Earth and Ocean Sciences

ALUMNI NEWSLETTER

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Message from the Head

Paul L. Smith
Earth and Ocean Sciences
Head

Dear Alumni and Friends

This has been a year of great achievement, increasing opportunity and growing long term challenges. Like all other organizations in the world, we see a looming demographic crisis as the baby boom generation approaches retirement. At the same time, the need for Earth scientists has never been greater, driven by pressing environmental issues combined with booming markets in the minerals and energy sectors. If we are to play our part in addressing this issue, we will need increased funding for student support and increased space to house more students.

The space problem is particularly pressing because, since 2000, we have already substantially expanded our research activities and this summer reached a record graduate student enrollment of 167. Our growing research stature is reflected in the fact that we now rank number one in Canada in terms of NSERC support per researcher. We are also the nation's most productive Earth Science department when measured by the number of research papers published. Our undergraduate course enrollment is creeping steadily towards 6,000 and will be boosted significantly in the Fall when EOS becomes home to the Environmental Sciences Program. We have also been included in phase one of the Carl Wieman Education Initiative (see p.19) which, with a $2 million budget for EOS over 5 years, will see us revolutionize our teaching, hire more lecturers and expand our IT capacity.

With the leadership and support of Mr. Ross Beaty (CEO, Pan American Silver), Professor Stephen Toope (President of UBC), and Simon Peacock (Dean of Science UBC), EOS recently launched a campaign to fund construction of a new home, the Earth System Sciences Building. The plan is to raise $65 million, split equally between the public and private sectors, to build a facility that will become the centre of activity for the entire Faculty of Science. Not only will the Dean's Office and major science teaching facilities be centred here, but it will also be the hub of science outreach. This is because an expanded Pacific Museum of the Earth in the ESSB will face the Beaty Biodiversity Museum currently being built on the other side of Main Mall. Reaching into the schools is the most important path to recruitment for universities, particularly for the Earth Sciences which are poorly represented in the school curriculum. However, not only do we plan to bring school children to EOS but we also intend to encourage and support the teachers who are trying to promote the Earth Sciences in our schools. In February, we opened the EOS Teachers' Resource Centre which will provide lesson plans, teaching resources and materials to visiting teachers and teachers currently training in the Faculty of Education.

I am particularly delighted to tell you that Goldcorp has stepped forward with a $5 million lead gift to help us achieve our vision. There are many other donations in the pipeline and under negotiation. I hope very much that if any of our alumni become involved in these negotiations, they will do all they can to support the cause. Please help EOS achieve its ambition to become one of the world's pre-eminent Earth Science departments.

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The Opening of the Precious Minerals Vault and the Teachers' Resource Centre The New Earth System Science Building Fundraising Kicks Off

Paul L. Smith, Head of Earth and Ocean Sciences

UBC President Stephen Toope

On February 28th the Pacific Museum of the Earth held the official opening of a new permanent display, the Precious Minerals Vault. The opening was well attended by faculty and staff of Earth and Ocean Sciences, UBC Administration, and members of the resource industry.

Remarks were made by Earth and Ocean Sciences Department Head Paul Smith, UBC President Stephen Toope, and Pacific Museum of the Earth sponsor Ross Beaty. Dr. Smith drew attention to the current discrepancy between the needs of industry and the availability of trained geoscientists of all varieties; at this year's Mineral Exploration Round Up, it was observed that 40% of the professionals in attendance would be retired within 10 years. At the same time, universities are supplying fewer trained geoscientists.

Departments such as UBC EOS need to attract more students. The Pacific Museum of the Earth is potentially a powerful tool towards this goal and it is approaching the problem from two directions. First, the Teachers' Resource Centre aims to help Kindergarten to Grade 12 teachers present geology in the classroom by providing Earth science education resources. Second, the Vault seeks to capture the interest and imagination of visitors by featuring some of the most beautiful and rare mineral specimens. For many people who go on to become geoscientists there is a moment in their past when they were "hooked" on the subject, when something fired their imagination. This is the moment the Vault seeks to spark.

President Toope spoke about the need to continue to support science education both in the general public and in kindergarten to grade 12 schools. He noted that the Vault and the Teacher's Resource Centre are steps in increasing our support for teachers. At the same time, we are also striving to build our teaching and research capacity at UBC, and President Toope emphasized the importance of the proposed Earth Systems Science Building in this endeavour and in the ongoing attempt to bring together diverse specialties and work across disciplines. The proposed Earth Systems Science Building is an ambitious project, and there is a great sense of optimism about its prospects.

Mr. Ross Beaty

Mr. Beaty acknowledged the many people who contributed to the museum's past and current success, including the board members of the former Pacific Mineral Museum Society Board, past curators, the current curator, and Department of Earth and Ocean Sciences and UBC administration. He also reiterated Dr. Smith's comments regarding the need for more geoscientists and called upon fellow members of industry to support the Earth Systems Science Building. The ESSB is an essential element in the drive to train more geoscientists, as it will provide the capacity for more students to be trained while at the same time bringing together the resources needed to support both teaching and research.

After completing their remarks, Dr. Smith, President Toope, and Mr. Beaty performed a ceremonial ribbon cutting in front of the speaker's podium. They then entered the Vault for the first viewing with curator Mackenzie Parker.

Built from beautifully stained and finished wood, the Vault displays are designed to provide a polished and elegant frame for high value minerals and gems. The wulfenite sample--formed of dozens of translucent, high-lustre orange crystals standing out from a pale orange background, rotates to display the clusters of crystals on both sides of the specimen. Slices of liddicoatite--a variety of tourmaline which shows beautifully coloured patterns in cross-section--were arranged much like panes in a stained glass window.

Most samples, including gold, emeralds, and diamonds, are displayed on black metal pedestals and are spotlighted with brilliant fibreoptics. Low lighting in the Vault room and black backgrounds within the display cases creates the impression that glittering samples are floating in the darkness.

Simon Peacock (Dean of Science), President Toope and Mackenzie Parker (PME Curator)

In addition to the primary displays, the Vault features seven drawers which can be pulled out by visitors to reveal additional samples. Drawers are lined with black material and are illuminated with daylight spectrum lamps to best bring out the colours of cut gems and light sensitive minerals.

Reaction to the Vault was extremely positive from both those who were familiar with the inspiring display from the former Pacific Mineral Museum and those to whom the installation was entirely new.

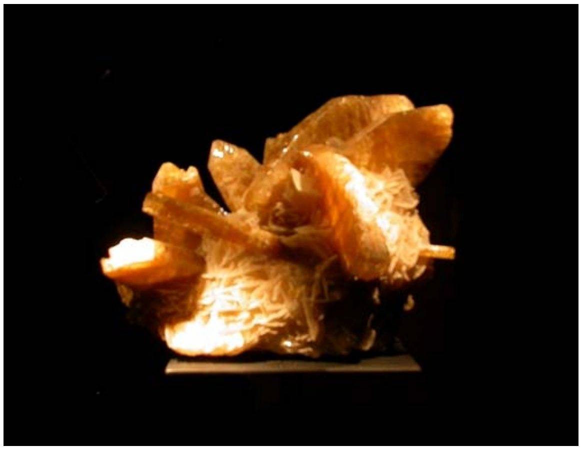
Throughout the evening, as attendees filtered into the Vault, there was a sense of great enthusiasm with regards to the Department of Earth and Ocean Sciences' future and the proposed Earth System Sciences Building.

Those of us who work with the museum on a daily basis were left with a feeling of immense excitement and the belief that there are many more great things to come in the museum's future.

~Mackenzie Parker, Pacific Museum of the Earth Curator

Interior of the Vault

Wulfenite

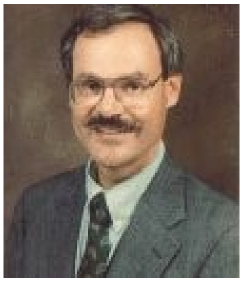


Barite

Mesolite

Calcite

CLIMATE CHANGE



Roland Stull
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Is Global Warming Caused by People?

1. Introduction

Many reputable science organizations have policy statements that strongly support the notion that recent global warming is caused by people.

But I am not so sure. The purpose of this essay is to explain my doubts in the context of how we do science.

Also, I see that the root problem is really overpopulation -- a religiously and culturally charged issue that politicians are happy to avoid. This is the second theme of this essay.

2. Who Done It?

There is strong evidence that global climate is warming. There is also excellent data showing that carbon dioxide levels have been rising, and other data showing that people are burning more fossil fuels. Thus, there is a strong correlation between anthropogenic (people-caused) CO_2 increases and global warming. But a correlation does not indicate cause and effect.

There is also a very strong correlation between global warming and the number of news reports and policy statements about global warming. Does this mean that global warming is caused by policy statements on global warming? Well...probably not, because a correlation does not indicate cause and effect.

A difficulty in finding the cause of global warming is that there is a superposition of myriad processes acting on the atmosphere. There are natural geologic-scale cycles, such as the increase in global temperatures that we expect to continue happening since the end of the last major ice age 20,000 years ago. We know that Greenland was relatively warm and green during the Medieval Maximum warm period of the Vikings 800 years ago, before the Little Ice Age. There are decadal oscillations, and shorter term El Niño variations. There is a natural 30 to 40-year cycle in Atlantic hurricanes. And added to this might be an anthropogenic signal of similar magnitude.

So how do we sort all this out? One approach in science is to do controlled experiments. Prevent everything else from varying except for the one hypothesis that you wish to test, and then measure the outcome. Nice.

Unfortunately, we can't control the atmosphere. Even laboratory experiments are useless because they cannot mimic the extremely large degrees of freedom in the highly nonlinear atmospheric dynamics. So we have already lost science's two most valuable tools in the quest for cause and effect.

3. Our Arsenal

But there is another tool in our scientific arsenal -- numerical simulation. These are very large computer programs, often consisting of hundreds of thousands of lines of code written by teams of experts over several years. In the jargon of meteorology, we call these programs *models*, because they numerically approximate (or model) the workings of the atmosphere.

Unfortunately, these models aren't perfect. There is no hope of simulating every turbulent eddy, every snowflake and rain droplet, every cloud, every plant and animal at the bottom boundary of the modeled atmosphere, and every wavelength of solar and IR radiation. So instead, the average effect of these physical processes are *parameterized* -- another bit of jargon that means we invent an approximation that empirically fits the observations.

Even the fundamental equations of fluid dynamics that govern the atmosphere must be *discretized*. This is more jargon meaning that we solve for the atmospheric state at only discrete points rather than for the infinite number of points in 3-D space that defines the real, smoothly varying atmosphere.

Parameterizations and discretizations don't come from first principles. Different scientists can invent different parameterizations for the same process, and indeed there are as many different parameterizations as there are scientists working in the field (many hundreds). None of them are perfect; most of them are reasonable; all of them give different answers when used in global climate models.

The power of a numerical climate model is that you CAN do a controlled experiment with it. Double the CO_2 while holding everything else constant, and see what happens. Alter the earth's orbit, change the amount of reflective dust in the atmosphere, move continents, melt ice caps, erupt volcanoes. Anything is possible, because with a numerical model you can be God.

Perhaps my doubt about numerical models stems from the fact that I have been a modeler for 30 years. Even supposing that you can remove all programming bugs (which is unlikely), there are hundreds of fudge factors in the model that you can tune to your heart's content. And the weird thing is that when you change one fudge factor, you often find that you need to change other fudge factors to compensate for their errors.

For example, suppose you change the size distribution of microscopic cloud condensation nuclei. This alters the cloud cover, which changes the amount of sunlight reflected, which alters the surface heat budget, which changes the evaporation rate, which perhaps desiccates the land more, alters the vegetation, changes the surface albedo (reflectivity), etc. The complexity is scary.

Even more scary are the physics in the real atmosphere that we don't even know about yet, and don't have in the models. Such as when it was discovered that phytoplankton (microscopic plants) in the oceans release a chemical called dimethyl sulfide gas. This oxidizes in the atmosphere to form aerosols (tiny liquid droplets and dust) that alter clouds, change the amount of reflected sunlight and trapped infrared radiation, and alter the heat budget.

When the first global climate models were run they were missing this dimethyl sulfide effect. Oops. The more recent model simulations include this effect now, but what other effects have we yet to discover? What will be the future oops?

4. An Imperfect Tool. A Handy Scapegoat.

Although numerical climate models do indeed allow us to run controlled experiments, we've seen they are imperfect tools. The spread between forecasts from different climate models is much much greater than the average predicted signal in global warming. Namely, the noise is greater than the signal.

> Stull's Conclusion # 1: Even if there is a portion of the global warming that has been caused by people, we are unable to detect it now with a strong degree of certainty, due to noise from all the other natural climate cycles and model imperfections.

But where science is unable to deliver a definitive answer, sensationalism can come to the rescue. "Record heat wave recorded" -- attributed to global warming (...perhaps). "Record cold wave blamed on global warming". Hmm. Sure, why not claim global warming causes increasing weather extremes. That way, we can blame everything on global warming -- a handy scapegoat. And the handmaidens of global warming are greenhouse gases like CO_2.

5. Wise guy

I don't think that I am producing more CO_2 than I was 20 or 40 years ago. In fact, by using cleaner cars I suspect I am producing less. So if I am not producing more CO_2, and if you are not producing more CO_2, then who is? Who's the wise-guy who turned up his CO_2 exhaust to spite the rest of us altruistic blokes?

You already know the answer. Even if every one of us takes action to not increase our CO_2 emissions, the fact that there are more and more of us on this planet means that total CO_2 emissions increase. Population is the root issue.

For many of the wealthier countries, population has nearly leveled off. But for many second- and third-world countries the population is still exploding exponentially. They have just as much right to seek the standard of living that we already have in North America, even if it means they must increase their energy usage and pollution production per capita. With their increased energy usage and pollution production comes more CO_2 emissions.

> Stull's Conclusion #2: If we presume that every individual on this planet has the same right to food, energy, and material goods, then the only way to reduce global energy and pollution is by controlling the number of individuals. Namely, population control.

Population control is a very sticky issue. It certainly is doable, as demonstrated in China. But other religions and cultures just won't stand for it. At least they haven't so far.

But societies are made of people, and religious and cultural leaders are people. People can change, particularly if they see it is for their own good. Ultimately, control of CO_2 (and control of anthropogenic global warming if you believe in it) is a social issue, not a scientific or technical one. While we physical scientists and engineers can provide temporary fixes and stopgap solutions (more efficient cars or light bulbs), the better solution is for society to change their values.

I'm not a social scientist and have no credibility in this area, but I suspect that some non-violent religious and cultural paradigm shifts happen the same way as scientific paradigm shifts. From the bottom up. From the younger people realizing a new truth, and eventually moving into positions of power as the intransigent oldsters retire.

A key to affecting this change is education of our youth. Using university students in my courses as an example, I see energetic young adults with a willingness to tackle difficult problems and an ability to consider and embrace new ideas. They all want to make a difference, and I believe they can.

6. Bumps in the Road

But bumps in the road to education are the biased reports the "expert panels" have produced so far (see citations at the end of this essay). The official documents that our youth can read don't focus on overpopulation as a root issue in the global warming debate. Some document's mention population in passing, but they don't present population control as a call to action.

Perhaps it is no surprise about the bias of these reports -- they are aimed at politicians. Politicians are smart. Their election/re-election cycle is rather short, so to get re-elected they are forced to focus on short-term issues. They are also astute enough to stay away from politically charged topics of religion or culture. Why should they bring up population control when they can skirt the strategic issue and deflect attention instead to CO_2? It keeps the population distracted while giving the appearance of being concerned and studying the problem.

But the real problem seems to me to be an overpopulation variant of "tragedy of the commons". What is "tragedy of the commons"? The classic example is when countries fish the same ocean. The ocean is common -- not owned by any one country. All countries might acknowledge that fish stocks are dwindling and that the best strategic course of action is to limit the fish caught each year, allowing fish stocks to increase to best serve all countries. But if any one country takes unilateral action to conduct unlimited fishing, then the other countries would be foolish to not race to catch their share. This action gives a short-term gain at the expense of a long-term disaster -- the extinction of desirable fish species that ultimately hurts all countries.

How does "tragedy of the commons" relate to human overpopulation? Our earth is held in common. It has a finite holding capacity of humans, based on food supplies, living space, energy, drinking water, and pollution. All nations, cultures, and religions might be able to agree that it is in their best interests to control population, to allow the highest quality of life for the individuals on the planet. But if any one religion or country unilaterally encourages families to have many children, the other religions or countries would be foolish not to race to produce their share of offspring. Again, this would be a short-term gain at the expense of a long-term disaster.

The end result would be an overpopulated earth with every individual living a marginal existence in a stew of pollution and in constant battle for limited food, water, and energy.

How do we avoid this tragedy? As I already suggested, this is a social change best accomplished through education of our youth. But it is best to start soon, while we still have the resources of energy, food, and water. If we wait too long, we might dig ourselves into a resource hole from which we can't escape.

7. A Non-problem

We live in a world of amazing connectivity. Information is shared over networks almost instantly. Many people are exceptionally mobile, moving to new jobs, new towns, and new homes frequently during their lifetime. Money and resources can be wired, shipped or airlifted to most places in a day or two.

To this buzz of society, now add the likely scenarios of increasing population, and its concomitant increases in pollution, water and food shortages, energy shortages, material shortages, and reduced living space. Oh! ... don't forget to add global warming.

Sea levels might rise a few centimeters a decade due to global warming, storms and arable locations might shift, but that would be the least of my worries. Instead, I would be more focused on the population-caused crises of:

- air pollution stinging my lungs, requiring drastic changes in transportation & industry,
- pandemics spread within immensely large urban areas,
- wars fought for control of oil-rich lands,
- diversion and draining of rivers for fresh water and irrigation,
- food shortages resulting in urban violence, etc.

A generation from now, I suspect our descendents will be incredulous as to why we let ourselves get so distracted with global warming as to let the really important population problems get out of hand.

8. One man's opinions.

I've aired my doubts about global warming, and raised an alarm about overpopulation. This essay is a call for discourse. Presented were my opinions, not a policy statement of my employer.

A decade ago I attended a talk on global warming by a distinguished, knighted, expert. At the end of his talk, he said "anyone who doesn't believe in global warming is dumb". Hmm...if he says so, it must be true. I may be dumb, but I care about our future.

Interesting Reports:

Sigma Xi scientific research society, 2007: Confronting Climate Change, *American Scientist*, May-June 2007, **95**, #3, suffix p1-5.

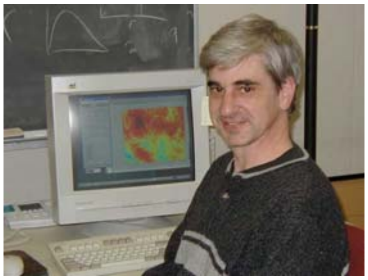
American Meteorological Society, Feb 2007: http://www.ametsoc.org/policy/2007climatechange.html .

National Research Council, 2001: *Climate Change Science: An Analysis of Some Key Questions*. National Academies Press.

National Research Council, 2005: *Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties*. National Academies Press.

Canadian Meteorological and Oceanographic Society (http://www.cmos.ca/PressReleases/pressrelease1June2006.pdf),

Intergovernmental Panel on Climate Change (http://www.ipcc.ch/).



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Placing Our Bets On Global Warming

(An annotated version of this essay and a list of suggested readings are available at http://www.eos.ubc.ca/personal/paustin/climatelinks**)**

Life is uncertain. We have to act on incomplete information, combining our knowledge with advice from friends and inspired guesswork to choose a college major, a career, a new home. As the Yiddish proverb says: "We make plans, and God laughs". If we're prudent and have the resources we can hedge our bets: we buy earthquake insurance or build a cash reserve that can pull us through the collapse of Plan A.

The message from the vast majority of scientists who study the Earth's climate is that humanity's Plan A has placed us on a development trajectory that carries a significant risk of lasting damage to the global environment. The consensus view, built on the peer-reviewed research of thousands of scientists and summarized by the Intergovernmental Panel on Climate Change (IPCC) in 1990, 1995, 2001 and now again in 2007 is that, over the past 100 years, human behavior has substantially changed the chemical composition of our planet's atmosphere, that this change has increased the average global temperature, and that the temperature change has been amplified by the climate system (that is, that the climate system produces a positive feedback when forced with increasing concentrations of greenhouse gases). In particular, the 987 page Fourth Assessment Report of IPCC Working Group 1, entitled "the Physical Basis of Climate Change", makes five statements I will expand on below:

1. "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."

2. "Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

3. "It is extremely unlikely (<5% probability) that the global pattern of warming observed during the past half century can be explained without external forcing, and *very likely* that it is not due to natural causes alone."

4. "The understanding of anthropogenic warming and cooling influences on climate has improved since the (2001 third assessment report), leading to very high confidence that the global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [with a range of +0.6 to +2.4] Watts/meter^2"

5. "The equilibrium temperature increase following a doubling of carbon dioxide "is likely to be in the range 2 to 4.5°C with a best estimate of about 3°C, and is very unlikely to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement of models with observations is not as good for those values."

Statement 1 addresses the *detection of* global warming, while statement 2 is concerned with the *attribution* of warming to human (anthropogenic) activity. In both cases the statements represent inferences made from millions of combined observations of the ocean, atmosphere and land surface. Eight of the 11 chapters in the Fourth Assessment Report are focused on measurements and data, while the other three treat the global and regional projections of climate models. How confident are climate scientists of the first two assertions concerning the observed climate? The term *very likely* in Statement 2 means "with greater than 90% probability". Similarly, "likely" and "very unlikely are shorthand for "with greater than 66% probability" and "with less than 10% probability".

How can scientists be certain that global warming is our responsibility, and not the product of outside factors like sunspots or galactic cosmic rays? We have decades of direct satellite measurements of the solar flux, and a thorough understanding of the heat trapping properties of greenhouse gases. Each day satellites use emitted radiation from carbon dioxide molecules to estimate the vertical profile of atmospheric temperature; these temperature measurements are assimilated into all weather forecast models. Any uncertainties about CO_2 absorption would show up as mismatches between these temperature soundings and standard balloon measurements done twice every day at more than 600 different locations. Satellites and balloons also tell us that the upper atmosphere is cooling while the lower atmosphere is warming. This is consistent with CO_2-induced emission and cooling to space, but inconsistent with an increase in solar radiation, which should add energy to the upper atmosphere. Thus, those who would question the primary role played by carbon dioxide in heating the planet have to meet multiple challenges: they need to find another explanation for the observed climate warming and also explain why meteorologists, physicists and chemists are wrong about the fundamental physics of CO_2 absorption. Finally, we know that the observed 30% increase in CO_2 is due to fossil fuel burning and not the natural carbon cycle; carbon dating of atmospheric CO_2 establishes that the molecules are more than 60,000 years old, effectively showing our fingerprints on the increasing CO_2 concentration.

What about statements 4 and 5 on the list? Statement 4 addresses the question of *climate forcing* (measured in power/unit area), while statement 5 deals with *climate sensitivity*. The expected change in the earth's temperature is the product of these two terms. Specifically, we know that doubled CO_2 will produce 4 Watts/meter^2 of additional heating. If the climate sensitivity is 3 degrees/doubling, then quadrupling the CO_2 concentration over the next century should raise the surface temperature by 6 degrees. But note the large uncertainties in the forcing and sensitivity estimates. The uncertainty in the forcing is partly due to the effect of atmospheric aerosols (industrial/automobile haze), which can both reflect and absorb sunlight. Predicting future forcing requires estimates of both CO_2 and aerosol emissions and their radiative impact. An additional complication is that CO_2 and aerosols have very different lifetimes: on average an aerosol particle will be removed via rain within a few days of emission, while a CO_2 molecule will stay in the atmosphere and upper ocean for centuries (and a quarter of the CO_2 we emit will remain in the atmosphere for the next 100,000 years).

Why do we think that the climate sensitivity is in the range 2 – 4.5 degrees per CO_2 doubling? Part of the evidence comes from global models, and much of chapter 8 of the IPCC report is devoted to the sensitivity estimates of the 23 climate models that participated in the fourth assessment. There are also important observational constraints. For example, we know that over the past 100 years the surface temperature has increased by about 0.8°C under a forcing of between 0.6 and 2.4 Watts/meter^2; that ratio can be used to infer a sensitivity. Complicating this estimate is the fact that the planet has enormous thermal inertia, and it is likely that there is another half a degree of warming in the pipeline, even if we were able to eliminate all of the forcing immediately. We can also estimate the forcing and feedback required to create and melt the ice sheets in both hemispheres during past glaciations, and observe the surface temperature response to the planet-wide cooling following major volcanic eruptions like El Chichon and Mt. Pinatubo. All of these estimates are consistent with a climate sensitivity of at least 2°C, and none of them exclude the possibility that the sensitivity is at the upper end of the 2 – 4.5°C range.

Given all of the above, it's a good bet that doubling the atmospheric concentration of CO_2 will result in a temperature increase of several degrees, with larger increases as we triple and then quadruple CO_2 . Uncertainties in the forcing and the climate sensitivity act generally in the direction of higher rather than lower equilibrium temperatures. Although it is now too late to return to pre-industrial levels of greenhouse gasses, it is still possible to stabilize CO_2 below twice that concentration. This will be expensive but not ruinous, economic analyses show that the cost will be between 1.5-5% of global gross domestic product in the year 2050. Given annual GDP growth rates of 2-3% this means that the price for ending the "carbon experiment" we've embarked on will be to arrive at the year 2030 with the economy we would have had in the year 2028 or 2029.

And what if we decide to continue the carbon experiment? To find a period in which the planet was 2-3°C warmer than present we have to go back 3 million years to the mid-Pliocene, when the sea-level was 25-30 meters higher than today. This doesn't mean that our children will live to see the tide take Richmond and Vancouver; melting that much of the Greenland ice cap is likely to require hundreds of years. It does mean that our actions constitute a climate perturbation that is large even in comparison to geological processes acting over millions of years. Can ecosystems adapt to these changes without significant extinctions? Will the new climate we've created support the extra 3 billion people that will arrive between now and 2070? Currently these questions can't be answered. It is a surreal feature of the climate debate that attempts to hedge against this uncertainty can be portrayed as unrealistic or radical. From a climate perspective the radical venture is really "business as usual", which is a head-long effort to change the Earth's atmosphere by injecting a radiatively active gas that will persist for dozens of centuries. Why not slow down the experiment and remember, in John Sawhill's words, that a society is defined not only by what it creates, but by what it chooses not to destroy.

Waste. Not.

Using Mine Tailings to Sequester CO_2

Greg Dipple
Professor, Earth and Ocean Sciences
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Ensuring a habitable Earth will require more than emission reduction and a switch to alternative energy sources. Finding ways to trap and store carbon dioxide is crucial to the future of this planet. UBC geologist Greg Dipple has discovered that mine tailings are a natural CO_2 sink, and he is working to harness and fast-track nature's mineral sequestration process.

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Reproduced with permission of the UBC Faculty of Science.
Mari-Lou Rowley, the author, is a science writer, poet and principal of Pro-Textual Communications.

The last place on Earth one might consider looking for a solution to global climate change is in mine tailings. These mountains of sand and fractured rock are known to leach toxic minerals and turn the landscape into a wasteland of rubble. It is difficult to imagine anything beautiful or beneficial about them. Nevertheless, UBC Earth & Ocean Sciences professor Greg Dipple has discovered that mine tailings are an enormous greenhouse gas (GHG) storehouse, with the potential to remediate thousands of tonnes of carbon dioxide (CO_2) emissions quickly and efficiently using Mother Nature's recipe for chemical weathering. "Other carbonation methods, such as increasing natural forest, soil and ocean sinks, and artificial sequestration are either short-term or low-capacity solutions," Dipple states. Mine tailings have the potential to sequester and store more CO_2 than other methods, in a more stable form. This could be achieved as part of ongoing mining processes that would also be GHG neutral.

In the natural cycle of mineral weathering and sequestration, rain falling on continents dissolves small amounts of minerals, and in the process, removes CO_2 from the atmosphere. In the subsequent recycling process, CO_2 is typically carried to the ocean and eventually becomes rebound in minerals. "This natural cycle occurs on a continental scale over millions of years," Dipple explains. "As a result, about 90 percent of the earth's carbon is bound in carbonate minerals, where it is very thermodynamically stable."

For the past decade, the US Department of Energy has been investigating mineral sequestration of CO_2 as a novel GHG sink. However, their model involves sending the CO_2 from a coal-burning power plant to a new mine opened specifically to extricate silicate minerals for carbonation. "The challenge is finding a quick, economical method that doesn't emit more CO_2 when generating the energy required for mining than you eventually store," Dipple says.

Existing mining environments provide a ready-made solution, albeit one that might seem too good to be true. "In the milling process, solid rock is ground up, thereby increasing the reactive surface of the rock a million-fold," Dipple explains. "A reaction that would normally take a million years can happen in a few years, or even months." He notes that some studies have shown the formation of carbonate crusts in mine tailings within months of their deposition. Dipple and colleagues were the first to study—and publish—how CO_2 sequestration occurs in mine tailings from existing mines.

Potential Greenhouse Gas Benefit

- Magnesium silicate minerals consume half their mass in CO_2 during carbonation.
- The tailing sequestration capacity of hardrock mines is five to ten times greater than their total Greenhouse Gas emissions.
- Using only ten percent of tailings as sinks could produce a Greenhouse Gas neutral mine.
- Approximately one million tonnes of CO_2 per year could be trapped and stored in a ten-million-tonne-per-year tailing operation.

Mechanisms of CO_2 Fixation in Tailings

With seed money from NSERC, the Yukon Geological Survey, and the BC Ministry of Energy, Mines and Petroleum Resources, and in collaboration with the Mineral Deposit Research Unit and the Pacific Centre for Isotopic and Geochemical Research at UBC, Dipple and UBC colleagues initially studied tailings in abandoned mines at Cassiar and Clinton creek. Their work involved quantifying the rate of CO_2 uptake, examining the different processes by which CO_2 uptake occurs, and determining what was attributable to the mining process versus natural weathering.

The carbon in minerals from mine sites comes from three reservoirs: the atmosphere, bedrock and the industrial process of mining itself. Determining the source of carbon that has been trapped in the tailings is crucial to their potential use for GHG remediation. "These three sources of CO_2 tend to form carbonate minerals that are isotopically very distinct," Dipple says.

He and his research group also identified the two distinct pathways by which magnesium carbonate minerals form as a natural consequence of silicate weathering. The pathway for the minerals nesquehonite and lansfordite is abiotic, or dependent on environmental factors, such as water chemistry and pH, and weather. For the minerals dypingite and hydromagnesite, the pathway is biotic, or microbially mediated.

Diavik diamond mine, Northwest Territories

Industry Acceptance Accelerates Research

Knowledge of the reaction rates, pathways and minerals formed is required to develop models and identify the processes needed for industry to use the science of mineral sequestration for tailing sinks. With funding from mining companies BHP-Billiton and Diavik, followed by matching funds from NSERC, Dipple and colleagues began studying two active mines: the Diavik diamond mine in the Northwest Territories, and the Mount Keith nickel mine in Western Australia. The group measured the difference between minerals formed by biotic and abiotic pathways, and discovered that the environment likely dictates not only the pathway, but the mineral formed and the rate of sequestration. Nesquehonite and lansfordite are commonly found in the Canadian Arctic. In contrast, dypingite and hydromagnesite were more predominant in tailings found in the Australian desert. "It seems that nesquehonite prefers a colder climate, and dypingite and hydromagnesite like the hot, wet tailing environment of the Australian mine," says Dipple. "One would expect an abiotic pathway in the colder environment and a microbially-mediated pathway in the hot environment, but we are still in the process of figuring this out."

Perhaps most significant of all, they found that the total CO_2 sequestration capacity in these two mines exceeds the total of their greenhouse gas production by a factor of five to ten.

Mt. Keith nickel mine, Western Australia

Global Impact of Silicate Sequestration

The rate of chemical weathering in nature and of carbon fixation in mine residues is determined by how quickly minerals dissolve in water. Dipple and his group are working in the field and in the lab on methods to accelerate this process. They are developing a geochemical model to predict sequestration rates as a function of the environment and of accelerated processes such as increased abiotic or microbial activity. This work would provide a verification protocol that will allow companies to forecast and track the rate of carbon uptake in mine tailings in order to trade carbon credits on systems like the European Emissions Trading System and the Chicago and Montreal Climate Exchanges. This could, in turn, help fund site remediation in abandoned mines. "In active mines, the companies just need to tweak an ongoing process. In abandoned mines, the infrastructure is gone," Dipple says.

With the potential of a single mine site to trap and store hundreds of thousands of tonnes of CO_2 annually, Dipple's research could have a huge impact on global climate change remediation. He is cautious about being overly optimistic, however. Since the world's major infrastructures— energy, electricity, transportation, economy—are all built around the fossil fuel industry, it could take at least 50 years to see the effects of both innovation and remediation. "After that time, we won't have to deal with these issues any more, because by then we will have moved on."

Mineral crust, Mt. Keith tailings

Accelerating Sequestration—with Bugs

Greg Dipple and colleague Gordon Southam of the University of Western Ontario are investigating various methods of accelerating CO_2 uptake by abiotic and microbially mediated pathways. They have discovered that the rate of sequestration varies by orders of magnitude between different tailing environments. The salinity and pH value of the water contribute dramatically to the rate of mineral dissolution and subsequent CO_2 uptake.

The abiotic method of the process relies on bulk changes in fluid chemistry to accelerate mineral dissolution. Dipple and Southam have found that microbes also accelerate sequestration, and their method is similar—but more subtle and sustainable. "Microbes change the chemistry of the water around their cell walls," he explains. "So you can get the same mineralogical effect both abiotically and biotically. The difference is that microbes only change the pH value in their immediate environment, so we don't need to change the composition of all the water in order to accelerate the precipitation rate."

Their experiments have shown that the biological pathway produces an increased rate of precipitation, without the further environmental hazard of waste water containing high salt concentrations.

Curtis Suttle,
Professor, Earth and Ocean Sciences
University of British Columbia, Vancouver, Canada

Finding Life Forms No One Knew Existed

Researchers examining DNA from viruses in the oceans are finding a host of totally new sequences.

Reprinted with permission of The Vancouver Sun and author Nicholas Read (dated July 8, 2006)

Consider this the next time you think about taking a dip in the ocean. Every time you go swimming - even in a pristine jewel of a cove in the middle of what looks like nowhere - you will swallow billions of viruses.

That's right, billions.

Of course, when you consider how abundant marine viruses are it's no wonder. If you were to line them up end to end, they would span 10 million light years, or about 100 lengths of the Milky Way. If you put them on a scale, they'd tip the bar at something like the equivalent of 75 million blue whales.

It makes you want to dry out your bathing suit forever. But it shouldn't, says Curtis Suttle, a professor of Earth and Ocean Sciences, Microbiology and Immunology, and Botany at the University of B.C. That's because even that many viruses in that yucky a concentration - roughly a billion per teaspoon - shouldn't do you any harm.

The reason is that despite their menacing reputation, viruses are host-specific, Suttle says. In other words, they're very particular about what or whom they attack.

But attack they do. The average ocean-dwelling microbe will survive about four days before it's infected by viruses that reproduce in it and kill it. Good thing, too, says Suttle, or we'd have even more algal blooms like the one currently off the west coast of Vancouver Island.

Red tides - named because of their red/brown colour - are essentially algae gone crazy. (However, the Vancouver Island bloom is blue/green.) Normally, viruses keep them in check. So when they do bloom the way they did last July - and more and more often - something is wrong. What, we don't know.

It just goes to show how little is understood about something so integral to the marine environment, says Suttle, who has been studying viruses for years.

"Certainly in some cases (the blooms) are related to pollution, although I don't think that's the case around here," he says. "Maybe there was some kind of environmental change, a change in the climate. Again, it's just not understood."

But more is being discovered all the time. As someone who sequences the genetic material in marine viruses regularly what fascinates Suttle is that the sequences aren't similar to anything found on land. Which means he and his grad students, are finding life forms no one knew existed. And they're finding them all the time.

"We're discovering life forms we've never seen before," Suttle says. His most recent discoveries were reported in the latest issue of *Science* magazine. "There's more genetic information in the ocean than one could even begin to imagine. So when we start looking at these virus sequences, 75 to 80 per cent of the sequences we pull out have no similarity to anything we've seen before. But there are exceptions. For example, some researchers now believe marine viruses transferred to a terrestrial environment by animals that eat sea life - think of birds that eat fish or bears that eat crabs - may be the original agents of several forms of hepatitis.

There is also evidence that the viral agents of avian flue may have originated in the ocean as well. Ocean-going sea birds consume them, without danger, but when they're transferred to chickens - or humans - watch out.

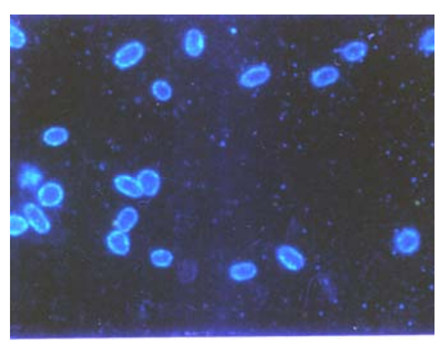
Viruses that specifically target algae that kill farmed salmon are close cousins to the viruses that cause polio and the common cold in people.

And to think that 30 years ago, Suttle says, no one knew such viruses existed.

If you still think marine viruses don't matter, consider this. All the creatures we normally think of as marine life - everything from seals to sharks to seaweed - account for just two per cent of the ocean's entire biomass. The other 98 per cent is composed of microbes, including viruses.

"It's a way of cataloguing life on the planet." Suttle says of his work. "It turns out viruses have more unknown genetic information than anything we've ever looked at.

"So the next time we have an epidemic that breaks out, it'll be good to have a base line of what kinds of viruses are out there and what kinds of viruses are out there circulating."



Marine bacterial cells surrounded by viruses, which are stained with a blue fluorescent dye. (Suttle files)

Retirements

Garry Clarke

On December 8th, 2006, a small group of glaciologists descended upon Vancouver, Canada, to celebrate the 65th birthday of Garry K.C. Clarke.

After serving for many years on the faculty of the University of British Columbia, Garry enters "mandatory retirement" at the end of 2006. Among his many scientific distinctions, Garry is a past president of the International Glaciological Society and the only recipient of both the Society's Richardson Medal and Seligman Crystal. He is also a past-president and Tuzo Wilson Medalist of the Canadian Geophysical Union, as well as a Fellow of the Royal Society of Canada and of the American Geophysical Union. Garry has made fundamental contributions to quantitative glaciology in areas ranging from glacier outburst floods, glacier surging, basal mechanics, ice-sheet modelling, subglacial instrumentation, and the interaction of the cryosphere with the global oceans and atmosphere.

To those of us who know him and have worked with him, Garry is much more than these accolades convey. As articulated by some of the symposium participants, Garry is a remarkable mentor, having the patience to afford his students freedom in their research and the wisdom to know when to offer his advice. Many of us have benefited from Garry's mentorship and insight, whether it be in the form of his generously distributed ideas, a weekend of his work that spawns thousand of lines of Fortran, a paper from three decades past that we still reread, or a kindly-posed question at the Northwest Glaciology meeting.

To honour Garry on the occasion of his retirement, a one-day symposium was convened at the University of British Columbia. Styled after the long-standing Northwest Glaciology meetings that Garry was instrumental in initiating, this symposium was informal--free of abstracts and registration fees, and self-catered by a buzzing posse of Garry's research group. The celebration began Thursday evening, with a reception and ice-breaker given by the UBC Department of Earth and Ocean Sciences. This brought together long-time UBC colleagues of Garry's and many of the symposium participants.

The symposium programme, which filled the next day, comprised 17 invited speakers coming from Iceland, Switzerland, the United Kingdom and all over North America. In attendance at the symposium were over 70 participants and many past students, postdocs and Trapridge Glacier field assistants of Garry's, including Erik Blake, Urs Fischer, Ed Waddington, Dan Stone, Tavi Murray, Shawn Marshall, Jeff Kavanaugh, Dave Hildes, Jeff Schmok, Barry Narod, Guy Cross, Marc Gerin, Fern Webb and Sean Fleming, as well as members of his current research group. Also in attendance was Stan Paterson, who still travels from his home on Quadra Island to attend such events. This event gave new graduate students from several northwest universities the opportunity to meet some of the people who have authored the books and papers they have recently read.

Represented among the symposium speakers were several of Garry's former students, some long-time members of the Northwest Glaciology community, several researchers from the latest generation of glaciologists, those with whom Garry has recently collaborated and other friends and long-time colleagues. The talks covered subjects ranging from the marine geophysical record of past ice sheets (Julian Dowdeswell) to the Southern Ocean influence on North Atlantic overturning (Andrew Weaver). Several personal and retrospective tributes were given, embodied by Ed Waddington's talk entitled "The GKCC glacier sandwich: A savory filling of hot and cold flowing ice, served on an intricate web of basal processes moistened to perfection, and topped with a hearty layer of climate boundary conditions and a garnish of windpumping". Alongside these tributes were presentations of current research addressing glacier surging (Helgi Bjornsson and Andrew Fowler), propagation of subglacial water pulses (Charlie Raymond), slip weakening of basal sediments (Neal Iverson), ice-sheet modelling (Shawn Marshall), simple formulations of mass balance, response times and glacier terminus dynamics (Will Harrison), subglacial instrumentation and basal mechanics (Martin Truffer and Urs Fischer), ice rheology (Kurt Cuffey), the relationship between subglacial lakes and ice-stream onset (Robin Bell), grounding line stability (Richard Alley), marine ice-sheet dynamics (Christian Schoof), glaciers and landscape evolution (Bob Anderson) and dynamic sub-ice-stream hydrology (Bob Bindschadler). Many speakers paid tribute not only to Garry but to the legacy of his students and their contributions to glaciology. Threaded throughout the scientific presentations was an articulated appreciation of Garry's scientific elegance, creativity, originality, and breadth of influence in our community.

The celebration continued into the evening with a banquet held at St. John's College on the UBC campus. In addition to most of the symposium attendees, a number of new guests arrived including Garry's family and several members of the UBC Department of Earth and Ocean Sciences, one of whom "Bob Ellis" related the story of Garry's hiring at UBC. Guests enjoyed a clarinet duo and slide show during a cocktail hour before Tim Creyts opened the banquet by reading a statement from Magnus Mar Magnusson, the IGS Secretary General, acknowledging Garry's important and long-standing contributions to the IGS. Shortly thereafter, the banquet took an unexpected turn as Richard Alley borrowed a guitar and performed a ballad of Garry Clarke's CV which he composed in the Chicago airport. He was accompanied by Tim Creyts on banjo. This unchoreographed moment was one of the great highlights of the evening.

The Trapridgites Glacier Cake

During dinner, several tributes were read and stories related by some of the many Trapridgites in attendance. After dinner, guests cut into a large-format cake rendered in the shape of Trapridge Glacier. The cake included a dirty basal (chocolate) layer, the distinctive medial (cookie-crumb) moraine, geophysically correct crevasse patterns and ice falls, and an edible figurine representing Garry while hot-water drilling.

After dessert, Garry was presented with a 30x24" oil-on-canvas commissioning of the Trapridge Glacier camp and surroundings. This gift was given to him on behalf of many of his students and colleagues and was created by a local artist.

To cap off the evening, a reel-to-reel film that Garry and others had made several decades ago was dusted off and screened. The film, entitled "Glacier!", documents an expedition to surge-type Rusty Glacier in the St. Elias Mountains. Round-the-clock hot-point drilling was carried out to test the thermal regulation hypothesis of glacier surging. A young Garry Clarke and his companions travel to this remote area of the Yukon and show us what glaciology was like before many of the modern comforts were introduced. The suggestion in the film that basal thermal transitions may provide a "simple" explanation of glacier surging garnered an audible chuckle from the audience.

The celebration continued Saturday morning at the Clarke-Cruikshank residence where a champagne breakfast was hosted. Many of us once again enjoyed Garry and Julie's famous hospitality. All in attendance at these events agreed that it was a pleasure to celebrate someone who has made both important scientific- and generous personal contributions to our community.

We all look forward to many more years of Garry's glaciological insight and friendship.

Commissioned Painting of the Trapridgites Glacier Camp and Surroundings

Obituary
Dr. George Lawson Pickard 1913 – 2007

Ann McAfee and Andrew Pickard are sad to inform you of the death of our father, George Pickard, on May 1, 2007. Dad was 93 years old, 3 months short of his 94th birthday. Following Mom's death, in 1994, Dad continued to live in our family home until February this year. Fortunately his final illness was short and he died peacefully.

George was born in Cardiff Wales on July 5, 1913. His father was killed in 1918 while serving with the British Forces in France. After attending Manchester Grammar School, George received a scholarship to Hertford College, Oxford. He graduated with first class honours, receiving his Doctor of Philosophy for studies in low temperature physics in 1937. While at Oxford George met and, in 1938, married Lilian Perry of St. Hilda's College.

With the onset of WW II George worked with Sir R.V. Jones, at the Clarendon Laboratory Oxford, on the first successful use of infra-red radiation to detect aircraft at night. In 1938 he was posted to the Royal Aircraft Establishment, Farnbourgh becoming Senior Scientific Officer and later Squadron Leader. George designed a simple two-spotlight beam altimeter to assist aircraft to fly at low altitudes for night attacks on submarines. He later applied this technique to Lancaster aircraft used for attacks on the Ruhr dams – a mission made famous in the book and movie "The Dam Busters". Testing navigational aids required many flights over water and occupied Europe. In 1942 George qualified for membership in "The Goldfish Club" by surviving after his plane went down in the English Channel. In recognition of George's contributions to the War effort, in 1946, he was decorated as a Member of the British Empire.

Water was an important theme in George's life. At Oxford he rowed both sculls and eights. He held the Hertford College senior sculls trophy for four years. He was a founding member of the Thorney Island Sailing Club winning Best Helmsman in 1946. He spent five years on naval vessels and in aircraft flying over, and on two occasions into, water. He later became an avid scuba diver. George received a Big Block from the UBC Men's Athletic Committee for service to men's athletics and the UBC Sailing Club.

After the war, George with his family moved to Canada, joining the UBC Physics Department in 1947, where he hoped to continue his research in low-temperature physics, interrupted by the war. "We don't do that here - that's for Toronto", said Gordon Shrum, then head of UBC Physics, as he steered George towards oceanography. The family moved to Vancouver and George to new research interests. He directed the Institute of Oceanography at UBC for many years and was a major player in the development of ocean sciences in western Canada. Many who took his courses, went to sea with him or studied under his direction will remember him as a kind, no-nonsense, supremely organized and dedicated scientist, with a taste for exotic exploration.

Following a year learning the rudiments of this new discipline at Scripps, he returned to UBC and joined the newly created Institute of Oceanography, launching a systematic study of BC's coastal fjords and building up the academic infrastructure which would eventually mature into a first rate interdisciplinary institution. Pickard's books on *Descriptive Physical Oceanography* and (with Steve Pond) on *Introductory Dynamic Oceanography* introduced a whole generation of students to the physics of the oceans. The latest edition of *Descriptive Physical Oceanography*, updated by William Emery and Lynne Talley, will be published this year. Through his publications and his role as Director of the Institute of Oceanography, George had a major impact on understanding of the biology of British Columbia inlets and fjords. His 1961 and 1963 single-author publications on oceanographic features of British Columbia inlets and the appearance in 1963 of the first edition of *Descriptive Physical Oceanography*, which might be called "the beginner's guide to physical oceanography", gave biologists a lucid account of what kind of processes could be governing biological production in the sea and provided a base upon which biological programs were developed and data interpreted. The establishment and continued success and interactions of the multidisciplinary faculty in the Institute of Oceanography were, in major part, a result of his leadership. The IOUBC coffee room in one of the old World War II huts on West Mall was the site of numerous discussions among students, faculty and staff that led to development of multidisciplinary projects. George's detailed surveys of the waters of BC fjords provide an essential base line for assessing the progress of climate change.

From 1958 to 1978, George was Director of the UBC Institute of Oceanography. He retired as Director in 1979, continuing, as an Honorary Professor, to teach. In 1982 George became a Professor Emeritus. George preferred field work to the laboratory. The early part of his oceanographic research focused on water circulation in the fjords of B.C., Chile, and New Zealand. This work contributed to the costal fishing industry. After a visit to Tahiti in 1961, George developed a second research interest in the previously little studied topic of water circulation in coral reefs and lagoons. From 1976 to 1986, he collaborated with members of the Australian Institute of Marine Science on research on the Great Barrier Reef. George also served as a visiting scientist at Section d'Oceanographie ORSTOM Noumea and New Zealand Oceanographic Institute. During this time George and Lilian visited over 128 islands in three oceans.

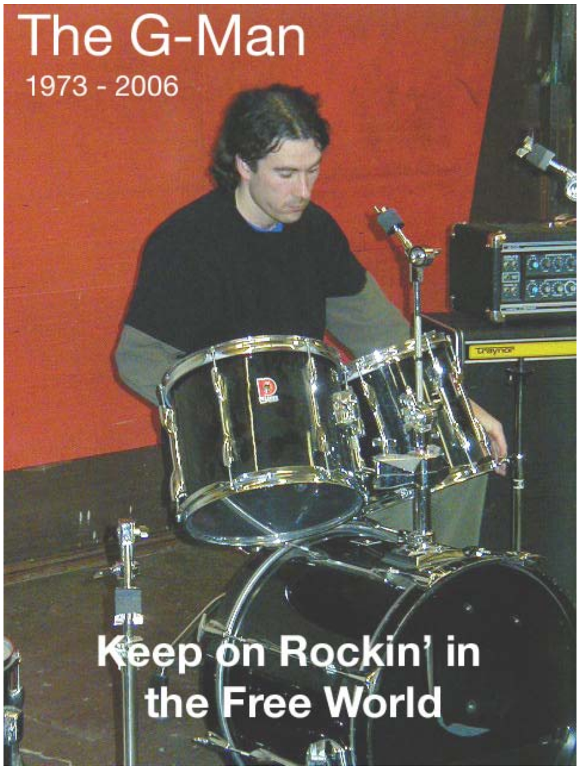
George was a member of the Fisheries Research Board of Canada from 1963-1972 and Canadian representative and Chair of the International Tsunami Committee from 1968-1975. He was a member of many committees including the National Research Council, B.C. Research Council, International Union of Geodesy and Geo-physics, UNESCO Marine Science Curricula Committee, Vice-President American Society of Limnology & Oceanography, President B.C. Academy of Sciences, and member the Pacific Science Congress.

George was elected a Fellow of the American Association for the Advancement of Science (1959), Honorary Life Member Vancouver Aquarium Association (1961), a Fellow of the Royal Society of Canada (1965), and Member of the National Geographic Society (1965). In 1976 he was recognized as one the "Pioneers of Physical Oceanography". He was honoured with the Tully Medal from the Canadian Meteorological and Oceanographic Society (1987). Other distinctions included the Canadian Centennial Medal (1967) and Queen's Silver Jubilee Medal (1977) in recognition of service to Canada. In 1980 Royal Roads Military College awarded George an Honorary Doctor of Military Science.

After acquiring his Private Pilot License in 1968, George spent many hours as "Pilot in Command" flying the skies with Lilian by his side. Following Mum's death Dad established two scholarships in her honour at St. Hilda's College Oxford, and Crofton House Girls School in Vancouver. George and Lilian spent 60 years together as students, husband and wife, and mother and father to Ann and Andrew. We will miss them and hope they are together again.

With sincere thanks and best wishes to all of you who shared George and Lilian's life.

In Memorium: Geoff Bradshaw - Keep on Rockin' in the Free World.



Geoff Bradshaw died in a helicopter accident on July 22, 2006 in the Wernecke Mountains north of Mayo, where he was doing mineral assessment field work with the Yukon Geological Survey. Geoff was 32 years old. He completed his Bachelor of Science in Geology at UBC in 1996 and then his Masters in 2003 under the supervision of Dr. Steve Rowins, also at UBC.

It is very difficult to adequately describe what a pillar of the departmental community Geoff was both as an undergraduate and graduate. Suffice to say that all those who knew him will remember his good humour, extreme enthusiasm for geology and expertise on the drums at numerous department events. Geoff, the "G-Man" will be sorely missed.

A scholarship fund has been set up in Geoff's name with the Yukon Foundation. The scholarship will support a student in studies of Yukon's geology. Donations to the scholarship can be sent to:

The Yukon Foundation
P.O. Box 31622
Whitehorse, Yukon
Y1A 6L2
Phone: (867) 393-2454
Email:
yukonfoundation@klondiker.com
URL: www.yukonfoundation.com

Please make cheques out to the Yukon Foundation and mark them with the "Geoff Bradshaw Memorial Scholarship Fund".

For more information, please contact
Jeff Bond (Jeff.Bond@gov.yk.ca) or
Mike Burke (Mike.Burke@gov.yk.ca),
or call 867-667-8508.

A memorial website has also been set up for Geoff and can be found at: www.bckids.org/bckids/index.html

A memorial cairn has also been built in remembrance of Geoff. It is located south of Whitehorse, Yukon and the a map with directions to it can be downloaded here: http://www.geology.gov.yk.ca/Bradshaw_cairn_map.pdf

CARL WIEMAN
SCIENCE EDUCATION PROJECT

EOS joins major teaching and learning initiative at UBC

Submitted by
Sara Harris, Chair of the EOS-Science Education InitiativeCommittee
For more information, contact Sara Harris sharris@eos.ubc.ca

These are exciting times for science education at UBC and in EOS! The Department of Earth and Ocean Sciences is thrilled to be one of the first departments funded for a major new teaching and learning initiative on campus, the Carl Wieman Science Education Initiative (CWSEI). Carl Wieman, Nobel prize winner in Physics, joined UBC in January 2007 to initiate and direct this effort. The overarching idea is to use a scientific approach to improve teaching and learning. Experiment, and measure outcomes to find out what works and what doesn't, then apply methods that are shown to be effective. In EOS, we are planning to identify learning goals at both the course and curriculum levels, develop new, creative teaching and learning tools, implement appropriate assessments aligned with teaching and learning goals, and build expertise within EOS that will sustain our commitment to excellence in teaching and learning for many years to come. Learning goals are specific statements that articulate what students should be able to do after their experience in a course or program. We have begun hosting seminars given by experts in science education (e.g. Dr. Eric Riggs from Purdue University), and have started up an informal departmental "brown bag" series to facilitate communication within the department.

This project will touch all aspects of undergraduate teaching and learning. At the curriculum level, we are developing plans for a "Curriculum Matrix" which will explicitly identify links in learning goals among courses, help us identify and remedy gaps, overlaps, and bottlenecks, and serve as a dynamic roadmap for future curriculum evolution. At the course level, we're targeting specific courses for attention and will work our way through EOS' curriculum, aiming to involve as many faculty members as possible. Revisions will be planned by course-specific "Working Groups", which involve not only primary instructors but also those who teach peripheral courses (pre-, post-, and co-requisites). Our first courses on the list are (1) EOSC 111 – "Laboratory Exploration of Planet Earth", (2) EOSC 114 – "The Catastrophic Earth – Natural Disasters", and (3) EOSC 221 - "Introductory Petrology" (Did you take any of these when you were a student?).

Beyond the content that students learn in EOS courses, we are interested in student attitudes toward science. Do students think about science in the same ways that working scientists do? Are there ways in which our teaching and learning environment can facilitate practice in "expert-like" thinking? To measure attitudes, and changes in attitudes, we are using a survey instrument, modified from one used extensively in physics. At the end of Spring term, we administered a proto-type survey with 40 questions to students in 7 courses. What did we find with this first pass? For one, that most students surveyed DO think that "what [they] learn in earth sciences helps [them] understand the global problems our society faces", and that more than half "think about the aspects of earth sciences that [they] experience in everyday life". Soon, the wording of our survey will be validated and we will administer both pre-course and post-course surveys to measure changes in student attitudes over time. Stay tuned.

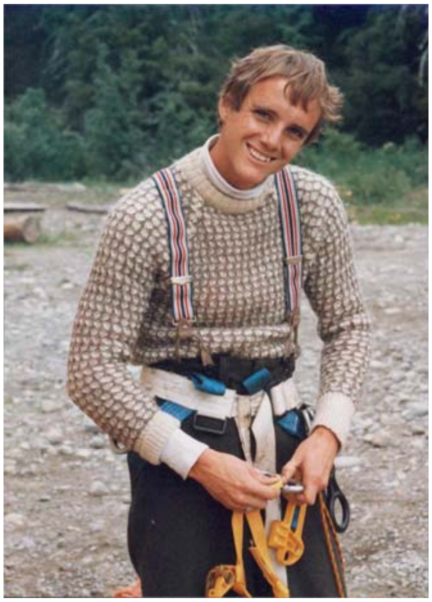
Although this project targets teaching and learning at the undergraduate level, EOS graduate students are crucial participants. Graduate students are the teaching assistants who teach most of our lab sections and who make our curriculum possible. We are planning for an organized TA training program designed specifically to address the needs of EOS courses and TAs. We anticipate that not only will undergraduates benefit from this effort, but so will graduate students, who will have formal teaching training useful for their future careers.

One of our challenges will be to make sure the effort that goes into this project over the next five years is sustainable. How can we make course resources useful and usable for new people joining the department in the future? A very important part of this project will be to design ways to preserve, modify, and pass along the good, workable ideas and tools for teaching. Check back in 2012!

In summary, EOS' participation in the CWSEI is an incredibly exciting undertaking and an unprecedented opportunity to improve science education for the general public as well as for future professionals in earth, ocean, and atmospheric sciences. We are in the process of hiring two Teaching and Learning Fellows to work full-time on this project, people with EOS-related backgrounds plus passion for and experience in the teaching and learning of science. We anticipate that their work, combined with the efforts of faculty and staff in EOS, will bring these plans to fruition.

Carl Wieman, Nobel Laureate,
has been hired to revolutionize science teaching at UBC.
EOS has been awarded $2 million over 5 years
to be a "phase 1" participant.

Awards and Honours



Aaron Craig Nicholls (1960-1987)

For anyone who has wondered how the Aaron Craig Nicholls Memorial Award came to be, this provides some information about who Aaron was. If you have seen the plaque on the bench near the doors of the EOS building, you may have made the connection between it and the award which is granted each year to a deserving student.

On May 27, 1987, Aaron graduated in geology from UBC. On June 27, 1987, on his first day of work, Aaron was killed. He and two other people were digging out a repeater station, high on the slopes of Mt. Henry Clay, in the St. Elias Mountain Range, straddling the border of Yukon and Alaska. On what should have been a routine flight, only three minutes in the air and at a high rate of speed, the helicopter crashed into the side of the snow-covered mountain. Three of the four people on board died. One was Aaron. His marriage was to have taken place the following February. He was 26 years old.

The memorial award was established very soon after the event by his family and friends. It is intended to assist deserving students and to perpetuate Aaron's memory and name.

Rick Zuran, a close friend and fellow student, chose his own way of commemorating his friend's death.

He designed the plaque of granite which bears Aaron's name, his graduation date and the date and manner of his death: this against the outline of Mt. Henry Clay in the background. Rick also handled the time-consuming and, at times, frustrating job of gaining permission to have the plaque placed on the back of the bench located in the courtyard of the E.O.S. building where Aaron always sat as soon as the sun appeared.

Eventually the plaque was relocated to a place that Aaron's family and friends thought was unsuitable.

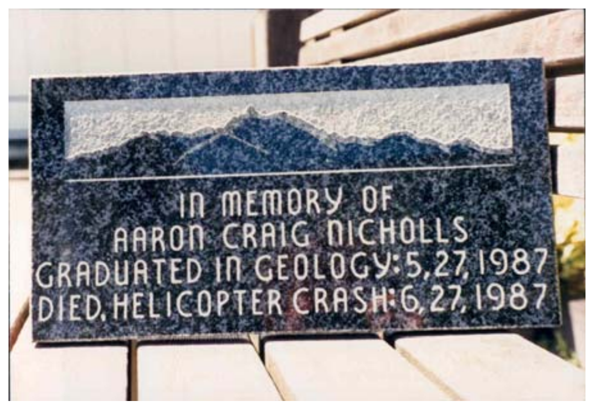
As this is being written, plans are underway to have the location changed.

Aaron was not an exceptional student, but he was in love with the high northern reaches and with climbing. He was the youngest of three brothers by six and eight years. He was a gregarious, gentle, sensitive person with a strong sense of humour and of fair play. He had a keen taste for adventure and an excitement about living. He was quick to appreciate the ridiculous as well as the sublime.

Life is infinitely precious. Students who never knew Aaron say that they have stopped to look at the plaque, calculate the dates and contemplate the simple, terrible repercussions resulting from a moment of carelessness or misjudgment.

Aaron's family looks forward to hearing from each year's award recipient. A mere name and address mailed from the Development office leaves so much unsaid. We want to know who you are, whether geology has been a good choice for you, and about your hopes and plans for the future. You may reach us via telephone, letter or email. The cumulative effect of such communication provides Aaron's family with assurance that his memory is sustained.

Jean Brownlee (mother)
Telephone: (604) 263-3426
Email: jeanbrownlee@telus.net
2550 West 35th Avenue
Vancouver, B.C.
V6N 2L8



The plaque designed and established by Rick Zuran for his friend Aaron.

Award Recipients:

I received the Aaron Craig Nicholls Memorial award in 2002. My time at UBC was before the new courtyard renovation, when the old ore cart was in the yard and the big wooden bench with Aaron's plaque was still out in front. I remember many breaks out on the bench eating lunch or enjoying the sunshine, and I remember being reminded many times of Aaron's life and the tragic dates of his graduation and death. Those dates on their own tell some of his story. Back then I did not know much about the circumstances of his life and death but always knew that there must have been a lot of love and longing for him to have lead to the bench being built and the plaque being designed and created in his memory.

After receiving the Award in 2002 I met Aaron's mother, Jean Brownlee over coffee to thank her and to hear more about Aaron. Jean has since become a very important person in my life and a very important friend. The geology work that I have been doing over the past few years would not have been logistically possible without her support here in Vancouver. And even more important to me have been the many, many meals shared at her house and the encouragement, support, and wisdom that she has shared at the same time. I really don't know how to thank her enough. These are things shared by friends, but I have her as a friend because of Aaron. I did not know him as a friend, I wish I had, but I do know that he was a smiling, caring, kind person who was loved by many people. His spirit and his memory are preserved in the relationships that have developed because of his award.

I think that having this very human and soulful award in the EOS department is a gift to all - to those who receive it at a time when cash is needed, to those who benefit from the kind network of friends and family that have grown up since Aaron's death, and to everyone who has the opportunity to pass by the memorial plaque and think for a few minutes on how lucky we all are to be here, how grateful we feel for all that we have in our lives. Study and work are important parts of a balanced life, but they are just a part of what we all need to learn to be whole humans. Aaron's memorial is a reminder to take some time to think of the rest. The plaque is still in the courtyard, go and have a look.

Fionnuala Devine

I ended up in geology via a circuitous route driven by a passion for the outdoors and inspiration from family, teachers and mentors. For a combination of seemingly unrelated reasons I still feel a strong connection to the dates of Aaron's graduation, May 27, 1987 and tragic death, June 27, 1987.

In the third week of June 1987, I flew into my first exploration camp in northern BC, not quite believing that someone would actually pay me to fly around in a helicopter, hike and climb in the mountains and live in a tent all summer. I had decided to take a year off from an arts degree and was lucky enough to get a job in the mountains to start my break. My career in geology began with wide-eyed fascination almost to the day that Aaron's life ended doing precisely the same thing, for what I know were very similar reasons. Four years later (my one-year break had extended longer than planned!) in the spring of 1991 I decided to take the plunge and enter UBC geology. I still vividly remember the first day I walked into the geology department to meet with Al Sinclair to try and persuade him to cajole UBC administration into letting me transfer into geology based on a passion for the science despite lacking the prerequisites. After a great and successful meeting I sat outside in the sun, on a bench in front of the department and read the plaque in memory of Aaron for the first time. I recall a profound sadness and an unusual connection to that tragic event and time in 1987.

In 1993 I received the Aaron Craig Nicholls Memorial award. For me there was a deep sense of honour and privilege to in some small way be connected to Aaron's legacy. Aaron, his friends and family helped me to get through university and to have the life I love; I will always be grateful.

Twenty years on from that first wide-eyed day in June 1987, I still love what I do; I have had countless adventures and have met many fine people. There is a part of me that remembers Aaron and his memorial each time I get into a helicopter, each time I see a new, young geologist get into a helicopter – that memory is in part a reminder to be careful, in part a reminder not to forget how fortunate we are, and a reminder to live life to the fullest, embrace the day and never forget the passion that drives us. Aaron's Memorial Award and the plaque at UBC are a poignant reminder to all who walk through the doors of the Department. Thank you to Aaron, his family and friends; you have touched many of us.

Andrew Davies
(Chief Geoscientist for North America for Teck Cominco Limited, based in Vancouver)

DEPARTMENT

In a report on research productivity in Canadian Universities (rankings based on publication output between 1999 and 2004) **EOS** (in the major, research-intensive category of institutions) topped the Earth Science Subfield with Toronto second, U of A third and McGill 4th. EOS was the only UBC department to come top of its group. (Biology came 2nd, Chemistry 3rd, Physics 4th, Math 2nd and Engineering 3rd).

FACULTY

Phil Austin (principal investigator) and seven co-investigators from Environment Canada and other universities received $2.1 million for a four-year project "Cloud-Aerosol Feedbacks and Climate" with the CFCAS research network.

Tad Ulrych will be the Spring 2008 Distinguished Lecturer for the Society of Exploration Geophysicists.

Catherine Johnson is a participating scientist for the MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) mission: NASA's current mission to Mercury. The probe was launched August 3, 2004. It will pass Venus in June and reach Mercury in January 2008. After a number of flybys, it will begin to orbit Mercury in March 2011. This year-long orbit will be the primary phase for data acquisition. The **MESSENGER** probe will collect data used to map the surface topography and determine the surface composition, planetary magnetic field, and remanent magnetic field in the crust; also the atmosphere composition and gross internal structure. For more information about the project, see http://www.nasa.gov/mission_pages/messenger/main/index.html

Roland Stull was made a fellow of the Canadian Meteorological and Oceanographic Society.

STAFF

Two Achievement Awards for Service were awarded to EOS in 2006 - The recipients are noted below. The Award carries a $2,000 cash prize.

Teresa Woodley, received an **Achievement Award for Service from the Faculty of Science**. Part of the citation reads: "In recognition of Teresa Woodley's diligence, leadership, initiative, tact and understanding in dealing with the undergraduate students in Earth and Ocean Sciences, and for her excellent service over many years to faculty, staff and students in the entire Department. Teresa has contributed greatly to the smooth running of the Earth and Ocean Sciences Undergraduate Program and the Geological Engineering Program. She deals with many complex and demanding tasks on a continual basis in a cheerful, caring and intelligent manner, and is always willing to tackle projects, whether large.... or small....."

She was also recognized with a gift certificate for her assistance to the Aboriginal Middle School's Cedar Day Camp in association with UBC First Nations' House of Learning. Teresa scheduled space and equipment for the camp in the summer of 2006. As our undergraduate secretary she was recognized with a gift basket for her assistance to the undergraduate science students and the Dawson Club during the 2006-2007 academic year. and with a gift certificate by the (GEOROX) Geological Engineering 2007 Graduating students in appreciation for her willingness to give the students personal attention and guidance

Maureen Soon received an **Achievement Award for Service from the Faculty of Science**. Part of the citation reads: " In recognition of Maureen Soon's contributions in developing and managing the EOS marine geochemistry laboratories over the last 25 years, for spending months at sea for sample collection and analysis and for doing it all willingly, with good humour and with remarkable efficiency. The most visible mark of her remarkable service record is the meticulous care and attention that she has devoted to the training of students and research fellows. Her training skills are exemplary, combining an ability to lay out and explain analytical procedures in a clear way, to instill good laboratory practices and to insist on the completion of sound analytical results. All of this is done in a sympathetic and supportive fashion, so that students and fellows quickly learn to fly on their own, but to feel that they can discuss unforeseen problems and snags with Maureen at any time. These activities have not been confined to members of the marine geochemistry group alone, but have involved the research groups of at least eight other faculty members, as well as researchers from other UBC departments and other universities."

Christian Schoof, Research Associate, was honored as an exceptional reviewer in the Geological Society of America journal GSA Today.

Kathy Scott received a letter of recognition from President Toope for her work as the Sustainability Coordinator for EOS

GRADUATE STUDENTS

Gareth Chalmers won an AAPG Grant-in-Aid for his project 'Methane Gas Potential and Sequence Stratigraphy of Lower Cretaceous Shales, Northeastern British Columbia, Canada'

Amber Henry (M.Sc.program 'Controls and chronology of gold veins at the Cowal E42 gold deposit, NSW, Australia') received a Canada Foundation Award from the Society of Economic Geologists

Kenneth (Daniel) MacNeil, (M.Sc. prog 'The evolution of the Donlin Creek gold deposit, southwest Alaska') received an award from the Society of Economic Geologists

Mohammed Maysami was awarded a KEGS Foundation scholarship for the year 2006-2007.

Janina Micko , (Ph.D candidate, The hydrothermal genesis of the alkalic Cu-Au porphyry deposit, northern British Columbia) received the Hugh E. McKinstry Student Research Award from the Society of Economic Geologists

Dianne Mitchinson, (Ph.D.candidate, 'Integrating geology, physical properties and geophysical inversion methods to build 3D subsurface models of Archean Orogenic gold deposits') received a grant from the Hugo Dummett Mineral Discovery Fund of the Society of Economic Geologists.Award .

Caroline-Emmanuelle Morisset, Ph.D. student, was awarded Second Prize in the Student Poster Contest at the Mineral Exploration Roundup 2007, in Vancouver, BC, for the poster: "Rutile-bearing hemo-ilmenite deposits in Proterozoic anorthosite massifs of Quebec" (Morisset, C.-E., Scoates, J.S. & Weis, D.). Caroline was also recognized by the Volcanology, Geochemistry and Petrology Section of the American Geophysical Union as having the outstanding student presentation at the 2006 Fall Meeting for the presentation "Trace element and Hf isotopic compositions of magmatic rutile from Fe-Ti oxide ore deposits related to Proterozoic anorthosite massifs" (Morisset, C.-E., Scoates, J.S. & Weis, D.).

Stephen W. Moss, Ph.D.;candidate, 'Volcanology of the Diavik kimberlites: implications for eruption dynamics and diamond distribution' received a grant from the Hugo Dummett Mineral Discovery Fund of the Society of Economic Geologists

Kirsten Rasmussen was awarded a Canada Foundation Award from the Society of Economic Geologists for her study entitled: "Mid-Cretaceous magmatism in the southwestern NWT and southeastern Yukon: a geochronological-geochemical-isotopic- and magmatic fluid composition-based approach to evaluating the potential for intrusion-related mineralization"

Daniel Ross won the J. Elmer Thomas Past Presidents' Memorial Award for his presentation at AAPG meeting entitled 'Gas shale potential of the Early Jurassic Gordondale Member, Northeastern British Columbia'

Stefan Wallier, Ph.D. candidate,'Geological framework, hydrothermal mineralization and evolution of the Manantial Espejo epithermal low-sulfidation Ag-Au deposit, Argentina' received a Newmont Student Research Grant from the Society of Economic Geologists

Malissa Washburn, M.Sc.program; 'Architecture of the Silurian cover rocks to the Cadia Valley porphyry Au-Cu deposit' received a Canada Foundation Award from the Society of Economic Geologists

Sasha Wilson, PhD student with Greg Dipple and Mati Raudsepp, was awarded the 2006 Mineralogical Association of Canada Foundation Scholarship. For her dissertation she is assessing greenhouse gas uptake during mining at the Mount Keith Nickel Mine, Western Australia and Diavik Diamond Mine, Northwest Territories as part of the MDRU research project on carbon sequestration in mine tailings. Sasha is also the recipient for 2007 of the Mineralogical Society of America Edward H. Kraus Grant for Research in Crystallography, Mineral Physics or Chemistry, and Mineralogy for her proposal titled "Quantifying uptake of atmospheric greenhouse gases in hydrotalcite- group minerals ".

Two incoming students were among the first recipients of the newly established Graduate Student Scholarships, awarded on a competitive basis to students just entering their first graduate program. Scholarships were received by **Kevin Byrne** (Trinity College, Dublin, Ireland) and **Elizabeth Stock** (Imperial College, London, England).

Siobhan Wilson (PhD) and **Laurens Beran** won a NSERC Canada Graduate Scholarship)

NSERC Postgraduate Scholarships were awarded to **Emma Brownlee** (MSc), **Deirdre Demerse** (MSc), **Julia Gustavsen** (MSc), **Elliot Holtham** (MSc), and **Heather Wilson** (MSc)

University Graduate Fellowships were awarded to **Pascal Audet** (PhD), **Amelia Bain** (MSc), **Luke Beranek** (PhD), **Katherine Jones** (MSc), **Yingyu Li** (PhD), and **Hideharu Uno** (MSc)

UNDERGRADUATES

Geological Engineering students **Marisol Valerio** and **Heather Stewart** were named Wesbrook Scholars. The Premier Undergraduate Scholarships and Wesbrook Scholars are the University's most prestigious designations, given to senior students with outstanding academics, participation in sports, leadership, and involvement in student and community activities. Marisol and Heather were the only students in the Faculty of Applied Science to win in this competition

Twelve students who participated in the Salt Spring field school in May 2007 (EOSC 223 were winners of prizes given by Shell Canada. Awards were based on a combination of grades and interest, enthusiasm, and aptitude for geologic field work:-

Science students (Honours Geology and Major EOS): **Chris Amy, Claire Brown, Andrew Pare, Kathryn Lucas, Corey Wall, and Morgan Wittstock**.

Applied Science students (Geological Engineering) **Robyn Barnett, Martin Birse, Christopher Clarke, Jeremy Groves, Leila Larson, and Andy Rios**.

Enrollments

Total enrollment in undergraduate courses offered by EOS. Numbers in brackets indicate increase over preceding year.

	2003	2004	2005	2006
1st Year	1414 (+6%)	1966 (+39)	1862 (-5.3)	1900 (+2)
2nd Year	465 (+55%)	580 (+25)	594 (+2.4)	693 (+16)
3rd and 4th Yr	1200 (+1%)	1458 (+22)	1752 (+20.2)	1827 (+4)
Service Courses	889 (+3%)	771 (-13)	580 (-24.8)	604 (+4)
TOTAL	**3968 (+8%)**	**4775 (+20)**	**4788 (+.3)**	**5024 (+5)**
Summer	621 (+16%)	446 (-28)	474 (+6)	366 (-22)
Distance Ed	399 (+3%)	363 (-9)	326 (-10)	321 (-1)
Grand Total	**4988 (+9%)**	**5584 (+12)**	**5588 (+.1)**	**5692 (+1)**

Number of Major and Honours students in programs offered by EOS

	2003	2004	2005	2006
EOS - Major	**58**	**69**	**100**	**86**
ATSC	**31**	**35**	**41**	**25**
GEOL	**38**	**38**	**43**	**35**
GEOE	**73**	**85**	**96**	**106**
GEOP	**9**	**8**	**12**	**9**
OCGY	**16**	**17**	**14**	**9**
TOTAL	**225**	**252**	**306**	**278**

Graduate Enrollment: 2006

	ATSC	GEOE	GEOL	GEOP	OCGY	TOTAL
MASc	-	5	-	2	-	**7**
MEng	-	6	-	-	-	**6**
MSc	4	-	38	6	11	**59**
PhD	8	3	42	15	17	**85**
Total	**12**	**14**	**80**	**23**	**28**	**157**

Graduate Theses Completed in 2006
Supervised by Earth and Ocean Sciences Faculty
Including Thesis Programs External to the Department
(Name of Supervisor in Brackets)

(i) Ph.D.

AMOS, Richard: Integrated Investigation of Natural Attenuation in a Petroleum Hydrocarbon Contaminated Aquifer (U. Mayer)

GALBRAITH, Eric: Interactions Between Climate and the Marine Nitrogen Cycle on Glacial-Interglacial Timescales (R. Francois/T. Pedersen)

GRANGER, Julie: Coupled Nitrogen and Oxygen Isotope Fractionation of Nitrate Imparted During its Assimilation and Dissimilatory Reduction by Unicellular Plankton (P. Tortell)

McDOUGALL, Scott: A New Continuum Dynamic Model for the Analysis of Extremely Rapid Landslide Motion Across Complex 3D Terrain (O. Hungr)

REUTEN, Christian: Scaling and Kinematics of Daytime Slope Flow Systems (D. Steyn)

***WIRAMANADEN, Cheryl:** Characterisation of Copper Binding Ligands from Marine Cyanobacterial Cultures Using Voltammetry and Mass Spectrometry (K. Orians)

(ii) M.A.Sc.

SAFADI, Catherine: The Role of Tidal Fluctuations in Influencing Rates of Submarine Groundwater Discharge (L. Smith)

STROUTH, Alexander: Integrated Use of Terrestrial Laser Scanning and Advanced Numerical Methods for a Total Slope Analysis of Afternoon Creek, Washington (E. Eberhardt/O. Hungr)

(iii) M.Sc.

CHAPUT, Julien: Seismic Interferometry Using Non-volcanic Tremor in Cascadia (M. Bostock)

DICKINSON, Jenni: Jura-Triassic Magmatism and Porphyry Au-Cu Mineralization at the Pine Deposit, Toodoggone District, North-Central BC (S. Rowins)

DZIKOWSKI, Tashia: The Crystal Chemistry of Gorceixite, Grandidierite, and Traskite (L. Groat)

FRAPPE-SENECLAUZE, Tom-Pierre: Slow Surge of Trapridge Glacier, 1951-2005 (G. Clarke)

GORDEE, Sarah: Volcanostratigraphy, Age, and Geologic Setting of the Lower-Middle Jurassic Upper Hazelton Group, West-Central British Columbia (J. Mortensen)

HAMILTON, Andrew: Biohydrography of Eukaryotic Microorganisms in a Cold Ocean Ecosystem (R.G. Ingram)

JURADO CARRASCO, Julio: Distal Alteration in the Carbonate-hosted Replacement and Skarn Systems at Yauricocha, Central Peru (G. Dipple/R. Tosdal)

KIDSTON, Joseph: Energy Balance Closure in a Boreal Mature jack Pine Stand and Clearcut, and Implications for CO_2 Flux Measurement (A. Black)

***LEKHI, P. Anka**: Cadmium in the Coastal Marine Environment: Pathways of Cadmium to Oysters and Using the Cadmium-Phosphorus Ratio as an Indicator of Biogeochemical Cycling (K. Orians)

MACKIE, Robin: Crustal Contamination, Sulphide Mineralization, and Compaction During Formation of the Marginal Zone of the Muskox Intrusion, Nunavut, and Implications for the Evolution of the 1.27 Ga Mackenzie Magmatic Event (J. Scoates/D. Weis)

McKINLEY, Bradley: Geological Characteristics and Genesis of the Kemess North Porphyry Au-Cu-Mo Deposit, Toodoggone District, North-Central British Columbia, Canada (S. Rowins)

MICHOL, Krista: Analysis of Strain in a Welded Block and Ash Flow Deposit, Mount Meager, Southwestern British Columbia (J.K. Russell)

PETERSMEYER, Chad: Assessing natural Attenuation of Petroleum Hydrocarbons Using Reactive Transport Modelling with Aqueous and Solid Phase Data (U. Mayer)

PODGORSKI, Joel: Postseismic Deformation Following the 1991 Racha, Georgia Earthquake (E. Hearn)

RICHER, Mathieu: Volcanic Framework, Geochronology and Geochemical Evolution of the El Dorado Gold District, El Salvador, Central America (R. Tosdal)

SHIRMOHAMMAD, Farshad: Triassic-Jurassic Stratigraphy and Paleontology of the Takwahoni and Sinwa Formations at Lisadele Lake, Tulsequah Map-area, Northwestern British Columbia (P. Smith)

STERRITT, Victoria: Understanding Physical Property – mineralogy Relationships in the Context of Geological Processes in the Ultramafic Rock-hosted Mineral Deposit Environment: Aiding Interpretation of Geophysical Data (R. Tosdal)

TURNER, David: Mineralogical and Geochemical Study of the True Blue Aquamarine Showing, Shark property, Southern Yukon Territory (L. Groat)

*** Thesis Program External to the Department of Earth and Ocean Sciences**

Alumni Feedback

Feedback - Reminder: We mail this newsletter to over 2,000 recipients, and we would really like to hear how YOU are doing.

Roddick, Jim
B.ASc. 1948, M.Sc., 1950, Ph.D., 1955.

I retired from the Geological Survey of Canada (GSC) in 1996, after 50 years of service. Many things have changed since 1946 when I first worked with the GSC. Most of my fellow grads from that class of 1948 are no longer above the ground they sought very hard to understand. Yet, they will be long remembered, even though now less-productive. Of course, some may have been challenged at the Pearly Gates, but most probably scraped through. Best wishes to all who remember the 1940s.

Thomas F. Pedersen
B.Sc. 1974

Former Professor in Oceanography and EOS, now Dean of Science at UVIC, was elected a Fellow of the American Geophysical Union in 2006.

Stanley, Clifford R.
M.Sc., 1984, Ph.D., 1988.

Returned from Sabbatical (year long) in Perth, Western Australia with CSIRO, Exploration and Mining, now Assoc. Prof. and Acting Head, Dept. of Geology, Accadia University with Drs. Sandra Barr (Ph.D., UBC), Peir Pufahl (Ph.D., UBC) and David McMullin (Ph.D., UBC)

Jensen, Carmen (nee McKnight)
B.Sc. Geology, 1993, B.Eds., 1997

We relocated to Calgary in June 2006. My husband's work at Superior Propane brought us here. Before moving I was on mat leave with our second child. We have 2 children now: Ryan, 5 years and Madison, 18 months. Up until my mat leave and the move I had been working in the Surrey School District teaching Geology 12 and Earth Science 11. Now that we are in Calgary, I am looking for work here and also considering returning to university for more courses. I'm sure there are other Geology alumni in Calgary. I'd love to catch up.

Rocha, Nelson
B.Sc., 1997

After graduating I moved back home to Prince Rupert to spend time with my family for about a year then moved to Nelson for 4 years where I did various forestry jobs. I have most recently started a Masters degree in architecture at UBC and am currently in my second year.

Guenkel, Patrick
B.ASc., Geological Engineering, 1998

After finishing my MBA at London Business School in 2004, I moved to Aberdeen to work for Total SA. I've now moved to Paris and am working in Total's Strategy Group.

Dilworth Katherine
M.Sc., 2003

Kathi and husband, Martin Telford, are both working at the Plutonic Gold Mine in Western Australia for Barrick Gold. We moved to Perth in 2005, (after 2 years in Venezuela) and have been doing lots of exploring of the Australian Outback in our time off.

KEEP IN TOUCH

Enjoy keeping up with friends and classmates in the Alumni News section? Why not return the favour - drop us a line. Please fill in your currect address below even if the Newsletter was correctly addressed - it helps us maintain our records, or email us at **alumni-contact@eos.ubc.ca** . Also visit the Earth & Ocean Sciences website at **www.eos.ubc.ca** . Please do not provide any information that you would not want published in the next Alumni Newsletter.

PLEASE PRINT

Name:____

UBC Degree:____________________ Graduation Date: ____________________

Address:____

Telephone:____________________Fax____________________

Email Address:____

Has the above changed since last year? ☐ Yes ☐ No

What's new with you?

☐ If I had to do it over ☐ Married? ☐ New job? ☐ Back in school?

☐ Reminiscences about life ☐ Take a trip? ☐ Promoted? ☐ See a classmate?

☐ Retired? ☐ New Baby? ☐ Other?

Thanks for your response

Our Mailing Address Below

UBC Dept. of Earth & Ocean Sciences, Alumni Contact, 6339 Stores Rd., Vancouver, B.C. Canada V6T 1Z4

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☐ Please use my gift in the Dept. of Earth and Ocean Sciences' area of greatest need.

- ☐ Please direct my gift to the following:
  - ☐ Earth and Ocean Sciences Student Development Fund (Student Scholarships)
    - ☐ Earth and Ocean Sciences Teaching & Learning Centre
  - ☐ Mineral Deposit Research Unit (MDRU) Endowment Fund
    - ☐ Pacific Museum of the Earth Endowment Fund
    - ☐ Other: ________________________________

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