

Department of Earth Sciences

Three Year Plan (2010-2013)

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Current Status

Current strengths and foci

The Department of Earth Sciences carries out research and provides undergraduate and graduate education across a broad spectrum of the Earth Sciences. The strength of our program lies in its breadth, which covers both traditional and environmental aspects of geoscience. In terms of research, we are able to address many parts of the whole Earth system. Our thirteen tenure-track faculty study many of the Earth's "spheres," including the asthenosphere (convecting mantle), lithosphere (tectonic plates), hydrosphere (mainly groundwater), cryosphere (ice and permafrost), biosphere and atmosphere. With such a range in research interests, augmented by the expertise of our three instructional faculty, we are able to teach our undergraduate students, and guide our graduate students and postdoctoral fellows, in almost every discipline of the Earth Sciences. Some of our faculty collaborate with social scientists to forge links between science and society.

The Department can be understood in terms of nine main divisions that correspond to (a) seven research groups (centred by thirteen tenure-track faculty), (b) instructional faculty (two Senior Lecturers and one Laboratory Instructor) and (c) staff (Departmental

Administrator, two secretaries, and two technical support staff). The Department operates in a highly integrated manner, with excellent communication and cooperation among its divisions. As a result, teaching is well connected to research, and undergraduate students are commonly involved in the research programs of faculty and graduate students.

Current Programs

The Department offers two main streams: *Geology* and *Environmental Geoscience*. Both are popular and satisfy the academic requirements for professional registration in the Association of Professional Engineers and Geoscientists of BC (APEGBC). A third option allows students to complete a degree with greater program flexibility but is not aligned with the APEGBC educational standards. Students typically select a stream after completing their lower division requirements.

The *Geology* stream is taken by students who are interested in a career in the minerals or hydrocarbon industries. Upper division courses in petrology, mineral deposits, petroleum geology and related topics combine to build a comprehensive education for both the “soft rock” and “hard rock” resource industries. The *Environmental Geoscience* stream is taken by students who are interested in working mainly in the environmental consulting field. Upper division courses on groundwater, engineering geology and surficial studies form the core of this stream. Many graduates from both streams continue their education by enrolling in graduate studies at SFU and elsewhere.

Current Research

Research in the Department of Earth Sciences is highly varied and is not strongly slanted toward certain disciplines. The breadth is a direct consequence of our need to conform to the course requirements laid out in the APEGBC syllabi for both the Environmental Geoscience and Geology professional options – and therefore a need to maintain a faculty complement with a broad range of expertise. Examples of our research foci are: climate change, petroleum geology, mineral deposits, gemstones, water resources, geotechnical engineering, natural hazards, landscape evolution, glacier dynamics, paleontology, sedimentology, modern coastal environments, volcanology, crustal evolution and structure of the lithosphere. Most of our research is “field based” with a strong emphasis on actual as opposed to theoretical problems, although much of our work involves quantitative analysis such as numerical modeling of rock and ice deformation, groundwater flow, geochemical and geophysical characterization, and plate tectonics.

Our research prowess is underscored by three endowed chairs with reduced teaching loads and vigorous, high-profile research programs in natural hazards (Clague), resource geoscience and geotechnics (Stead), and glaciology (Flowers). These chairs have elevated the international profile of the Department and have attracted considerable external support.

Many of the research programs in the Department of Earth Sciences are compatible with the environmental emphasis outlined in SFU's Strategic Research Plan 2005-2010. Research on the topic of resources, in our department and elsewhere in the University, is considerable and could be included under the Environment moniker used in the Strategic Research Plan, particularly under the descriptor "multifaceted approach is to provide a sound basis for sustainable development and the responsible use of our natural resources, but also risk assessment, management, and historic and economic considerations." The Plan defines the important areas of Environmental research as "chemical, molecular biological, toxicological, physiological, and behavioural studies." If the terms *geological* and *study of natural resources* were added to this description, the Plan would then capture the majority of the research being carried out in our department.

Departmental Resources

Human Resources. As of Sept. 1, 2009, the Department's human resources will consist of sixteen faculty and five staff (our seventeenth faculty member, Peter Mustard, will be taking early retirement on Aug. 31, 2009). Our faculty comprise three endowed chairs, ten regular tenure-track faculty, and three instructional faculty. Two of the endowed chairs are Canada Research Chairs (tiers 1 and 2), and the other has an endowment from the former Fisheries Renewal BC fund from the Provincial Government. Of the tenure-track faculty, four are Assistant Professors, three are Associate Professors, and six are Professors. Of the instructional faculty, one is a Laboratory Instructor and two are Senior Lecturers. Our staff consists of one Departmental Administrator, two secretaries, and two technical support persons. Earth Sciences commonly draws upon two or three sessional lecturers per year.

Space. The Department of Earth Sciences is located on the ground floor of the TASC1 building. We have additional space (three rooms) in the Kinesiology part of the Shrum Classroom Block, one room in the Physics part of the Shrum Science Building, and one room in TASC2. All tenure-track faculty have an office plus a lab; instructional faculty have an office. Four of our larger rooms are teaching laboratories. In addition, the Department has a small seminar room, six rooms for shared use by visiting scientists,

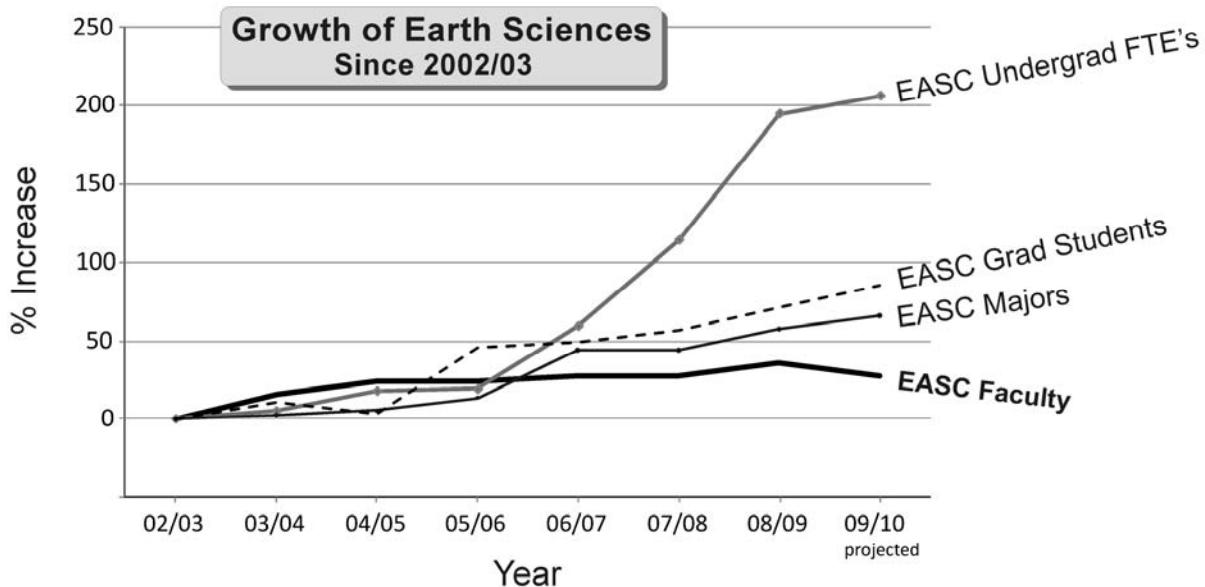
postdoctoral fellows, sessional lecturers and teaching assistants, plus modest storage space.

Equipment. Equipment in the Department, for both teaching and research, is orientation toward field studies, and includes a broad range of items designed for the collection and assessment of field data (e.g., camping gear, compasses, GPS units, surveying equipment, a laser scanner, photographic equipment, air-photo viewers, water sampling and portable analytical equipment, ice sampling equipment). We also have a moderate amount of laboratory equipment including devices for geochemistry and geophysics of rocks, minerals, water and atmospheric gases, microscopy and mineral separation. The Department owns two aging vehicles for field schools and course field trips: a small "school bus" and a pickup truck. (Last year, our two low-mileage 15-passenger vans were confiscated by the university and sold for a paltry \$25k.) Two faculty own research vehicles (one SUV, one pickup truck), one of which doubles as a Department vehicle when available.

Budget. The Department presently operates on a non-salary operating budget of approximately \$100k. It is adequate for short-term maintenance of the department but provides little ability to purchase new equipment for our undergraduate program or renovate our rooms. We have insufficient funds (\$25k) in our vehicle account to address our transportation needs over the next several years. Beyond the funding of our research chairs, our department has received no endowments, although we have obtained modest support from the oil and gas industry in terms of donated software and travel funds. Our department is relatively new and most of our graduates remain in junior or intermediate positions in the work place, and are not yet in positions where they can authorize donations or endowments to SFU. We believe that this situation will change over the next several years and that Earth Sciences may receive support from alumni and the firms they represent.

Changes and Trends

Undergraduate and graduate programs in the Department of Earth Sciences are undergoing steady growth. By 2009-10, the number of the undergraduate FTE's will have risen by 200% from 2002-03 levels. Over the same interval, the number of Majors (FTE's) and graduate students (head-count) will go up by 60-80%. In contrast, the number of faculty will have increased by 28%, down from a level of 36% in 2008-09 due to an early retirement.



The Department will face two main challenges: (1) having enough instructors to teach all of the courses required for the *Geology* undergraduate stream, and (2) providing a sufficient number of Teaching Assistants to accommodate the increasing number of students and laboratory sections. The geology side of the program was affected strongly by an early retirement, as the retiring faculty member had taught at least two classes per year in subjects such as field geology, tectonics, regional geology and petrology. Currently we are relying on a highly qualified sessional lecturer to teach in the upper division, but this arrangement may not last beyond one year. Consequently, Earth Sciences is in serious need of a new faculty member who can teach in the *Geology stream* of the program; the current preference is for a mineralogist, petrologist or economic geologist.

Plans for 2013

Undergraduate Program

Two Academic Streams. Our undergraduate curriculum is designed to satisfy the academic requirements for professional registration in the Association of Professional Engineers and Geoscientists of BC (APEGBC), in both *Geology* and *Environmental Geoscience*. As such, our program is guided largely by the needs of practicing geoscientists, mainly in the fields of mineral exploration, hydrocarbon exploration, and environmental consulting. Offering both streams is essential because of the cyclical nature of the geoscience industries – while one industry may be down, another may be

up. Offering both streams means that students are able to shift their course selections to match current employment opportunities.

Articulation of the Program. Over the next three years, the Department will ensure that the nature of the undergraduate curriculum will continue to be communicated effectively to our undergraduate population, by (1) encouraging one-on-one consultations with academic advisors, (2) providing yearly sessions on career options, stream design and APEGBC registration, and (3) developing a flow chart which illustrates the recommended course sequence for each of the streams (presently underway). Course selections for several semesters in advance will be posted on the Department's web page. Exposure to field work in the form of field schools and field trips is a principal feature of our program and will remain a high priority. Coordinating our program with other post-secondary geoscience programs in British Columbia has been successful and is ongoing.

Research Opportunities and Career Support. Providing opportunities for undergraduate students to become exposed to research will continue to be part of the culture in Earth Sciences. Many students are hired by faculty each year to help with field and laboratory research alike. NSERC Undergraduate Student Research Assistantships and work-study programs are two of the main funding sources for hiring undergraduate student assistants, and we will continue to access these and other sources. Faculty will be encouraged to include examples of their own research programs in their undergraduate courses, where appropriate. The Department will continue to support job fairs organized by the undergraduate student society, and recruiting sessions by geological surveys and geoscience firms.

Relevance through Employment. The undergraduate program is relevant to the broader community largely through employment. Geoscientists continue to be in high demand, and professional associations predict that a shortage of geoscientists will develop over the next decade due to numerous expected retirements. As such, our department is poised to fill some of the forthcoming need in the geoscience industries, and contribute to the national and international economies. The expertise of our students will also find its way into secondary schools, colleges and other universities, and may form the foundation for other careers such as business or law.

Graduate Program

Knowledge and Skills. Entrance to our graduate program normally requires knowledge of some discipline in the Earth Sciences (e.g., geophysics, geochemistry, geomorphology). However, we also welcome students with non-geoscience

backgrounds as long as their abilities are appropriate for their particular thesis projects (for example, a degree in mathematics might be a suitable background to study some aspects of geophysics; a degree in chemistry might be suitable for the study of hydrothermal veins). The range in abilities on entrance, and the range of problems that are available as thesis topics, makes difficult the definition of “core disciplinary knowledge.” *Our principal concern is that incoming graduate students are qualified to carry out the research programs designed by their supervisors.* For that reason, a student is admitted to graduate studies in our department only after one of our faculty members has reviewed the student’s case and has agreed to be the student’s supervisor.

Common Goals. In the course of their graduate programs, our students are required to (a) complete a research program to the satisfaction of the thesis committee and external examiner, and (b) effectively communicate the results in oral and written formats. Naturally, most graduate students will develop a broader understanding of the Earth Sciences through course-work, attendance at talks, and interaction with faculty and other students. As well, our students typically become competent in collecting and analyzing new data, reading scientific literature and compiling data, evaluating existing ideas and generating new ones, and substantiating a preferred model with facts and logical arguments. We expect that these skills mirror those required of graduate students in other departments, particularly in the Faculty of Science.

New Master’s students are required to take EASC 600, a non-graded course that provides information and guidance on a range of topics. The other courses that a student will take as part of his/ her program are typically those which have greatest relevance to the student’s thesis project. Doctoral students also take EASC 600, plus other courses, but they must also pass an Oral Candidacy Examination in which they must demonstrate competence in one principal subject area, and two others. The subject areas are normally selected collaboratively with the senior supervisor, and typically reflect the knowledge and skills that will be required for completion of the thesis. Remedial course work or directed readings may be assigned to students who pass but do not demonstrate an adequate level of knowledge in all of their designated areas.

Uniformity of Graduate Research. The graduate studies program in Earth Sciences, like the undergraduate program, reflects our broad and well-balanced distribution of faculty expertise. Maintaining this balance is consistent with the academic vision articulated by the Provincially mandated professional association, APEGBC. As such, our graduate program is rather evenly distributed among seven research groups, all of which are considered equally valuable. We see great value in operating as a rather complete

geoscience department and have no plans to elevate one avenue of research over another.

Relevance. Although many of our graduate students go on to other institutions to continue in academe, others go to work for environmental consulting companies, mineral exploration and mining companies, oil and gas firms, and other employers. The record of our graduate students finding jobs or academic positions is enviable by any standard. With no weak links among the research groups, or gaps in the employability of our MSc and PhD graduates, our plan is to provide a departmental atmosphere where all facets of our graduate program are equally supported.

Funding. We typically guarantee our students a minimum salary of just under \$20k. The funds come from a combination of Teaching Assistantships, Research Assistantships, Graduate Scholarships and Fellowships, and both in-kind and direct support from the private sector and government (Federal, Provincial and Territorial). This array of funding sources has served us well and we anticipate continued access to them over the next several years; the level of funding guaranteed to the students may rise over time.

Faculty and Research

Groups. Research in the Department of Earth Sciences can be understood in terms of seven research groups:

1. Applied Research in Ichnology and Sedimentology
2. Engineering Geology and Resource Geotechnics Research Group
3. Glaciology Research Group
4. Groundwater Resources Research Group
5. Quaternary Geoscience Research Group
6. Petrology and Tectonics Research Group
7. Physical Volcanology Group

All of these groups are active, productive and deserving of support. The Department also hosts the Centre for Natural Hazards Research, which includes members from some of the seven research groups. As well, the Department has expertise related to both hydrocarbon and mineral exploration, although those divisions have not been formalized.

Balance and Professional Registration. One of the Department's main attributes is its balanced distribution of faculty expertise and ability to deliver a dual curriculum that meets APEGBC standards in both *Geology* and *Environmental Geoscience*. It is critical that balance and APEGBC compatibility be maintained. If our program becomes unable to satisfy the requirements for professional registration in one or both areas, it will quickly lose credibility in the geoscience community and fail to meet the career needs of our students.

Search for Endowments. Over the past year, our department has been working with the office of the VP Advancement to explore the possibility of acquiring private funding for the establishment of two research chairs. One chair would be in field of hydrocarbon exploration, and the other in mineral exploration. Although the desired results have not been realized, companies in the hydrocarbon industry have expressed considerable interest and we remain hopeful that funding for that chair may materialize in the next year or two.

Hiring. One of our faculty who has taught chiefly on the *Geology* side of the program will be taking early retirement on September 1, 2009. Our department will then face a critical shortage of expertise which will threaten our ability to deliver the academic requirements for the *Geology* option of APEGBC. In 2009-10 we will continue to deliver our *Geology* stream without issue by employing one of our Adjunct Professors as a sessional lecturer at the senior undergraduate level. Our good fortune in finding such a well-qualified instructor cannot be guaranteed in subsequent years and we emphatically request a replacement faculty position with expertise in *mineralogy - petrology - economic geology* to provide stability to our program. If additional persons were to retire in the next three years, we would need to examine how their absences would impact on our program and what sort of expertise new faculty members should have for us to maintain a balanced, professionally relevant curriculum.

Budget Contingency

Our current Departmental budget is \$1.904M. If that were to rise by 2% (\$38.1k), we would use the additional funding for equipment for and renovations to our undergraduate laboratories and classrooms. Some priorities include new computers for our computer laboratory, mounted data projectors in our undergraduate laboratories, and additional reflected light microscopes for our petrology classes.

If funding for a new position were to become available, after our immediate need for a mineralogist / petrologist / economic geologist (as described above) is met, we would consider hiring a carbonate sedimentologist, particularly with experience in the

petroleum industry. Such a person would help to consolidate our position as the leading department in hydrocarbon research in British Columbia. There is also interest in gaining a cross appointment with the new Faculty of Environment, but discussions on the discipline and nature of the arrangement have not yet taken place.

Communication

The ideas and information in this report are those derived from numerous discussions with faculty and staff concerning our needs for the next three years. Our hiring priorities were established by a comprehensive poll taken in 2008 followed by a discussion of those priorities in 2009 in the context of the forthcoming early retirement by one of our faculty.

Addenda

Research and Teaching in the Department of Earth Sciences

Research Groups

Applied Research in Ichnology and Sedimentology (ARISE):

The Applied Research in Ichnology and Sedimentology (ARISE) group focuses on developing sedimentological and ichnological concepts in both the modern and ancient and applying those results to the rock record. The group consists of Dr. Shahin Dashtgard and Dr. James MacEachern and their respective graduate students. ARISE brings together researchers who consider process-response observations in modern settings and the preserved character of similar deposits in the rock record. Modern research is presently focused on the southwest coast of British Columbia. However, over the next 3 years additional field sites will be established. Ancient studies are more widely distributed, and include sites in North America, Europe, Australia, and Asia.

Engineering Geology and Resource Geotechnics Research Group:

Under the direction of Doug Stead, Chair in Resource Geoscience and Geotechnics a strong engineering geology and resource geotechnics research group has been established with 7 graduating students to date (2 PhD and 5 M.Sc.) and currently involving 5 PhD students and 5 M.Sc's. Two post doctoral fellows have been employed as part of the research group with a new post doc to commence in May 2009. The next three years will see a continued refocusing of the activities of the research group to address a wider range of resource geotechnics and natural hazard issues. Current research reflects this change with significant funding from the mining and forestry sectors. Dr. Stead has been a Principal Investigator on three major grant proposals with UBC Mining and Geological Engineering including NSERC CRD and NSERC Strategic grants. He has also been principal applicant on four successful NSERC equipment grants in collaboration with SFU colleagues, UBC and the University of Alberta. Further diversification of the Chairs activities has involved successful research grants applications from the Canadian Space agency. It is anticipated that the research program will continue to grow over the next three years both in the resource and natural hazards sectors. A high degree of synergy has been developed between the FRBC Chair and the Director of the Centre for Natural Hazards (John Clague) with co-supervision of three graduate students. Current major grant applications have been submitted to the BC Innovation Council on surface mining and with Italian Colleagues on natural hazards. The research group has a comprehensive and state-of-the-art suite of numerical modeling software running on high performance PC's (up to 32GB RAM/8 processor). Students also have access to ground based laser scanning, photogrammetry and InSAR equipment.

The FRBC Chair, in addition to numerous graduate special topics courses, offers four undergraduate course as part of the Certificate of Forest Geoscience. Two of these

courses are an important part of the Earth science curriculum. In 2007, EASC 313, Introduction to Soil and Rock Engineering, became a core requirement of the Environmental Earth Science stream. EASC 413 Resource Geotechnics forms an option in the Earth Science program. Both courses have had good enrollments for the Earth Science department and have been well received by students.

Glaciology Research Group:

Since its inception in 2006, the SFU-EASC glaciology group has been gathering strength as a field-based and modelling-intensive research team. The group is broadly concerned with the role that glaciers and ice sheets play in the global climate system and the physical processes that govern the behaviour of these ice masses. Current projects range from the development of state-of-the art numerical models of arctic tidewater glacier dynamics to detailed measurements and modelling of the glacier surface energy balance. The group's field efforts are focused in the St.Elias Mountains in the Yukon, where the influence of glacier dynamics on regional-scale glacier-climate interactions is being investigated.

Groundwater Resources Research Group:

The Groundwater Resources Research Group has developed methodologies for linking global climate model (GCM) climate predictions to groundwater models to simulate predicted groundwater level variations under scenarios of climate change. Ongoing research is focused on developing approaches for understanding groundwater processes in mountainous regions, specifically the contribution to groundwater recharge from high elevation catchments to the valley bottom aquifers.

Quaternary Geoscience Research Group:

The Quaternary Geoscience Research Group (QGRG) was established in 1998 to conduct basic and applied research on Quaternary processes, deposits, and landforms. QGRG supports students in geology and physical geography seeking M.Sc. or Ph.D. degrees. It also houses postdoctoral fellows and visiting scientists from other universities and government laboratories. Students and faculty typically participate in collaborative research projects spanning two or more disciplines. Financial support is provided by Simon Fraser University, NSERC, and other sources. QGRG currently comprises Drs. John Clague and Brent Ward and their graduate students. It maintains a website (<http://www.sfu.ca/~qgrc/>) that provides information on activities, current and former students, and publications.

Petrology and Tectonics Research Group:

The Petrology and Tectonics Research Group consists of Drs. Calvert, Marshall, Gibson and Thorkelson, and students. Using methods ranging from seismic reflection to geochemistry and geochronology, coupled with field work, this group seeks to characterize the crust and upper mantle, and its mineral occurrences. An emphasis is placed on understanding geological processes such as plate tectonics, crustal deformation, and hydrothermal mineralization. Studies range from those of the modern environment to the Precambrian.

Physical Volcanology Group:

The Physical Volcanology Group (Williams-Jones and students) investigates the physical and chemical processes controlling persistently active volcanoes. By integrating the study of geophysical signatures with geochemical and remote sensing data, we are trying to characterize the precursory signals to volcanic activity and the mechanisms that trigger volcanic eruptions.

Centre for Natural Hazards Research (CNHR)

The Centre for Natural Hazard Research (CNHR) was established 2005 as a SFU Schedule A Centre. Led by CRC Chair John Clague, CNHR promotes teaching and research in the field of hazardous Earth processes and natural disasters. It fosters a program of inter- and multi-disciplinary natural hazard research involving geologists, geomorphologists, remote sensing and geographic information system (GIS) specialists, geophysicists, biologists, and social geographers. A key element of CNHR is public policy research on how to effectively transfer results of scientific research to the people who need and can use it. The Centre supports and initiates research, publication, non-credit and credit instruction, colloquia, conferences, visiting speakers and researchers, and national and international collaborations. It hosts lectures in the Department of Earth Sciences and is currently co-hosting (with Earth Sciences) two Italian researchers, Drs. Marta Chiarle and Marco Giardino. CNHR has an NSERC-supported collaboration with MacDonald, Detwiler, and Associates (MDA) supporting training of graduate students in applications of satellite-based remote sensing. Further information on CNHR is available on the Centre's website at <http://www.sfu.ca/cnhr/>

Resource Geoscience and Geotechnics Chair Activity (formerly Forest Renewal BC)

Doug Stead is our Forest Renewal BC (FRBC) Chair who combines geological engineering, remote sensing and numerical modeling techniques in geological research on surface and underground mines and unstable mountain slopes. The FRBC Chair was re changed in 2005 from Terrain Analysis and Forest Geoscience to Resource Geoscience and Geotechnics Chair. Dr. Stead's activity in 2006 -9 has focused on the application of geotechnics to the resource sector emphasizing mining and forestry in addition to natural hazards as a member of the Centre for Natural Hazard Research.

Tier 2 Canada Research Chair (CRC) in Glaciology

Gwenn Flowers is a Tier 2 Canada Research Chair in Glaciology who joined SFU in 2005. Support from the CFI Chairs Infrastructure Fund permitted an ambitious field-based research program to be launched in 2006 which has helped attract personnel and external funding to the group, and has provided fertile ground for collaboration and participation in outside research projects. The research group currently comprises 1 PDF, 1 graduate visiting scholar (École Normale, Paris), 2 undergraduate research assistants, and 3 M.Sc. students, two of whom are graduating in spring 2009. Over the

last 4 years, a total of 6 undergraduates (from computing science, earth sciences and physics) have worked as research assistants either in the laboratory or in the field, with one completing his B.Sc. thesis in Physics on this research in spring 2009. The research focus of the current group is on glacier dynamics and glacier-climate interactions from process- to regional scales. Most group members contribute to the field program, with 5-7 weeks of field time per year. The resulting data are at the core of all student theses in the group, and now comprise long enough records (some 3 years of continuous data) that timeseries analysis is becoming possible. Two new courses, one at the graduate level (EASC 605) and one at the undergraduate level (EASC 314), have been introduced by the Chairholder. These courses address glaciology from first principles (with a difference in the sophistication of the approach) and involve substantial scientific writing, mathematical and computational (Matlab-based) problem sets, reading of the professional literature, and student-led discussion. Both have been taught twice. EASC 711 was taught as a directed-study hybrid of these courses for a UNBC student visiting SFU on a Western Deans Agreement.

Undergraduate Program

Virtually since its inception the EASC undergraduate enrollment has continued to increase. From the 2003/04 to the 2007/2008 school year the EASC annualized FTEs have more than doubled from 55 to 112. This was accompanied by a corresponding increase in majors from 37 to 52.

In addition to the WQB university requirements of 2006, the EASC program also changed from one stream to three. The two dominant streams: The Geology and Environmental Geoscience streams are designed for professional accreditation by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). The third stream, the General Earth Sciences stream, meets the SFU BSc requirements, but is not designed to attain professional accreditation. Since the development of the three streams 50% of the declared majors have been in the Geology Stream, 40% in the Environmental Geoscience Stream with the remaining 10% in the General Stream.

The EASC first year offerings have been extremely successful over the last few years with EASC 101, 103, 104, 106 and 107 enrollments maxing out at least once per course, including the Surrey offerings of 101.

Undergraduate Program – Faculty of Environment

John Clague (committee chair) and Diana Allen were members of the Faculty of Environment Planning Committee. Earth Sciences may participate in a new interdisciplinary program that focuses on Water Science. Diana Allen and Dirk Kirste are actively involved in the development of this program, which would provide strong science-based interdisciplinary training in the hydrologic and climate sciences, complimented by courses in biology/ecology, social sciences, and law (governance).

Specifically, the compliment of undergraduate (and possibly graduate) courses in hydrogeology would be included in the curriculum.

Graduate Program

The Department has operated an accredited MSc program since 1996 and a PhD program since 2005. The number of enrolled graduate students has continued to increase, rising from 42 in 2006/2007 to 48 in 2008/2009 and a projection of 52 in 2009/2010. The most notable change over the last three years has been the rapid increase in the number of PhD students to over one third of the program. The department has graduated one PhD student in each of the last three years, but this figure will likely jump to five in 2009/2010. Over the next few years, it is likely that despite increased recruitment incentives the total program enrollment will level off due to the retirement of one faculty member and a halt to graduate student enrollment by another. Two new graduate courses have been established: EASC 605 Glaciology and EASC 610 Petroleum Geology. Many students continue to take courses at UBC under the Western Dean's Agreement in order to meet their program requirements

Interdisciplinary Research

Dr. Allen is the project leader for an interdisciplinary research team based at SFU and funded by the VP Research under the auspices of the Community Trust Endowment Fund (CTEF). The project title is "Secondary Impacts of Climate Change on Human Health and Ecosystem Health: A Risk-Based Approach". The research team, called the Climate Change Impacts Research Consortium (CCIRC) brings together a group of researchers with expertise in climate, water, air quality, disease, ecology, human health, risk analysis, emergency preparedness, and visualization.

Diana Allen sits on the Program Committee for the Pacific Institute for Climate Solutions (PICS), a new institute established in BC through a \$94 million endowment. Building on the strengths of BC's four research-intensive universities, PICS aims to harness the intellectual resources of BC to develop innovative climate change solutions, seek new opportunities for positive adaptation, and lead the way to a vibrant low-carbon economy.

Diana Allen also co-leads (with K. Bakker at UBC) a project funded by the Canadian Water Network (NCE) entitled "Developing a Canadian Water Security Framework as a Tool for Assessing Cumulative Impacts and Improving Watershed Governance". The research group includes social and physical scientists, spanning a number of disciplines. The research team aims to create a Water Security Framework (WSF) composed of a Water Security Index and associated decision support tools, with the objective of improving water security in Canada, specifically through improving governance for source protection and land use.

Dr Calvert is the leader of the Nechako basin project, which seeks to understand the structure and evolution of the basin. He is coordinating the synthesis of a broad range of

geoscientific results from researchers in a variety of organizations, including universities, government agencies, and industry.

Dr. Clague conducts research with biologists, geographers, and archaeologists at SFU and seven other universities in Canada and abroad. He is an Associate Member of the SFU Department of Archaeology and the School of Resource Management. Clague is a principal member of the Western Canada Cryosphere Network, a group of geographers, hydrologists, and geophysicists funded by the Canadian Foundation for Climate and Atmospheric Sciences to conduct an interdisciplinary research program on present and past glaciers in British Columbia.

Dr. Flowers collaborates with biologists, ecologists and other glaciologists in a multidisciplinary International Polar Year project (NSERC funded) addressing tundra ecosystem dynamics in southwest Yukon Territory. She is also involved in the SFU-CTEF-funded project “Secondary Effects of Climate Change on Human and Ecosystem Health: A Risk-Based Approach” led by Dr. Allen.

Dr Stead is currently working closely with the Department of Mining and the Geological Engineering Program at UBC and with the Department of Civil Engineering at UBC (Okanagan) including collaboration on a multi-national block caving research through a 4 year research proposal funded by Diavik Diamond Mining (Rio Tinto) and NSERC CRD and Strategy grants.

Dr. Williams-Jones's research is multidisciplinary, applying geophysics, geodesy, geochemistry and satellite remote sensing to elucidate questions regarding the trigger mechanisms of volcanoes and the impact of persistent volcanic degassing on the local and regional environments. For example, he is currently involved in a multi-year project which integrates geophysics and geochemistry with ecology and entomology.

International Activities

Dr. Allen is a member of the Expert Group for UNESCO's GRAPHIC Programme (Groundwater Resources under the Pressures of Humanity and Climate Change). GRAPHIC seeks to improve our understanding of how groundwater interacts within the global water cycle, supports ecosystems and humankind and, in turn, responds to complex and coupled pressures of human activities and climate change. GRAPHIC was developed to incorporate a collaborative effort and umbrella for international research and education.

Dr. Allen is currently working on one major international project, based in Mali, Africa. She has partnered with Global Aquifer Development Foundation, a Canadian Charitable Organization with the aim of providing developing nations with training, tools and education, through financial and technical support, to understand and sustainably manage their groundwater resources. Dr. Allen has led two field expeditions to Mali in the past two years. One graduate student is currently conducting research on various aspects of groundwater recharge in sub-Saharan Africa.

Dr. Calvert is currently involved with collaborators from Europe and North America in a project to review what is currently known of arc-continent collision, and to write a book synthesizing this knowledge.

Dr. Clague is the co-leader, with Dr. Marco Giardino, of an earth-science student exchange program between Simon Fraser University and the University of Torino in Italy. Clague is pursuing research in the Southern Alps of New Zealand in collaboration with Dr. Mauri McSaveney (Institute of Geological and Nuclear Sciences), Dr. Tim Davies (University of Christchurch), and Dr. Oliver Korup (Swiss Federal Research Institutes WSL/SLF). He also is conducting collaborative research in Argentina with Dr. Jorge Rabassa (CASIC-CONICET) and in Bolivia with Dr. Reginald Hermanns (Norges geologiske undersøkelse). Clague is Past-President of INQUA (International Union for Quaternary Research) and in that capacity interacts with scientists in 45 countries around the world.

Dr. Flowers will be collaborating with colleagues at Columbia University/Lamont-Doherty Earth Observatory on Antarctic subglacial hydraulics with funding through a Marie Tharp Visiting Fellowship in fall 2009. Dr. Flowers is also a co-P.I. on the Canadian component of two International Polar Year projects (Arctic tidewater glacier dynamics; tundra ecosystem dynamics). She will soon be joining the U.S.-led international development of the “Community Ice-Sheet Model” intended for the next IPCC assessment.

Dr. Stead is involved in underground mining related research in South Africa (Palabora mine) and Australia (Northparkes mine). He was awarded a European ERASMUS Research Scholarship for 2009 through the Universities of Delft (Holland) and Exeter (UK). He was responsible for the setting up of a letter of agreement for research collaboration between the University of Bologna, Italy and SFU and a principal member of a European Grant application (Clague/Giardini) supporting Collaboration between Canadian and Italian Universities. Dr Stead is currently a member of an International Association of Engineering Geology Commission on Landform processes.

Dr. Williams-Jones's research is dominantly international in nature, involving studies on a variety of active volcanoes in the Americas, Europe and South East Asia.