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ORAL HISTORY PROGRAM

Christopher Bale and Arthur Pelton: The 50 Year Journey Creating FactSage

2018

PREFACE

The following oral history is the result of a recorded interview with Christopher Bale and Arthur Pelton conducted by Tom Battle on August 29th, 2018. This interview is part of the AIME Oral History Project.

ABSTRACT

After 50 years, Christopher Bale and Arthur Pelton's friendship remains strong. Their united journey through academia and research influenced one another's careers. Bale and Pelton began working together at the University of Toronto where they both took an interest in thermodynamics. Soon, the influence of computer programming sparked an idea to create the software FACT. It was at Ecole Polytechnique at the University of Montreal where FACT was born. When Pelton became a professor at Ecole, Bale followed him, and they met Bill Thompson; together the group developed one of the largest, fully integrated database computing systems in chemical thermodynamics in the world – FactSage. Over the years, Bale and Pelton have worked together in collaboration with professionals and other universities, forming models and databases, to create this dynamic application for thermodynamics. Bale and Pelton remain fascinated with the wonderful world of thermodynamics as they continue to promote it passionately during their retirement.

Readers are asked to bear in mind that they are reading a transcript of the spoken word, rather than written prose. The following transcript has been reviewed, edited, and approved by the narrator.

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PART 1

00:19 Introduction - First Recollections on Using FACT

Battle:

Good morning. This is Wednesday, August 29th, 2018. And we're in the Westin Hotel in Ottawa, Canada. My name is Tom Battle. I'm an extractive metallurgy consultant and TMS volunteer, and I'm here at Extraction 2018 with professors Arthur Pelton and Christopher Bale from the Ecole Polytechnique in Montreal. Welcome, gentlemen. I appreciate your taking the time to meet with us today and talk about your careers, particularly your work with the thermodynamic software package now called FactSage.

I can't help recalling the first time I used your package, which was known as FACT at that time in 1990. It was only available through a phone connection to the computers at McGill University, which wasn't always available. The software wasn't particularly user-friendly, and the results of the analyses rather cryptic. Certainly, you'd agree it's primitive by today's standards, but it strikes me now with all my grumbling and complaints at using your software at the time that, if I wanted to do the same slag metal equilibria calculations I was interested in then, but didn't have FACT available, what would I have done?

Pelton:

You would have taken out your hand calculator and spent a few days doing the calculations.

Battle:

Well, I would have had to find the thermo tables.

Bale:

You'd need the models as well, you know. Stated, it would be tough.

Pelton:

It would be difficult.

01:59 Teaching - The Motivation to Learn Thermodynamics

Battle:

Now, was this difficulty in doing these complicated calculations part of the research that led you to develop FACT in the first place?

Pelton:

Why did we develop FACT in the first place? Well, everything just sort of came together at the right time. Chris and I worked together at the University of Toronto. We were demonstrators in a laboratory of thermodynamics given by my professor, and that's where we taught each other thermodynamics because we had to teach it to the students the next day. So, we kind of had a motivation to learn it. And, we like thermodynamics.

Bale:

We used to go through the problems with the students. And so, it was like a demonstration class. Prof. Flengas handed out questions, and we helped the students answer the questions. And, that's how we slowly built a relationship together. We were students.

I was doing a Master's. I think, Arthur, at the time, was doing a PhD, was two years ahead of me. We got to know each other through that course. That's really where everything started to develop. But, why would we get involved with thermodynamics and calculations? Well, at that particular time, I had just arrived in Canada, and computers had just come out. So, we started in this in 1968. And so, I took a computer course. I know Arthur did some of his programming language for his thermodynamics because he knew how to do that as well using computers. And so, it was really a question of timing in respect to computers and good fortune that we were together. At that particular time, obviously, there's no way we'd realize we'd still be in the business 50 years later. So, that's how we started, and we slowly became good friends.

4:01 The Origins of FACT/FactSage in Montreal - Facility for the Analysis of Chemical Thermodynamics

Battle:

So, for people who don't know, explain what FACT is and what it stands for.

Bale:

FACT, well, we didn't start FACT then. We started FACT in Montreal many years later.

Battle:

Okay.

Bale:

We should maybe go into how that happened, too -- FACT. After Montreal, after then, Arthur went to MIT. I eventually got a job at Ecole Polytechnique in Montreal. Ecole Polytechnique was the engineering faculty of the University of Montreal. Arthur got a job there and became a professor eventually, and I joined him as a post-doc, and that's how we, with Bill Thompson from McGill University, that's how we started to work together on the FACT system. The acronym, for FACT, F-A-C-T, was faster. It came after M*A*S*H because M*A*S*H seemed like a good name at the time, from the TV show, so we called it F*A*C*T.

Battle:

Then, that stands for?

Bale:

Facility for the Analysis of Chemical Thermodynamics. That came about in 1976.

05:26 FACT - Computer Programs that do Thermodynamic Calculations

Pelton:

Later, when we joined with ChemSage people and GTT-Technologies in Germany, they had a software called ChemSage. So, then we put them together and got FactSage.

Battle:

Right.

Pelton:

You asked what FACT is? FACT is a set of computer programs that does thermodynamic calculations based on Gibbs energy minimisation of an entire system. So, you can calculate the equilibrium state of a complex system. And, the data are taken from extensive databases, which are, for the most part, critically evaluated and optimized databases. These aren't just databases we've taken out of tables in the literature, but databases that we have used for a complex solution like a molten slag oxide. We look at all the data that are in the literature. We take a model which relates the thermodynamic properties to the structure of the solution so that we can then optimize or parameterize the data that are already known and then use the model to extrapolate into composition temperature regions that are unknown. We have many databases for different materials, steels, metals, oxides, and so on. With thermodynamic software that accesses these databases and that can present the results of many different ways, equilibrium calculations, multi-phase, phase diagrams of many different types, and all types of different paths one can take to equilibrium calculations. You can even cheat, sometimes induce quasi-equilibrium, and so on. So, it becomes a tool for engineering research and for industrial research and industrial practice as well, that's been built up over many many years.

Bale:

When we got started in '76, we were in a group of three of us—Arthur, myself, and Bill Thompson. We got a cooperative grant from the NSERC – the Natural Sciences and Research Council of Canada. That inspired us to work as a team between the two universities, and I think really what set us going was the NBS (Nat'l Bureau of Standards) meeting in 1977 when you had a conference on phase diagram, and phase equilibrium, thermodynamics, and that sort of inspired us to get going. We demonstrated our; I think we called it a Canadian Data Bank System, at that time, it was a workshop. We were just getting started in doing these particular calculations, and we'd do simple reactions. The program I had written, called the Predominance program, enabled you to take a system, in this particular case, the potassium sulfur oxygen system. We could do what we call predominance area diagrams as an option. We were demonstrating that in the workshop in Maryland and John Elliott passed by and Arthur had worked with John Elliot as a post-doc, and I had met him at MIT, and he came by and said, "Chris what are you doing?" I said, "Well, this is the predominance area diagram calculation of the potassium sulfur oxygen system." John said, "That's impressive; what systems can you do?" I said, "You can do any system you like as long as it contains potassium, sulfur, and oxygen!"

Battle:

You had to start somewhere.

08:41 First Computer Courses - 1968

Battle:

Then going back to my original question, if I had to do these calculations, I would have had to scour the literature, if I want to do it right. Find the data available in that system. Do the analysis to figure out what's good data and what may not be good data. Maybe do some experiments. Have a model to extrapolate, and if necessary, interpolate. And, basically, you did all of that. So, a good chunk of FACT is, is you've gone through that, and we can trust that hey, this is the quality data available for that system, right? And then, the second part is we got to pull it out—the particular stuff you need for your calculations. So, the software that interfaces with the database. Right. So, I mean that could take me weeks to do- to reproduce-

Bale:

Yes, as you said, it would take a long time to get the data, and you have to know how to use and calculate it. So, it's sort of done for you. The FACT-FactSage system simplifies that operation.

Pelton:

And, even if you have the calculator, if you had all the numbers ready, the computer does it by iteration. Thousands of calculations coming into the results. Even if you had everything ready, it would take you a long time to do what the computer now does. So, this all came together at just the right time. We, well, we taught the thermodynamic course together, and we were both, we were about the same age as the students.

Bale:

He's much older.

Pelton:

He doesn't look it though.

Battle:

You've aged him.

Pelton:

The students say he's younger than you are. We were both the same age as the students, so the students had no respect for us at all, which was really good. If we said to them two and two is four, they made us prove it. So, that's where we learned thermodynamics. And then, at that time, computers were just coming out. He says he took the first course; I took the first engineering course at U of T in computers.

Bale:

I think for me, my first course.

Battle:

Your personal first.

Bale:

My personal first course in computing because I came from the University of Manchester, and we didn't have any computer courses that I remember. This is 1968, and, as a post-graduate, the first computer course, I think, given to the post-graduates. I remember, I did really well on it. I thought wow, this is a cool subject. I didn't realize I was becoming a geek at that time. But clearly, I was. I used that programming to help my programming, and one thing led to another. It was good timing about computing and good fortune that we met each other, but we didn't realize at that time what was going to happen.

11:35 First Thoughts on a Thermodynamic Data Computer System

Pelton:

And then, I thought we could have some sort of thermodynamic data computer system, but that we would have to say give them- My idea was, at the time, was that anybody who wanted to use this, we would have to send him a pile of punch cards, and he can run it through his own computer at random because they didn't have what they call the timeshare. Interactive computing was not there.

Battle:

Okay, even the Mainframe-

Pelton:

No, not even the Mainframe.

Bale:

Back then, in 68' or 69', for example, to write a simple program that would do Gibbs integration, you'd use the box of cards, and there's two thousand cards in a box. So, if you were walking around with two boxes, you obviously had a really big program- You had like 3,000 lines of programming-[[[crosstalk]]]

Battle:

And, if you get them out of order at all or drop it, its death [[[crosstalk]]]

Bale:

If it was a damp day, you had to reread it. One of the consequences of that was that you would submit your job to get the card reader to read all the cards, you know. And, if you were lucky, you'd get the answer in 24 hours. You became a very proficient programmer because if you made one mistake on one line, you had to wait 24 hours to fix it, and do it all over again. So, you were very, very careful in your programming to get it right the first time. That was good. Taking 24 hours to get the calculations sounds ridiculous, but at the time, this was high tech.

Pelton:

People say well you got- we got into it at that time. But then, we must have been visionaries when we realized that interactive computing would be coming in and the personal computers. No, I wasn't a visionary at all. We were just a bunch of overconfident idiots.

We liked what we were doing. I never thought that there would be interactive computing when it first came out. I thought gee-

Bale:

I remember in Toronto when we were working together. In experimentation where you're often controlling options to solve for potentials, and I thought it'd be really neat if we could have for any mixture, input mixture of CO, CO2, SO2, hydrogen, and so forth. There was the four elements carbon, hydrogen, oxygen, sulfur, any input mixture. If we had a program that could calculate the potential options to solve for or the other way around for a given potential of options to solve for. What would be the initial input to it? Solve for possibilities. So, we wrote something down. It was just simple elimination. I thought it was a fabulous program. At the time, it seemed earth-shattering. It seemed revolutionary, but nowadays, of course, that's nothing. I remember, at the time, being able to use the computer to do this very complex system, four-component system, to solve for option potentials. That was the first time I saw the value of the computer. And, I ended up using the computer calculations and some of Arthur's theories in my PhD. So, he had an impact on my research. He was two years ahead of me.

Pelton:

I'm still ahead of him.

Battle:

Was this all in Fortran?

Bale:

This was all in Fortran at the time.

Pelton:

Fortran II.

Bale:

It was Fortran IV.

Pelton:

Four? Well, you were advanced.

Bale:

I was more advanced than you.

Battle:

You were going to say- I'm sorry—some cutting remark.

Pelton:

Yeah, I probably-

14:56 Teaching Fortran

Bale:

We eventually got to working together at Ecole Polytechnique, the three of us, in Montreal. We eventually proposed the FACT system. Everything at the time was done in Fortran. I ended up in the university, teaching Fortran for the electrical engineering department. So that's how I learned a lot of programming by giving courses to the students. My courses were in French too, so that was a bit of a challenge. That was fun, but that's another story.

15:31 The Start of Interactive Computing - McGill's MUSIC

Pelton:

So, the interactive computing also just came at exactly the right time for us. Make FactSage a commercial product that people would phone in to, as you mentioned at the beginning, phone in through the acoustic coupler, through your modem. Young people, they don't even know what that is. You call up on your telephone, you put the telephone receiver into a little receiver, and it goes beep-beep-beep, beep-beep-beep. And, that sends sound signals down to the computer. You can imagine the speed of this hundred baud or something. So, that worked for a long time, and everybody complained about it, but that got us to- We had people connecting up from, we had one person from Perth Australia, which is as far away from Montreal as you can get on the surface of the Earth. So that worked, but endless complaints. Then personal computers came out in 1980.

Bale:

I want to interject something. We were very fortunate in the timing of this because Bill Thompson was the third person in that development. McGill University developed a computing system called MUSIC. Mulit-User System for Interactive Computing. So, we could use our Decwriter, our terminals, to communicate with the central computer system. So, we were very fortunate at that time.

16:49 First Satellite Conference Transmission

Battle:

There were probably only a few universities that had that at that time, maybe very few.

Bale:

Very few universities had that. So, we were able to take advantage of this new technology emerging from the university, and then we ended up sending, as Arthur pointed out, people would phone in, and McGill University then made their system available to the outside world. And, Arthur pointed out, for the calculations from Perth. Also, Rodney Jones, many times, tried to calculate ternary systems from South Africa. He knew the phone number by heart, and the speed at that time was 1200 baud. He was very persistent in certain calculations, but those were the mid-80s. We also demonstrated, at that time, for a conference transmission by satellite.

Pelton:

First time ever.

Bale:

For the first time ever. You want to explain that.

17:39 Transmitting Around the World

Pelton:

Some group in California wanted to show- it was before the internet. It was at the beginning of the internet.

Bale:

In 1983, I think it was.

Pelton:

Something around there. This group in California had this system, and they wanted to show how we could transmit things around the world. So, there was a conference being held in Israel, in Jerusalem. At noon in Jerusalem, and they wanted us to- They had a big screen up there, and we were supposed to run the computer in Montreal, where it was four in the morning, and demonstrate- Chris would press the keys, and I was going to talk. So, we were giving a talk in front of this audience, and this was being moderated by the people in California who- So, people in California hadn't gone to bed yet. We had gotten up at four in the morning. The people in Israel had had breakfast and were watching this, and the whole thing just worked.

Bale:

I remember the guys in California had been up all day and celebrating, and they sounded like it.

Pelton:

They were half drunk, and they were laughing- they were actually high.

Bale:

And, what happened?

Pelton:

They were laughing away in the background.

Bale:

And, what happened was initially you had to transmit the same speed, and we were operating at 1200 baud, and they were operating at 2400 baud. These are technical details at the time. We couldn't really communicate, and, when we figured it out, there was this big roar in the auditorium in Israel that we heard. Hey! And, you could see this teletype thing going across the screen—a good luck transmission. So, the birds were coming outside to sing in Montreal, and we were all happy.

19:12 The High-Tech World of the 1980s

Pelton:

This sounds silly, but, in those days, this was high-tech. We came home- think what we did. This was unbelievable, halfway across the world. So, as things came out, we were there at the beginning. We were there at the right time, for that sort of thing.

Battle:

Yeah, we're spoiled now, trying to explain to my children—things like card punch readers and all that.

Pelton:

Well, I watch my granddaughter talking to her grandfather in Hungary. I mean, she just dials him up, and he's there in 10 seconds.

Battle:

And, it sounds like he's next door.

Pelton:

So, she can't understand something like this.

Battle:

It wasn't always this way.

Bale:

At the time, when we were using the MUSIC system at McGill, we had to take our programs over there. There was no email, so you couldn't send it online, so taking the program from one computer to another involved putting it on a big tape. So, you had to formally present it to the tape manager at McGill, who would then load it into the tape reader and so forth. So, this was quite the challenge at the time, and it seemed really high tech. I remember; eventually, we ended up rather than using a tape; we brought the computer center a great big hard disk. I think you've got more power now on your hand calculator. The big mainframe computers, they were huge, and they were thousands of dollars. That was back then.

20:37 Engineering, Construction, or Psychology?

Battle:

So, let me go back a few years. Arthur, you were born in Windsor, Ontario. Now, are you from a scientific family? Was it fated that you would go into engineering, or were you the black sheep? [crosstalk]

Pelton:

Absolutely not. My father was a construction contractor.

Bale:

Well, that explains a lot.

Pelton:

He built houses and things, so, no, it wasn't.

Battle:

So, what made you go to Toronto and to go into engineering as opposed to trade or something?

Pelton:

You sort of fall into things. I wanted to be a psychologist. And then, a couple of people told me-

Battle:

Is that why you paired with Chris?

Bale:

That's psychiatry, not psychology.

Battle:

Well, close enough.

21:20 Engineering Science Course at the University of Toronto

Pelton:

So, they told me all people who go into psychology do it because they're trying to work out their own problems or something. So anyway, I thought science was okay. Now I had no interest in engineering because I didn't think I was very practical; I couldn't turn screws and things. So, I wanted to go into pure science. So, I was going to take a pure science course. And then, my aunt said, "Well, there's this course at U of T called engineering science which sort of combines them both. It's an engineering course-" [crosstalk]

Battle:

Kind of- [crosstalk]

Pelton:

[crosstalk] No. No, it's very heavy. Very heavy in basic sciences as well as being very heavy in engineering. It is for anybody who wants it. It's an excellent course. My son took it as well. Well, my son took it a few years later. And, he was always after me," Dad, I want to go to Cornell. You want to send me to Stanford or something." I said," I'm not going to spend $300,000 when you've got a perfectly good thing here." So, anyway, he then ended up doing his PhD in Stanford.

Battle:

Sounds familiar.

22:19 If you Want to be an Engineer, Learn the Basic Fundamentals

Pelton:

Yeah. He spent his PhD in Stanford in the U.S. He came back, and he said, "Well, all his students, all his colleagues, and first-year masters and doctorate, they're working like hell to learn the stuff." He says, "I've already learned it." It is one of the best courses, so I was really lucky to take a good course. It was my aunt who said take that course. It's the only thing she ever told me that was any good, but that was a really good piece of advice. I would recommend that course to anyone. I'd recommend it to anybody in engineering- Who was I talking to yesterday? Peter Hayes. We were saying that in engineering, you want to be an engineer. You want to do practical aspects but learn the basic fundamentals. That will then stand you in good stead in the future. If you learn, you can learn some of the practical stuff. But, if you don't understand the fundamentals, then you're not going to be able to learn anything more than what you already know. Once you know the fundamentals, learning different processes and so on. I always wanted to be a fundamental scientist. FactSage has been perfect because it goes the whole way. We have fundamental science. The models we're developing is like fundamental theory, and then we apply it. People use it which is--

Battle:

Gratifying.

Pelton:

It's very gratifying that you can do the fundamental stuff and get somebody to do something with this as well. So, I've never regretted taking engineering science, and that was the best. The best thing was actually getting into that course.

Battle:

So, your undergraduate degree is what?

Pelton:

Engineering Science, U of T, with the materials option.

24:05 Oh, Yes, I Always Wanted to be a Professor

Battle:

Now were you automatically thinking of grad school by then?

Pelton:

Oh, yes, I always wanted to be a professor.

Battle:

You weren't ready for the real world.

Pelton:

I never wanted to go to the real world. I never wanted it.

Battle:

You knew enough to not want to go to the real world.

Pelton:

I knew enough not to want to go to the real world. But, I realized, at a certain point, that I could sort of have the best of both, which I think I've managed to do with FactSage. So, I'm in the nice warm environment of academia, but we still have all our contacts in industry. And, we're doing something that I think is useful and commercially viable, so it worked out very well that way. But, no, I didn't want to be in the real world. I always wanted to be a prof. I always just kind of naively assumed I was going to get a job as soon as I graduated, which I did, but we can't count on that these days. Even in those days, you couldn't count on it. That's again, another bit of luck. Everything kind of came together.

24:59 Working with Professor Flengas

Battle:

And then, you worked for Professor Flengas?

Pelton:

Yes, he was my PhD supervisor.

Battle:

And how did that- I mean, I know the name, but I don't really know who he was?

Pelton:

Well, he was a chemist by training from Imperial College. He'd worked at CanMet for a while, and then he was a professor at Toronto. In Metallurgy/Materials Science, he did most of his work the molten salts. He was quite a fundamental guy. But, he was an excellent- I complained about him bitterly when he was my professor, but in hindsight, he really taught us how to do things properly. We had a really good group, and the group worked together, teaching each other. And, we did a lot of experimentation. I haven't done much experimentation in my career, but with the solid background in experimentation-

Battle:

It helps.

Pelton:

It helps a lot to- [crosstalk]

Battle:

To understand.

Pelton:

If you read a paper and somebody says the melting point was measured to a hundredth of a degree, you know that that's not real. That's not possible. So, I got a good background in that, and he was just very interesting. So, that got me interested in the thermodynamics. So, why thermodynamics? Well, because I had a professor who made it interesting.

26:19 Bill Winegard Made Metallurgy/Materials Science Sound Really Exciting

Battle:

A lot of people say that it took one teacher that- [crosstalk]

Pelton:

And, in engineering science, the way that course worked, the first two years were very general. And, then in the third and fourth year, you got a specialty. And, the professors from all the different specialties came and tried to tell us how wonderful their specialty was, and it was Bill Winegard who made Metallurgy/Materials Science sound really exciting. So, there wasn't much more to it than that. It wasn't like all my life I wanted to be a material scientist, but he just made this sound like fun. He made it sound like fun because it was the breadth of the field. I thought if I'm going to get into something big like electrical engineering, I'm going to be working in some narrow aspect of it because there's such a huge field. Whereas in Metallurgy & Materials you could go from physics to chemistry and cover a wider area of science and engineering, and a smaller field, a smaller pond, with more width, and that that kind of appealed to me. So, that's why I took it, and that worked out okay, too.

27:32 Cleveleys, England - University of Manchester

Bale:

My background is a little different. I was born and brought up in England. I spent my youth in a place called Cleveleys, which is on the west coast of England. And, I liked chemistry in high school, and I ended up going to the University of Manchester to do a bachelor's in chemistry. But, I wasn't so much into theory. I liked applied stuff. And, I remember in the chemistry courses, there was a course in physical chemistry, which is equivalent to or similar to the thermodynamics we now do. I think I was dead last in the class. I wasn't very good at theory, and so, I thought I should do something about this. Fortunately, at the time, the metallurgy department offered a joint degree with chemistry. So, I transferred from pure chemistry to chemistry and metallurgy and ended up with a joint chemistry metallurgy degree, bachelor’s after four years.

In '68, and this is where the timing and just coincidences are incredible, I went around Europe with a friend. We were visiting various countries. On my way back home to Cleveleys, I passed through the University of Manchester. It was about quarter to 5:00 in the evening, and I dropped off to see my old supervisor because, you know, I'd left university. I wanted to say bye. So, he said, what are you going to do? And I said, I'm not really sure, I like research. I'd like to travel around. And, he pointed to a poster on the wall. So, there's the University of Toronto. Why don't you go there? I didn't know where the University of Toronto was. I ended up, eventually, in Toronto. If I hadn't bumped into him on my way back going through Europe, and if the poster hadn't been there, and if the University of Toronto hadn't sent the poster out, and if the librarian had not posted the poster, we would never have met. When you think about it, you could go nuts thinking about the possibilities. You know they say all roads lead to the same destination. That's actually quite something.

29:33 University of Toronto Scholarship

Battle:

And what were they advertising? Engineering?

Bale:

Advertising metallurgy. Department of Metallurgy/Materials Science, and I ended up, I got a scholarship with Professor Jim Toguri. So, I went there in October 1968. He was a fabulous guy, fabulous professor. He worked with Flengas. They were in the same department, and I really learned a lot from Jim Toguri. He was as experimentalist and applied stuff, which is what I liked. I wasn't so much into theory until I got hooked into computers, and I thought, well, this is pretty easy, and I should use the computing in my science and so forth, and, eventually, I got hooked up with Arthur. So, my background was-- I also should point out I spent six months at Anglo American Company in Africa as a mining operator in the extractive, mineral treatment business. So, that was valuable, and I realized doing that-- I thought well, maybe I should go back to university and do the research; hence, I ended up in Toronto, and it's a decision I've never regretted. It was a great move, and this is where we met, and that's my story.

30:42 Supplementing Income as a Course Demonstrator

Battle:

And you ended up teach- we call teaching, TA'ing, teaching assistant.

Bale:

Yes, we were [crosstalk]

Battle:

In that thermo class that was taught by Flengas, perhaps? But, you were the ones who translated it to—

Bale:

Yes. Well, it was a way of supplementing your income as a student. We would be the course assistants or demonstrators; I think they called us. We were in the same class, and I think we did two or three years on the run. And so, we got fairly proficient in the thermodynamics, and this led on to the bigger and better things.

Pelton:

In the third year, Flengas was on sabbatical, so I actually taught his course that year as well as doing the laboratory.

Battle:

That's the way to learn, under fire.

Pelton:

The way to learn something is having to teach it. It's like the way to learn French is to have to be the lecturer.

Bale:

I mean teaching chemical thermodynamics, it's not the most exciting of subjects. That was a challenge trying to get the students involved and excited, and it became applied. We applied it to real situations, oxidations—

Battle:

Gets their attention.

Bale:

It gets their attention, and it got my attention, too. I thought, oh, this is really neat. I like this. I like this kind of stuff.

Pelton:

As I said, Professor Flengas was a very good teacher. It was his undergraduate course in thermodynamics that really got me interested, and that's why I went with him for a doctorate. He gave his course on the theory of thermodynamics, but every question on every test, every exam, was a numerical question. It wasn't describe one of these, describe some theory, develop the Gibbs-Duhem equation, or something like that. It was with real numbers, and you did a calculation. So, we brought the whole thing back—

Battle:

And, you didn't have calculators then.

Pelton:

No, we didn't have calculators. We had slide rules. We had open-book exams. He didn't believe that you have to memorize equations, but every question was a practical question with a numerical answer. I always ran every one of my thermodynamics courses through my entire career the same way. I never asked students to develop something. It was always, use it to extrapolate—

Battle:

Solve a problem.

Pelton:

Solve a problem. There are so many courses you get at university where you don't see-- Why am I thinking this? What is the point? If I'd only known, I would have listened. I had no idea. This especially applies to math courses, as you might know.

Battle:

It’s a requirement.

Pelton:

Why ever am I learning that? Gee, I wish I had listened to that. I thought that was a good teacher. A good teacher is important, very important.

Bale:

One of the things with FACT and FactSage is-- When I took thermodynamics and chemistry, and I didn't really like it. I wasn't good at it. Basically, what you were doing was learning a relationship, like Maxwell's, where you're just applying it here, calculating a heat, or an entropy, or whatever. I had no use. The thing with FACT and FactSage is that it does it for you. So, you've already done the calculation. Now, all you have to do is apply the numbers to the real-life situation. I think that's what really helps is that it gets away from the monotony of having to calculate these things in the first place. You've got the answer right there, and then you can apply it right away. You learn a lot coupling the thermodynamic values to the real-life processes.

Pelton:

As long as you understand what the computer is actually doing. But, it can go a little too far, like using a hand calculator to multiply two numbers when they don't quite understand the concept of multiplication.

Battle:

Or significant figures.

Pelton:

Or significant figures, yes. You can use FactSage, get an answer and just get nonsense because you didn't understand what you were doing to start. You have to be able to formulate the question.

Battle:

Yes.

Pelton:

And, in principle, be able to do it yourself, if the computer weren't there to do it for you. But, we haven't had too much of that. People that use it seem to catch on, and I think they actually learn from it. As Chris says, you learn thermodynamics because you see the answer coming out.

Bale:

You get a real feel for the numbers. I mean, you know, you say the heat is so many kilojoules, and you don't know what that is; you're lost. But, having seen it a few hundred times, it starts to mean something. You know, you get a feeling for what the number is. One part, one part per million, or one percent, or whatever of volume or kilojoules or BTU's, whatever you're dealing with. You get a real feel for the numbers. You get a better understanding, and, of course, we don't just calculate these numbers. We use these numbers in a meaningful way, like we produce phase diagrams, for example. We chart contours of data and so forth. So, the FactSage system produces these very useful outputs: phase diagrams, spreadsheets, and the like.

35:43 Thesis Defense – Postdoc Work & Influences

Battle:

So, Arthur, you did your thesis defense when?

Pelton:

Doctorate in 1970.

Battle:

In 1970, and then you did a postdoc or couple postdocs. Weren't you in Germany, as well as—?

Pelton:

I did one in Germany.

Battle:

Now, did you plan to do postdocs or?

Pelton:

Yes, I wanted to do postdocs, see the world.

Battle:

Before you settle down, wherever.

Pelton:

Well, the postdoc in Germany was excellent. Professor Schmalzried was a brilliant scientist. I learned a lot about phase diagrams and thermodynamics.

Battle:

From their perspective.

Pelton:

From that perspective. That's helped a lot. It was the best year of my life. In Germany, a small town, wonderful time. Then I went to MIT, a little bit different.

Battle:

Meeting Chipman and Elliott.

Pelton:

Well, I worked with John Elliott, who was my supervisor there. I did meet Chipman and his people.

Battle:

They have a long family tree in extractive, including me. Yeah, I worked for John Hager and Bob Pehlke, who were both Elliott grad students. Maybe a little before your time, like mid to late '60s.

Pelton:

Well, Chipman was retired when I was there, but we had lunch a couple of times. Elliott was a very different man to work for than Spiro Flengas was.

Battle:

We want to hear about that?

Pelton:

No, maybe not [laughter]. I decided not to stay at MIT when they offered me a job, although it was in the hopes of a job offer that I went there in the first place.

Battle:

Oh, Okay.

Pelton:

When I got the offer, I decided I would have an ulcer by the time I was 40 if I stayed in MIT. Maybe we could put it that way.

Bale:

You mentioned–

Pelton:

Plus, they took the title Assistant Professor very literally [laughter].

Bale:

You mentioned Pehlke. I was influenced very much by his book on Unit Processes of Extractive Metallurgy – 1973, because it had all these nice computer programs in it.

Battle:

That's true [crosstalk]. Little Fortran things. [crosstalk]

Bale:

The Simplex algorithm and other various things they used, that was a big influence on me.

Battle:

That was the first book I had, too, before I went to CSM.

Bale:

So, I didn't know him, but his book influenced me greatly.

38:03 Becoming a Professor & Having to Relearn French

Pelton:

Since we taught the thermodynamics course together at Toronto, we had this idea that we were going to write a textbook on thermodynamics, Chris and I. And Ecole Polytechnique was offering a job for a professor, which I didn't get the first year because there was somebody else. But, I told them, I said, "Well hire me as a Research Attaché, and Chris will come, and we're going to write this textbook on thermodynamics." So, he came.

Battle:

And, that all came together.

Pelton:

It all came together, but we never did write the book because we got sidetracked on FACT.

Bale:

We got sidetracked in this computing thing.

Pelton:

At the same time, this- Two months later, this NSERC Co-op grant came out. We got together with Bill Thompson and started to work on that, and we kept pushing the book back, and back, and back. And, we never did write the book, but we ended up doing FactSage—

Then, about a year later, I got a professorship. Then, a year after that, Chris had a professorship and so—

Battle:

And, of course, you'd been speaking French since you were young, right?

Pelton:

Yes, I learned French in Ontario High School, and I had to unlearn it in Quebec; then, I had to relearn it.

Bale:

When I arrived at Polytechnique, I knew it was French-speaking. I didn't know it was only French-speaking.

Battle:

So that's the crash course.

Bale:

That was a shock because I knew diddly-squat. I couldn't understand it. But, I knew the professorship job was coming up later after about two years—

Battle:

But, you did a postdoc first.

Bale:

So, I did a postdoc there.

Battle:

You had to learn French as you were doing—

Bale:

Well, I didn't need French to do the postdoc, but I thought I'd like to be-- I really enjoyed working with Arthur, and I enjoyed the environment, and I thought that I'd really like to have this job as a prof. I knew that one of the conditions of being a prof is that you had to be bilingual in English and French. And, I knew there would be a lot of French applicants from France who would not know English, and my English is not bad.

Battle:

English, not American.

Bale:

I had taken high school French, but I didn't understand any of it. So, I thought I've got to learn this. I used to sit down with a technician, Lucien Gosselin, every day, and I'd buy him a beer. Bonjour, Lucien, comment vas tu? And, I spoke to him every day for a bit and bought him a beer, and I picked it up. I used to listen to the television in French all the time, and that was the only way to pick it up. I'd have to say that, apart from working with Arthur, learning French is the most difficult thing I've had to do in my life.

Battle:

What a build-up. [laughter]

40:41 The Most Difficult Thing: Teaching in French

Bale:

The most difficult thing I've had to do. Arthur picked up French a lot quicker than I did. I'm not into languages. I'm more into this stuff, but I picked it up, and we both ended up teaching in French, and I think we're proud of ourselves. Can you imagine you're in a class in front of 80 students, and you have to speak in a foreign language, but you don't really speak it.

Pelton:

They were always very understanding.

Bale:

Very accommodating, the students. The French-Canadian students were wonderful. My hat's off to them. They were very nice and very understanding. The first class I gave, one of the students in the back stood up, "Monsieur Bale is this in English or in French?" I could have killed him [laughter]. They were very accommodating, and my hat's off to them. And, this is where we learned French, by speaking to the students. We're engineers. We're not into linguistics, but we picked up on this, and we've won awards for teaching now, believe it or not.

Pelton:

People at Polytechnique, from the students to the staff and everything. That's the other thing that's come together very well. At Polytechnique, the administration has strongly encouraged professors in doing spin-off companies.

Bale:

Very supportive.

Pelton:

Very supportive of this type of thing. And, there are universities that say, oh no, you must remain in your ivory tower, and you're permitted to do four hours of consulting per week.

Battle:

Right.

Pelton:

You notice, the best universities in the world do not do that. At Ecole Polytechnique, they have a Centre de Developpement Technologique that promotes commercialization and so on, and this has been a tremendous help. So, they've been behind us all the way with these things.

Bale:

My hat’s off to them, and I hope they see this interview because we think very highly of them.

Pelton:

And the students, too. Some people from the ROC, that's the rest of Canada—

...think the French Canadians are very, very un-understanding, if you don't speak French, they just snub you, but it's just the opposite. They are very, very accommodating. The first year I was there, I wasn't a Professor, I was a Research Attaché, but they let me give a graduate course. I gave the graduate course in English. The students asked the questions in French, and it worked out very nicely. But, there was never anybody saying, hey, why don't you guys learn better French**?**

Bale:

No, never.

Bale:

Of the thousands of students, we've met, I've never had anybody complain. They've complained about your French, but they've never complained about mine. I'm just kidding.

I wouldn't care. I actually wouldn't imagine that somebody at an English University, University of Toronto, who spoke English as badly as we spoke French, would have gotten away with the way we did. So, they were very, very understanding.

It's been a pleasure to work there, and that's why we stayed there, because we could have left.

Battle:

You've had opportunities, I'm sure.

Bale:

We've had a wonderful environment to develop our system, the FactSage system.

PART 2

00:21 The Development of FactSage – Forming the CRCT

Bale:

We formed, which year was it, 1980? We founded the research center some 25, 30 years, '86 was it?

Pelton:

I think so.

Bale:

We formed the CRCT, the research center that now operates, and, actually, I believe it was the first formal research center founded in Ecole Polytechnique. We were the first one, and so, that makes us the oldest one.

Pelton:

Ecole Polytechnique has grown tremendously. When we went, it was a very small University. Now, I think it has the biggest, certainly chemistry has the biggest, research grants in total of any University in Canada; it is considered one of the top four.

Bale:

The University of Montreal has got 50,000 students, to give you an idea of how big it is. We were just a small cupola to engineering faculty within that environment. I think we had about 1,200 people.

Battle:

How did the Ecole relate to McGill? I mean, you're physically fairly close to each other, but that's it?

Bale:

One's English and one's French.

Pelton:

Ecole Polytechnique is also quite separate from the University of Montreal, administratively. It's not the engineering faculty in the same way that most universities—

Battle:

Right.

Pelton:

It's an engineering college associated with the University of Montreal. Let's put it that way.

Bale:

But, when you get a degree, it is a degree from the University of Montreal.

Pelton:

It's grown tremendously and is now one of the top four universities.

Battle:

So, Arthur said he always wanted to be a professor; was that your thought as you—

Bale:

No, it sort of evolved. I liked applied stuff. I liked to get my hands and fingers dirty. I built a color T.V. once. I just like to do that kind of stuff. I wanted to build stuff, and I didn't really think I'd be teaching thermodynamics, particularly since I was dead last in it at the University of Manchester. So, this evolved. [crosstalk]

Battle:

It obviously scared you?

Bale:

It obviously scared me, but then something happened. We worked together, and, eventually, I ended up teaching and becoming a prof., and I really enjoyed that. But, the most satisfying thing we've done is developing the FactSage system. It evolved through the years. Little did we know, way back in '76, 40 years ago, when we started it, that it would become what it is. It's got a mind of its own. It's evolved through the years. There was no big major plan. We originally started it as a tool for performing calculations in chemical thermodynamics of pyrometallurgy, high temperature. We didn't realize, eventually we would be moving into ceramics or into steel—

Battle:

Molten salts.

Bale:

Molten salts, and now we're doing work with energy storage systems and all this kind of stuff. I mean, the applications are just very, very diverse. It's great. It's been real fun.

03:35 Partnering with Gunnar Eriksson – Developing Databases

Pelton:

We do have to mention Gunnar Eriksson.

Bale:

Oh, yeah, we're not alone. We're not just the two of us. We talk as if we are, but there are many people involved in supporting this thing. Many other players have helped us develop the Fact, FactSage system: Gunnar Eriksson, GTT in Germany. There are some 10, 15 other people who have contributed largely and extensively to the development of FACT, FactSage. Basically, FACT, FactSage, consists of program software and databases. So, there's two aspects to it.

Battle:

Right. We have to interrogate the software, interrogate the databases, basically.

Bale:

So, for the databases, depending on the database, there are different sources. One of our databases was developed in the US by Philip Spencer, the hard materials database. We have the steel and alloy databases developed initially by SGTE and extended by Philip Spencer and In-Ho Jung. We have developed our own particular databases at the CRCT. Arthur's particularly involved in slags, and the modeling of slags, and so forth. So, we're not alone. There are many other people involved, and we have some great people at our CRCT help us to maintain and to develop the system: some great workers and great research personnel.

Pelton:

Dr. Gunnar Eriksson, in particular, a Swede, he works out of Germany, But, he spent some years with us, and now he spends at least two months a year with us in Montreal. He's the father of the Gibbs energy minimizer, which is the core, the present core of FactSage. He wasn't there in the beginning. And then, he has his general Gibbs energy minimizer called SOLGASMIX, and we helped develop that as well. He's devoted his entire life, started his PhD-- His entire life has been this one Gibbs energy minimizer program, which he tweaks and tweaks, and this is the heart of the Gibbs energy minimization of FactSage. If it wasn't for Gunnar, we wouldn't be here either. So, Gunnar is a major part of the whole—

Battle:

That sounds trivial, but doing that right, SOLGASMIX means so much across metallurgical fields, right? An amazing number of calculations require— [crosstalk]

Pelton:

I think it's the best Gibbs energy minimizer there is. We're trying now to improve it, but it's—

Bale:

We're always trying to improve it.

Pelton:

So, that has been a big-- I mean, Gunnar Eriksson has absolutely been essential to the whole FactSage system. We would be remiss if we didn't give him credit in this.

06:06 NSERC Grant – Formation of Thermfact Ltd.

Battle:

So, if you needed to say, what's year zero, is that when you got the NSERC Grant?

Bale:

No, it actually was to develop a Canadian database system. And, I do remember with them; they pointed out that, since two universities were involved, should it become commercial, we should form a third entity that was separate from the two, such that there'd be no conflict between the universities.

Battle:

They were already part of the original grant.

Bale:

They had that spot on. It was Thermfact, Ltd. that we ended up forming. So, they had that right at the very beginning.

Pelton:

Well, they said that we should form a company.

Bale:

And, that was very- it was wonderful advice from them. They had the foresight to see that.

Battle:

So, what was Bill Thompson? He was part of this.

Bale:

He was part of the original—

Battle:

And, where did he fit in in terms of what he was doing in the project?

Pelton:

Well, at the beginning, we were all sort of doing everything. We were all writing programs. We were all developing databases—

Battle:

Running them off each other.

Pelton:

Chris ended up more with the geek stuff. I got into more databases, and then Bill left. He left Montreal.

Bale:

He left in 1980.

Battle:

He went to Queens?

Bale:

Yeah.

Pelton:

He went to Royal Military College and also Queens.

Battle:

And so, he was kind of—

Pelton:

At a distance.

Bale:

And, it just died off then.

Pelton:

Kind of died off.

Bale:

Which was unfortunate, but—

Battle:

When did—

Pelton:

We bought him out.

Battle:

Okay. And, when did Gunner Eriksson— Was he your next— [crosstalk]

Pelton:

'78, '79. The late 70s, yeah.

Bale:

We met him at—

Pelton:

We met him at Stockholm.

Bale:

At Stockholm, at a CALPHAD Stockholm conference. At the time, he was handing around these computer cards on the SOLGASMX program that he had at the time. Bill Thompson ended up getting a copy of the cards and using them. So, we worked from a long distance. It was an arm's length relationship. We [weren't] directly involved with each other. It was only in 19-- What, in the year 2000, 2001, that we-- the FACT system, and the German, the GTT systems, what they call ChemSage system, that Gunnar Eriksson was involved in, that we had a fusion. We collaborated together to form FactSage. That's 2001. And so, such that this would formally cement the relationship we had with Gunnar and his program, so we would share.

Pelton:

We shared his program in FactSage before in FACT, before that.

Bale:

But, this made it a formal relationship with them.

Pelton:

Gunnar was the next major step. We couldn't go further without that.

Bale:

No, no, we couldn't.

Battle:

Now, when you were doing this work, and getting more and more to the computing stuff, were you unusual in your department? You know, your colleagues say, what do you, spending all your time playing, or was that—

Bale:

I do remember, originally, before we formed a research center, the CRCT, which is basically computing. I do remember in the late '70s, my professor from Toronto, my former Professor Jim Toguri. I remember once he said to me, when are you going to do some real stuff? When are you going to do some real research rather than wasting your time playing with computers? I remember that. And, I couldn't answer the question at the time.

Battle:

Did he change his mind later?

Bale:

I never—

Battle:

I don't know?

Bale:

I don't know.

Pelton:

Oh, yes, he changed.

Bale:

Oh, yeah.

Pelton:

FactSage was really moving in 2000, and we applied for an NSERC CRD Grant, Cooperative Research and Development. We got a consortium of 15 companies around the world together, and then NSERC put in—

Battle:

Matching-

Pelton:

Matching funding. This was of the order of a few million dollars over some years. So, there was a big committee who met, and we had to make our point that we needed the money. And, some of the members of the committee really didn't get what we were doing. We tried hard to--their idea was," Oh, you're just taking numbers out of the literature and typing them into the database. That's not science." Anyway, Toguri was the chairman of the committee, and he stayed up all night—

Bale:

He must have felt guilty at what he had said to me.

Pelton:

He stayed up all night and convinced them that they should give us this three million dollars. That was a major step in FactSage, too because then we hired, for about four years, we hired some of the best people around. We hired Phil Spencer in the US to do the database on steel. We hired our former student, Patrice Chartrand, who then worked to do the database on salts, and we had Dr. Sergei Decterov on oxides. So, the FactSage database really built up rapidly during the time. And, that was thanks to Toguri, else we wouldn't have had it. So, he came around. [laughter]

11:20 Computer Models & Processing

Bale:

Just in general terms, Arthur's mentioning modeling and databases. That's his area of main expertise in FactSage, and my expertise is in the programming. So, I would tend to work with Gunner Eriksson and the programming, and Arthur would be working with the guys and doing the modeling and improving the databases.
That's generally speaking—

Battle:

I think it's important for people to understand that even with the greatest experimental data, it never covers the entire space of composition and temperature you're interested in. You need to interpolate and extrapolate. They can't all just do some linear or something like that.

Bale:

This is where the models—

Battle:

Were there many models when you started? I mean, you developed, codeveloped quite a few models?

Pelton:

You can find different models around that have been developed.

Battle:

But, I mean, say, back in the '70s.

Pelton:

Many— [crosstalk] —expanded the models.

Battle:

When I think of Professor Toguri, I think of the viscosity work they did, which I was involved in, and you ended up putting viscosity into FACT. And, I think a lot of it is because you thermodynamically, can-- We know the silicate structure, and how it breaks down as you go to lower silica and so on, and that is a major part of the viscosity.

Pelton:

That's how the viscosity model works. We, first of all, take the thermodynamic database from the model that tells us how many silicates are joined together, the average size of these silicate chunks.

Battle:

Right

Pelton:

And, from that, we relate that to the viscosity, and it actually works.

Battle:

Yeah, and that's not the first thing you think of with FactSage, is that you can do these kinds of ancillary properties, which, if you're doing a slag, if you don't know the viscosity, you know, you're in trouble, from a practical point of view. So, you've said a bit about this, but, maybe, say a bit more about the unique challenges you faced. You started with card punch readers, but if I remember, by 1980ish, at least we had keyboards. You didn't need the card punch anymore.

Bale:

No, they—

Battle:

It might have been dumb terminals connecting to the mainframe.

Pelton:

But, we didn't have screens, so everything came out on one of these printers.

Bale:

Everything was on [typewriter] printers.

Battle:

Okay, the teletype. Yeah, I felt like you were in a newsroom, you're hearing the [makes typing sounds].

13:54 Personal Computers – Changes and Challenges

Bale:

The biggest changes for us came through with the personal computer in the late '80s. That's when we could then move away from doing all the computing on a mainframe, to putting on our own computer, own personal computer, and do everything. That involved other challenges, and we eventually had to use Windows programming. So, I learned Windows programming. These were challenges for the time, and then we ended up using the various languages they use for Windows programming, Visual Basic, C++, and all these other, Pascal, Delphi. So, we ended up having to master these and apply them.

Battle:

So, Fortran code at the core is gone? There's nothing left?

Bale:

This is really interesting. Okay, people have learned Fortran, love the Fortran, because it was so efficient, and straightforward, and simple. It was developed in the '50s or '60s.

Battle:

Right

Bale:

"Hidden Figures," you know, the NASA-- is a good start to how it got set up and wonderful for calculating. Fortran was a terrible language, to turn the program from a calculating to an interaction. You couldn't create, really, an interaction using Fortran. It was very, very hard to get the Fortran to ask you a question, and you get back, and so forth. You just couldn't do it that easily.
Then, Lahey came along, and that helped us, but it was still always a question that you actually had to develop your program with something else, like Visual Basic, and then tack on the Fortran separately somewhere else. Then Intel had come along, and, believe it or not, Intel invested a lot of money and time in optimizing the Fortran program. They're doing it right now, and the Fortran program is wonderful, and it couples indirectly with Windows Visual Studio. You can go through your code in real-time, or use your Visual Studio, or your Microsoft Windows C++ all together with the Intel interface. And, it's fabulous. And, the final execution of the form of Fortran developed by Intel is like one or two percent of the space required the old thing. It's just marvelous. So, no, Fortran has not died off. Believe it or not, it's been revitalized. It's born again. It's a fabulous language to do this kind of stuff. It's a very straightforward and useful program and easy to debug. In the old days, you'd have to write stuff out to figure out an error and, now, you can step through the program in real-time. We couldn't do that originally. So, that's been very, very helpful. Thank you, Intel.

Battle:

I think that gets to another issue. In the early days, memory was precious.

Bale:

Right, very much so.

Battle:

For storage and so on.

Bale:

Very much so.

Battle:

I remember writing Fortran code, and it allows you to put comments in, but that took up memory.

Bale:

But then, you would use things like common block in Fortran. Common blocks because if you put them together, you can share space and so forth. Of course, now, memory is not an issue anymore. So, of course, maybe your program is not as efficient as it could be.

Battle:

Yes, it forced you then, to be very parsimonious with your code. I'd go back six months later and not remember what I did because I didn't put comments in to save—

Bale:

Yeah, you wanted to be as efficient as possible with the program, and that's changed. And, because you no longer have those restrictions of space, and the computing time is so much [more] rapid- We're not really restricted by the computers anymore, and that was the case for some time. The languages are so versatile that our FactSage system is a nice blend of Visual Basic, C++, Delphi, Pascal, Fortran, and just about anything else you want to put into it. They did this to talk to each other, and it's kind of cool.

18:07 Evolving Computer Technology and FactSage

Battle:

So, we've been talking about how FACT evolved into FactSage, and now it's this entity that's used by how many companies around the world? I mean hundreds.

Pelton:

Several hundred, about 900 users -- half companies, half universities.

Battle:

And, this is all from that kernel you developed in the 70s. When you developed it, you weren't thinking, okay, it's going to be this big thing, eventually, and it's going to require administrative support. And, you've wrestled with computers coming out that can't use your old software. Do you change the software payment models, version, and dongles and things on the computer? All these things have evolved. How have you dealt with the fact that, to make this company, to keep this company going, you have to do things that aren't technical, that are administrative or financial?

Pelton:

There are two aspects, Chris can answer one. This has to do with the fact that computers keep changing, and we have these dongles, these USB security keys, and people want to put it on servers, and we have to have some sort of security. Plus, when we come out with new versions, you don't want to be sending out CDs the way we used to. This has to be done quickly over the internet, and how do we keep up with that without spending all Chris's time doing that? And then, you have the book keeping. We have 900 users, and we come up with new versions every year. They pay update fees, and they have maintenance and support questions. How do we deal with just the straight administration? I could answer that because that's what I've been doing. Do you want to talk about—

20:00 Moving from Floppy Disks to Internet Programs

Bale:

The first thing, with the computing, we have to keep on top of the technology, and we try and make things as efficient as possible. It's easy to say, but in the old days when people were sending updates, we'd literally mail out floppy discs. These little floppy discs.

Battle:

I remember—

Bale:

You remember those floppy discs. And then, eventually, this evolved to CDs. Oh, that was great. We could just send out a CD now. That made life a lot easier. And then, we've evolved to automatically updating. We have it set up on the internet so that you can download the program through the internet if you enter the appropriate passwords and stuff. From time to time, we have to update files. Send people new profiles, update their particular status on the system, and so we tell them how to do that. That will change next year, that will be done automatically by the program, if you're running the program. It'll update just like Windows and IBM. It will just do it.

Battle:

If it may give you an alert, do you want to—

Bale:

It'll give you an alert; do you want this or not; and then you can go ahead. So, that aspect has worked. We try to make it is as efficient as possible, we want people to have access to the system. We want people to use the system; and so, we've come out with an education version. This is important. It's just come out—it'll come out next week. It will be available to anybody who wants to download it through the website. So, from the educational point of view, this is our contribution, to have a free version that's pretty powerful. Pretty powerful, in comparison with the commercial version. So that's coming out next week. As far as security and dongles, this is always an issue. We're going to come out with virtual dongles at some point. There will be no physical device. It'll be a software device. So, this is something that's always being developed, and we always try and simplify.

22:02 The Growth and Future of the Company

Pelton:

Just the complexity, we have like seven or eight different kinds of databases, and different users use different databases. They have to have a profile that says what they can use and what they can't use, and then some user wants to buy this database and stop using that one. And, we're not a big enough company that we can have somebody who does just this, so we end up doing it, and that's starting to get rather heavy. It is getting heavy. In the future, we have to come up with some way — we're going to have to hire personnel to do that kind of stuff, administrative people. In terms of sales, this has worked out very well because we have agents around the world. We have agents in China, Korea, Japan, Australia, India, Europe, a couple in Southeast Asia. They take care of sales and the paperwork down there. Plus, if you're going to deal with those countries, you absolutely have to have somebody in the country. There's no way you can sell anything in China if you don't have a Chinese agent. It's just impossible, the paperwork. So, more and more the agents take care of the sales and the maintenance and support. That's really the only way. We have a U.S. agent and are probably going to get another. So, we've taken care of it that way. But, in terms of the just the administrative and the bookkeeping, it's starting to get heavier and heavier. We're going to have to get someone to take care of that; the trouble is it's hard to— It's difficult to get a new customer who wants to negotiate and talk about things. They don't just want to talk about prices, but what does this do and what does this program do. Do I really need this? So, you need someone who is technically savvy as well as someone who can do the financial part of it. These are very difficult people to find, so this is a bit of a problem, especially since we're retiring. So that's one thing in the future we have to work out. You ask, well, what is the future when the company gets big enough? We're not quite big enough yet that we can have a sales department and a publicity department, but that would be nice. We would have a salesperson, and a publicity person, and a marketing person, but we don't quite do that yet. We do have the next-generation well taken care of. We have two really bright guys that are working now, professors now in our research center, Patrice Chartrand and Jean-Philippe Harvey. And, there's In-Ho Jung, who used to be at McGill; he's now back in Korea, but he is still also very strongly involved with it. And, this is the next generation who can take over, so I think the future in that way is assured. It's not going to die out when Chris and I retire. I think these guys are going keep it going.

24:52 Our Program's Educational Value and the Synergy Award

Bale:

And, its fortunate by the nature of what it does. It really fits in very well with the new university environment because it involves research and development of the program. It involves theory, which is research in the modeling and stuff, and the product has an educational value. And so, the University is very happy we're developing this because we're satisfying all the things they need. We're bringing them in some money because it's sold, brings in money into the University. There are research articles coming out, and it has added educational value. And because of these contributions, we won a really neat award from the Canadian government. You want to talk about that, the Synergy Award?

Pelton:

NSERC, the Natural Sciences and Engineering Research Council of Canada, has a Synergy Award, which is one of the top awards that goes to groups for university/industry collaboration. They give one per year, and we won it in 2013. It was a nice award. You go see the Governor General who shakes your hand.

Bale:

And, we saw the Prime Minister of Canada, hook his hand and had our picture taken with the Prime Minister.

Battle:

With no idea what you had done. [Laughs]

Bale:

Had no idea. Presented to the House of Commons. And then, we got an award, and what was the value? $200,000.

Pelton:

To us nothing, but they gave us research money.

Bale:

To the university.

Pelton:

So, that was very nice.

Bale:

That was a very prestigious award.

26:17 The Next Generation – Chinese and Macintosh Software?

Battle:

Now, I want to follow up on that, but one last question about the software. When you market it in China, is it in English?

Bale:

Well, everything's in English.

Battle:

So, everything's in English. So, at least that's one hurdle. You haven't—

Pelton:

There is a Chinese website, the website is in Chinese. Our agent translated it, so the website is all in Chinese.

Battle:

Okay, but when they run the program—

Bale:

All the science, like Fortran is always in English, it's always, all that stuff's in English around the world no matter what—

Battle:

But, you haven't translated it to Macintosh yet? The Mac world is—

Bale:

You'll have to wait a little bit longer for that.

Battle:

The next generation.

Pelton:

Some people want to put it on iPhones.

Battle:

I want it on my watch. I wanted to push a button, and I get the TiO_2 content of the slag.

27:07 Automated Software – "Alexa Please Calculate…"

Pelton:

What's this one they talk to? Alicia?

Battle:

Alexa.

Pelton:

You could do that. You could say, "Alexa, please calculate for me– what's the slag metal equilibrium–

Battle:

My son works for Amazon on the Alexa team. So, maybe we can, maybe we can have a joint venture here.

Bale:

I'm sure Amazon would really love to market FactSage.

Battle:

I mean, I'd love to wake up in the morning to having it tell me some equilibria operating at the current outside temperature or something.

Bale:

Talk about automation and stuff we offer, one of the things we do offer is an internet service, FactWeb. It's free, and people can go online and do the calculations. In the last 22 years we've had 10 million hits. It's pretty popular. We've set it up now so that, if it goes down, I get an email from the computer. This is automation, so when things aren't running the computer tells me it's not running and sends me an email. This is the sort of way we're making advances in technology, makes things a little simpler. So, when I get home later today after the conference, I hope I don't see half a dozen emails, “Help, help, help.”

28:21 Joint Awards and Recognitions

Battle:

Yeah, so you talked a bit about this particular award. Now, you both received a number of awards over the years from your contributions. Are there any that stand out other than the SYNERGY?

Bale:

Well, Arthur’s had several individual awards, but the other joint award we had was the Falconbridge.

Pelton:

Falconbridge Innovation Award, which I think is the one they gave last night. They don't call it the Falconbridge Award now.

Bale:

The MetSoc.

Pelton:

MetSoc Innovation Award, but it used to be called the Falconbridge.

Bale:

And, in the US, we got the Distinguished Lecturers’ Award.

Battle:

It was the EPD Lecturers’ Award. I think the first time that it was given by two people at once rather than by just one person.

Bale:

That was in San Francisco.

Pelton:

The Innovation Award was the first time they gave it to a University. It had always been given to industry before.

Battle:

Yeah, that was kind of neat.

Bale:

Yeah.

Pelton:

Those were the joint awards we've had.

29:22 Involvement in METSOC, TMS, and AIME

Battle:

And then, you've both been active in MetSoc over the years to various extents.

Pelton:

He much more than I.

Bale:

I was involved for many years with the society. I was involved with the Computer Applications Committee and then the Basic Science Committee. I think you were involved in that at some point. Then I was treasurer of MetSoc for five years, and then I became president in 1989, in Montreal, President of MetSoc. And, I do believe, Tom, that's where I met you. And, if I remember correctly, you were on your honeymoon with your wife, and she's never forgiven you for taking her to the conference. Maybe I got that wrong?

Battle:

Well, the key thing was the accommodations were dormitories at McGill.

Bale:

Yeah.

Battle:

Which is not exactly what she was looking for, but it fit our budget.

Bale:

You say, honey, we're going to Montreal for a good time, and you end up in student accommodations.

Battle:

Well, I was on the male floor, and she was on the female floor.

Pelton:

Oh. [Laughs]

Battle:

So, we have not repeated that!

Bale:

Then, that's where I met you, and I can't remember why, maybe you looked lost. I just don't remember how we met, but I was becoming the President and you were a budding student at the time, and we ended up talking about various items.

Battle:

Yes. Now then, you're both members of TMS; of course you bring in the AIME connection for— since you were grad school, or when did you actually join?

Bale:

I've joined on and off.

Pelton:

I’ve been with TMS a long time. I don’t know how long I've been a member of TMS. We were both on the, I’m sorry, ASM—

Bale:

We were both in ASM for years.

Pelton:

ASM years ago, had an alloy phase diagram program—

Battle:

Right, right.

Pelton:

We were category editors for that.

Bale:

For alkaline metals.

Battle:

Is that still around? The Bulletin of Alloy Phase Diagrams, is that being—

Pelton:

Yeah, I think the Bulletin is still around.

Battle:

I think that's what they called it.

Pelton:

Plus, they published a couple of big thick things. Anyway, we were category editors for alkaline metal binary systems, and we were supposed to do all those. That has been my major interaction with TMS, I guess. At MetSoc, I was technical chairman of one of the meetings when he was the President or Vice President.

Bale:

And, that's many years ago.

31:40 Society Conferences and Workshops

Battle:

But, I've certainly seen you at enough TMS meetings where you've come to present or—

Bale:

Workshops.

Battle:

Oh, right. You've had workshops for the software. Now, how has your presence at TMS complimented your MetSoc involvement? Is it kind of a different demographic to you, or…?

Bale:

It's a question of size. For example, here in Ottawa, we have the TMS people here, and it's a little cozier, a little smaller. Seven hundred people in comparison to, what, 3,000 when we were down in San Diego, or 4,000. So, that's the big differences there. They're both great, it's just one's a lot bigger than the other. One thing I did notice here is what they have for the exhibits, it's in a nice cozy central area where you can get your coffee, and your tea, and your drinks and stuff, and a lot of people are milling around in that central area. But, I remember, for example, just last year in Pittsburgh, you had to go to a different floor in a different cold area. And, there are lots of exhibits, but it wasn't close by. I guess it's a question of size and being able to squeeze them in, but if you can compact everybody in, right in the middle of the meeting, I think that would add a lot. And, the exhibitors would be happy with that because it's busy here at the exhibition. You go inside there and everybody's— Oh, and another thing too, is in the hotel, there are no seats anywhere unless you go into a lecture or you go to the exhibition. That's what they should do. Hide all the seats, and put them all in the exhibition. That would get a lot of people in there.

Battle:

Yeah, seats and food? Well, and drink for—

Pelton:

And, the food was good.

Bale:

The food was very good.

Battle:

Yeah, and this is a different type of conference, and we've spent, with TMS, MetSoc, and SME; spent 15 years really trying to find a way to get together because we program separately from each other. And, if you're an extractive person, and you really want to keep up, you've got to go to all three meetings, plus maybe AIST. And, the idea of having us try to do it all together— and the only complaint I've heard for the three days is there's too many good presentations at once and you can't—

Bale:

That is true, and the presentation—

Battle:

That's a good problem to have.

Bale:

And, the attendance is excellent.

Battle:

Yeah, so.

Bale:

I mean, you go to an education meeting at eight o'clock in the morning, and the room is full. You can't get in, and there are over a hundred people there. I mean that's fabulous. It's great. I think this is a wonderful idea.

Pelton:

The MS&T meetings have just become way too big, and they're not much fun.

34:20 The Company's Line of Succession

Battle:

Well, then my wife talks about Pittcon or something analytical chemistry, and there's 30,000 people at the conference. You know, how do you get anything done? So, we talked a little about your succession planning. When did you first realize that, you know, this might outlive us, and we may need to have, rather than retire, and okay your work's done and—

Pelton:

Fifteen years ago.

Bale:

Oh yeah, many years.

Battle:

It built enough that—

Pelton:

Well, my best student ever, Patrice Chartrand, right from the beginning, I thought, "Got to keep this guy here." Right from the day he started his doctorate, so now he's a professor, and he's co-director of the center now. And, he got a student, which would be my—

Battle:

Your grand student.

Pelton:

My grand-student, and he said the same. He said, "We've got to keep Jean-Philippe here." So, he sort of groomed Jean-Philippe all the way through, and he's finally become professor.

Bale:

Both guys are really smart.

Pelton:

It's taken years. You can't just hire somebody. It has to be somebody that has been trained in the environment for a long, long time. So now, we have that. And, there's professor In-Ho Jung who is another one of my former students from Korea. He was a professor at McGill, and now, for various reasons, he's gone back to Korea, which makes it a little bit harder to collaborate, but he's still part of the central team.

Battle:

Well, he doesn't have to call in to McGill on the dedicated phone line.

Bale:

That's true.

Battle:

So, it is a little easier.

Bale:

That’s true.

Pelton:

And, the telecommunications these days makes it awfully easy to collaborate long distance, and it's—

Bale:

And, it costs nothing.

Pelton:

Even when In-Ho was at McGill, we hardly got together face-to-face. He was across the mountain, and we would talk to each other on the phone or on the computers. It isn’t all that much different now that he’s— You can do things a lot at a distance these days. Anyway, I think we have the succession worked out.

36:27 Retirement – Working for Fun

Battle:

So, you two now, you’re Emeritus Professors. So, you’re retired in a sense, but you're still going into the office.

Bale:

Retired. When did you retire? 11 years ago? We've been retired for years. How long have you been retired? I've been retired 11 years.

Pelton:

Since 2007.
So, he's been retired 12 years, I've been retired 11, people don't realize that. We're not being paid anything.

Battle:

Just doing it for the fun.

Bale:

No, the University has been very good to us. Although we're not formally on staff, and we're retired, they still give us an office and space and secretary and stuff because they appreciate what we're doing. And, we very much appreciate the fact they give that to us. We can come and go as we see fit, and, as you know, a lot of my time is not spent in Montreal, it’s spent down south. But, they’re very accommodating.

Battle:

Well, down south is Windsor.

Bale:

Down south is Florida. [Laughs]

37:24 Most Meaningful Part of Career, Each Other – The Odd Couple

Battle:

Yeah, so I think it's appropriate now to kind of wrap up things.

Battle:

So, when you look back on all those years, you know, what's been your favorite part or what do you think is the most meaningful part of your careers?

Bale:

I think the meaningful part is the relationship I've had with Arthur. So, its 50 years we've known each other, and I really value his friendship, and I've always valued his opinion. We look at things differently. We complement each other in terms of how we think about stuff, and so, I value that, and that's really led to our success. But, the thing that really turns me on the most is how much people have appreciated FactSage. People come up to us in the conferences and say, “Oh, you're one of the developers of FactSage; we really like it.” And, there's a wonderful sense of accomplishment, and a sense of satisfaction that we’ve achieved something that's really useful, and it's still growing. And, we know it's growing because we can see the numbers on the computer of the people who use it and so forth. So, that is the biggest satisfaction to know that we, this thing that we've developed, it's still growing and very much appreciated. And, we get a nice warm feeling when people say that they're happy with it. Very satisfying.

Pelton:

Chris says people call us the odd couple.

Bale:

We know who's odd though—

Battle:

Well, you have the same sartorial splendor from that wedding picture that you sent us.

Pelton:

We complement each other. We rarely come to fisticuffs.

Bale:

We've never argued.

Pelton:

We seem to get along. I think as Chris said it— well, the nice thing about FactSage is you do work, and then you can see it being used, and you feel that what you've done is being of some use to somebody. That's the satisfying thing that I've done. I think this is a good thing I've done, but other people seem to think so too, and that kind of validates the fact that I haven't just been wasting my time. I've been doing something that's done some good somewhere.

Battle:

And, I think one of the other benefits is this isn't just valuable to people who've been in the field for a while. This is an educational tool, right? I'm sure you've used it in classes for years. You have this new version coming out, you were saying. But, I just think of the questions that when, you know, you were superseded by Gaskell, probably in a thermodynamics textbook. But, he couldn't ask really complicated questions, you know, for homework because people just didn't have the time, but now using the software—

Bale:

You can do really deep stuff.

Battle:

You don't have to necessarily know the grunge— They should learn the grungy details because that's the fundamentals to all of this. But, to be able to do some really complicated but realistic problem where they see this isn't a made-up problem. This is a real problem faced by industry. You can use your tool to help get the answer.

40:35 Advice for Success – Delegate, Delegate

Battle:

So, this will probably be viewed over the years by the students, the ones who are going to take our places, our grandchildren or great-grandchildren. Do you have anything, any advice? What will help them be as successful as you? You have to get lucky; it sounds like.

Bale:

You have to get lucky.

Battle:

But, you got to be looking for it.

Bale:

Yeah, the right place at the right time, and timing and luck counts. And, you have to have a good idea, and you have to just go with it. If you feel as though it's a good enough idea: think you're going to be a great golfer or a great tennis player or whatever it is, you go for it. You may, you may not succeed. We've been very lucky. Very, very lucky.

Pelton:

I was always self-confident. Being overconfident is better than being underconfident. Things aren't usually as hard as you think they're going to be.

Bale:

And, go against the grain. If people say, "Well you shouldn't be doing that, it sounds stupid," like Toguri told me one day. I thought, "I'll show you." So, if you believe in yourself, I think that's the bottom line. You've got to be lucky, the timings good, and you have to work with good people. You can't do it all by yourself.

Pelton:

They had a little party for me for my 70th birthday, and they asked the secret of success. I said, "Get a bunch of good people, and get them to do the work." But—

Battle:

Delegate.

Pelton:

Delegate, but make sure you've got good people doing it.

Battle:

Yes, before you delegate, make sure they can do it.

Pelton:

If I can compliment myself, one thing I've done well is getting good people and getting them to do the work. Yeah, this guy, and Patrice, and Jean-Philippe, and Gunner, and Sergei, and In-Ho. Yeah. A lot of really good people—

Battle:

Yeah, I, if you were—

Pelton:

These are all good people; we have great people—

Bale:

Great people.

Pelton:

Great people working with us.

Bale:

And, they love what they're doing. We're a team.

Battle:

Yeah, and there are enough people like you who have built companies who have ended up having nervous breakdowns practically because they kept trying to do everything. Even when it was a bigger organization.

Bale:

Yeah, that's an important point.

Battle:

You have to learn what you could—

Bale:

We stayed with our core business, which was thermodynamics and equilibrium, and we haven't moved on to diffusion or kinetics and other areas. We stayed with our core stuff of thermodynamics.

Pelton:

The only problem I have with the succession team, is that they want to go a bit wider. I keep saying depth first, then breadth. If you don't have the depth or the quality, it doesn't matter how wide it is. So, don't try to do everything. Get something you do really well, and then do better than anybody else.

Battle:

And, you have the advantage that there are 92 stable elements in the periodic table. So, you're not done until you have the multi-phase solution for all 92 elements together.

Pelton:

Let the good people do their own thing too, don't try to be a control freak. Because people don't do very well when they're told what to do. They do well when they—

Battle:

You tell them what needs to be done, not necessarily how to do it. Right. Anything else come to mind that you might want to say?

Bale:

I do remember crossing the Canadian-US border, and the man in the immigration customs said, “So, what are you?” I said, “I'm a chemical engineer.” He said, “What is your speciality?” And, I said, Sir, my speciality is high temperature reversible chemical thermodynamics.” And, he looked at me and says, “Have a good day, and take it easy.”

Battle:

And, he couldn't be making that up. Well, it's been a pleasure to spend this time with you retracing your journey through the wonderful world of thermodynamics. Thank you very much again for your willingness to share your story with AIME.

Bale:

Thank you for the time.

Pelton:

Thank you for having us.

Bale:

Thank you very much.