oil stays high and the price of energy stays
1189 low, or the price of heat stays low, then maybe steam will be used, maybe some of other technology,
1190 maybe solvent technologies can be used in the right circumstances because then you don't have heat
1191 losses, but then you have to have a higher recovery factor for your solvent, you can't afford to put in
1192 expensive solvent and produce crappy oil you know, you've got to have an economic balance there
1193 and that has been the problem that has plagued all solvent projects to date, is a low solvent recovery
1194 factor which hurts the economics, but with Vapex concepts, maybe, maybe there's something there.
1195 Maybe we're going to start to use Vapex in these Lloydminster type reservoirs.

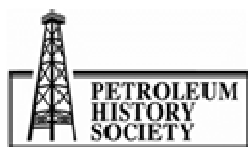
1196 BB: Vapex just stands for vapour extraction?

1197 DUSSEAULT: Vapour Assisted Petroleum Extraction.



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- 1198 BB: I don't know, are we running out of steam, so to speak?
- 1199 DUSSEAULT: To coin a phrase. It's up to you, I mean.
- 1200 BB: I think we've covered most of what I had in mind. Are those my notes?
- 1201 DUSSEAULT: Yes.
- 1202 BB: Well somebody said that you were exemplary of the addictive buzz the industry creates.
- 1203 DUSSEAULT: Not sure what they meant, am I enthusiastic? You bet. Do I love it, I love my job, I
 1204 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
 1205 this area. Am I enthusiastic? Yes. Am I optimistic? Yes. Do I communicate well? Fortunately I do
 1206 and people are willing to listen, so yeah, I suppose that I helped create that buzz, it's not...you know,
 1207 it's just because I'm having a heck of a lot of fun.
- 1208 BB: You still do, would be considered pure science, or are you more into the overview kind of
 1209 things?
- 1210 DUSSEAULT: Well, like right now, I have a student who under my guidance, and but then don't get
 1211 me wrong, largely himself, you know, let me read you his email okay, now this was not planned but
 1212 let me read you his email that he sent me, he went to a conference in Australia presenting a paper
 1213 this last week, so, then he sent me this email this morning and I was kind of, it made me feel good,
 1214 so where are we here...okay, he said, "Maurice, the **Due Process** Conference was the first I've been
 1215 ever at, you're so generous to support me to make it possible for me to attend and that was
 1216 extremely valuable. For the last two and a half years that I was doing my PhD I was working
 1217 somewhat in isolation, I had no real interaction with other students and professors about my work,
 1218 the subject was very multi-disciplinarian, I was confused between geo-mechanics, which I studied in
 1219 civil engineering and mass transferred from chemical classic engineering and fluid mechanics from
 1220 mechanical engineering and I had to put these things together and most of the people that I
 1221 discussed with were pessimistic about the future of my work and reluctant to participate, probably
 1222 they felt a bit insecure about all this.
- 1223 Academics prefer to avoid something completely new; that is what happens to you when you spend
 1224 years and years in a limited area. All of this gave me the feeding over the last few years, that I'm
 1225 doing something totally irrelevant to anything scientific or doable and probably would be no future
 1226 for me in any of this. The 3-day conference has finally changed my mind and I see people from
 1227 around the world doing exactly what I'm trying to do and what you've asked me to and they've tried
 1228 to use the same understanding that I am trying to develop. I've learned how much background is
 1229 related to carbon sequestration and capture, cyclic steam injection and other technologies and when
 1230 I learn that these problems are important and realistic and how little of them is understood about
 1231 the physics of them, and how naive is the mathematics to this area, my work is going to be applied
 1232 in all of these sciences, I can say that this is the field that I want to be in, for my career, thank you."
 1233 So there, after two year in the wilderness, he's kind of realized that what I've been asking him to do



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1234 has very, very profound implications, that is what being a professor is all about. That makes me feel
1235 great!

1236 BB: That's addictive buzz!

1237 DUSSEAULT: That's an addictive buzz, yeah.

1238 BB: Well it exemplifies exactly what are, however put your name forward on this list was talking
1239 about.

1240 DUSSEAULT: There have been so many new ideas generated in the last 30 years, if you had told
1241 me 30 years ago, we would be where we are today, again, I would have simply laughed. You know,
1242 it's been an incredible kick, and AOSTRA had a big part to play, Alberta Government has had a big
1243 part to play and I think Alberta Government is going to have a big part to play in the future, I think
1244 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
1245 saying this on my own, you know, I'm a consultant to them, I think Alberta Government has a new
1246 appreciation of how necessary it is for governments to try to create an environment of technical
1247 innovations, scientific innovation and in part, promote that, even to the extent of working with
1248 industry to address specific problems at a scale that the government alone can't not achieve, the
1249 tailings, management is a good example of that. And I think for about a decade, after the end of
1250 AOSTRA, the Government of Alberta has not really kind of been as proactive as they should be and
1251 I think we're getting into another decade of proactive government, environmental questions. I think
1252 it's going to be a real fascinating decade, 20 years, 30 years, 50 years, it just seems to go on, there's us
1253 and downs but it's a great area to be in.

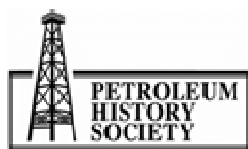
1254 BB: The one other thing I meant to ask is about the Syncrude Research Center with their fairly large
1255 research staff, but mainly applied to their problems.

1256 DUSSESAULT: Sure, its commercial research.

1257 BB: But how do they fit in. Before we talked about academia, industry and so on, but they were a
1258 little bit more than your normal industry.

1259 DUSSEAULT: Yeah, that's a kind of a difficult question for me to answer because many of their
1260 research issues that they address were very, very commercial, like for example, trying to reduce the
1261 water content of the whole tailings stream by a few percent but putting in a little bit of a nudge here,
1262 a little bit of a nudge there. This is not scientifically publishable research, a lot of it, but it's very
1263 important commercial research, so they did a huge amount of that okay, and of course, it wasn't just
1264 in rock mechanics or tailings, but in all areas extraction, transportation, for example Syncrude
1265 pioneered I believe the concept of slurry, pipeline transport of ore bodies.

1266 BB: Yeah.



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1267 DUSSEAULT: They tried out one technology, that's the draglines and bucket wheel reclaimers and
 1268 they have gone away from that because the bitumen oxidizes and that hurts the recovery process in
 1269 the extraction plant, so now they have a much less residence time for the ore under the atmosphere
 1270 so you that you have much, much lower level of oxidation and that improves the recovery in the
 1271 extraction plant and actually makes the tailings better to handle too. Remember that that extraction
 1272 plant is a multi-billion dollar refinery, is essentially what it is, an upgrader, so they've always been
 1273 looking for ways to fine tune this, improve a little bit here. So that's what industrial research is all
 1274 about. It's not basic, they haven't...and this is no criticism, they have not contributed to basic
 1275 research, really, they've contributed to applied research and commercial research. And like I say,
 1276 that's not a criticism, that's just the reality. I'm going to see if I can show you the...a document here,
 1277 which contains a slide that I want to show you, okay where are we... no, this is just Alberta
 1278 Innovates... hm. Darn, I'm having trouble, I'm sorry.

1279 BB: Is this something you might email to me?

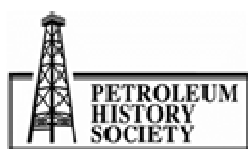
1280 DUSSEAULT: Well yeah, this is the strategic research program that the Alberta Government is
 1281 working on which I can't send to you because it hasn't been made public, but basically, the graph
 1282 that I wanted to show you is something like...concept to commercial, fundamental, bench, applied
 1283 field project, pre-commercial and then of course, infrastructure, decreasing risk but increasing cost,
 1284 so commercialization is very, very low risk, but very, very high cost. Basic research is very high risk,
 1285 but very low cost. Okay so you fund an academic and give him \$100,000 a year and if it doesn't
 1286 work out, it doesn't work out, but you can't build something out of a billion dollars a unit, unless
 1287 your risk is extremely low, so we go from here to here, that's fine, but then there's a great big
 1288 problem in breaching the gap. Companies handle the pre-commercial and the scale up and the
 1289 infrastructure development, but they don't handle this jump from the lab and bench scale to the pre-
 1290 commercial, that's a very difficult...

1291 BB: That's that Valley of Death you were talking about.

1292 DUSSEAULT: ...that's the Valley of Death, yeah.

1293 BB: Hey what happened to Taciuk, the dry process?

1294 DUSSEAULT: Well, here's the problem, you've got cubic meter of ore at the 30% porosity,
 1295 basically it contains maybe a barrel of crude oil from the Taciuk process, so if you cook it in the
 1296 Taciuk process you burn some of the energy in it and cook the rest, and then the Taciuk process of
 1297 course has all this kind of heat exchange and you need to try to be thermally efficient, so you have a
 1298 barrel of product, but then you have dry tailings, or not tailings, dry waste. But it's not a cubic meter
 1299 anymore, it's about a 1.1 cubic meters, it's not 30% porosity, its higher porosity. How do you
 1300 transport that and put it into place. Pipelining is extremely, extremely cheap. So like somebody said,
 1301 well gee, you take the stuff, slurry it with water and then pipeline it, well now you have tailings again,
 1302 or then its conveyer belt and that's, you know, like five times as expensive as pipeline. Furthermore,
 1303 the high temperature process creates chemicals and residues in the sand that are less benign than the



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1304 residues that are in the tailings from the hot water extraction process. They're not as
 1305 environmentally favourable. The next thing is Taciuk, can it be scaled up. A Taciuk reactor is, I don't
 1306 know, a few tonnes, maybe 50 tonnes a day, maybe something like that, but we're talking scales that
 1307 are 500,000 tonnes a day, 400,000 tonnes a day, so there's a huge scale-up issue and there's the
 1308 handling of materials.

1309 Okay like some people said, well look, you could just have a bunch of small reactors and have them,
 1310 you know, just right where the ore is, put the ore in and get the...well, hmm...there's technological
 1311 risk, so your Shell oil or say, another oil company coming into the oil sands, you're going to go to an
 1312 unproven technology at a scale of 300,000 barrels a day, where you're going to have process 500,000
 1313 tonnes of ore, you're going to go to an unproven technology? No. You can't take the technological
 1314 risk; your backers will not permit it. The backers will say use proven technology and hot water
 1315 extraction is proven. And we're getting better and better at hot water extraction; remember when
 1316 Syncrude started off with hot water extraction the temperature of the water of the water was like 85
 1317 to 90 degrees Celsius, now that they've reduced that to like 40 degrees Celsius.

1318 BB: Yeah well a lot of the extraction is actually done in pipeline.

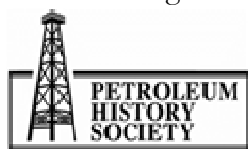
1319 DUSSEAULT: Pipeline, exactly. Shell oil uses aliphatic hydrocarbons as their solvents, which are
 1320 not as nice environmentally, aliphatic solvents are less environmentally damaging and that has
 1321 benefit, okay.

1322 BB: How do you spell aliphatic?

1323 DUSSEAULT: A-L-I-P-H-A-T-I-C. That means thing like, just hexane and C6, C5, C7, you know
 1324 the simple molecules, whereas the solvents used by Syncrude had a lot more aromatic molecules in
 1325 them so they're not as environmentally friendly. Syncrude has increased the recovery from 90% or,
 1326 88% back in 1980, '85 up to 93%, 94%, these are improvements. And the same companies that say
 1327 that we can take some of the residue and get another couple of percentages of the oil out, Titanium
 1328 Corporation, for example, believes that. All these things are good developments and they're all
 1329 commercial research but their all on the right hand side of that graph, low cost, sorry high cost, low
 1330 risk. It's the academic like me, and that's why the government has to continue funding academics,
 1331 now companies have trouble funding academics because the academics say well I want to pursue
 1332 this odd idea and the company says, well that doesn't help us, well actually it does, but they can't
 1333 justify that in the short-term that they think, okay, so it's a problem, the government has this
 1334 important role, this very important role to play in funding basic research.

1335 BB: What about some other things like PTAC, or is that more conventional, the Petroleum
 1336 Technology...what is alliance or...

1337 DUSSEAULT: Yeah, well PTAC is a good agent say to, kind of try to bring industry together,
 1338 identify problems, define the problems, etc, this is...but PTAC also you know makes
 1339 recommendations about basic research and things that have to be look at to their industrial clients
 1340 and also the government, the government participates in PTAC and listens to PTAC as well, and of



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1341 course, other people there. So this is the, you know, you're not going to get a copy of this, but this is
 1342 the strategic research plan that I've been working with the government and, you know, overall policy
 1343 objectives and here is, the chart that I mentioned on energy density, so here we are, and this
 1344 unfortunately a mega jewels per litre and this is mega jewels per kilogram, so this is density and
 1345 volume, so here's hydrogen gas, way over here, in other words, huge volumes are needed. If you had
 1346 hydrogen going down the highway, you'd have two trailers, one to carry the hydrogen, one to carry
 1347 the load. We're never going to have hydrogen vehicles, except as what I call city vehicles, you know,
 1348 short haul, but the other thing is, where do you get the hydrogen from?

1349 BB: That to me is the bigger question because you could use hydrates or something to store it,
 1350 but...yeah.

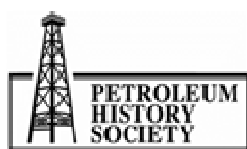
1351 DUSSEAULT: That's right and we don't have the technology and hydrogen is notoriously
 1352 challenging to put into a tank.

1353 BB: Oh yeah, or through a pipeline.

1354 DUSSEAULT: Or through pipeline, yeah. Now if you go up here, you'll see that here is ethanol,
 1355 carrying some diesel, and if you look at ethanol and diesel in terms of energy per litre, you realize
 1356 that ethanol compared to gasoline, ethanol has only 68% or 70% of the energy, no 60% of the
 1357 energy as a litre of gasoline, so when you buy a litre of ethanol, they're charging you the same as a
 1358 litre of gasoline but you're only getting 60% of the energy, your mileage drops off, and people say,
 1359 aw but the pollution is less. That's not true, pollution is no better or worse than for gasoline, it's just
 1360 that in the old days we measure pollutants that were typical of gasoline and now if you measure
 1361 pollutants that are typical of ethanol, you find that oh gee, it's not that great after all. So what we
 1362 want...is a very dense, the best thing that we can do for our environment right now is just to switch
 1363 every vehicle over to high quality diesel, we would reduce our carbon footprint by about 20% in
 1364 North America, its dieselization, that's the concept, the Europeans have done it, but the reason
 1365 they're doing it is that they have different crude sources, our crudes are more aromatic and don't
 1366 make as good diesel, on the other hand, our crudes are the best in the world for big, low, RPM
 1367 engines like diesels, locomotives and ships and cats, and big heavy duty diesel equipment, that's
 1368 where our diesels shine, but they're not so good in the high RPM, high compression, little engines
 1369 that Europeans have on their cars.

1370 BB: The new diesel standards are better.

1371 DUSSEAULT: Ah, that's just on sulphur though, no, what I'm talking about is fundamental,
 1372 something called the **seitan** number, our **seitan** numbers are weak, the European diesels are better
 1373 quality, so that's another area we're going to go into is trying to, it's the carbon, west Texas
 1374 intermediate, this is the kilogram per barrel, you've seen this from the CRA, okay, what is that?
 1375 Okay, so here's the fundamental applied, applied field pilot pre-commercial infrastructure, that's the
 1376 commercialization, and the universities, okay. And these are funding projects, okay, Department of
 1377 Energy, they IETP, they're funding here, carbon capture and storage, funded again by the



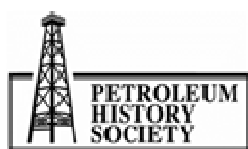
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1378 Department of Energy and that's only on the demonstration side, and I'm just trying to see, shoot
1379 I'm sorry I missed it, I'm trying to see the Valley of Death, if I can show you the Valley of Death
1380 here. No, it's another slide from a different presentation, it's too bad I can't show it to you but, no,
1381 but basically the Valley of Death is right in here, going from you know, fundamental and basic and
1382 bench, up to pre-commercial demo.

1383 That's where a lot of good technology now looks, at everyday, not every day, every month, the
1384 Department of Energy gets emails, presents, even people flying up from Atlanta, or Houston, or
1385 Europe to give a presentation because they found a new method to extract oil sands from the sand
1386 and mining operation and it's just great. No company is going to take the commercial risk of
1387 implementing an unproven technology that has not gone through the Valley of Death and build a
1388 plant around it, they will only touch proven technologies, the hot water process is absolutely well
1389 understood and proven and gradually improving, year by year. People say, well look, we need a
1390 hydras technology; I don't think it's going to happen in my lifetime.

1391 BB: I think we'll turn it off for now.

1392 **[END OF RECORDING]**



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