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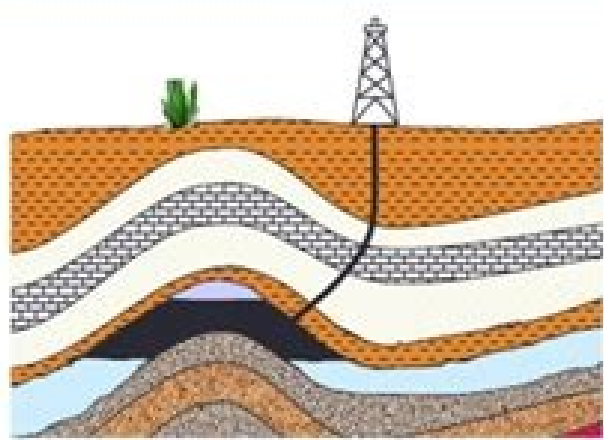

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BASIC GEOLOGY

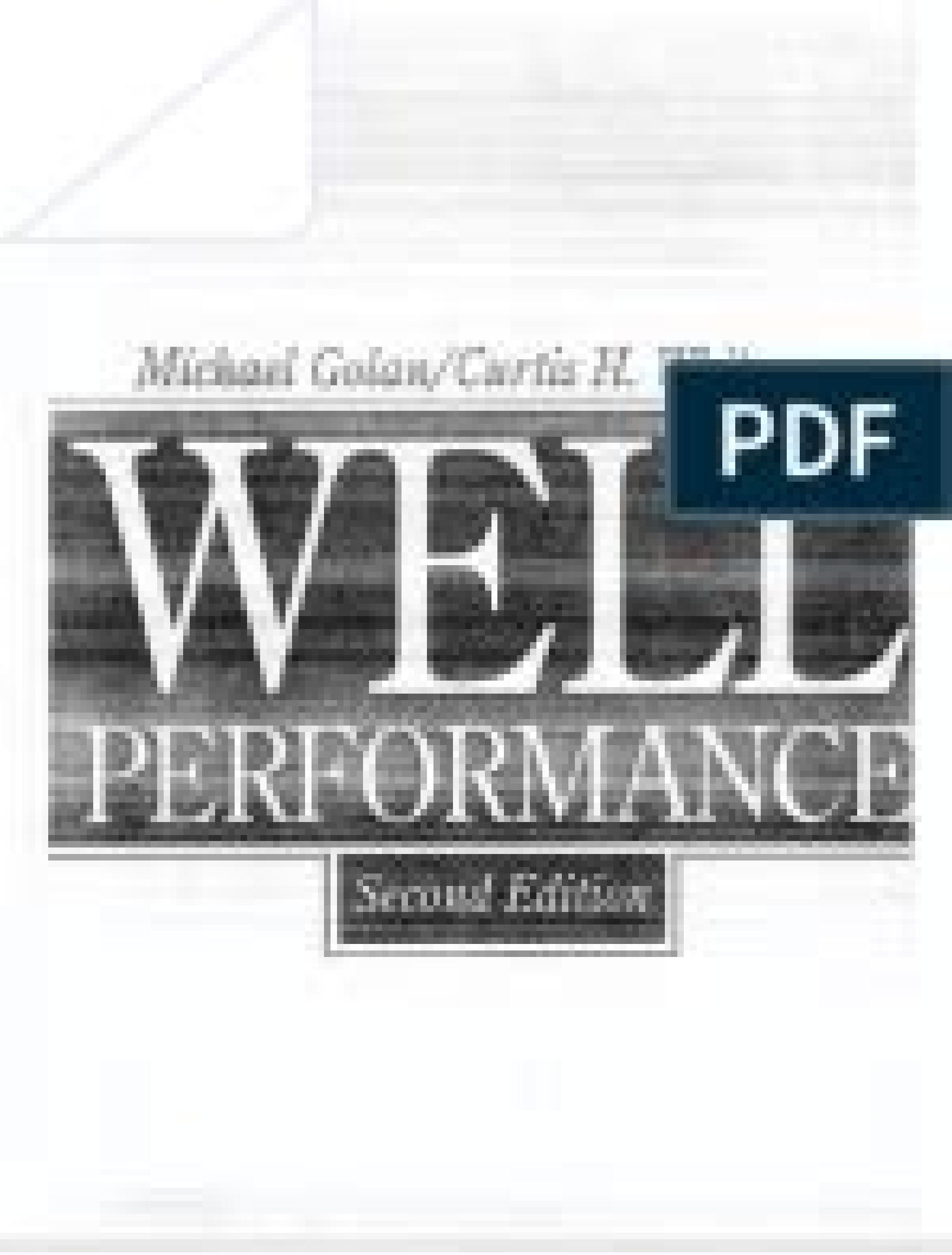


Learning Objectives

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- Explain the main types of rocks
- Identify rocks by their lithology
- Explain the two main physical properties of reservoir rocks
- Describe four geological components of a prospect
- Illustrate different types of petroleum reservoirs
- Describe structural features that affect drilling
- List methods used for evaluation during drilling





What has been your philosophy towards your professional growth and what personal and professional goals are you working towards? Okay, that's why the first question that I asked, you were quite frank; even regarding the politics on campus you were quite frank. Just this past month I think, there was a reprints volume I compiled on 3D interpretation that came out for the AAPG. At Penn State I was integrating 3D seismic data with core and logs and started integrating production data. Work hard. Bruce, was there any question that you expected me to ask and I didn't? The geosciences will provide a world of constant discovery and challenge. Do you see anything coming along like 3D seismic did in the 1980s? So you spent your sabbatical assessing work situations right there and now, since you liked it so much want to make that move? I feel like I've put in a lot of time and effort trying to do things that will help the industry and it hasn't felt like a two-way street much of the time. When I moved to New Mexico, I was hoping to keep going on seismic stratigraphy, integrating logs, core and 3D seismic data, but I kept being offered projects on things like fractured reservoirs, porosity prediction in carbonates, structural interpretation and other things. The theory of plate tectonics is a good example of how empiricism can lead to wonderful new discoveries. That is because when people out there hear about the Petroleum Industry it is related to wars, climate change, pollution, corporate profits and stuff like that. Athabasca or? Let's start with lifelong learning. Working with seismic attributes in general. In principle, the porosity should be best developed at stratigraphic levels that have primary depositional fabrics that are conducive to letting the porosity-generating fluids enter. Hopefully that is going to change. In much of Canada and the United States, there is a prevailing wisdom that fundamental research is great and applied research is not real science. In most Universities the Profs end up having to do a lot of the administration, and so I have had various types of administrative roles in the Department. Thereafter the geophysicists do the "complicated" stuff like predicting physical properties and the geologist doesn't get involved anymore. We also have been using forward modeling to study attributes. You enjoy publishing? Pertaining to geology? In terms of graduate students we've got about forty or so. Even doing something simple like generating zero- offset synthetics that tied to the seismic data was a problem. Keep jumping on new learning curves, continuously re-invent myself. It was kind of a test drive to see how things would go and you know it was great. I am not sure about the Mining Industry. This year I am the Undergraduate Director which means that when undergraduates have questions about which courses they should take and those kinds of things, they come to me. To me, as someone who has spent a lot of time working on stratigraphic problems, the stratigraphic complexity of reservoirs is commonly overly simplified by users of this approach, but those simplifications make the physics tractable. Working hard and having fun aren't necessarily mutually incompatible. What work did you carry out? The number of ways in which Mother Nature has arranged rocks of different physical properties is nearly infinite, and so trying to be predictive and specify a limited number of stratigraphically significant attributes that will work in all settings is not possible right now. It is a three- year program in Quebec, there are only about ten students per year - undergraduates - and most of them want to go off and do hard- rock geology or environmental geo chemistry. The short courses that you are putting on are helping? When I saw an opening for a sedimentary geologist at McGill in 1999 I figured I'd apply for it, and I ended up getting it. There was a constant stream of in-house talks about different aspects of the G&G business. Which is difficult. Then I asked her to use that result to help interpret the geology. As I have moved around from being somebody working on carbonates to somebody working on fractures and lately somebody working on deep water clastics. It got me using side-scan sonar imagery, bathymetric profiling and taking core. I just generally love what I do and in that kind of case it's not work and it's fun. It's getting tougher and tougher to find Canadian graduate students because of the way the Mining and Petroleum Industry work in this country. In general terms they all sound like clichés. Sometimes you make mistakes, but hopefully you don't make the same mistake twice and you learn from your mistakes. It is going to be published by AAPG on CD so that I can have unlimited colour and movies and various other things. As such, my philosophy has been to try to image the porosity using various combinations of seismic attributes. So that's my new thing that I want to do. Strumming guitar - I am a strummer not a virtuoso guitar player, masters swimming - I've been doing master swimming for the past 7 or so years, and then on top of that and work I've got three kids and that doesn't leave me much time for much else. Well when one takes such a step, one looks at it in totality, so that's a good decision. Interesting. His excellent communication skills, and lucid style of presentation, have also seen him being invited for several keynote presentations, both within and outside the United States. So that's good, but I am now writing a book to be titled "An Introduction to Seismic Interpretation". They came and went, that's right and now I still see that there are people in some business units and in some companies who aren't doing the fundamental things right. It's a tough sell out in Eastern North America doing something that is petroleum- related. An interesting aspect of Bruce's work is that being well-trained as a geologist and having researched in different areas in geophysics, he understands the exact geological basis of the objective and is then able to achieve it by successful application of geophysical principles. I received my Bachelor's Degree in Geology from McMaster University back in the early 80s. And obviously the next step would be from Associate Professor to become a full Professor at the University? And at least they are all classics projects. It has been a really satisfying thing to see that take off. In terms of the types of things that people are looking for - I talked earlier about Applied Research - there seems to be some places that are doing well--Calgary, Edmonton, even Memorial and Dalhousie are doing okay because they are in provinces where the provincial governments recognize the importance of supporting petroleum-related research. Hydrothermal dolomite reservoirs are major hydrocarbon producers in North America and are receiving increased exploration attention around the world. So they came and went. From a stratigrapher's perspective, that might be an acceptable approach for a few reservoirs in a few places, but generally it's a bad reservoir model and all you need to do is look at a few outcrops before you realize that the stratigraphic record isn't always simple. I've got another student, Javier Herbas, who is working the North Slope of Alaska and... From there I went on to do a Ph.D. in Geology at the University of Western Ontario. Within the fault networks you need to look for places where you've got extension, because it is in these areas that faults and fractures tend to be open, and allows the fluids to either move up or down. Bruce, let's begin by asking you about your educational qualifications and your work experience. I think somehow during my Master's I realized that research was a lot of fun. It's a really great and rewarding experience. So were you always looking for a teaching job, or it just happened for you? It seems that you can get money thrown at you that way! If you are not doing those kinds of things it's tougher. I saw an opening in New Mexico at the New Mexico Bureau of Mines and applied for it and got it. What we have done is to try to enhance the frequency of the seismic by whatever method, provided it doesn't distort amplitudes, that could still give you some reasonable information in terms of the layers - say the top of the base of a reservoir. At some level I am still a stratigrapher, but some people think of me as a carbonate guy, or a fracture guy. What are your responsibilities? Here in North America, and in particular Canada, it's also getting tougher and tougher. So that might be something in line with the work you are carrying out to understand the stratigraphic layers or stratigraphic information within those boundaries. It also seems that many companies in Calgary can't see past the Saskatchewan border when it comes to supporting projects. Tell us about the Department of Earth and Planetary Science at McGill. I would like you to comment on the campus politics that prevail in every University big or small, and how it affects the teaching in the department and the students. Have you been working on these and textures and spectral decomposition and all the rest in seismic interpretation? The industry is full of fabulous people that can be very helpful, and you can learn things from them and sometimes help them in return. I have noticed over the years that there are people who are strong proponents of things they call physically significant attributes. I found an attribute called "sweetness" to be incredibly useful for defining depositional elements in the deep water environments. We have found that reflection strength is commonly a great attribute for predicting where the porosity is going to be. Sometimes things work out and sometimes they don't. I mean about the program that is being offered and what type of research that is being carried out and what sets it apart from other universities. Lateral heterogeneity over spatial scales smaller than the Fresnel zone will reduce amplitudes in the stacked data. The empirical evidence for plate tectonics was overwhelming long before the mechanisms for how it works were established. For somebody like me, who uses seismic data to study sedimentary, structural or petroleum geology, there hasn't been anyone to collaborate with. The university has high resolution standards, so they get very good students but it's a very small department. You get to meet young people in places like Kuala Lumpur, Cairo and Copenhagen, not to mention Houston and Calgary, and hopefully teach them things that will help them throughout their careers. AAPG has a reprints series on CD that they are calling "Beginning in..." on various topics like deep water clastics or carbonates. My impression is that if a geologist works with seismic data, and many or most do not get access to those data, they will do a basic interpretation, perhaps helping to pick the tops and bottoms of layers. It was the early 90s and Departments were closing down and laying off people. I mean we've found some success in this area, especially with curvature to see channel definition - how the layers are arranged so that comes out nicely. Have fun. The acoustic impedance inversion is showing pretty clearly where the unconformity is but it's not very helpful for distinguishing sands from shales in the overlying clastics of the Mannville because of the low impedance contrasts between lithologies in that interval. Hopefully, that's right. For years now people exploring for hydrothermal dolomites have recognized that you tend to get low amplitude areas, including positive and negative amplitudes, peaks and troughs, where the porosity is developed. They hire people with undergraduate degrees and so we have a problem trying to convince Canadian students to stick around when we can pay \$18,000 a year and the companies are saying, "Don't do a Master's, we will pay you \$80,000 a year." So in terms of getting home grown graduate students it has been really tough lately. If you are a really, really good geoscientist with a great publication record you can get maybe \$27,000 a year which is enough to fund one graduate student. I guess besides teaching there would be some research component to it and apart from that what else do you like to do? Sabrina's study is a case like that. Well financially it is also going to be much more rewarding isn't it? My Ph.D. was in sequence stratigraphy and sedimentology. And then in the late 90s I was looking for ways of identifying subtle structures in fractured reservoirs because I thought they would be areas where you could have higher permeability associated with fracture swarms. These people are looking forward. You might also touch upon things like funding problems, problem-oriented research--you have alluded to this a little bit but I was looking for a little more complete answer. West Saskatchewan. If you work hard chances are you are going to do well and that will open up opportunities for you. There are many people who aren't even using standard interpretation techniques properly and to me that's what I tend to like focusing on - bringing people up to speed on what they could and should be doing. Lately I have been teaching week-long short courses on seismic interpretation, six or seven times a year in various parts of the world and that has been really satisfying. That you helped build up last summer? Financially it is more rewarding than that's right, but that's not the main reason for leaving McGill. Tell us about the work that you published recently in the TLE. I don't quite understand how the Mining Industry funds projects and so I don't quite know whether people who are doing mining-related research are doing well or not. I've got a Master's student, Melik Smaili, who has just started with me and is doing some acoustic impedance inversion work to image the unconformity of the attribute studies, or look at the results of the inversion, because they will learn something about the geology that they couldn't have learned working only with logs and core. You end up taking people who come from different places and you are not always sure what you are getting. Meet people, network... lesser and lesser? Which can be very experience. I like that. Your research interests include areas like 3D interpretation, integrated reservoir characterization, sequence stratigraphy and fractured reservoirs; tell us how you developed these interests. The empirical approach that my group and I have been using has been very eye opening. If you want Federal Government funding the best thing to do right now is to do something that is related to climate change. Yes. I decided that was something that I wanted to learn about - I got hooked on attributes. These are very, very complex systems and it is not possible to adequately predict the distribution of physical properties using only geologic principles. So last year I was on sabbatical with ConocoPhillips and it was great. Bruce has been conducting a short course on 3D seismic attributes for some time now, which is one of the most popular courses conducted on the SEPM platform in recent years. Tell us some of the memorable moments in your professional life and perhaps a success story you might want to share with us if the two are different. Last year, on my sabbatical, I was employed as a seismic stratigrapher and worked on data from deep water West Africa, Texas, the North Slope of Alaska and other places. They are being left behind, and that can't be good for them or for the industry. I was asked to put together a compilation of influential papers on 3D seismic interpretation. Although I couldn't publish anything from Nigeria, ConocoPhillips generously provided me with access to some 3D seismic data from the Gulf of Mexico that I could use in a publication. There is less and less money and it is getting harder and harder to get. I can't really talk too much about European Universities, but I was talking to somebody from Paris last week and he was saying that in France they are having trouble getting French students involved in petroleum geology at the Graduate and Post Doc Level. They are incredibly complex. In August I am joining ConocoPhillips in Houston. The differences in wave shape arise because of interference effects between closely spaced reflections, in other words convolution. My hunch is that the attenuation is related to the presence of fractures, but so far we haven't been able to examine those effects in any significant way. I'll be in their Subsurface Technology group that acts as in-house consultants, runs training programs and does other things. Yes, that's right. Interesting. Alaska, Alberta and then Saskatchewan. I worked on the Cretaceous Cardium Formation in Alberta and B.C. using logs, core, and outcrops but no seismic data at all. If the quality of the seismic is not good enough to give you that detail, i.e. the wave forms don't have the kind of information to give you the type of information you are looking for, then you could have problems. Now you are working as Associate Professor at the University. A small company here in town has been having problems using conventional seismic analysis to map the unconformity, and they've asked me for help. These people usually limit their attribute work to using physically significant attributes because the theoretical relationships between those attributes and physical properties are well established. After that, and again trying to stay out of the petroleum industry, I got a job with the Geological Survey of Canada on Vancouver Island working on the Modern Fraser Delta using single channel air gun seismic and Hunter profiling, side-scan sonar and sediment cores. So now Melik will be undertaking an attribute study to see if that will help. I think in Eastern North America in general, people who are doing petroleum- related research are the black sheep of the geo- family. I do know about your book on Seismic Interpretation for Geologists that was published by SEBM; apart from that have you published anything in the form of a book? Similarly, sand filled channels from deep water or fluvial systems can be imaged well by the sweetness attribute. From your experience, could you tell us something about characterizing these reservoirs in a general way? Most of these courses were run by geophysicists who would talk to the geologists about the distributions of azimuths in bins and other geophysical things. Yes, and the main goal of her project is to integrate all these different data sets into a coherent reservoir model. What important developments do you think that we can expect in geosciences in the near future? I keep pushing geologists to look at the results of the attribute studies, or look at the results of the inversion, because they will learn something about the geology that they couldn't have learned working only with logs and core. You end up taking people who come from different places and you are not always sure what you are getting. Meet people, network... lesser and lesser? Which can be very difficult when you are in Montreal. What is your general impression about the current state of these Universities in general with respect to Geosciences in particular, not only McGill but all the Universities in Canada; how do they compare with the North American or European Universities? She has done a seismic attribute study to predict lithology and come up with results that are pretty good. I look backwards and I see that there are a lot of people who aren't keeping up. I really got excited about the way you have to try and make all the different pieces fit together. The company also wanted me to put on some in-house training. I think they are also missing some wonderful opportunities, both from the practical perspective of predicting reservoir properties and from the theoretical perspective of tackling a rich scientific problem. My thought is that the mining industry works in slightly different ways. That's very interesting. What's my salary going to be at ConocoPhillips? The hydrothermal dolomite folks says that the fluids come from below, but there are other people who say that mechanism doesn't work - the fluids must come from above. He has published and presented several dozen papers at the AAPG, SEG, CSEG, CSPG and other Conventions/workshops. He has received many awards, some of them being the SEG best reviewer for "Geophysics" award in 2006 and Distinguished Educator Award, Southwest Section AAPG 2002. She has been looking at cores, 3D seismic... The geochemists love it because they are surrounded by other geochemists. Keep an open mind. There are some people who get strongly into geochemistry, or geophysics, or structural geology, or whatever, and they come to think that their approach is going to give them all the answers all the time. Bruce Hart is a well-known geoscientist who has been working on the application of data driven solutions to exploration problems. I had excellent quality data and there were wonderful submarine channels in the data. Started talking to him and started getting interested in using curvature. I decided to call attributes that result in stratigraphy "stratigraphically significant." There are not a lot of people who are looking at how attributes can be used to distinguish between different types of stratigraphic successions, even though those differences can be very important on the reservoir scale. They'd had various people do attribute amplitude extractions and found various features but they didn't have a coherent stratigraphic framework for the level. That sounds real good. I've been teaching the course since 2001, and so it's all roadtested material. It was just fabulous, and refreshing, to be surrounded by people who are supportive, who understand what you do, who can answer your questions and will ask you questions. More recently, he has revisited a newer attribute called "sweetness", which he has shown can be used in a semi-quantitative way for detecting channels and other stratigraphic features when such features can be distinguished from background lithology, by a combination of complex trace attributes (frequency and envelope). Bruce when you look back on your career so far what have been some of the successful landmarks for you? I know there are people who are constantly coming out with new technologies and approaches, things like spectral decomposition and pre-stack inversion, new ways of looking at the seismic data. We end up getting new geologic insights this way. So that said, if you look at logs from a hydrothermal dolomite field there are places where you find porosity at the top, or in the middle, or at the base, but there are also places where you find porosity through the entire interval, or perhaps the porosity is not present at all. So do I. In the recent past I have had students doing porosity prediction in Jurassic carbonates, working on hydrothermal dolomites and other things. Bruce's work on seismic attributes as a whole has been remarkable and is a very significant contribution that has gained widespread application and notice. So all of this means that someone like me fights a lot of uphill battles. So you will be going to Houston? One last thing has been teaching short courses. There also seem to be attributes that are related to attenuation that keep coming up in our empirical studies. NSERC funding is drying up. What are some of the projects that you have been working on with your students? In a recent publication we have put in a couple of examples to explain such issues. There is undergraduate teaching, and typically I teach three undergraduate courses a year. This usually means starting with amplitudes derived from pre- or post-stack analysis. For example thin layers of porous rocks interbedded with tight units cause interference effects, and so the amplitudes go down. It was an interesting experience to go from the great seismic data quality of West Africa to the poor quality seismic data of East Texas. You see low reflection strength associated with the faults. "Stratigraphically significant attributes," that was a nice paper, we like the idea that you explained but--maybe you would like to explain it more? Well, I got my Master's degree on modern sedimentology. Later I developed some free ware that somewhere between 350 to 400 people have e-mailed me for a copy of. It's a different viewpoint than the answers I normally get to this question. So in the June 2008 issue of the AAPG Bulletin I have a paper that describes what sweetness is, and tries to illustrate when it is and isn't useful for defining channel systems. As I was preparing for that I watched various videos and went to various presentations that were introductions to 3-D seismic interpretation. I saw a presentation in 1994 at a Landmark Technology Forum where people were working with instantaneous frequency, instantaneous phase and reflection strength - things that I had seen buttons for in the software, but I didn't really know how to use. I helped run a short course for the first time in 1995 with Bob Hardage, then started doing courses and workshops on 3D interpretation in the late 1990s. Okay, Lloydminster? And so if you are doing applied research you are sometimes not valued by the Administration or your colleagues and that can be very frustrating. I worked with data from West Texas, the North Slope of Alaska, and the company's heavy oil areas. Okay, you have done a lot of work on hydrothermal dolomite reservoirs. Bruce you have been a proponent of the use of seismic attributes in seismic data interpretation. The geologists in the crowd would roll their eyes back and fall asleep, right? I think it's fascinating and rewarding to be constantly jumping on learning curves. Last year, while on my sabbatical in Houston, I presented a paper at a Geophysical Society of Houston Symposium in honour of Tury Taner. Similar attribute studies that Bruce has taken up, have been aimed at quantitative applications that include prediction of physical properties such as porosity and lithology of reservoirs, which are very useful. Some people get to a point in their career where they want to be recognized as the expert in their specialty and so they may be afraid to try new things and to show ignorance by asking questions. Following are excerpts from the interview. I've been getting paid to do what I love doing and that's great. Then I try to find graduate students. To me, that means not being afraid to ask questions. Yes, my time at McGill has been a very unrewarding experience for me. Bruce, what are your other interests apart from the science that you practice for a living? I am not afraid to ask questions. McGill's main focus is geochemistry and hard rock geology and so for me it has not always been a satisfying experience to be at McGill. Coherency attributes are very helpful for that purpose. I think they are great. I notice that you are quite active in publishing your work. In Houston. There have been some companies that have been supportive but on the whole most of them haven't been. Right. Keep going. In addition to the sedimentary group I was in there were structural people, petrophysics people, the seismic analysis people, the acquisition people and other groups nearby. It's very clear that the fluid flow is intimately related to fault networks, so you have to understand and map out the fault networks. I worked on a project in deep water West Africa. Reflection strength is amplitude independent of phase, and so you see these areas of low reflection strength where the porosity is present. I'd get bored if I did the same thing for 20 or 30 years. I was quite happily employed there but my kids were growing up not knowing their aunts and uncles and cousins (my wife and I are both from Eastern Canada). By 2000 I had started doing inhouse courses and now I am doing six or seven a year around the world. I had gone from being an Undergraduate who wasn't always the best student to learning that through hard work you can learn a lot of fascinating things. I mean, in the late 90s, people were saying that visualization and visionariums were going to be huge. Again, no openings were coming up in Canada for stratigraphers at that time. I wanted to talk about some of the attribute work that my students and I have been doing over the past 10 years or so, and I called the talk "Seismic Attribute Analyses: Observations of an Empiricist." I tend to be not afraid to try things, find out what works, and then figure out why it works. Bruce was in Calgary during the month of May 2008 to deliver an invited talk at the CSPG Luncheon, and Sinder Chopra was able to sit down with Bruce and interview him. Then I worked in a field in Central Texas where the seismic data was "quality challenged." Very bad multiples, low acoustic impedance contrasts between the sand and shales, and even the logs were bad because the interval is over pressured and hot, making it a hostile drilling environment. I needed to try to find money to buy equipment and so I took on some of these projects and a lot of them worked out, which meant that people asked me to follow up on them. What would be your message for young entrants to geoscience; what are the most rewarding aspects of picking up a career in geosciences? What would you say for the use of more recently developed attributes like curvature? Well, actually the next step is going to be from becoming an Associate Professor to becoming an Industry person. Enjoy it. To me the people who are strong proponents of sticking to only physically significant attributes are running away from the physics of how the convolution of reflections from closely spaced beds of differing physical properties affects seismic attributes because it's too complicated. It's been an interesting mix. Inversion can only partly compensate for these effects, especially when working with thin beds. Apart from the journal publications, have you published your work in the form of any book? So it seemed to me that there was a need for somebody to speak to geologists about 3D seismic interpretation using language that they could understand. What is it that would attract students to come and work there? To me the thing I am happiest about is the short courses. I was a postdoc and I was trying to get a teaching position at a University in Canada but nothing was coming up at the time. The dolomitizing and porosity-generating fluids move through the fractures and the carbonate petrologists disagree amongst themselves in terms of how the fluids flow. In Canada, because we've got such a strong mining component, people doing mining tend to look down on people who do sedimentary and petroleum things. There are other pots of NSERC money that people go after, but usually the money is for research in a few targeted areas like Arctic research, or climate change. I've got a Ph.D. student, Sabrina Sarzalejo, who is finishing up. Back in 1995, just after I moved to New Mexico, I was asked to put on a half-day long work-shop on seismic interpretation for local Independents. The intent is to make it a publicly available version of the 5-day short courses that I have been doing for companies lately. However, so far, other than curvature, I haven't really had a chance to integrate some of these things into my work or my students' research projects. I was mostly interested in sedimentary geology so I started a Master's on modern sediments at the University of Quebec in Rimouski. (laughter and jokes) I like to think of all the possible questions so--thank you for giving us this opportunity and all the best for your talk today. He has studied such reservoirs in Trenton-Black River, Saybrook, Ohio and made significant contributions. Remember that if you love what you are doing it's never work. Her project is an integrated interpretation of a heavy oil field. While you were on sabbatical last year, what did you focus on professionally? Trying to track down projects is another duty, and so I have been pounding the pavement out here, in Houston and various other parts of the world trying to dig up projects, which means getting funding and data. Geology, and then when I got to the Geologic Survey of Canada I started integrating cores with high-resolution seismic data and side-scan sonar imagery, and I found that kind of integration between geology and geophysics great. You know it's ten undergraduates per year in each of the three years, so the department has about thirty or so undergraduates. There is a variety of reasons why you get low reflection strength values. I saw a presentation by somebody named Andy Roberts, from a company in Norway, who was using curvature to identify subtle faults in conventional reservoirs where they could be compartment boundaries. So that got me working with some of their other data sets, trying to generate exercises for the course. Another philosophical outlook I have was captured by something I heard Henry Posamentier say: If you love what you do it's never work. For somebody with broad interests like me, it was great. I've continued several of those projects at McGill. So now what are your aspirations for the future? For example, the seismic response of a coarsening-upwards package will be different from that of a fining-upwards package. Not only this, Bruce's scientific contributions have crossed over to other areas like coal bed methane and time-lapse seismic. Climate change or environmental change, and especially if you go up North. Oh, you are quitting McGill University? It was pure exploration in an area where the company could be drilling some wells in a few years. Seismic attributes can capture aspects of wave shape, which manifest themselves in terms of things like amplitude, frequency, phase and other attributes. That has been a rewarding duty really, because I get to meet them and hopefully help them. Oh, that 3D stuff that you mentioned in an email? Those changes in reflection shape are the seismic response to changes in physical properties but also to the way those physical properties are arranged - the stratigraphy. I love teaching, but it's been very tough being a petroleum person out in Eastern Canada and in my Department in particular. At the time I wanted to stay away from the Petroleum Industry. Bruce realized the value of curvature attributes early on and developed software for horizon based curvature attributes and not only used this for his own research applications, but had it available on his website for download to interested geoscientists. No, I understand. Wonderful. Another question about the Canadian Universities. So high quality students, but only ten or so graduating each year; is that the maximum you can handle, or are there plans to expand? Nowadays the trend is to go for pre-stack analysis and use AVO analyses to derive physical properties and use those predictions as attributes. I have found myself in unfamiliar places scientifically, and I don't care. I got the opportunity to take a two-year contract position at Penn State working the offshore Gulf of Mexico using 3D seismic, log and production data. Bruce has written two books, one on 3D interpretation and the other on Getting started in 3D seismic. Graduate level teaching is something else, and maybe that means teaching one or two graduate level courses on top of the undergraduate teaching. People in those areas can go for additional NSERC funding and that helps. So then you have to try and hope you can get industry funding if you are doing petroleum work. The presenters were showing how you could use those things to characterize reservoirs and it just fascinated me.

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