TONY SETARRI

Date and place of birth (if available): 1943; Czech Republic

Date and place of interview: Offices of TAURUS Reservoir Solutions

Name of interviewer: Peter McKenzie-Brown

Name of videographer: Peter Tombrowski

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

Consent form signed: Yes

Transcript reviewed by subject:

Interview Duration: 1 hour, 45 minutes

Initials of Interviewer: PMB

Last name of subject: SETARRI

SETARRI: There is actually no oil industry in Czechoslovakia. So, I studied mechanical engineering like many people in the oil business they came from all kinds of other places professionally. And, I started a pilot plant engineering boilers and turbines and so on. And, I came to Calgary right after the Velvet Revolution in 1968. So, I came to University of Calgary to do graduate school. And, then I was already interested in simulation, computer simulation. So, I ended up working with Professor Kajild Aziz. So, we used to be in University of Calgary and so I was one of his first graduate students, maybe second or third one. He then moved to Stanford University where he became the head of the department. We have collaborated on a lot of things over the years. We are still good friends.

So, after I finished school then I put everything that I owned into my car and drove down to Houston to get a job at a company called Intercomp. And so, that was at the time the leading company that started developing computer simulation of the oil fields. That was a rapidly expanding discipline in petro-oil engineering. And, we had lots of fun in those years. I joined them in 1973. It was like a real explosive growth in the methods and we have also, at the same time, there was real growth in the computers, right, and the hardware that we could use. So, it was all very exciting. And, that is where I got actually involved in looking at the oil sands very early on. Then, in 1982...

PMB: Before you leave that, so you got involved with the oil sands at what time, roughly? What year?

SETARRI: Well, in late 70s I spent my first two years in the Houston office of that company, that consulting company. Then I was transferred back to Calgary. And then, this was like mid-1970s where companies were starting to actually make efforts to understand what to do with the oil sands. Of course, Imperial Oil was already ahead of everybody else and Cold Lake was already under development. But, in terms of technology, it was still very much in its infancy. Because, we were applying methods of analysis that worked for conventional reservoirs and so we were finding it just did not work.

PMB: It didn't work for the oil sand?

SETARRI: Because, their nature was so much different, right.

PMB: Now, I would like to go back just a couple of minutes. You said that you were born in what is now the Czech Republic and you went to the University of Brno.

SETARRI: That is correct, yeah.

PMB: May I ask, please, what year you were born in the Czech Republic.

SETARRI: I was born in 1943, two years before the end of the War.

PMB: Can you tell me a little bit about your experiences as growing up in the USSR or part of that...

SETARRI: Soviet Bloc?

PMB: Soviet Bloc, yes.

SETARRI: Oh, that would be a long story. I guess.

PMB: Five minutes would be fine.

SETARRI: Yeah, it is different world altogether. And, I think that the memories are really quite...

PMB: Distant.

SETARRI: Distant now. People don't even understand how restrictive that whole environment was and how isolated these countries were in every way. The obvious ways were that you were controlled how you could travel. You could not travel freely. There we these forced elections. There was only one candidate to vote for.

PMB: But, you still had to vote.

SETARRI: You had to vote. If you voted against them then everybody would know somehow; so, starting with things like that in your every-day world....And, it also translated into the world of science and engineering and so on because we were very isolated from everything that was not channeled through Russia, right. So, whenever there were new books, let's say published in the West, we had to wait until the Russians, they had this big publishing house called Izvestia. And, so we had to wait until they would take a book and then translate it into Russian. And, we would get it in our book stores as a Russian book. And, we could buy it and then we could read it in Czechoslovakia.

PMB: So, what that would mean is that your studies were behind the times in terms of the West.

SETARRI: That's right. There was always this time lag. And, I remember quite clearly because my family, actually, my grandparents lived in the US and my mother had a US passport and it was always a big problem in itself. But, also what it meant to us is that we had some connections to the West, right. And, one time we had relatives in Chicago, so one time somehow we smuggled some dollars into our possession, US money. And then, I had about $20.00 dollars and I managed to go on a trip to Austria. So, I went to a book store and I bought this brand new book about numerical simulation methods, right. And, so I bought that book. It was of course in English and then I started reading it with great difficulty because I did not know English. Or, maybe it was in German? I'm not sure. But, by having that book I had this distinct advantage against everybody else and I had that before everybody else, you know. It was just quite ridiculous.

So, that actually prompted me actually to try and get out of there because I knew that we were really restricted in what was available to us professionally. And, this is not actually to say that the Russian science was behind, but because they had some tremendous things in science, right. But, in terms of applying the science to technology, making that connection they were always sort of behind in that, whereas especially in the US all the scientific discoveries because of the free enterprise there, they were immediately being applied to technology and things like that. And, that is sort of the difference I think, to some extent still exists today. Because, you see there Russian scientists, they are brilliant today, they're brilliant in math and computer sciences but the connection with the technology is not there. It was in Russia secretly because it was all for the purposes of the Cold War. It didn't permeate into the consumer world.

PMB: Now, you talked about the Velvet Revolution in 1968. Can you tell us a little bit about that?

SETARRI: Oh, my God. Yes, it was like a nightmare. It was for me...

PMB: That time you were in Brno.

SETARRI: I was in Brno, yeah. And, I was getting to work on public transportation. So, I was getting on my bus in the morning to go to work. And, I was living in the suburbs and we were getting closer to the city centre and everybody had their radio on, the bus driver, there was all this stuff about rations and so on. And then, there we started seeing the tanks driving around with the soldiers and everything. It was totally unreal. It was totally unreal.

PMB: Now, what had happened, if I can remember, is that Czechoslovakia as it then was basically tried to exercise some independence of the Soviet Union.

SETARRI: Yes.

PMB: Then, effectively, the Russians or the Soviets sent in troops to bring you under control.

SETARRI: Right, right. And, initially there was like this passive resistance that was just total... And, they were just looking for their armies and were totally brainwashed because they were expecting Americans. They really were expecting the political people in the army they indoctrinated them that they were looking for a fight with Western armies, right. And, they were just driving around trying to find an enemy. There was no enemy.

PMB: And, the enemy was the people.

SETARRI: Yeah, yeah. So, it was really, really quite amazing. It took actually a couple months before all of the underground radio stations were silenced and so on. And, then it took them almost a year to get complete control of the country because they had to actually secure enough collaborators so that they could actually start running the government. I actually left to go to Calgary about three weeks before they finally sealed the borders. And, I know stories of other people who had decided to leave after me. They would sell their house, give the money to their relatives and then get on the train to, let's say to Germany and they were stopped at the border and returned. And, they had nothing.

PMB: Wow.

SETARRI: All kinds of stories, yeah.

PMB: So, at that time there was an open border and there were no restrictions for you to leave Czechoslovakia?

SETARRI: Yeah. It was basically the Czech police and border police. They were just waving people through. There was just no collaboration against the Russians.

PMB: Against the Soviets.

SETARRI: Against the Soviets, so. And, there were many, many people who were undecided what to do. So, they would just go to Vienna, let's say, to Austria because it is so close. And then, they would just stand around or walk around and the Austrian Government actually set up tent cities for them. And, some of them decided to apply to go to various countries. Some people got cold feet and went back and so on. So, it was just a very confused situation.

PMB: And, in your case you applied to come to Canada.

SETARRI: I applied to go to Canada actually even before this happened; before the invasion, which was in August of 1968. Because, I wanted to go graduate school and I didn't want to do -- I was doing my post-graduate work in Brno already. But, I wasn't satisfied with that because that is another story how the government -- it was so politicized. The science was politicized. It depended on who you knew and who you were working with and so on. So, I wanted to get out. But, there was no information about Western schools and so on. It was very hard to come by. So, I was actually lucky that one of my professors actually gave me information about the University of Calgary. And, I looked at it and the first thing I had to do was to go into the library and look at the map and see where this place is.

So, if I got information about something in Australia. I would be in Australia, I would not be here. But, the admission process because of all the difficulties just took so long. That I finally had everything in place and about a year later, I could actually leave. Part of it was the English TOEFL exam. That is the proficiency exam for English for foreign students. So, finally I was ready and I wanted leave legally. So, in the place where I worked, which was a research institute for power plants, I went through all the channels. And, the communist party still existed right, it is just that people were very lenient and liberal compared to what it was before. So, I got all the approvals to leave, to get a leave of absence. Then, they even actually paid for my airline ticket. But, they only bought me a one-way ticket, no return.

PMB: That's too bad. If they bought you a return ticket you might be back there.

SETARRI: Yeah. So, it tells you a little bit about the mind-set. And then, I left in the summer of 1969 which was almost a year after the Russian invasion. So, I came to Calgary.

PMB: So, let me ask you about that one-way ticket. Did they almost expect you not to come back?

SETARRI: I don't know because this was all -- the communist party had local unit in every place. So, I kept away from those people. I didn't socialize with them. So, I couldn't read their minds. So, I don't know.

PMB: So, you came to Calgary and while you were here you got a PhD from the University of Calgary in mechanical engineering focusing on petroleum engineering.

SETARRI: Right.

PMB: You got that in 1973.

SETARRI: Right, yeah.

PMB: So, I've gone back because I find that piece of history very interesting. So, you have this PhD from the University of Calgary. It is 1973. Would you sort of continue your personal biography from then to the present?

SETARRI: So, I had two offers for employment: one from a company called, Scientific Software which was based, at that time, out of Denver. And, the other one from a company called, Intercomp Resources Development, just short for Intercomp.

PMB: And, that was in Texas?

SETARRI: That was in Texas. And, they did have an office in Calgary already as well. So, I took the job with Intercomp and then drove down to Houston and started working with that company. And, my decision was primarily because that company had all the "stars" in the simulation business which was very rapidly expanding then. And then, I was waiting for my Canadian citizenship, so the company transferred me back to Calgary so that I would have the requirements. So, I then spent a few years in the Calgary office. And then, in 1980 there was a period of time when the North Sea oil discoveries started and there was a real rapid development of the North Sea oil business.

So, Intercomp had an office in the UK, in London. So, I was transferred to the London office and worked there for a couple of years, which was a really nice change. Then after that I decided to actually leave the company because I felt I was ready to actually start my own business. And, my first consulting job was a long-term assignment with what, at the time, was called Elf-Aquitaine. They also happened to have an office in Calgary. So, I moved with my wife to the south of France. We lived in France for a year and a half. And, I started my own business. And, that was the company called, Simtech Consulting Services.

PMB: Simtech, that stands for Simulation Technology.

SETARRI: Yeah, that's right. So, the first start-up time happened in France and then we moved back to Calgary in1983, I think. And, at that time, there was nothing downtown except the Bow Valley Square One, so my first office was in Bow Valley Square One. Actually, sorry, there were already a lot of downtown buildings but Bow Valley Square One was the very first high-rise building. So, that was the smallest building.

PMB: The smallest of the four, fairly larger towers.

SETARRI: So, that's where we started. There were several people from the Intercomp company that joined us because the company got merged -- first, it got sold to someone and then it merged with the arch rivals, Scientific Software and so on. No, it was a turnover. We then ran the company out of Calgary. We also had an office in Denver. And, in 1994 the general office employees wanted to become independent so he sold them our interest in that. Shortly after it, in 1996 it seems like it was sold to Duke Energy which is large power based... Then we were part of the petroleum consulting unit under, a subsidiary under Duke Engineering and Services. And then, I spent four years with Duke and then in the year 2000, took one of the employees, young employees, Dale Walters who is now the VP of this company. And, we started this company and so we are still in the consulting business. I was approached by the university to apply for the Petroleum Engineering Chair that Roger Butler has vacated because he retired. So, I went through the process and I was offered the

chair in 2001 on a part-time basis, not 100% because I wanted to keep the connection with the industry and run the consulting company.

PMB: Now, Simtech, from the time you started it to the time it was taken over by Duke. When it was taken over by Duke Energy, how many employees did you have?

SETARRI: After we sold, we sold the first company with ourselves to the US company. We had about ten employees at the time.

PMB: Ten employees?

SETARRI: In the US. Then after that, when we sold to Duke we had about 12 people in Calgary.

PMB: So, it's a reasonably substantial company.

SETARRI: Yeah, it was a reasonably large for our -- for the way that we do work which is highly technical it was actually sort of the maximum size of the company that you can manage technically. Because, once you start solving difficult problems then each problem is like a little mini-PhD thesis or something like that. And, you want to have control of it. You want to make sure that everything is done to the best quality. And so, once you have concurrently so many projects then it becomes really taxing on people to keep the quality up. So, we didn't want the company to be any larger anymore.

PMB: Then, later on you established TAURUS Reservoir Solutions with one of your former colleagues. How many people do you have here now?

SETARRI: We have now, actually five people in Calgary office and then we have one person -- they have two people who are like full-time contract people but they don't live in Calgary. So, one of them lives in Czech Republic and the other one lives in Panama. And then, we have a few people who actually work on a part-time basis. We have one person who is very accomplished mountain climber. So, he only works between his climbing and stuff like that. So, the working environment has changed as you know.

PMB: It has changed a lot.

SETARRI: But, we have basically some people that are full employed.

PMB: Now, based on what you've told me so far I gather that you are pretty good linguist. You must speak Czech still and German. And, you must be reasonably fluent in French.

SETARRI: Not anymore.

PMB: And, your English is quite good.

SETARRI: Not anymore. I wish I had more time to actually go back and keep the language and stuff. My German is almost non-existent. I can read German. Interestingly, I used to be fluent in Russian because Russian was a compulsory second language. And, that is pretty much all gone totally.

PMB: What they say about language is that you use it or lose it. And now, is there anything else you would like to add based on that? You've been adjunct professor at the university for quite a number of years.

SETARRI: Yeah.

PMB: You have Roger Butler's former chair which is something to be proud of, I am sure. I'm sure you fill that seat well.

SETARRI: I try. I have always juggled the consulting world and the academic world side by side. It's not easy.

PMB: Now, you started earlier on to talk about your involvement with the oil sands and I think you told me that your first work with it was in the 70s. And then, I'm sure that since then you've done quite a bit more. I'd really like you to focus on that. But, could you just quickly mention what is the main kind of work you've done with the oil sands. When have you done it? So, just first of all in the 70s we did this and in the 80s that and the 90s this and right now, we are doing the following. And then, we'll go into the details in a few minutes.

SETARRI: So, my work was always on the technical side of the recovery processes, what now we call down-hole engineering. In the oil sands way back when, when people started looking at that and recognizing the viscosity of the crude, we had difficulties to explain how we can inject fluids into that to provide the heat and steam. Also, how it would actually flow back.

PMB: Now, you've mentioned crude but we're talking about bitumen reservoirs?

SETARRI: Bitumen, yes. Sorry, bitumen. I remember there was this celebrated paper by Mike Prats about this shale development in Houston. Imperial was already injecting steam in Cold Lake and so he tried to do an analysis of whether we are fracturing the formation or not. Using the conventional concepts he came up with these estimates the fractures would be very, very long. They would be like kilometres long when you inject steam. And yet, everything was confined in the field. So, that was one thing, the classical fracture mechanics concepts didn't fit.

PMB: When did Prats write this paper?

SETARRI: Prats wrote this paper, I believe in the 1960s, actually. Then the other thing was also, is that the classical fracture mechanics were built for hard rocks. We know that the oil sands are not consolidated. The oil sand when you wash all the bitumen out of it, it becomes a pile of sand. So, it doesn't behave the same way. So, there was a big debate about whether you can actually apply the

fracturing sort of concepts the oil sands. And, obviously if you did that without any new concepts then you would be getting very large fractures. So, it was obviously wrong. So, I got involved in hydraulic fracturing, which is the technique that we use always for stimulating the wells in any kind of reservoir. And nowadays, it's the hot potato of the shale development where we do the multiple fracturing of shale wells and everybody now is discussing the environmental concepts and so on. But, that has been going on from 1940s obviously, for a very long time.

PMB: Multiple fractures have been going on for that long?

SETARRI: Not multiple fractures, but each one of these multiple fractures is the same fractures we have doing in vertical wells for 50 years now. So, the new aspect of the multi-fracturing is that we now have the field equipment that can efficiently do this in a rapid succession.

PMB: And, you have the horizontal wells.

SETARRI: And, we have the horizontal wells. So, it's a combination of the horizontal well drilling technology and the ability of the fracturing technology to actually do multiple fractures very rapidly. Like, they can do them every four or five hours or something like that, whereas in the past each one of them would take days. In 1970s, actually I was heavily involved in developing the modelling technology for conventional fracturing that the service companies do. Then there was a guy in Gulf Canada who said, "Why don't we apply this and try to see now what's happening in the oil sands."

PMB: What was his name?

SETARRI: His name was Mike Raisbeck and he was with Gulf and then he moved over to Alberta Energy when it was AEC when Mr. Mitchell was running Alberta Energy Company. So, that was the first contact I had with the oil sands, that was in late 1970s. Of course, that technology was really modelling. We didn't know very much about how the oil sands behaved and so on. And then, I went overseas and when I came back then people from Imperial Oil got a hold of me and they said, "Well, we need to ask you to put some science into all this." So, one of the instigators of that was Rick Kry and you may have also talked to him.

PMB: I don't know him, no.

SETARRI: He had a long career with Imperial in the research lab. And, the other guy there was Tom Boone and he now back at Imperial. But, he's sort of a worldwide advisor on technology for Exxon now. So, these two guys said, "Well, we need to actually do stuff." And, at the same time, people like Norbert Morganstern at University of Alberta they were doing a lot of... Norbert Morganstern is a very prominent geotechnical guy in the industry. And, they started setting up labs to do laboratory work on oil sands. Don Scott was the other person in the department then and they did some excellent work in actually characterizing the oil sands and their properties. And so, we started to get some more basically data that we could use to do some simulations better.

PMB: Now, to put this into context, this was in the period when Imperial was developing the Cold Lake oil sands project, which was really the pioneer in in-situ projects in Canada.

SETARRI: Yes, this was before SAGD. And, so we put together a group of companies for a research project and went also to the government. The government had this funding vehicle called, CANMET.

PMB: That's the Federal Government.

SETARRI: Federal Government, right. So, we joined the project and we started looking at the modelling issues and understanding the mechanics of what actually happens in the oil sands. So, it was driven primarily by Imperial people. And, we had at one time, I think about 12 companies involved in that. Some of them don't exist anymore but... companies like Husky, Petro-Canada, Gulf Canada, my goodness I forgot the predecessor of Suncor. Anyway, so we were running...

PMB: The predecessor of Suncor was Sun Oil Canada, wasn't it?

SETARRI: Yeah, yeah. I forgot how it was in there. But, all the players in the oil sands were supporting our project. And, we rolled it over three times I think. So, we started in the mid-1980s and it became apparent that the largest difference between conventional reservoirs and the oil sands is the geo-mechanical behaviour of the reservoir itself. The geo-mechanics mainly means how the erupted part of it actually behaves when you inject to produce, changes stresses and so on. And so, that then has actually allowed us to become more realistic in the modelling compared to what we were doing before.

So, we were running these projects until about mid-1990s. And, that was one of the things in our company in Simtech that actually developed our geo-mechanical capabilities. And, that's what we're known for now, because we now apply the same modelling techniques. I mean there are some different slants to it, to many other problems like subsidence of reservoirs, faulty activation, induced earthquakes, all kind of problems like that. Geo-mechanics now is actually a rapidly expanding part of reservoir engineering and modelling as well. So, it sort of echoes the 1970s, 1980s when we were doing the conventional reservoir stimulation where there was a rapid expansion and capabilities there. So, one of the actually seeds of that was for us at least, was for this project in looking at the mechanics of oil sands which a spanned a decade and a half in mid-1980s to mid-1990s.

PMB: That was primarily at Cold Lake?

SETARRI: That was primarily at Cold Lake but we were also looking at Wabasca. And, everybody of course was looking at what Imperial was doing in Cold Lake, but some of the other companies with holdings elsewhere. They were starting to look at Athabasca as well. So, the interest was spreading out. It was thought it was mostly the best and richest oil sands in the Cold Lake area at that time.

PMB: This is also the period, I think you said the late 80s spanning into the 1990s, this was the period when interest in SAGD was developing?

SETARRI: Right. And, that was the other thing was that AOSTRA project was starting. They drilled the wells. They did the phase 1 and they were going to phase 2 and our modelling capabilities at the time were not good enough to actually capture all that was happening in SAGD. But, the understanding of the physics of the process would apply to both. And so, then there was a transition then to as the business actually... It is very interesting, because in my view the technology and the science always lag behind business. That's typical of North America. If you look elsewhere in the world, let's say we do some work in Europe and the European companies they have a tendency to first study the problem before they ever touch the oil in the ground. Here it is the opposite. You have an idea and it goes to a point that you patent the idea and then do it in the field and then you worry about how to explain it. So, that was happening with SAGD as well. So, it wasn't until later that we... And then, of course CMG also made a contribution in the modelling.

PMB: Who is CMG?

SETARRI: Computer Modelling Group. They were also involved in the development in the forward flow modelling capabilities for the oil sands.

PMB: Where are they headquartered?

SETARRI: In Calgary. Now, they're probably a public company. And, CMG was actually originally founded by my advisor, Kajild Aziz. So, there were contributions from different parts. So then, when we get to a point like at the end of 1990s I guess, then the commercial sector is with SAGD and then everybody started looking at SAGD. And then, Imperial is really practically the only one left operating the...

PMB: CSS.

SETARRI: CSS. So, it is also working in Peace River. But, a lot of the other companies they just go on SAGD. And, that is because the SAGD works. It can be made to work in lower quality formations than what Imperial has in place. But, CNRL also does some CSS still.

PMB: There are a couple of questions that I want to ask you. But first, could I ask you to go back and give me a course in Reservoir Simulation 101. So, you basically have instruments being inserted into the reservoir at Cold Lake, for example. And then, they would the information back to on-sight computers. And then, you would take all of that information and you would process it here, I presume. Can you give me a slightly more sophisticated version of that explanation?

SETARRI: Sure. The instrumentation that you mentioned is vital because what we're trying to do in simulation is we're trying to build a mathematical model. Then, in terms of equations that describe the physics of the problem. Then we solve them numerically on computers and so that that maybe creates a simulation model of the reservoir as best as we can. So, then we run the model and it will

create simulated behaviour of that reservoir. How the fluids flow, how the temperature changes as you inject and so on. Much like what the pilots do when they are being trained on simulators. But then, these models because there are so many assumptions and so on, if you would just construct the model with the best information from the geology and geo-physics and so on, there are going to miles wrong. They are not going to be on target. So, we need all the information that is being measured in the field because that is known that that is something you can trust. And, then we modify the models and tune them such that they will replicate existing history of that field. And then, if we can do that successfully, then sometimes we find that we are missing some physics in the problem.

Like, in that problem of the fracturing and the fractures were miles long and we knew from the field that they were only a couple hundred feet. But also, we have to modify the model because some of the data is not known or is poorly measureable and so on and so forth. So, we tune these models to the data we collect in the field. And, the primary data is of course, how much we are producing. In both CSS and SAGD, we are producing some bitumen, hot bitumen, you are producing some water and you might be producing some steam along with that. And so, that's the data that the model has to reproduce.

PMB: When you started doing this in the late 70s, the instrumentation and the drilling techniques, all of this was completely different from what's available today.

SETARRI: Right.

PMB: There was no really horizontal drilling. The instrumentation and sensors were pretty basic. Can you kind of walk us through how the instrumentation has changed?

SETARRI: Yeah, that has seen a tremendous change. And, a lot of that has been imported from other industries obviously. So, basically what we used to have in the old days was we had our water production and oil production because that's what you measure or you sell.

PMB: Water production and oil production?

SETARRI: Right. Water we have to dispose of or you can sell. So, you have to measure those. Then we would measure pressure in the reservoir and in order to do that, you have various what we call pressure gauges where basically they're measuring devices. And, those have evolved over time. Now, we can have permanent gauges that will measure pressure and temperature and so on. But, we have now fiber optics that can actually look up and down the wellbore and all kinds of things like that. We have logging techniques now. The logging techniques originally were just developed to try to look at saturations of the fluids that are in the porosity and maybe even permeability. Now we have logging techniques that can look at stresses in the formation and things like that. You can look at fractures.

So, all of that has really seen a tremendous development. There are specialized companies in Calgary especially, it's like a hotbed of these innovators that get one idea and then try to pursue it and try to

get market and develop it into a business. So, we see new things all the time. Testing of the, let's say, the hard rock over the reservoir, that is going through a new phase of re-evaluation and so on because it just recently has been a focus of the regulators, ERCB, as well partially because of the Joslyn blowout. In order to evaluate that, that is really a geo-mechanically based problem. Because, with the conventional reservoir simulation, what we do is we basically focus on modelling and how the fluids flow into the reservoir and maybe the heat; the temperature changes and so on. But, the conventional reservoir simulation does not tell you anything about how the stresses change in the Earth without the formations let's say above the reservoir and so on. So, therefore, that model can evaluate the risk of let's say, breaking through the cap rock.

So, we have taken the tools that we started developing the geo-mechanical capabilities back in the 1980s and at the time, it was thought of as something very esoteric that is not going to be at all mainstream. Sort of, part of the tools that the reservoir engineers need to have, but it has developed through that really there is a widespread application for it. And, one of them that started and I am really focused on right now, is this cap rock integrity issue because every company that is applying for the SAGD permit now, is going to apply for maximum operating pressure.

PMB: This is because of the Joslyn blowout?

SETARRI: Well, not only that but because the Joslyn blowout has contributed to the attention that the ERCB now is going to give to that. Because, in the old days they would just say, "Well, okay you can only inject to the pressure that is 80% of the overburden stress," or something like that. Some very, very blanket type restriction. But, there is so much variability in the conditions. In some projects, we have a very thick and strong cap rock and some of them you don't have one. You may have a weaker one, thinner one and so on. So, each project needs to be evaluated on its own merits, right.

PMB: Would this have been influenced also by Imperial's remember the T-Pad episode about 1997?

SETARRI: Right. Historically and then CNRL had some steam to surface as well. So, these things do happen occasionally and if you go into history and look back; let's say, if you look at California where they have heavy oils and they have been doing thermal recovery for many, many years. There are so many incidents of steam breaking through to the surface and things like that. So, it does happen.

I think that now just to be fair, the companies now do have actually some environmental responsibility consciousness. So, they don't actually want to have a blowout like Joslyn because then you have to shut down and pack up and leave from that project, basically. So, they do have that vested interest in operating safely. And also, the other side of the coin is that if they are too conservative then their project is not going to be as efficient and therefore, it not going to be as good as it could be. So, you want to go to the close but not exceed the safe limit. But, if you stay too far away from it, you are hurting yourself financially. If you go too close, you are hurting yourself because you're carrying a big risk that something will happen. So, the interest is now both on the

side of the companies and the regulators to actually have better design. And, the key to that design is now going these simulations combined with geo-mechanics of the reservoir simulation. That is what we do.

PMB: Micro-seismic, is part of your model?

SETARRI: Micro-seismic?

PMB: Micro-seismic, does that feed into your model at all?

SETARRI: That feeds through the models as well. But, the primary application of that is not really in the oil sands because... There is, also application for micro-seismic in the oil sands but I think there is a subtle difference. So, in the oil sands because the oil sands are granular, it is like sand on the beach but is under compressional stresses it so it feels solid. But, when you change stresses in the formation it doesn't produce micro-seismic events in the oil sands. But, it can produce them above the oil sands because then you have hard rocks that have stiff rocks. So, generally the micro-seismic monitoring does not tell you as much in the oil sands as it tells you, for example, in shale gas or tight gas. So, in those areas those micro-seismic is really an integral part of the overall picture of data gathering and so on and it is used very heavily.

In the oil sands business there is micro-seismic monitoring as well. And, I know that in heavy oils in California they are using that as an early warning sort of a mechanism that they do actually continuous monitoring. And, when they start to see new events they say, "Okay, something is going wrong." So, you focus on that area to see what could be happening. Something is starting to happen.

PMB: So, would this be actual micro-seismic events or would this just be micro-seismic monitoring? In other words, instruments on the top, if it would be on the surface it would be measuring what's going on underneath?

SETARRI: Well, the micro-seismic monitoring does actually try to detect micro-seismic events. So, when you monitor it and there are no events then...

PMB: Because, sometimes they actually generate micro-seismic events, surface explosions? Is that not correct?

SETARRI: No, no. Those are two different things.

PMB: Please explain.

SETARRI: Okay. So, what you're talking about if you're generating vibrations then that is seismic, that is not micro-seismic. Seismic is what we use for exploration, all the time, everywhere. So, on land you run the seismic line. You put dynamite charges in. You fire them and then you listen. So, you create both the event and then listen to it.

PMB: I do understand about seismic. But, it's my understanding that in some cases, in micro-seismic you would use some kind of seismic event on the surface to be reading what's happening down below.

SETARRI: No.

PMB: That's not correct?

SETARRI: Micro-seismic monitoring monitors the events that happen spontaneously rather than being involved by us to actually record them. So, what it means is that when you, let's say, pressure a certain part of the reservoir, pressure it up or if you're producing it the pressure is dropping somewhere but it's not dropping here, you are creating pressure differentials and the rock in the reservoir has flaws and fractures and so on. Just like when you see when you go the Rocky Mountains, you will see the exposed sides of the mountains and you see all the rock fabric. And then, you can get slip on this, very small slips. But, the slips release energy and that energy then travels through the rock mass and it can be measured by the micro-seismic geophones. Just like the energy that you created at the surface by blasting it. And so, in the micro-seismic you don't have a source of energy. The source of energy is how the rock actually behaves and how it internally slips in places and so on. And then, we try to interpret that and link it to what we are actually doing to the reservoir in terms of well production, injection and so on and hydraulic fracturing as well.

PMB: Thank you for clarifying that for me.

SETARRI: But, that's a big difference and as a result of that also, the micro-seismic monitoring deals with smaller energies than the conventional seismic. The conventional seismic if you don't use dynamite than you use these thumpers that are...

PMB: Thumper trucks.

SETARRI: Yeah, the trucks that continually produce the waves. So, you're putting a lot of energy in and that's why seismic nowadays can create really much better images of what we see down there. But, micro-seismic relies just on the energy that is released spontaneously due to the rock movement.

PMB: Great. Thank you very much for that. Now, at the very beginning of this discussion you said that some of the early work you did, your models found that the fractures were extremely long, extremely big. And, I wasn't sure whether they really were very big or whether the model you were using was just showing them as being much bigger than they were?

SETARRI: Yeah, the models were just totally, totally wrong for these kinds of applications.

PMB: Now, here we are talking in the 1970s?

SETARRI: Right, right and into the 1980s. And then, we did some work actually with Imperial as a part of this multi-company project because they gave us some data. And, they actually then could show that if we included the physics of the oil sands, that is different from conventional rocks, then yes, you can get these small fractures. It will actually agree with what actually you see because, for example, in Cold Lake, Imperial when they do the patterns and the wells are fairly closely spaced so it can monitor wells when you're creating fracturing in other wells and so on. And, there are various methods that you can use to actually tie it down and say, "Okay, the fracture's likely this long and it's going in this direction." And, that was some of the work that was quite satisfying because we saw that if we included geo-mechanics into the problem, then we can get closer to reality. To a point that now we can actually start adjusting the data that goes into the model and tune the model such that it will duplicate reality.

PMB: Great.

SETTARRI: That was work that we did with Rick Kry and Chi-Tak Yee and so on.

PMB: Now, somebody once explained to me that when you look at conventional oil reservoirs as they used to be. Now, they're changing a lot today. But, in conventional oil reservoirs usually you really have nice quality oil. But, you have awful reservoirs. Whereas, in an oil sand reservoir you have terrible oil, you have bitumen, but you have really great reservoirs. Is there truth to that? And, what does that suggest to you?

SETARRI: Sure, yeah. See, I guess the way to explain that or to illustrate it is that the oil will move according to what is called a mobility of it. And, the mobility is proportionate to the permeability of the formation. But, it's universally proportionate to the viscosity of the stuff that flows through it. That's a very simple notion that does not consider how the fluids interfere with each other. In a conventional reservoir you have an oil viscosity of [hours/ores] centipoise, then 1, 10, 100... and 100 is heavy oil already.

PMB: Sorry, that was centipoise. Is that correct?

SETARRI: Correct, yeah.

PMB: And, 1 centipoise is very slow, very...

SETARRI: So, 1 centipoise is like water, let's say. Water has a viscosity of one centipoise.

PMB: And, then 100 centipoises would be?

SETARRI: Would be like syrup that you pour on the pancakes.

PMB: So, you're talking about some kind of bitumen?

SETARRI: Well, it's not bitumen yet. No, no.

PMB: What would bitumen be?

SETARRI: Bitumen is...

PMB: How many centipoises?

SETARRI: Bitumen starts at 100,000, well 50,000 maybe, 100,000 and Athabasca bitumen is a 1,000,000 centipoises. So, Athabasca bitumen is basically the stuff that you see on the road. And, in the summer when it's really hot, when it starts to get...

PMB: It bubbles.

SETARRI: Yeah, yeah. That's what it is, yeah.

So, the viscosity is the thing that it makes it flow but it's the permeability of the formation which basically measures how big the pore space is, right. How easy it is to flow through it. So, in a conventional reservoir we measure that in units that are called millidarcy. So, conventional reservoirs they found with all kinds of permeability right. But, the oil sands because it's a relatively course sand that is in there, in comparison with conventional reservoir.

Conventional reservoir: it could like a rock on the road; that when you look at it, you cannot see the pore space, it's so small. As opposed to the oil sands, that if you take sand on the beach if it compares to that maybe, if it was very sand and it could be an alloy to that. So, the permeability of the oil sands is at the top of the range of all the reservoirs that we find. At the bottom of the range, we have the shale, the tight gas. And, tight gases we have are measured in microdarcy, which to the 100,000th of a millidarcy. Now, in shale gas we have nanodarcy which is another 3 [hours/ores] of magnitude less. Then conventional oil reservoirs can be in millidarcy, 100 millidarcy and the oil sands, their permeability is on the [hour/ore] of darcy; one, two, three, five darcy. So, they are the top of the range in terms of the ease of the flow, but also the viscosity is the opposite, because it's just so much higher so the k/μ: "k" being the permeability and "μ" being the viscosity.

PMB: And, "μ", being a Greek character.

SETARRI: Right. That is the mobility of the fluid to go through. It's very slow, very small. That's why it won't move unless the viscosity is reduced.

PMB: That's done by steam or solvent usually.

SETARRI: Right.

PMB: That was a very interesting commentary on that. That was very helpful for me at least. I'm kind of running out of questions. What else can you tell me that is very specific to the oil sands that would be of interest? In terms of your involvement in helping him get developed or helped to develop the science of oil sands production and so on?

SETARRI: Well, I think that it's generally accepted that now the geo-mechanical behaviour of the oil sands reservoir is one of the important things to consider, when we are trying to engineer it and predict it and so on. I think that there is going to be increasing attention paid to the environmental affects as well. And so, that's another reason why the geo-mechanics is able then to predict a model of the environmental effects. In order to, let's say in CSS, the ground when you are steaming your pattern like a pad, let's say, the ground can come up by as much as 20 or 30 centimetres. And then, during the production cycles when you go down again and during the next injection cycle is going to go back up and so on.

PMB: So, the ground actually rises during this period of...

SETARRI: Yeah, that's right.

PMB: ... I didn't know that.

SETARRI: It is actually similar to or reverse to what happens in large reservoirs that are being depleted, because those reservoirs will collapse down there to whatever depths they are. And then, part of that compaction of that reservoir then gets transferred to the surface. Then we see subsidence either on surface or subsidence on the sea floor if it's an off-shore reservoir. And so, that can be sometimes large so that becomes a real environmental issue. Now, our oil sands projects are usually in the areas that are not inhabited. And so, these effects can be mitigated more easily than if it happens somewhere under a city or something like that. Those are the aspects and of course, the Joslyn blowout or the concerns about actually the breaching the seal above the reservoir. The same part of that, because it will heave and then in addition to that if you have the steam coming through by fracturing then you have a real problem.

PMB: Actually, you've now got me onto one of my favourite topics. I had never even thought of ground heave and subsidence as being a potential environmental problem relating to that kind of environmental problems. Can you tell me a little bit about other environmental effects of oil sands development, in your view?

SETARRI: The other effects of course, that everybody is and companies are very well aware of is that even if you don't see any steam on the surface it doesn't mean that steam doesn't travel somewhere above the reservoir. And so, if it gets close to, let's say freshwater aquifers then you can contaminate those and that's what the farmers and people who live in the country, they rely on for water supply and so on. So, the freshwater protection is also part of the responsibility of the ERCB and it's an integral part of the assessment of the oil sands project. And, we did work in the past actually on one interesting case where we were investigating for Imperial Oil where the Cold Lake operation in one particular place, is actually contaminating the clear water aquifer. And, that's because I believe that now the companies are obligated to actually monitor the pressure in the aquifers over the oil sands projects. And, you can sometimes see some pressure responses to the production injection activity. And, they have to be explained and they want to make sure that it

actually didn't happen by a breach to that aquifer, even though it may stop there and not travel to the surface, it still could be a potential hazard.

PMB: In the sense that it pollutes the underground water.

SETARRI: Right. As we develop the oil sands more, with more detailed analysis we see that we have actually some faults in the geology in many places; especially, in the pore areas. And so, the faults are in natural weak spots where you could actually establish communication along those. And, so that's another area that I think people are becoming more aware of that. That we need to actually maybe make an assessment of whether these faults can be penetrated by the steam and the floor, and this is a problem that is not specific to the oil sands and it exists in many parts of the world.

Let's say, in off-shore fields and we worked on some of these. In conventional reservoirs, for example, you can have a field. You take a part of the field and you usually go after the best part of the field. So, you lower the pressure there. You put a stress on this fault and this fault slips. And then, number one, you could induce a small earthquake; these earthquakes can be measured obviously because we now listen all over the world. But, they're not going to be actually dangerous the people, buildings and so on. But, what they could do, they could actually provide a hydraulic communication through that fault. And, if that communication comes to the sea floor let's say, then you could have seepage from the reservoir...

PMB: ... into the ocean...

SETARRI: ...into the ocean...

PMB: ...or in a lake or something?

SETARRI: Things like that. So, the oil companies are now really aware of that in many other circumstances. So, that also is coming I think into the oil sands business probably.

PMB: Can you help me out with one thing? I've been trying to have the opportunity to talk to somebody from Shell about their Peace River project. And, they seem to be a very secretive company and I'm not sure... And, I haven't found anyone who would talk to me yet. Would you mind telling me what you know about Shell's Peace River project?

SETARRI: What I know is what you obviously can find in papers and so on. I think Shell has struggled over the years. And, Peace River, they have tried many different techniques. They try some innovative drilling techniques, multi-laterals and things like that and so on. And, they have shown some data that shows that were not able to access all the reservoir thickness because of shale breaks and so on. We are not working with Shell in the oil sands part of it. We work with them quite a bit on tight gas and shales.

PMB: A few years ago, they actually tried introducing electric heaters into oil sands reservoirs.

SETARRI: That's right, yeah.

PMB: Have you heard whether that's been successful at all?

SETARRI: Okay, that's an interesting subject because we were involved in that as well. In the past, and it's a good example of how people try to step out and see what else is there. There are two types of heating methods: induction heating and the other one is microwave. In other words, if you can microwave the reservoir down there then the oil would drop its viscosity by two or there [ore/hours] of magnitude -- it would be great, right. But, the question is: how much power would it take compared to what you can get up? So, we actually worked on microwave heating with a company from New Brunswick that had the microwave technology. And, we did a pilot sort of investigation of potential pilot for Imperial. So, Imperial has also looked at that. Actually, Mobil Oil has done -- sorry, sorry not Mobil. Texaco has done some experiments in California with that. Chevron has also done some work evaluating that technique, actually using our models.

PMB: This is microwave techniques?

SETARRI: Microwave techniques. And, the parallel work has gone also with the induction heating. Which is basically, putting a current in; microwave technique so you put in microwave energy. Otherwise, you can just put two electrodes and then just flow current through it.

PMB: So, it's like sticking two wires in the ground and then the current will flow through what, water?

SETARRI: You have to have water because the oil is poor at conducting electricity comparable to water. It doesn't have to be movable it just has to be there. So, none of these things have actually proven to be really commercial as yet. Now, Nexen has a project now on their property\ where they are partnering with, I believe, Harris Corporation. And, they are trying again a hybrid process which will be part solvent and part microwave heating; alternating solvent, microwave heating. So, I don't know how that is proceeding. But, all of these things are still very experimental.

We have actually developed models specifically for the microwave heating and try to apply them not just to oil sands but to heavy oil because we have a lot of heavy oil in our dirt in Saskatchewan. And, the economics were not there. The problem is that you are using very highly clean energy, electricity that has to be generated. And, there are losses going from some fuels for the power plants; the electricity comes out on the other end and you already have some losses there, and then using it again to recover the "dirty energy" which is hydrocarbons.

PMB: So, there's a disconnect between energy in and energy out.

SETARRI: If you can get a very cheap source of energy. Let's say you build a nuclear power plant which is one of the projects I was looking at years ago. They said, "Well, we're going to put in a nuclear power plant, cheap sources of electricity and then we're going to go and apply it to the oil sands." Maybe...

PMB: That might have worked.

SETARRI: But as it is, most power generators still burn fossil fuels.

PMB: Well, that would have been kind of a double-whammy wouldn't it from the environmentalists; using nuclear energy to produce dirty oil. That would have been a hay day for them.

SETARRI: But, it's an interesting technique. I know that there is interest in it worldwide. Maybe just in this last year, we were talking to one of the guys that oversee a large company about some applications of heavy oil. So, people are still nibbling at it. So, maybe one day it is going to become more efficient. I don't know.

PMB: I'm going to ask you one more question and then I'll give your own... You were here in the 70s when AOSTRA was set up. And, of course, that made available about a billion dollars in, I think, 1981 money to basically subsidize oil sands development. And of course, right now it's my understanding that the Provincial Government is developing what they're calling AOSTRA II which will make three billion dollars available for the same kinds of purposes. So, my question is this: What is the role of government in oil sands development? Or, what do you think it should be? Has it been supportive? And, has regulation been effective or should it be more stringent?

SETARRI: Well, that's a lot of loaded questions.

PMB: I didn't mean any of them to be loaded. I'm not trying to put you on the spot.

SETARRI: I know, yeah. It's interesting because we all look at it, right. And, here in Alberta we have this sort of, really entrepreneurial view of everything. And, it's a good question. I think that without AOSTRA the SAGD could maybe not have happened. Because, just financing the UTF project, that was mostly AOSTRA money.

PMB: They got fifty million dollars just to build the shafts and tunnels.

SETARRI: Yeah, right. The thing is nobody would actually step in and say, "I'm going to do this," because it was highly experimental at the time. The industry always comes in and then once they see success then it's like a herd of buffalo and they just go after it, in the same direction. So, I think the government does have a role in that. And, there are other government agencies that are set up to force this sort of a transfer of science into technology and applications. But, they're not as effective I think because they just -- I don't know. We have used in our company some of these. The other kind of way is actually I think, a good vehicle in small ways. But here, you're looking at something that is so large that you cannot easily get to the other vehicles, you would just be nibbling at it. So, I think AOSTRA did play a large role in the oil sands development; a positive role, I would say.

PMB: Now, you were involved with Canmet?

SETARRI: Right.

PMB: Canmet helped fund your -- which is the Federal Government, helped you fund your original model.

SETARRI: Right, right.

PMB: And, of course then AOSTRA was funding field work.

SETARRI: Right, right. And, that was also a good way because Canmet was I guess the administrative burden has really evolved and they stayed with our project as long as we were getting industry money, they were putting in their money. And, it helped. It was probably about, because they had ceilings, there was about maybe one-third of the funding was federal money and the rest of it was industry. But, it allowed us to do more things.

PMB: And, in the case of AOSTRA, I think it was 50/50.

SETARRI: Right.

PMB: I think a lot of the projects were funded 50% by the Provincial Government.

SETARRI: Right.

PMB: Did you read the International Energy Agency Report that came out about a week or so ago?

SETARRI: No, I heard about it. No, I didn't read it, no

PMB: Okay, well just let me just put this idea to you, well first of all I'm sure you read it in the papers last week that the pipelines are full. So, you've got expansion of the oil sands business in Alberta, but no pipeline capacity to send new production overseas. And, in the IEA Report it suggested that new technologies like multi-staging fracking and horizontal wells, all of that kind of thing, is going to basically create a continuing surplus of oil, especially in North America. The United States might be self-sufficient by 2030. I think from an oil industry producers' perspective it was extremely negative. Because, as you know right now, bitumen producers are selling their bitumen at $30.00 or $40.00 less than they could sell it if they could get into the world market. I think that's a reasonably accurate summary. Would you comment on that, please?

SETARRI: Well, it's really interesting because the companies, the activity in the oil patch I think is now being driven as much by Wall Street as it is driven by their own needs and what they think is going to happen and so on. So, it's really very difficult to actually predict what is going to happen. For example, I know that some people in the financial world about six months or so ago, they were predicting that the gas price is going to go down to what they call, no bid. That nobody would buy any gas. So, actually the price would go down to 0, right.

PMB: And, in fact it's gone the other way.

SETARRI: Exactly, right. I think that there are always more forces in the market than we are aware of and then the financial business, they will actually figure these other things out afterwards, maybe. So, I think there is probably more stability than we think.

PMB: Let me put what you just said into context for future reference: that last spring natural gas was down to around $2.50 per thousand cubic feet. And, people were suggesting at that time it would go down to no bid and in fact, today it's around $1.00 or higher for MSF.

SETARRI: Right, right. So, what happens is that the industry, we work with the number of the companies in the shale gas business and they just stopped drilling. Because, the cost side of it there is not much you can do about it, you can do more technology, better technology but that's slow and it works over time. And, that helped us, I think, on a long-term scale because the price of our fuels is in real terms is still lower than it was anytime. But, in terms of actual response to losing money, just stop drilling. And, that's what has happened in the US in virtually all pure gas shale places that people then switch their money into the oil. So, they're drilling only in places like: Haynesville, Eagleford and other liquids-rich plays and that's where they can still make money. Now, if it goes on for long enough then the gas prices are going to come back up, then they're going to start drilling in gas again.

PMB: So, your argument basically is that in the end, markets equilibrate. They find their own equilibrium.

SETARRI: Yeah, yeah. They have to and when you look at before this shale craze, this was happening on these long cycles all the time.

PMB: Yet only, four or five years ago people were very concerned about peak oil. And now, all of a sudden, the concern is about an oil surplus. And, I think that has been another pattern going back 150 years. The surpluses, the shortages, the surpluses, the shortages; it's been a constant boom and bust cycle.

SETARRI: Yeah, yeah. And, I mean you look at the US and if there is really an oil surplus people will actually use more energy. And, it's going to come back into a situation the other way eventually. There is enough environment or restraint that people would actually not feel the gap between the supply and demand, I think. Because, we do so many things that we look at environmentally: recycle and those things. And, when you trace down the chain of the energy usage through these, none of them will actually save us much energy. No, you recycle glass bottles and the first thing that they do is that they have to steam clean them, right, use energy. So, the only true environmental action is to actually stop consuming. That's my view. And, I come from the old country where we have very little and we were happy with what we had. But, that's the only really, 100% environmentally efficient way to save energy is not to consume; not to buy anything.

PMB: I'm going to suggest one other thing. It needs to be: (a) stop consumption, and (b) reduce the global birth rate. Because, you have more and more and more consumers, we now have seven

billion. When I was born, I think it was two and a half billion or two billion or something like that. So, there needs to be those two things.

SETARRI: Absolutely. I'm not too worried about that the US is going to have surplus of oil. I don't know. I don't see it happening, really.

PMB: Okay. And, as far as I'm concerned that's the end of the conversation. I leave the last word to you. This has been an excellent interview. It has been very, very helpful. Is there anything that you've thought of that really needs to be said here?

SETARRI: Well, I wish that the population at large would actually be better educated about what the energy industry does and the consequences of what it does. And, what actually are the consequences of not having the energy for our living on this planet. So, I often hear these really naive views from people who have access to a lot of distribution of thoughts, media coverage.

PMB: A lot of it comes from the internet.

SETARRI: The internet.

PMB: Diatribes on the internet.

SETARRI: Yeah. And, a lot of it just so poorly founded, the knowledge.

PMB: "You have to stop using oil now."

SETARRI: You mentioned the example of peak oil. The peak oil, the idea was here with us since King Hubbart wrote that original article. And, the peak has been moving now for 70 years or so. We will never have peak oil because the whole idea of peak oil is based on price, at a given price. You give me a price of the energy and the geologists can go over the globe and say there is this much energy at this price. So, they have peak oil. If you would double the price, they will find more.

PMB: I once saw a US geological survey report which talked about imminent shortages of oil supplies. This was printed in 1919. So, the forecast has been around since then. I'm going to turn this off now. Thank you very much for your help.

SETARRI: Thank you.

[END OF RECORDING]

PETROLEUM HISTORY SOCIETY Sponsors of The Oil Sands Oral History Project include the Alberta Historical Resources Foundation, Athabasca Oil Sands Corp., Canadian Natural Resources Limited, Canadian Oil Sands Limited, Connacher Oil and Gas Limited, Imperial Oil Limited, MEG Energy Corp., Nexen Inc., Suncor Energy and Syncrude Canada.