

Research in Geophysics at the University of Alberta

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Introduction

The wide variety of research in Geophysics at the University of Alberta includes both applied and more fundamental studies. The core faculty of solid earth Geophysicists are in the Physics Department but workers are also scattered throughout other departments and faculties. There have been many changes at the University of Alberta over the last five years and this is a good opportunity to update the community on current research. In this report, I will give some history of Geophysics at the U of Alberta, briefly describe the research programs of the current faculty, the research topics of graduate students, and give an overview of the infrastructure to support this research.

People

The group in Geophysics at the University of Alberta has had a nearly complete turnover in staff in the last few years and is still in a rebuilding phase. This makes it important to briefly review the group's history before describing the present rapidly evolving state of Geophysical research.

Geophysical exploration techniques played a key role in finding the initial large oil discoveries at Leduc during the late 1940s. This motivated the appointment of the first position in Geophysics in 1954 to Dr. George Garland who worked on potential field measurements and set the stage for further growth. A list of faculty that worked at the U of Alberta (Table 1) illustrates the pattern of growth. Early researchers carried out a wide range of studies that included potential fields (Garland), geochronology (Lipson), electromagnetic methods (Vozoff) and seismology (Cumming). Ernie Kanasewich carried out his M.Sc. work on gravity surveys over the Athabasca Glacier under George Garland's guidance during this period.

Examination of Table 1 shows a rapid growth in the Geophysics group from the late 1960's through the early 1970's. This growth was accompanied in part by a large grant obtained from the National Research Council in 1969 to establish the 'Institute for Earth and Planetary Physics' with Jack Jacobs as the first director. This allowed the group to bring in a number of visiting assistant professors, postdoctoral fellows and graduate students. The first Institute report from 1970 lists 15 faculty, 10

Faculty Member	Specialization	
George Garland	Gravity	1954-1963
Keeva Vozoff	Magnetotellurics	1958-1965
Joseph Lipson	Geochronology	1957-1961
George Cumming	Seismology/Geochronology	1959-1994
David Rankin	Magnetotellurics	1964-1982
Ernest Kanasewich	Seismology	1963-1996
Roy Krouse	Stable Isotope	1960-1972
Jan Hospers	Paleomagnetism	1963-1967
Ian Gough	Magnetotellurics, Stress	1966-1987
Jack Jacobs	Core Dynamics	1967-1975
Dai Jones	Paleomagnetism	1967-1968
Gordon Rostoker	Space Physics	1968-1997
Chris Chapman	Theoretical Seismology	1969-1975
Earl McMurray	Paleomagnetism	1969-1972
Walter Jones	Magnetotellurics, Geothermics	1971-2003
John Gray	Stable Isotopes	1972-2000
Ted Evans	Paleomagnetism	1972-1998
Frantisek Hron	Theoretical Seismology	1974-1998
Edo Nyland	Seismology	1974-1997
John Samson	Space Physics	1980
Tim Spanos	Porous Media Theory	1980
Douglas Schmitt	Rock Physics	1989
Mauricio Sacchi	Seismic Imaging and Inversion	1997
Moritz Heimpel	Geodynamics	1999
Martyn Unsworth	Magnetotellurics	2000
Vadim Kravchinsky	Paleomagnetism	2002
Jeffrey Gu	Global Seismology	2004

Table 1. Faculty at the University of Alberta

postdoctoral students, 19 technical staff and 34 graduate students. It is worth quoting Dr. Gough on his reminiscence of the rapid growth of the University and the Geophysics group given at the recent 30-year anniversary of the Institute's formation: "The late sixties were years of growth in the University, not unlike the present time, and I do not suggest that the Institute caused this remarkable increase in numbers. Rather the Institute was one expression of a general rise in activity in scientific research, and in support for it, in those years".

These early workers came up with a number of important discoveries and only a very short and incomplete listing can be given here. Since we would like to write a more formal history, I

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would very much appreciate hearing from anyone who may have some interesting facts. Some of these important discoveries and observations include:

- The first long term magnetotelluric observations in wellbores near Calmar, by Keeva Vozoff.
- The development of sensitive mass spectrometers to carry out lead isotope age dating, by George Cumming and co-workers.
- Detection of seismic reflections from the deep crust. This was described in a series of papers by Ernie Kanasewich, his student Ron Clowes and George Cumming, who carried out some early tests near Edmonton. Earlier workers had declared such observations impossible. This work added reflection seismology to the box of tools used today to deduce the structure of the earth's crust and uppermost mantle.
- The discovery of regions of high electrical conductivity coincident with the TransHudson orogen recorded in the crystalline basement of North America and in the interior of British Columbia in surveys by Ian Gough and co-workers. Both of these zones remain somewhat enigmatic to the present day.
- Recognition that 'wellbore breakouts' indicate crustal stress directions. This also was noticed by Ian Gough in collaboration with S. Bell of the Geological Survey of Canada. This may be the technique employed most to provide us with difficult to obtain stress information.
- Statistical evidence for the 'Axial Dipole Hypothesis'. M. Ted Evans showed that the earth's magnetic field has been on average aligned with the earth's rotational axis - a key tenet of paleomagnetic studies.
- Application of numerical methods in modelling electromagnetic responses. Walter Jones was the first to employ numerical methods in the calculation of magnetotelluric responses over complex geological formations.
- Developments in the Asymptotic Ray Theory. Franta Hron provided important theoretical contributions to ray theory that is used in the modelling of seismic responses. As well, he carried out some important early work on seismic anisotropy.
- Microseismicity in seismic monitoring. Edo Nyland and co-workers carried out some early work in applying microseismicity to monitor acoustic emissions from enhanced oil recovery sites in Southern Alberta.
- Finally, it is interesting to note that some of the most important work in geochronology - the development of potassium-argon dating by Joseph Lipson - was carried out in rather close proximity to Jan Hospers, a paleomagnetist. The crucial point was that these researchers had the equipment and wherewithal to make important correlations between rock magnetism and age. Similar capabilities led other groups to develop the reversal scales of the earth's magnetic field that in turn supported evidence of sea floor spreading and plate tectonics¹. Unfortunately, the Alberta group focussed on Cretaceous age rock mainly because there is not a lot of Tertiary section here and correlations were more difficult in the older Cretaceous materials.

At the time of my arrival in 1989, the Geophysics group included George Cumming, M. Ted Evans, John Gray, Ian Gough, Franta Hron, Walter Jones, Ernie Kanasewich, Edo Nyland, Gordon Rostocker, John Samson (our current chairman) and Tim Spanos. By 1998 only Walter Jones, newly hired Mauricio Sacchi, Tim Spanos and I were left in active teaching roles but a solid hiring plan was already in place. At present, the group is in a significant phase of rebuilding and while this will not be of the magnitude of that experienced at the time of the creation of the IEPP, it is significant nonetheless. This has brought on new members Moritz Heimpel (High-Level Computational Geodynamics), Martyn Unsworth (Magnetotelluric Exploration) and Vadim Kravchinsky (Paleomagnetism). Jeff Gu, a global seismologist, was recently appointed and will arrive in 2004. My recent appointment as a Canada Research Chair should free up an additional position we hope to have filled by mid-2004; this will likely be in the area of environmental monitoring/near surface geophysics. A photograph of the present Geophysics group at the U of Alberta (Figure 1) includes nearly all of the researchers currently working in solid earth geophysics from just-arrived graduate students beginning this January through to our distinguished Professors Emeriti, including Dr. Gough who has been at the University for nearly 40 years.



Figure 1. Graduate students, Post Doctoral Fellows, Research Associates, Technical Staff, and Professors in solid earth Geophysics in the Physics Department at the University of Alberta, 2003.

Profiles of Current Faculty

There is a wide range of research going on in solid earth Geophysics at the University of Alberta, and we strive to find a good balance between applied and basic science. Here, I will briefly overview the various research themes in progress from both current faculty and active Professors Emeriti. Additional information can be accessed through the website² that has links to all the researchers, their research and teaching.

Dr. M. Ted Evans is a Professor Emeritus since 1998. He is involved in several projects involving environmental magnetism

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aimed at improving our understanding of past global change. These include the natural archives residing in windblown continental deposits (loess) in China, Russia, Argentina and the United States, as well as lacustrine sediments in Lake Baikal. The two main objectives are to decode systematically the climatic fluctuations recorded in the sediments and to address the problem of how magnetoclimatological signals are geologically encoded in the first place. For these projects he is actively collaborating with colleagues in the ETH, Zürich, the Chinese Academy of Sciences, Beijing, Northwestern University, Xian, the Russian Academy of Sciences, Moscow and LEMIT, La Plata, Argentina, as well as University of Alberta colleagues (N.W. Rutter, Earth and Atmospheric Sciences and V.A. Kravchinsky, Physics Department). Dr. Evans also continues his research concerning the secular variation of the geomagnetic field recorded as thermomagnetic remanence in pottery kilns that were fired in antiquity. In this context, he is an active participant in the recently-funded European program AARCH (Archaeomagnetic Applications to the Rescue of Cultural Heritage).

Dr. Jeff Gu currently holds a prestigious postdoctoral fellowship at the Lamont-Doherty Earth Observatory in New York and will join the faculty as an Assistant Professor at the U of Alberta in 2004. He is primarily an observational seismologist and has already worked on a variety of topics related to the upper mantle of the earth, particularly related to the discontinuities at 410-km and 670-km depths. Presently, he is working on issues related to the anisotropy of the mantle and has started new research into crustal refraction profiling.

Dr. Moritz Heimpel has been an Assistant Professor since 1999. He conducts research in two main areas of geodynamics; the dynamics of planetary cores (Figure 2) and the mechanics of earthquakes and faulting. A focus of his work in earthquake mechanics is to better understand how earthquake scaling is related to the tectonic environment. A primary region of study is the Western North American plate boundary region extending from the San

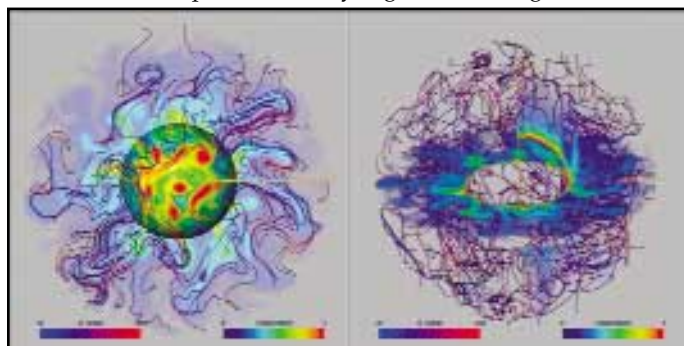


Figure 2. Visualization of temperature and magnetic field lines from a high resolution geodynamo model run on the MACI supercomputer by Moritz Heimpel and co-workers. The left and right images are view from the pole and from mid-latitude respectively. Thermal plumes are seen in the equatorial plane, originating at the inner core boundary. The geometry of magnetic field lines are modified by the flow field and are coloured according to the local strength of the radial magnetic field.

Andreas Fault in the South to the Queen Charlotte Fault off the coast of British Columbia. The planetary dynamo project is aimed at understanding how the complex motions of liquid metal in the earth's outer core and the cores of other planets sustain the global magnetic field. Core dynamics are investigated primarily through computer simulations, based on a three-dimensional spherical convection code. Work is in progress to assemble an advanced visualization system, with the goal of enabling real-time visualization of time-dependent 3D flow and magnetic fields. This will be carried out in a visualization laboratory with a fibre optic connection that runs from the University of Alberta supercomputing facility (MACI) to the physics building.

Dr. Vadim Kravchinsky was hired in 2002 and works in a broad area of paleo and petro-magnetism and their application to solid earth and environmental studies. He was previously Director of one of the largest paleomagnetic laboratories in the former Soviet Union (1996-2001) with a team of eight permanent researchers and technicians with equipment and financial support. Dr. Kravchinsky hopes to construct a cryogenic magnetometer facility, the only one of its kind in Canada, that would attract a wide variety of researchers to the University for studies ranging from core orientation that will allow determination of hydrocarbon migration pathways to high resolution stratigraphic mapping. He is planning to use his previous experience in dating of rocks and geological processes to study the process of kimberlite magmatism. Dr. Kravchinsky's current research is in the areas of paleoclimate, paleoenvironment, magnetic properties of rocks and sediments, catastrophic global changes during the eruptions of flood basalts, plate tectonics and the behaviour of the outer core.

Dr. Walter Jones conducts research in three areas: electromagnetic induction in the earth, geothermics and Earth tides and tilts. The electromagnetic induction work has included numerical modelling of 2- and 3-dimensional conductivity anomalies in the earth from small local inhomogeneities to down-going slabs, as well as magnetotelluric studies in areas as geologically diverse as the Western Canada Sedimentary Basin and the region of the intersection of the Messejana Fault and Ferreira-Ficalho Overthrust in Portugal. The geothermal work has involved laboratory measurements of thermal conductivities of rocks, theoretical studies of borehole stabilization, numerical modelling of heat flow through inhomogeneous media and down-going slabs, as well as analysis of temperature data from the Western Canada Sedimentary Basin and the Jeanne d'Arc Sub-basin in offshore eastern Canada. The earth tilt research has included construction of both uniaxial mercury-level tiltmeters and novel biaxial mercury-level borehole tiltmeters, measurement and analysis of Earth tides in western Canada and monitoring of surface inflation associated with petroleum recovery enhancement processes. Dr. Jones has collaborated with the Geological Survey of Canada, Ottawa, and is currently working with collaborators from the University of Évora, Portugal. Dr. Jones is the current Director of the Institute for Geophysical Research and the Coordinator in the Department of Physics for the Faculty of Science Industrial Internship Program. This program

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allows third year undergraduates to work for extended periods from eight to 16 months in a professional industrial job prior to completing their fourth year studies.

Dr. Edo Nyland is a Professor Emeritus since 1997 and is presently working towards the development of a PC based geophysical analysis package. Geophysical knowledge can be used effectively and accurately by non-specialists if the techniques they require are contained in self-checking programs that run on simple PCs. Nyland and colleagues are using Mathematica and Java to develop TerraNotes, a platform independent package of programs that uses the nature of the data the user presents to suggest methods of processing, display, or interpretation.


Dr. Mauricio Sacchi joined the staff in 1997 and is currently an Associate Professor. His research interests are in the field of applied seismology and, in particular, seismic imaging methods. He is the founder of the Signal Analysis and Imaging Group, an industry supported research initiative that focuses on the development of 3D imaging methods, inversion algorithms and signal analysis techniques. Recent research encompasses the full spectrum from fundamental problems in wave propagation theory to the development of inversion algorithms to image fluid-bearing formations under massive salt bodies. The latter is a problem of great importance in hydrocarbon exploration in marine environments such as the Gulf of Mexico. Dr. Sacchi also works on multi-dimensional filtering problems, signal and image processing methods and Bayesian inference. He was elected by leading researchers at Schlumberger as one of the recipients of the Schlumberger Foundation Research Grant in 2001.

Dr. Douglas R. Schmitt joined the U of Alberta in 1989, he is presently a full Professor and was awarded a Tier 1, Canada Research Chair in Rock Physics in late 2002. He works primarily in the field of experimental Geophysics with a focus on rock physics and its application to near surface studies and geophysical monitoring. He is currently carrying out laboratory research on the physical properties of wave propagation in anisotropic and saturated rock, on geophysical fluids under pressure and temperature, and on scattering media. Field studies focus on the evaluation of near surface properties and structures with present recent field projects related to exploration and monitoring with collaborators at sites from the Arctic to Italy on themes from gas hydrates through heavy oils to ground water. He directs the 'Seismic Heavy Oil Consortium', a 5-year long project set up to examine issues related to the seismic monitoring of heavy oil and bitumen reservoirs. He also works in rock mechanics and continues a project that employs optical interferometry to measure the elastic properties of rock. He serves as the Canadian member on the Interim Scientific Measurements Panel whose mission is to plan for shipboard laboratory and well logging measurements to be made as part of the currently forming international Integrated Ocean Drilling Program.

Dr. Tim Spanos is a Professor and joined the faculty in 1980. He conducts research primarily on theoretical studies on saturated

porous media. In particular he has examined a variety of aspects of wave propagation, fluid flow and the mechanics of such materials, particularly in the context of sanding of wells during heavy oil production. Some of this work related to induced pressure pulses in fluid filled rocks has motivated field studies applying his ideas to enhanced heavy oil recovery and environmental remediation. This has led to a commercial company that is having good success in environmental remediation of contaminated ground water sites in North America and Europe. Dr. Spanos' earlier research was primarily theoretical in nature but included some laboratory measurements of flows in porous media.

Dr. Martyn Unsworth is an Associate Professor since 2000. He studies electromagnetic geophysics and continental dynamics and is presently focused on using the magnetotelluric (MT) method to understand global tectonics. As a research professor in the United States he developed an extensive research program that included multidisciplinary studies of the Tibetan Plateau, the San Andreas Fault (Figure 3), the Cascadia subduction zone, the Chicxulub Impact Crater and the East Pacific Rise. A second research theme is using electromagnetic imaging in environmental applications, involving the development of new computer algorithms for the interpretation of controlled source electromagnetic data and applications in environmental geophysics. Recent awards will fund the purchase of state-of-the-art MT instrumentation and also fund a study in the Canadian Cordillera with an emphasis on seismic hazards in British Columbia. A project in Turkey will continue his study of continent-continent collisions that began in Tibet. Dr. Unsworth is co-investigator on three pending National Science Foundation proposals for studies in Taiwan, Tibet and the United States. He is also a member of an independent consortium for the environmental assessment of former nuclear weapons test sites in Alaska.



Senior Processors and Supervisors

The successful candidate will have a degree in Geophysics or related discipline with 10+ years of proven experience in processing of 2D + 3D land data. Excellent communication skills and extraordinary problem solving skills are essential. Experience in processing data from international basins would be a definite asset.

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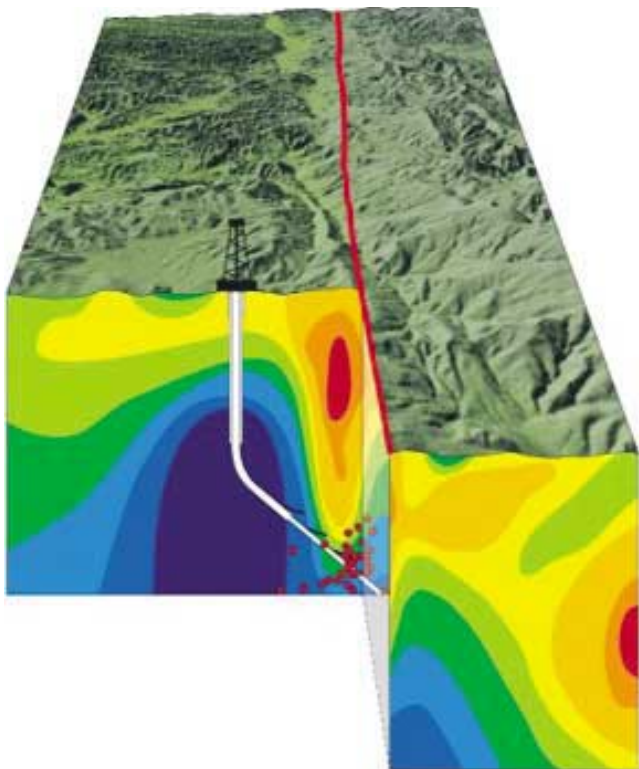


Figure 3. Oblique view along the San Andreas Fault showing trajectory of the proposed San Andreas Fault Observatory at Depth (SAFOD) deviated wellbores. The colour contours are resistivities obtained in the inversion of Dr. Unsworth's magnetotelluric observations showing a highly conductive zone in the immediate vicinity of the San Andreas fault.

Graduate Students: With the influx of new faculty, the graduate student numbers have grown significantly in the last few years and a critical mass of researchers has been rebuilt. There are presently 22 graduate students and we anticipate that this number will continue to grow as the programs of the new faculty members solidify. Table 2 contains a list of some current and recent thesis research topics. The number of postdoctoral researchers and visitors fluctuates more widely with only three at present but having as many as eight in 2002.

Graduate students are supported by a number of scholarships³, by teaching assistantships in the Department of Physics and by individual professor's research grants and contracts. Two industrially funded projects, the Seismic Heavy Oil Consortium and the Signal Analysis and Imaging Group, provide funds for both graduate students and some postdoctoral research assistance.

Several graduate students have been recognized for their research accomplishments in the last few years. Uli Theune received a Summer Internship to work in the Schlumberger Cambridge Laboratories this last summer. Youcef Bouzidi was awarded in 2002 a tectonophysics section 'Outstanding Student Paper' award at the Fall 2001 American Geophysical Union annual meeting. At the 2001 CSEG meeting, Carrie Youzwishen received a best student paper award and Henning Kuehl a Chairman's award. Kristen Beaty shared the 'Best Student Paper' award for her study of surface wave dispersion presented at the 2000 SEG meeting.

Last, but not least, it is important to mention Len Tober, who provides the group with field and laboratory technical assistance.

Ph.D. Theses

- Least Squares Wave Equation Migration
- Inversion of the Generalized Radon Transform
- Robust inversion of Angle gathers and estimation hydrocarbon estimators
- 3D pre-stack wave equation migration and inversion with application to subsalt imaging and robust estimation of fluid indicators
- Seismic wavefield reconstruction and the impact of interpolation method in AVA imaging
- Determination of the elastic co-efficients of rocks using measurements of P- and S-wave velocity anisotropy.
- Processing, inversion, and interpretation of time-lapse seismic profiles: Application to Enhanced Oil Recovery Methods.
- Forward Modelling of Complex Geological Structures using the Spectral Element Method: Application to Time-Lapse Seismology
- Seismic Reflectivity from Fluid-Saturated Formations: Fundamental Experimental Tests and Application to Amplitude Versus Offset Analyses
- P-wave Velocity and Attenuation of Geophysical Fluids under Pressures and Temperatures

- Accounting for Rock Texture in Seismic Anisotropy: Application to Sedimentary Basins, Metamorphic Cratons, and the Upper Mantle.

M.Sc. Theses

- Application of magnetotelluric exploration in hydrocarbon exploration in the WCSB
- Seismicity and faulting along the Juan de Fuca Plate Boundary
- High Resolution Geophysical Study of a Sweetgrass Igneous Dike: Allerston District, Southern Alberta
- Amelioration of Cultural Seismic Noise
- Seismic Response of Seam Coals in the WCSB
- Determination of Rock Elastic Properties using Optical Interferometry
- Non-linear Sparse Blocky Constraints for Seismic Inverse Problems
- Rayleigh wave study of near surface variability

Undergraduate Theses

- P-wave Velocity and Attenuation from Dipole Sonic Logs
- P-wave and S-wave Anisotropy of Wet Shales Under Pressure
- Very long period MT measurements
- Comparison of observed and modelled magnetic field variations

Table 2: Some Current and Recent Ph.D., M.Sc. and Undergraduate thesis research topics at the U of Alberta

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Len is well known now to a complete generation of U of A Geophysics alumni as he has schooled them, and not a small number of U of Saskatchewan grads, in the detailed operation of the 48-channel DFS-V obtained by Edo Nyland and Ernie Kanasewich with roll-box system used in our field schools till the early 1990's. The brand new and modern, but passive, distributed Geodes may be able to acquire much more data but this passive system is not nearly as much fun, the undergrads at field school cannot make serious roll-switch mistakes any longer and something has certainly been lost!

Research Infrastructure

Geophysicists have been very successful in obtaining infrastructure for field and laboratory studies over the last few years. As well, some of this equipment is available for use in the Geophysical field school and is being heavily used in a variety of locations for a variety of purposes.

Dr. Unsworth is putting together a series of broad-band (Phoenix V5-2000) and long period (Narod) magnetotelluric systems now being deployed in a variety of locations in Canada and elsewhere.

Dr. Kravchinsky has recently applied for a cryo-genic magnetometer. This highly sensitive equipment would be the only such system in Canada and would



Figure 4. U of Alberta IVI Mini vibrator in action at 69.8°N for the Mallik Gas Hydrate studies in February 2002. Vibrator unit provides 6000-lb peak force with sweep capability from 10-Hz to 500-Hz. The mass can also be mounted horizontally for shear wave generation.

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attract a variety of researchers from across the globe. There is a great deal of interest from industry towards such a facility in Canada, as this would make certain rock core studies more practical.

Drs. Schmitt and Sacchi obtained funding in 2000 for a variety of systems particularly for near surface studies. The centrepiece of these is the 240-channel Geometrics Geode semi-distributed seismic data acquisition system and a 6000-lb force truck mounted IVI seismic minivibrator (Figure 4). This system can be used for seismic investigations of the uppermost kilometer and as such is ideally suited for seismic monitoring studies in heavy oil and bitumen plays. At the field school site, the vibrator provides sufficient signal to image the contact at the top of the metamorphic basement at a depth in excess of 2 km. Although this seismic source has only been in use for two years, a variety of studies have been carried out, such as imaging within the permafrost at the Mallik Scientific Wellbore in the MacKenzie Delta of the NWT in 2002, VSP studies in Northern Saskatchewan, repeated surveys at SAGD sites near Fort MacMurray and in the Lloydminster oil plays in Saskatchewan and over a Sweetgrass dike in Southern Alberta for field school. The Geode recording system has been used at all of these sites but is also employed in a number of near surface studies including for ground water at Utikuma Lake, Alberta, for geotechnical ground motion studies at an oil sands mine near Fort MacMurray, for near surface aquifer studies in Milan and Padua, Italy, for passive monitoring of wellbore minifrac tests and for explosive blast intensity measurement for biological monitoring of fish habitats in the NWT. This system is very busy and is attracting collaborators from a variety of disciplines.

This grant also enabled the purchase of a modern GEM magnetic proton-precession magnetometer system with recording base-station, a SARIS tomographic resistivity profiling system, a RAMAC ground penetrating radar system and a differential GPS surveying system. As well, the old blue 'Betsy' seismic doghouse truck, beloved by an entire generation of U of A alums and babied by technician Len Tober, was sent out to pasture in 2001, being replaced by a new 1-ton 4-wheel drive truck that gets much better gas mileage but, sadly, has an automatic transmission.

Other seismic equipment includes a pickup-mounted accelerated weight drop seismic source, a 20 in³ airgun that can be used in wellbores and a Betsy-gun. A light, seven-conductor geophysical wireline system has been used for a variety of vertical seismic profile and ultrasonic televiwer studies at sites from New Brunswick to British Columbia.

The rock physics laboratory (Figure 5) has a number of high speed digital oscilloscopes used primarily in ultrasonic measurements of P-wave and S-wave speeds through material under pressures as high as 300 MPa and at different temperatures. As well, the group here has carried out a number of technical ultra-



Figure 5. Rock physics laboratory showing pressure vessels used to subject rock samples to in situ pressure conditions. Len Tober (left) and Dean Rokosh (right) are discussing issues related to fluid property measurements.

sonic transducer developments used in detailed elastic wave anisotropy studies to more fundamental measurements of the unique 'slow' P-waves that exist in fluid filled porous rock.

The rock magnetism laboratory is similarly well equipped. The lab boasts a Permalloy magnetically shielded room and includes a variety of sensitive magnetometers, susceptibility meters and related equipment to make magnetic measurements on rock, unconsolidated loess samples and archaeological materials.

The Physics Department has excellent machine and electronic shops; resources that make possible development of complex equipment or experiments. For example, the electronics shop developed a special high speed digitization board to acquire large volumes of ultrasonic borehole televiwer information. This equipment was used in the logging of a wellbore to provide information on stress states in the crust from a deep scientific wellbore in Russia.

Computational support is good in the Department. A dedicated RAID system is used to archive geophysical data, much of which is freely available for use in the community⁴. Drs. Heimpel and Sacchi are early members of the MACI (Multimedia Advanced Computational Infrastructure) consortium with access to five parallel machines with up to 236 individual processors⁵.

The Institute for Geophysical Research⁶: The 'Institute for Geophysical Research', as renamed by its current director, Dr. Walter Jones, has been an important resource for the Geophysicists at the U of Alberta. Under Dr. Jones, the Institute has become particularly active in the support of graduate student research. As well, there are numerous other researchers who are part of the Institute but are from a variety of depart-

ments including Earth and Atmospheric Sciences and Mathematics. Topics covered by these researchers cover a wide range of complementary areas, including ocean wave modelling, meteorology, space physics, glaciology, geochemistry and fluid migration in sedimentary basins. The activities of the Institute are announced to the worldwide community via the quarterly newsletter 'Inukshuk'.

The Future

The last few years at the University of Alberta have been like riding a roller coaster! This new, and not yet finished, group is already very active in many areas of Geophysical research and a solid critical mass of students, postdocs, technicians and professors is gelling into a strong unit. The flow of undergraduates has been strong for the last few years and this year's graduating class is the largest I have seen since my arrival 13 years ago. We cannot forget these undergraduates provide the base without which there could not be any research and they too contribute very greatly to research programs during summer work terms and in their undergraduate thesis courses.

There are a lot of exciting directions Geophysics will take in the next few years and the group is well positioned to take advantage of whatever is thrown at us. The conventional exploration paradigm will remain but new areas related to geophysical monitoring of reservoirs and for green house gas sequestration will likely start to siphon off professionals into new tasks. Computational resources will likely continue to advance rapidly, opening up the possibilities for increasingly sophisticated modelling and inversion for both applied and fundamental geodynamical studies. As well, our concerns with ground water are likely to require even more stringent testing of aquifers. Some exciting new possibilities could open up with respect to previously untapped resources such as methane bearing gas hydrates and for understanding better the permafrost that overlies such deposits. Despite the fact that plate tectonic theory was developed 35 years ago, there still remain numerous unanswered questions as to why plates move, what the role of fluids are and how the continents were constructed. Scientific drilling in the oceans and continents will increasingly be used to address basic scientific questions and to validate earlier geophysical explorations. This is particularly true as the new riser drilling ship 'Chikyu' now in completion in Japan is brought to bear on deep ocean drilling. Earth materials are much more complex and interesting than anything humans can make and there remains a great deal of experimental and theoretical efforts required to better understand them. In short, there is a lot to keep Geophysicists busy for the next few decades and the group at the University of Alberta is very well placed to continue contributing to teaching and research in Geophysics.

Acknowledgements

My colleagues provided the brief overviews of their research and their key figures. Ian Gough, Walter Jones, and M. Ted Evans lent their thoughts on the history of Geophysics at the U of Alberta to me but this is a job we have not yet completed and hopefully we can give a more complete view in a later RECORDER article. Finally, it is appropriate that Len Tober be particularly recognized for his contributions to Geophysical research and teaching at the U of Alberta over the last two decades. *R*

Footnotes

¹This missed opportunity is discussed at length in 'The Road to Jaramillo: Critical Years for the Revolution in Earth Sciences' by W. Glen.

²<http://www-geo.phys.ualberta.ca>

³see <http://www-geo.phys.ualberta.ca/scholarships.html>

⁴There is freely available seismic data acquired in four field school programs at <http://cm-gw.phys.ualberta.ca/seismic/>, we would appreciate acknowledgement if this data is used.

⁵<http://www.ualberta.ca/CNS/RESEARCH/MACI/index.html>

⁶<http://www-geo.phys.ualberta.ca/institute/>



Doug Schmitt is a Professor in Geophysics at the University of Alberta. He wanted to be a scientist since he was 5 years old, his motivation being the fact that it was scientists (ironically many of whom were seismologists at the U of Alberta) that made the large test explosions at Suffield not too far from the farm on which he grew up. He worked as an exploration Geophysicist at Texaco Canada after graduating from the

University of Lethbridge in 1980 with a B.Sc. in Physics. He returned to graduate school obtaining his doctorate in 1987 from the Seismological Laboratory at Caltech, Pasadena and carried out postdoctoral research on logging and stress measurement at Stanford University. He joined the faculty at the U of Alberta in 1989 and has built a group whose research focuses on issues related to rock physics, near surface geophysical studies, and time-lapse monitoring. He was awarded an A. vonHumboldt research fellowship that allowed him to work at the Geophysikalisches Institut at Uni-Karlsruhe, Germany in 1996-97 and in November 2002 was promoted to a Tier 1 Canada Research Chair in Rock Physics. The photo also attests to his capabilities as a high-latitude juggie.