ASH FALL

Newsletter of the Volcanology and Igneous Petrology Division
Geological Association of Canada

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From the Editor

Happy New Year and welcome to the latest edition of Ashfall. In this issue we have accounts of field work in Greenland from Ali Polat, a report on work in the Ferrar Province of Antarctica from Pierre-Simon Ross and James White and a round up of the work being undertaken by students and faculty at McGill, that was pulled together by Crystal Mann. I would like to take this opportunity to thank all those who have contributed and encourage anyone out there with ideas for articles to get in touch.

Some of you may have noticed that the VIP web site has moved to a new location www.vip-gac.ca. With the help of Glyn Williams-Jones the transition was a smooth one and will allow us to update the site more easily. We have added a notices section that can be used to publicise upcoming meetings or graduate student opportunities. We have also posted a number of the back issues of Ashfall on the site, if you have electronic or paper copies of earlier issues then I would like to hear from you. If you have any other suggestions for the site then please let us know as we would like to develop the site into a useful resource for the geological community.

On the subject of web sites, the Smithsonian Global Volcanism Program has created a placemark file for Google Earth that will display all known and inferred Holocene volcanoes. The recent eruptions at Home Reef, Tonga in August 2006 are also the subjet of a number of web sites. Satellite images and aerial photographs of the new island formed by the eruption of the submarine volcano can be found on the web site of Alain Bernard, while photos of the pumice rafts taken by the crew of the yacht Maiken can be found on their site. I will include links to these site on the VIP web page for those who cannot access them through this PDF file.

Finally a reminder that the 28 February deadline for nominations for the gold (Ph.D.), silver (M.Sc.) and bronze (B.Sc.) Léopold Gélinas medals is fast approaching. Details can be found on the awards section of the web site.

Volcan Lascar, Northern Chile. Recent eruptions in 2006 caused evacuations in nearby villages. Photo courtesy of Amy Shute.

Adventurous Field Work in SW Greenland

Ali Polat, University of Windsor

In this short communication I will highlight the main points of our field work in SW Greenland in the summer of 2006. Field work was undertaken in the Meso- to Neoarchean greenstone belts and anorthosite-leucogabbro complexes in the Fiskenaesset region. The work was supported by GEUS (Geological Survey of Denmark and Greenland) as a part of a larger project on Archean greenstone belts in SW Greenland. Our team included Peter W.U. Appel, Wouter Heijlen and me. We spent about four weeks between July 15 and August 15 in the Fiskenasset region, visiting several greenstone belts and anorthosite-leucogabbro complexes. The work was conducted in the Ikatoq, Bjornesund and Qeqertarssuatsiaq (Fiskenaesset) areas. Our work was focused mainly on understanding the field relationships and lithological characteristics, and undertaking geochemical sampling of greenstone belts.

Because of dense fog and heavy rain, we were forced to spend most of our time in the wet tents. Our camp was often visited by hungry arctic foxes. They chewed our tents, the antenna wires of our radio, ate our food, spilled the heating fuel and ripped the garbage bags. Wouter set up a fox trap using string and canned fish. But he failed to trap any foxes. Foxes came back to the camp and took Wouter's socks away while we were in the field. The problem was solved when we moved the camp to another location. Because of dense fog, it took the helicopter pilot several attempts to land at our camp sites to move us.

On the island of Ikatoq, amphibolites, ultramafic schists (serpentinites, actinolite-tremolite-chlorite schists), mafic to felsic tuffs, pyroclastic rocks, garnet-mica schists, deformed pillow basalts, and metagabbros were recognized as major rock types. In addition to these lithologies, there were garnet amphibolites, quartz-feldspar-mica schists, and mafic to felsic dykes on the island. Contacts between different rock types, except for dikes, are predominantly structural, including shear zones, asymmetric folds, and S-C planar fabrics (Fig. 1b). Many contacts include variably deformed one to forty centimetre thick quartz veins. Locally, intrusive relationships between greenstones and mafic to felsic dykes were observed.

Pyroclastic rocks include deformed tuffs, lapilli tuffs, and ignimbrites (Fig. 1a). They occur mainly in the central part of the belt. They range from mafic to felsic in composition. In addition to felsic tuffs, there are ten centimetre to three metre thick felsic dykes and/or sills. Tuffs and ignimbrites range from one to three hundred metres in thickness. Pyroclastic rocks are spatially associated with pillow basalts and their deformed counterpart amphibolites. Flattened amygdules and vesicles are locally preserved in some volcanic clasts.

The greenstone belt in the Bjornesund area has similar rocks types to those exposed on Ikatoq island. The lithotectonic assemblage in the Bjornesund greenstone is composed predominantly of metagabbros, amphibolites, pillow basalts, and ultramafic schists (Fig. 2a). Calc-silicate formation (epidote ± garnet ± diopside) is locally well exposed. Contacts between different lithologies are marked by deformation, quartz veins, and metasomatic alteration mineral assemblages. Contact between gneisses and greenstone belt is generally characterized by strong deformation (folding and shearing), but intrusive relationships have also been observed (Fig. 3).

Like those in the Ikatoq area, ultramafic rocks in the Bjornesund area occur as tectonic lenses and are characterized predominantly by serpentinites and actinolite schists. Primary magmatic textures are locally preserved

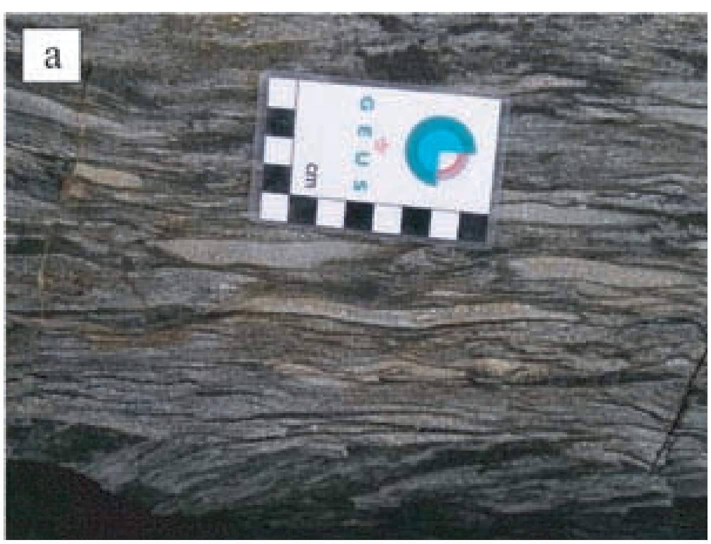

Figure 1a. A deformed pyroclastic outcrop composed predominantly of pumice and dacite fragments within mafic to intermediate tuffaceous matrix (Ikatoq island).

Figure 1b. A deformed contact between amphibolites and quartz-mica-feldspar schists (Ikatoq island).

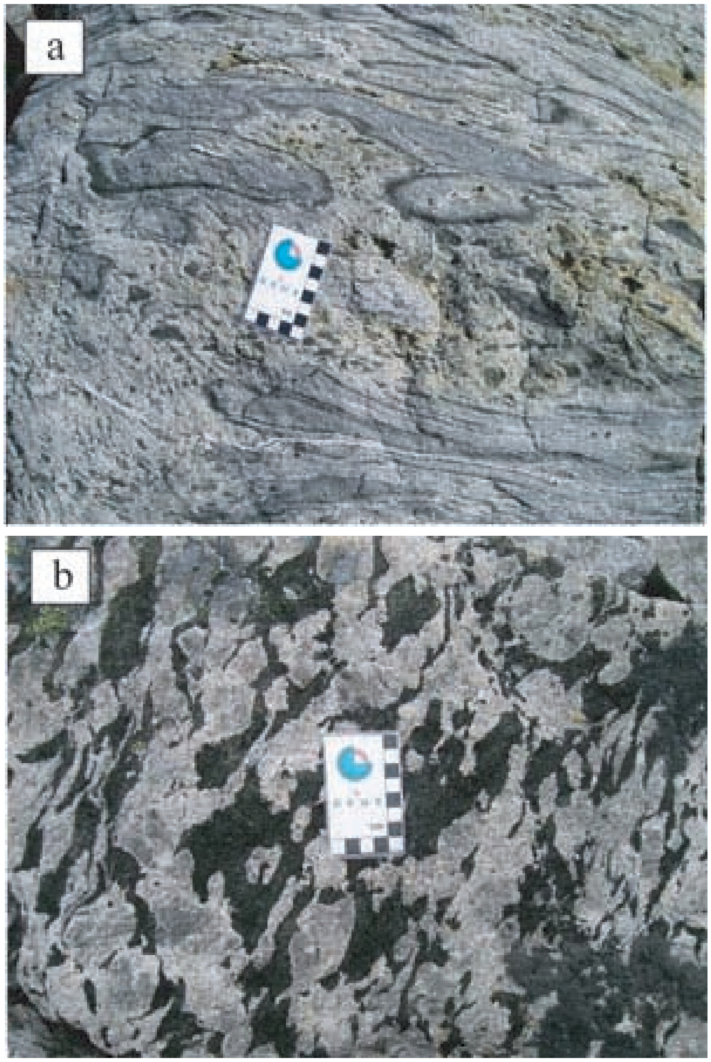

Figure. 2. (a) Brecciated metasomatized gabbro (Bjornesund). (b) A deformed cumulate texture in leucogabbros (Qeqertarssuatsiaq).

in metagabbros in low-strain zones. Epidote-rich calc-silicate alteration is common within metagabbros. In addition, some metasomatized gabbro layers display breccia structure (Fig. 2a).

In the Qeqertarssuatsiaq area, orthogneisses, anorthosites, leucogabbros, gabbros, amphibolites, ultramafic schists constitute the major rock types. Contacts between anorthosite-leucogabbro-amphibolite association and gneiss are strongly deformed. These contacts often display multiple phases of folding and shearing. Contacts among anorthosites, gabbros, leucogabbros, and ultramafic schists are often structural. Because of intense deformation and metamorphism primary magmatic relationships between different units (e.g. anorthosites and leucogabbros) have been modified.

Anorthosites and leucogabbros are the dominant rock types in the area. They have variable thickness, ranging from several metres to several hundreds of metres. In low-strain areas it is possible to see a transition between anorthosites and leucogabbros. Leucogabbros grade into anorthosites with increasing content of plagioclase. Primary magmatic structures such as cumulate layers, are locally preserved in low-strain areas (Fig. 3a). The size of plagioclase in cumulate texture ranges from a few millimetres to fifteen centimetres. Interstitial minerals between cumulus plagioclase are mostly amphiboles (hornblende). Some gabbros and leucogabbros have pyroxene of probable metamorphic origin as a cumulate mineral. Several centimetres to several tens of centimetres thick chromitite layers are also present in the anorthosites and leucogabbros.

Ultramafic rocks are composed primarily of serpentinites, actinolite schists, and bronzitites (Fig. 3b). They mostly occur as tectonic lenses. Their thickness ranges from several tens of centimetres to two hundred metres. Foliation in ultramafic schist is parallel to those in the amphibolites, anorthosites, and leucogabbros. Bronzitites tend to occur within leucogabbros, anorthosites, and in between them (Fig. 3b).

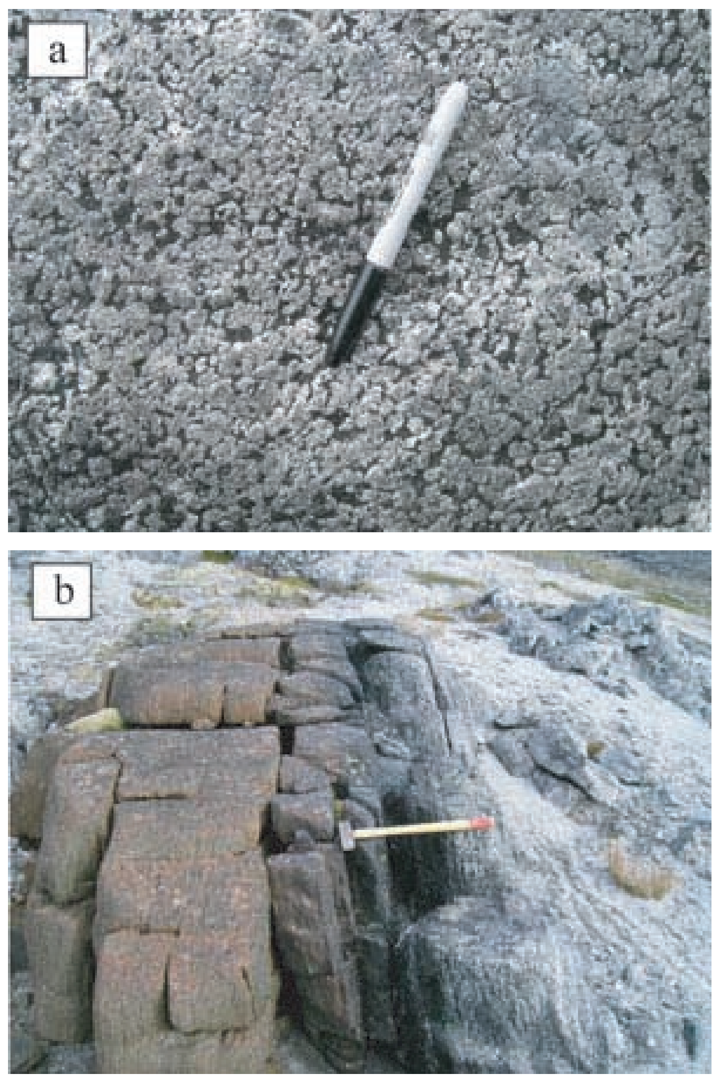

Fig. 3. (a) A deformed cumulate texture in anorthosites (Qeqertarssuatsiaq). (b) An ultramafic layer (bronzitite) in leucogabbro-anorthosite transition zone (Qeqertarssuatsiaq).

Mafic volcaniclastic deposits in the Ferrar Large Igneous Province, Antarctica

Pierre-Simon Ross, Geological Survey of Canada and James D.L. White, University of Otago (New Zealand)

In relatively young continental flood basalt provinces such as the Deccan Traps or the Columbia River Basalts, the lower part of the volcanic stratigraphy and the subvolcanic rocks are not well exposed because the flood lavas can form km-thick piles. In older provinces such as the Ferrar LIP in Antarctica, the lavas have been partly eroded, so the early stages of the eruptions – preserved as mafic volcaniclastic deposits (MVDs) – can be studied. MVDs are also known from several other LIPs and these occurrences are reviewed by Ross et al. (2005).

Some 98% of Antarctica is covered by ice, but excellent outcrop exists in the Transantarctic Mountains. The preserved thickness of Jurassic flood lavas varies from 380 m to 780 m, and the basalts are everywhere underlain by MVDs ranging in thickness from 10 to >400 m. Some of the best and most extensive exposures are at Coombs Hills and Allan Hills. At the former site, MVDs are interpreted to fill a large volcanic vent complex, also known as a 'phreatocauldron' (White and McClintock, 2001) because of the inferred phreatomagmatic fragmentation mechanism and the overall cauldron shape of the complex (Fig. 1). In other words, much of Coombs Hills represents a partly eroded volcano and we can have a look at the conduits through which explosive eruptions of the Ferrar LIP threw debris toward the paleo-surface. The conduits are preserved as cross-cutting volcaniclastic bodies in the vent complex (Ross and White, 2006). The pipes filled with country rock-rich lapilli-tuff or tuff-breccia (Figs. 2, 3) are interpreted to have formed following phreatomagmatic explosions occurring near the walls or floor of the vent complex, causing fragmentation of both magma and abundant country rock material. In contrast, some of the cross-cutting zones filled with basalt-rich tuff-breccia or lapilli-tuff could have been generated following explosions taking place within pre-existing basalt-bearing debris, well away from the complex walls or floor. Other basalt-rich zones, accompanied by

Figure 2. Outcrop aspect of a 10 m plus wide pipe filled with country rock-rich lapilli-tuff (depressed elliptical shape under standing person) inside the unbedded mafic volcaniclastic deposits at Coombs Hills.

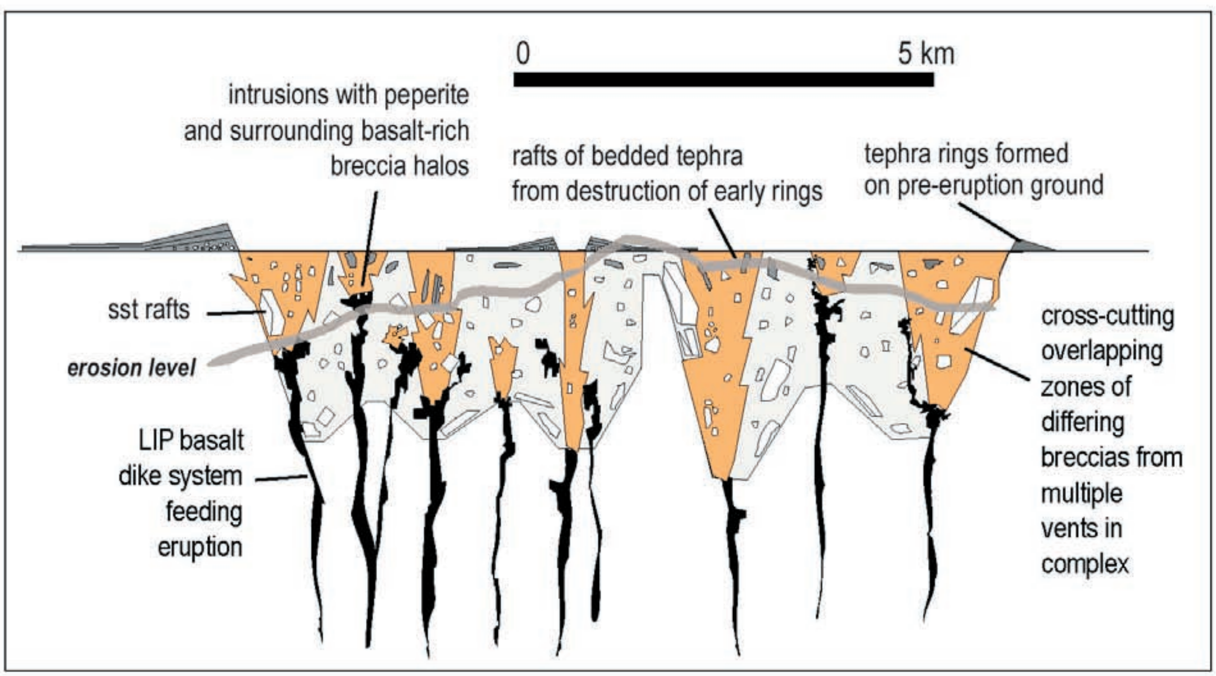

Figure 1. Schematic vertical section through the Coombs Hills vent complex, modified from White and McClintock (2001). The Jurassic cauldron-shaped complex is over 5 km across and consists of a series of coalesced diatreme-like vents, fed from mafic dikes (shown in black). The uppermost country rock (Triassic sandstones of the Beacon Supergroup) was poorly cemented/lithified in the Jurassic and represented a good aquifer. When magma reached this aquifer, phreatomagmatic explosions occurred and jets of debris (fragmented country rock, fragmented magma, recycled clasts) and fluids (magmatic gases, external water in vapour ±liquid form) travelled upward inside transient conduits (Ross and White, 2006). This was repeated over and over as magma kept coming up and water was in abundant supply. Rafts of soft country rock (shown in white) and layered volcaniclastic deposits (in grey) slumped into the vents.

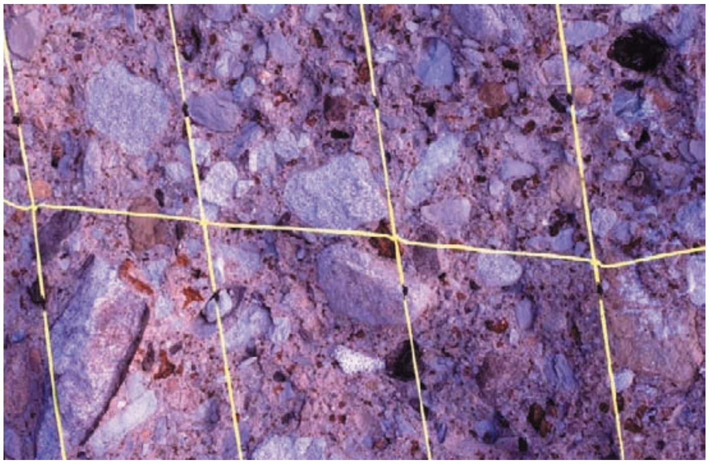

Figure 3. Detail of the country rock-rich material filling a pipe similar in shape to that shown in Figure 2. Pale grey lapilli-grade clasts are sandstone, medium grey clasts are mudstone, and the brown ones represent juvenile basalt (formerly glassy) altered to palagonite and clays. The ash-grade matrix consists principally of (i) detrital quartz crystals (derived from disaggregation of quartz-rich sandstones from the country rock) and (ii) formerly glassy non-vesicular to poorly vesicular basaltic clasts. Black nodes on the clast-counting net are spaced by 10 cm.

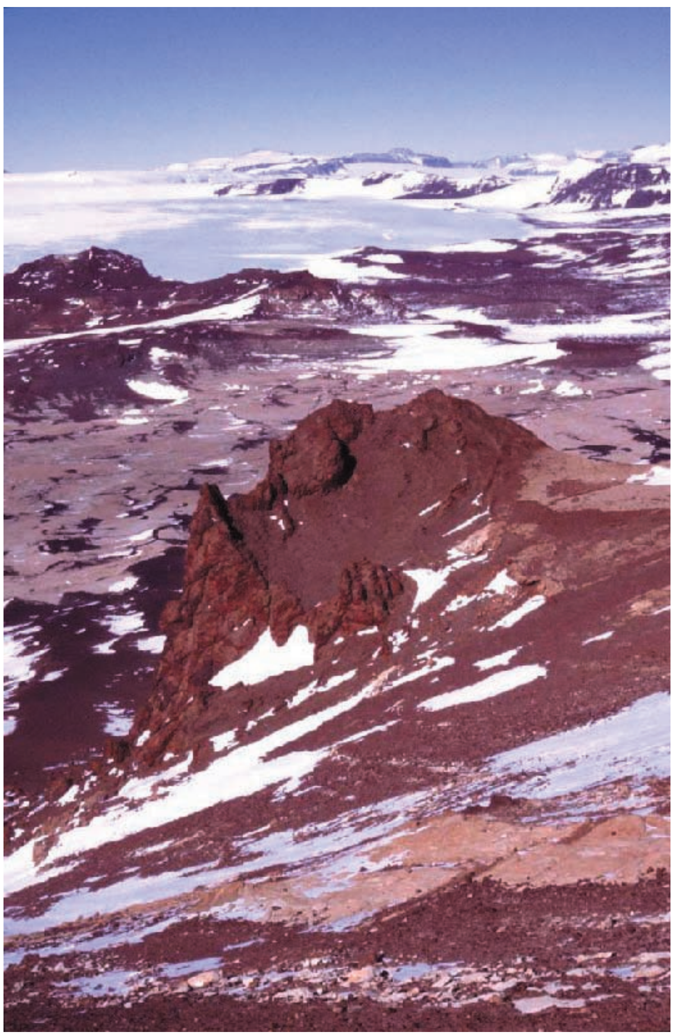

Figure 4. A 140 m-wide basalt 'plug' (prominent dark brown mass) invading the unbedded volcaniclastic rocks (foreground) at Coombs Hills. Such basaltic plugs could have served as feeders to the Ferrar flood lavas overlying the mafic volcaniclastic rocks. The flat outcrop area in the background is occupied by sedimentary rocks of the Beacon Supergroup, with large Ferrar intrusions on the left.

domains of in situ peperite and coherent basalt, are inferred to have originated by less violent processes.

Following the development of the vent complex at Coombs Hills, coarse unbedded MVDs were invaded by mafic plugs, some more than 150 m-wide (Fig. 4). These plugs could represent feeders to the lavas higher up in the sequence, as their diameters are more than sufficient to accommodate the inferred mass eruption rates for continental flood basalts and their chemistry matches that of the lavas. Both the plugs and the older MVDs were then cross-cut by volcaniclastic dikes up to 75 m-wide. Such clastic dikes are among the largest exposed anywhere on earth and we infer that the ash-grade material filling them was obtained by mobilization and sorting/filtering of the coarse vent-filling debris by fluidization above large basaltic intrusions (Ross and White, 2005a).

A few km away at Allan Hills, the MVDs can be divided into two members. Member m1 consists essentially of sedimentary material from the underlying Beacon Supergroup, and is interpreted as a 180 m-thick debris avalanche deposit (Reubi et al., 2005). Member m2 consists predominantly of metre-thick mafic volcaniclastic layers that fall into three broad categories: (a) poorly sorted, coarse lapilli-tuff and tuff-breccia; (b) block-rich layers (Fig. 5); (c) tuff and fine

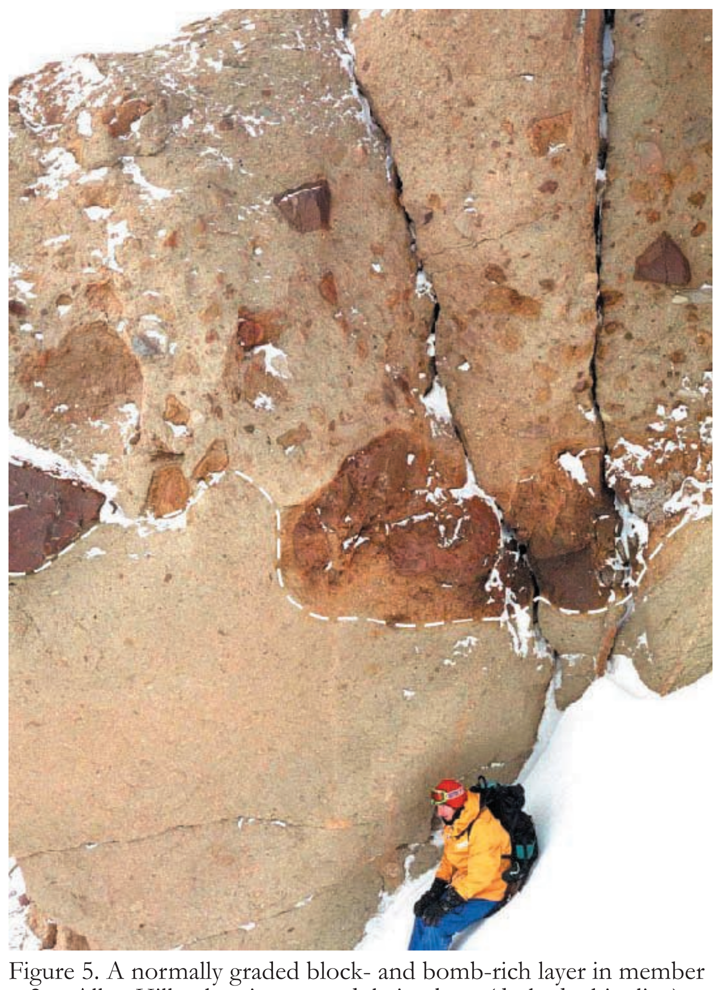

Figure 5. A normally graded block- and bomb-rich layer in member m2 at Allan Hills, showing an undulating base (dashed white line) because the largest bombs penetrated the underlying layer.

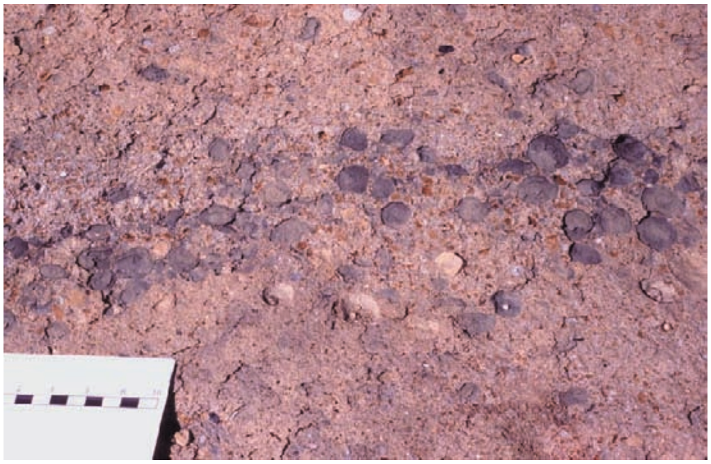

Figure 6. Accretionary lapilli-bearing volcaniclastic layer at Allan Hills. Scale bar is graduated in cm.

lapilli-tuff. The former type is interpreted as the deposits of high-concentration pyroclastic density currents, probably formed during the collapse of phreatomagmatic eruption plumes (Ross and White, 2005b). Occasional block-rich layers probably were formed by both ballistic fall from local vents and pyroclastic flows, and the finer-grained layers were probably deposited by dilute currents. Dilute, moist turbulent pyroclastic density currents were also likely responsible for the generation and deposition of large (≤4.5 cm) rim-type accretionary lapilli (Fig. 6). It is inferred that all these layers from the m2 member were deposited in a pre-existing topographic depression.

The presence of surface water in the Jurassic is easily demonstrable at Carapace Nunatak, to the south of Allan Hills. There, after the emplacement of the first lava, a 40 m-thick unit comprising pillow lavas and pillow-palagonite breccias was formed. The overlying lavas were likely sub-aerial, indicating the lake had dried-out or had been filled by coherent and fragmented lava at this stage.

In summary, MVDs of the Ferrar LIP predominantly consist of coarse lapilli-tuffs and tuff-breccias up to 400 m-thick which either fill self-generated, composite, holes-in-the-ground (phreatocauldrons) or pre-existing topographic depressions. They underlie the Ferrar flood basalts throughout the Transantarctic Mountains and represent the phreatomagmatic precursors to flood volcanism. Surface water and groundwater played a major role in controlling the eruption styles. The potential for MVD-forming eruptions to generate significant environmental impacts (perhaps even causing mass extinctions) remains to be evaluated.

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This report constitutes an abbreviated version of the IAVCEI Large Igneous Provinces Commission's December 2005 "LIP of the Month" (http://www.largeigneousprovinces.org/LOM.html). The research was carried out while Ross was a PhD student at the University of Otago. He is now working on the products of explosive submarine volcanism in the Abitibi Greenstone Belt, as a postdoc at the Geological Survey of Canada.

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Update on Volcanology and Igneous Petrology Research, McGill University

By Crystal Mann

Contributions: Kim Berlo, Michelle Campbell, Guillaume Girard, Shoshana Goldstein, Jonathan Hanson, Marie-Claude Hébert, Christoph Helo, Charles Maurice, Jonathan O'Neil, Stephanie Palmer, Don Baker, Don Francis and John Stix.

This report is intended to update the geology community at large as to research taking place in the Earth and Planetary Sciences department, McGill University. The volcanology research group currently comprises Dr. John Stix and his students Crystal Mann, Guillaume Girard, Christoph Helo, Marie-Claude Hébert, Michelle Campbell, Stephanie Palmer, Jonathan Hanson and postdoc, Dr. Kim Berlo. The volcanology group is made up of an international group of students who combine their varied backgrounds to answer questions about how, when and why volcanoes erupt. The igneous petrology research group comprises Dr. Don Francis and his students Shoshana Goldstein, Jonathan O'Neil, Charles Maurice, Sheldon Modeland, David Clark, Michael Patterson and Yuliana Proenza. The igneous petrology group conducts extensive work within Canada to answer fundamental questions on evolution of the Earth's mantle. The high-temperature experimental geochemistry and petrology group is led by Dr. Don Baker and students Liping Bai and Marina Alletti. Their work applies fundamental physics and chemistry to investigate the mechanisms of magma degassing and volcanic eruptions. Although concentrating on laboratory experiments, they collaborate with physicists in the U.S.A., volcanologists in Italy and climate scientists in Israel to create a multidisciplinary team of scientists using fundamental principles to understand complex systems. Read on to find out what everyone is working on.

Volcanology

The volcanology group is led by Dr. John Stix. John and his research group are involved in many different aspects of volcanology, which results in studies of volcanic systems all over the world. John is primarily interested in what causes volcanic eruptions, as well as magma plumbing systems beneath volcanoes. To tackle these questions the volcanology group focuses on supervolcano systems, including caldera processes, magma transport, and degassing processes, thinking about how volcanic systems channel magma and gases from the mantle to the atmosphere and the transition from effusive to explosive behaviour in submarine volcano systems. John has also started a project on how volcanoes can generate large tsunami waves.

Crystal Mann (Ph.D.4): I am interested in the nature of magmatic recharge in volcanic systems currently undergoing eruption. My field area is the Soufrière Hills volcano on the Island of Montserrat, West Indies.

February 2006, Crystal Mann describing mafic enclaves from the 8 December 2002, block and ash flow, Soufrière Hills volcano, Montserrat. (Photo taken by Tyler Barton)

The ongoing eruption of the Soufrière Hills volcano began with a phreatic event in July 1995. The eruption is typified by dome growth and dome collapse cycles sometimes followed by vulcanian explosions. Basaltic to basaltic-andesite enclaves observed in the andesitic dome rock indicate the presence of a more mafic magma at depth. The question I am exploring concerns the mafic magma and what this material contributes to the ongoing eruption. I use the mineralogy and geochemistry of the mafic enclaves collected from block and ash flows (1997 to 2006) to determine geochemical evolution over time. Thermobarometry techniques are used with H_2O and CO_2 contents to estimate temperatures and pressures of phenocryst formation, and thermometry techniques will be used to determine enclave quench conditions. With this information I can estimate the path of evolution undergone by the observed mafic material and make some scientific contributions as to what happens to the mafic magma before, during and after intrusion into the shallow reservoir.

Guillaume Girard (Ph.D.4) focuses on the evolution of magma chambers at large silicic centers, with an emphasis on Yellowstone caldera in Wyoming, United States.

Yellowstone, one of the world's largest super volcanoes has been episodically active for the last 2 Ma, with eruptions as young as 70 ka. There is a noteworthy cyclicity between tremendous caldera-forming exlosive eruptions and large effusive eruptions, probably involving shallow batholith-sized magma chambers. However, the erupted products, high-silica rhyolites, are compositionally very similar regardless of the age and type of eruption.

Analogue experiments of recharge of magma chamber by using water-corn syrup solutions help me to understand the mechanisms of magma mixing induced by injections of compositionally similar material. Although the injected

Guillaume Girard pointing at a contact between 2 parts of a fallout deposit from Huckleberry Ridge Tuff, Yellowstone NP.

analogue magma generally does not mix easily with the resident phase, such injections allow denser particles from a basal mush, modeled by plastic grains, to be transferred (1) into the upper liquid part of the reservoir, and (2) from the injected material to the resident material.

Micro-analyses of matrix glass and melt inclusions on Yellowstone tuffs and lavas by electron microprobe and laser-ablation ICP-MS, coupled with quartz zoning studies by cathodoluminescence and Ti geothermometry, help me to assess (1) whether the melts at micro-scale are still as homogeneous as the bulk rock and whether different types of melts could have been involved prior to eruption, and (2) whether the crystals have been remobilized in a different physico-chemical environment. Again, a spectacular homogeneity is found, but this in turn raises fundamental questions about the formation and sustainability of such large homogeneous reservoirs.

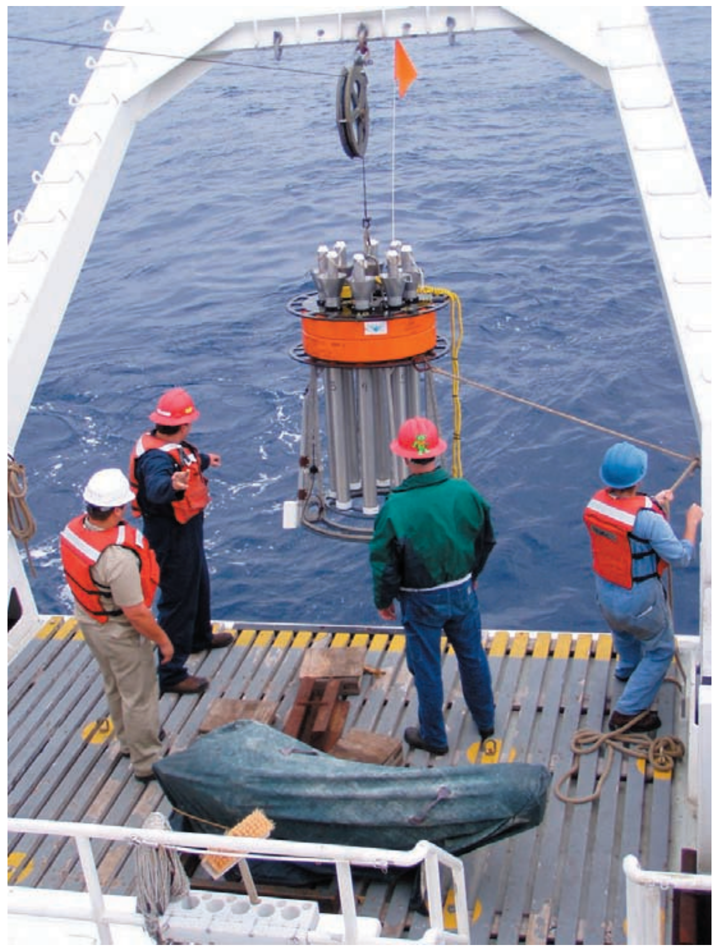
Just arriving from Munich, Germany, **Christoph Helo (Ph.D.1)** is a new addition to the group and is involved in a project looking at the formation of submarine calderas and their associated explosive phases.

Volcaniclastic samples taken from Axial volcano, Juan de Fuca Ridge, during a MBARI cruise the summer of 2006 (Ashfall No.62, Oct. 2006) display variability in the pyroclastic material deposited on the flanks of the volcano, ranging from fine-grained ashes to beautiful limu o pele (bubble wall fragments) and peles hair.

Some important questions are, what eruption style/stages do these deposits represent? What are the mechanisms behind these explosive eruptions in 1400 m to 2000 m water depth? What is the hydrothermal component to these eruptions? By getting a handle on the degassing history and efficiency of the ash and limu forming processes and analysis of the microstratigraphy of the pyroclastic deposits, I will try to solve some of the mysteries of explosive submarine eruptions observed on Axial.

Just arriving from Bristol, England, **Dr. Kim Berlo**, recently joined the group as a postdoctoral researcher.

My previous research has focussed on the ascent and storage of magma in the crust, the study of plagioclase crystals and their record of magmatic processes, and the time scales of magma degassing. It is the latter subject which I want to continue to explore during my stay at McGill University. Issues of interest are gas distribution prior to eruption, mechanisms of gas ascent through magma and variations of emissions at the surface, which I hope to tackle using a combination of geochemical analyses and experiments.



The Crew of the RV Western Flyer of the Monterey Bay Aquarium Research Institute (MBARI) retrieving the elevator with the volcanic sediment cores, which were taken from the E-flank of Axial Seamount, Juan de Fuca Ridge.

Stephanie Palmer (B.A, McGill School of Environment), spent the summer of 2006 in México at the Universidad Nacional Autónoma de México, México City, working with Dr. Hugo Delgado on diffusive degassing in monogenetic volcanic fields. Stephanie received support from the Earth Hazards Consortium to conduct the necessary research in Mexico towards a project she is continuing as an honours project at McGill.

Continuous diffusive carbon dioxide (CO_2) emission is


Stephanie Palmer enjoying a little time at home on Prince Edward Island.

characteristic of all volcanic and geothermal areas, including quiescent periods in volcanic systems. As CO_2 is the main non-condensable component of magmatic gas, changing soil CO_2 flux may be indicative of changing magmatic activity at a given location, and is a useful parameter to monitor changing volcanic activity. To date however, monogenetic volcanic fields have been excluded from such study. The Michoacán-Guanajuato volcanic field in central Mexico is an example of such a monogenetic field. The goal of my research is to test the usefulness of soil CO_2 flux monitoring in determining magmatic pathways of anomalous activity. This, combined with data on fault and fracture zones, seismic data and cinder cone clustering, is expected to better enable spatial prediction of magmatic activity. The specific measurements taken during this period serve as setting background flux levels for this field.

Marie-Claude Hébert (B.Sc.) spent the summer in Mexico, working at Volcan de Colima with Dr. Nick Varley. Marie-Claude's attention is focused on correlating the thermal images and seismic signals of the ongoing eruption to find a correlation between temperature and strength of eruption. Marie-Claude's research is also supported by the Earth Hazards Consortium and is continuing as a research project at McGill.

Thermal analysis was done of eruption columns between February and May 2006 at Volcán de Colima in Mexico. Images of eruption columns were taken with an infrared camera and were analyzed to find the average and maximum temperatures of the plumes at five second intervals. The thermal results for each eruption are compared to the length and amplitude of the seismic signals, the ascent rate, and approximate ash content with photographs, to find a correlation between temperature and strength of eruptions at Volcán de Colima.

Michelle Campbell (B.Sc) and **Jonathan Hanson (B.Sc.)** are currently doing research on quartz crystals from Valles Caldera, New Mexico. Using the zoning patterns


Marie-Claude Hébert with Volcan de Colima in the background.

in quartz crystals, revealed using cathodoluminescence, and the Titanium-in-Quartz Geothermometer Titaniq, they hope to determine a growth history for the crystals related to temperature, with an eye towards making conclusions related to magma chamber evolution. They are focusing on the Otowi and Tshirege members of the Bandelier Tuff, respectively.


Michelle Campbell collecting samples of the Lower Bandelier Tuff, Valles caldera, New Mexico.

Igneous Petrology

Dr. Don Francis continues to focus his research on the evolution of the Earth's mantle through time, supervising six graduate students pursuing projects using kimberlites, alkaline ultramafic intrusions, and picritic basalts as probes of the Earth's interior.

Michael Patterson (M.Sc.1) has just begun a project on the Renard kimberlites in the Otish Mountains of central Québec. Although he only goes into the field next summer, he already has a nice suite of samples to keep him busy.

Michael Patterson combining his two passions; geology and back packing. This photo is taken along the South Kaibab Trail during a spring 2005 trip in the Grand Canyon, United States.

Shoshana Goldstein (M.Sc.2) spent three weeks in western Ontario this summer, finishing the field part of her study of 2.7-3.0 Ga alkaline ferropicrites, and hopes to finish her thesis this coming summer.

I am studying 2.7 – 3.0 Ga ferropicrites from three greenstone belts in the western Superior Province. My research goals are to determine the mantle source and conditions from which these magmas formed, to determine if ferropicrites represent Archean equivalents of modern day alkaline volcanism, and to use these rocks to determine whether the composition of the Earth's mantle has evolved compositionally over time.

I have collected ferropicrites samples from the Steep Rock and Lumby Lake greenstone belts of the Wabigoon subprovince, as well as from from the the White River-Dayohessarah and Schreiber-Hemlo greenstone belts of the Wawa subprovince. These rocks are ultramafic (≥ 18 wt% MgO) pyroclastic volcanics and intrusive cumulates characterized by high Fe contents (15 – 22 wt% FeO*) and low Al contents (Al_2O_3 <10 wt%, often <5 wt%). They have high TiO_2 (1 – 2 wt%), are enriched in incompatible trace elements, and have fractionated REE profiles (La/Yb = 4 – 18; Nb = 3 – 17 ppm; Nb/La = 0.8 – 1.3). These geochemical characteristics closely resemble those of modern alkaline picrites associated with ocean islands (OIB), and these lavas represent alkaline ferropicrite magmas formed in the Archean. Most strikingly, these rocks, along with other Archean ferropicrites, are much richer in Fe and poorer in Al than their modern OIB equivalents, a feature which may reflect a change in the composition of the Earth's mantle since the Archean.

I have spent two months in western Ontario collecting approximately 200 rock samples. Certain areas of interest were mapped in detail in the field. All the geological field data, including sample locations, lithologies, lithologic contacts, and major structural features have been put into a digital GIS format using MapInfo. These rocks have been, or are currently undergoing whole-rock geochemical analysis for major and trace elements using X-ray fluorescence. REE analysis on selected samples is done using ICP-MS, and Nd isotope work will soon be done by ICP-MS on selected samples at GEOTOP-UQAM-McGill. Petrogenetic modeling will be done to try to determine the mantle source composition, as well as pressure and temperature conditions, under which these primary ferropicrite magmas formed.

Jonathan O'Neil (Ph.D. 4) had another successful field expedition to Porpoise Cove (Nuvvuagittuq greenstone belt), along the Hudson Bay coast, for his study of one of the oldest mantle-derived suite of rocks in the world (3.8 Ga). He now spends most of his time sequestered at

Shoshana Goldstein on the edge of Ngorongoro Crater, Tanzania

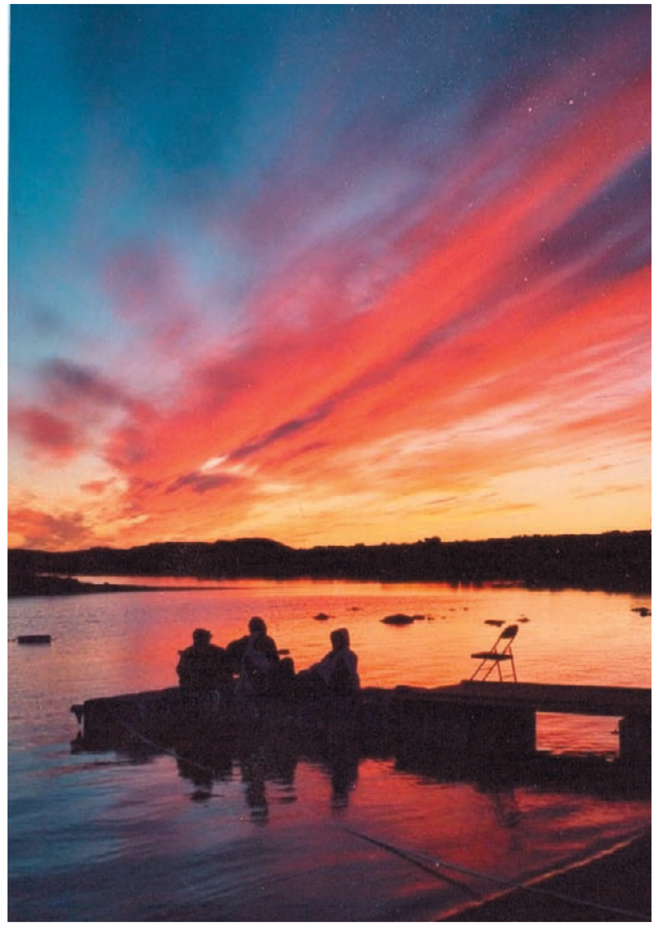
Jonathan O'Neil doing field work on the 3.8 Ga Nuvvuagittuq greenstone belt, Hudson Bay coast.

the GEOTOP-UQAM-McGill, obtaining Sm-Nd isotopic results on these fascinating rocks.

My thesis is on the Porpoise Cove (Nuvvagittuq) greenstone belt. This volcano-sedimentary belt has been dated at 3.8 Ga which makes it one of the oldest (with Isua, Greenland 3.7-3.8 Ga) mantle-derived suite of rocks. For the last three summers I have mapped the belt at a scale of 1:2000 in order to understand the relationships between the different lithologies. My principal interest is to investigate the Eoarchean Earth mantle and to understand it's chemical evolution through time. The presence of both aluminium-depleted komatiite (ADK) and aluminium-undepleted komatiite (AUK) in the same 3.8 Ga volcanic sequence contradicts the commonly held view that there has been an evolution from ADK to AUK over time during the Archean. I am also doing a detailed isotopic investigation using several isotopic systems (Re-Os, Sm-Nd, Lu-Hf and Fe) to isotopically characterize and constrain the different magmatic reservoirs that could have contributed to the formation of the 3.8 Ga Porpoise Cove greenstone belt. Preliminary isotopic results for the Nuvvuagittuq rocks indicates a derivation from a mantle source that had already experienced long-term trace element depletion. There is also a banded iron formation in the belt, and the presence of heavy Fe isotopic enrichment in the Nuvvuagittuq belt BIF confirms its origin as a chemical precipitate which, along with similar results in SW Greenland, may indicate that life was already established on Earth at 3.8 Ga.

Charles Maurice (Ph.D.5) is in the last year of his study synthesizing all the igneous data obtained by Québec's Grand Nord mapping project on the Ungava Peninsula. He is in the enviable position of being paid as a full time employee in Val d'Or while finishing his thesis.

I had the opportunity between 1999 and 2003 to map rocks of the Northeastern Superior Province (NESP), in northern Québec. My work in this area, combined with the large amount of data collected by the Ministère des Ressources naturelles et de la Faune and the Geological Survey of Canada offered me a unique opportunity to pursue a Ph.D. study to better understand the genesis and the assembly of this part of the Canadian Shield. Specifically, my study focuses on the secular chemical and isotopic evolution of 1) Archean greenstone belt assemblages and 2) Proterozoic mafic dykes of the NESP.



Playing guitar under the sunset at Qalluviartuuq lake, July 2001.

The chemical data show that the mantle melting domain that produced 2.78 Ga basalts a was deeper than older (2.82 Ga) and younger (2.76 Ga) ones. Also, U-Pb zircon ages acquired by my colleague J. David (GEOTOP-UQAM-McGill) on 2.78 Ga assemblages show evidence of the entrainment of 2.82 Ga stratigraphic units. The recognition of similar relationships across the NESP suggests that despite their large physical separation (>200 km), the scattered greenstone belts were once part of the same autochthonously growing mafic crust, before the emplacement of voluminous late granitoid plutons.

Bulk rock chemistry, Nd isotopic data and U-Pb ages obtained on 2.48-2.00 Ga mafic dyke swarms throughout the NESP reveal chemical systematics that are independent of their age of emplacement. These characteristics appear to rather record the lithospheric thickness and the extent of recycling to which the crust they intruded experienced. Such observations allow a new approach to map the morphology of the sub-continental lithospheric mantle, perhaps more precisely than craton-scale tomographic images.

David Clark (M.Sc.) has been away working in mineral exploration in Ungava this summer, but returns shortly to finish his study of the Raglan ultramafic sills in the Cape Smith foldbelt.

David Clark, Goldbrook Ventures' Raglan camp, Cape Smith foldbelt, northern Quebec

Although now working full time in Saskatchewan, **Sheldon Modeland (Ph.D.)** still hopes to finish his study of Proterozoic alkaline picrites in the Bravo Lake Group of central Baffin Island. Finally, **Yuliana Proenza (B.Sc.)** is carrying out a study of V - Sc systematics in mantle xenoliths from the Canadian Cordillera in order to constrain the oxidation of the lithospheric mantle. Looking forward to next summer, Don already has plans for new projects on Proterozoic ultramafic alkaline intrusions in the Labrador Trough and Archean ferropicrites in northwestern Ontario.

High Temperature Experimental Geochemistry and Petrology

Dr. Don R. Baker, his students and his colleagues in the U.S.A., Italy and Israel are working to constrain the role volatiles in igneous processes, the mechanims and rates of volatile release during volcanic eruptions, and the affects of eruptions on Earth's climate.

Yanan Liu (M.Sc.) finished her Master's degree in 2006 with the creation of a model to predict the sulfur concentration in silicate melts saturated with a sulfide phase. This model can be applied to determine the maximum amount of sulfur that can be stored in a silicate melt at common oxidation states for anhydrous and hydrous melts ranging in composition from komatiitic to rhyolitic at pressures from 1 atm to 9.0 GPa. Scientists can now predict when sulfide saturation will occur in most magmatic systems, or given the knowledge of sulfide saturation and melt sulfur concentration estimate the temperature at which saturation occurred. This information also provides a fundamental constraint on the maximum amount of sulfur that volcanoes can degas. Yanan is currently in charge of the electron microprobe at the University of Toronto.

Liping Bai (M.Sc.) finished his Master's degree in January 2007; he studied the formation and growth of water bubbles in a shoshonitic, basaltic melt at one atmosphere using x-ray microtomography on the Advanced Photon Source synchrotron. His study demonstrated that the bubble size distribution in basaltic melts follows a power law when the system is far from equilibrium, but as the system approaches equilibrium the distribution evolves toward an exponential one in only seconds to minutes; this indicates that natural samples with power-law bubble size distributions preserve evidence of only the last few minutes of their evolution. Although addition of CO_2 to the system delayed nucleation, he found no affect of CO_2 on the resulting bubble size distributions. Additionally his work demonstrated that the samples first evolved into foams before popping, suggesting that bubble expansion in foams is responsible for magma fragmentation. Liping plans on beginning his Ph.D. studies at McGill in the summer of 2007.

Marina Alletti (Ph.D. 3), University of Palermo) is almost finished with her research on the transport of halogens in basaltic melts and their partitioning into a coexisting hydrous gas phase. Through a combination of experiments on diffusion and melt-gas partitioning experiments at McGill and in Orleans, France, she is able to quantitatively constrain the ratios of halogens in gas bubbles and therefore in volcanic emissions. This research holds the key to being able to interpret changes in the halogen ratios of magmatic gases in terms of changes in the pressure of degassing and the bubble growth rate, and therefore may be used as one tool for eruption prediction. She is looking forward to defending her thesis before the end of 2007.

Working with collaborators G. Paul, S. Sreenivasan and H.E. Stanley, Don's group is applying computer simulations based upon statistical mechanics to investigate volcanic mechanisms and predict eruptions. Our Italian collaborators A. Aiuppa, L. Colo, C. Freda, R. Moretti, M. Polacci and M. Ripepe provide us with challenges to investigate and natural samples that we study and compare against our experiments. Our work with colleagues Y. Ashkenazy and H. Gildor in Israel is currently investigating the effects of eruption size and frequency on Earth's climate.

Marina Alletti observing the Summer 2006 eruption of Mt. Etna, Sicily.

Meeting Announcements

GAC-MAC 2007

Yellowknife will host the first spring GAC-MAC conference north of 60°. "Yellowknife 2007, For A Change Of Climate" will feature a full technical program that highlights Canada's North: its climate, its culture, its mining heritage, and its future.

Symposia will include:

- Mitigation of Environmental Impact of Mining in the North
- Permafrost
- Mineral Deposit Models and Regional Exploration Symposium and Workshop

Special sessions are:

- Submarine Volcanism and Associated Mineralization: Modern vs. Ancient
- Geospatial Information and Tools in Support of Geosciences in the Canadian Arctic
- Recent advances in the geology of Laurentia
- Short-lived magmatic events of the Slave Province and environs: critical time markers and indicators of tectonic processes
- Northern Energy and Sedimentary Basins
- Northern Mineral Deposits
- Geoscience Skills Development for Canadian Comunities
- Diamonds: Exploration to Production - a northern Canada perspective
- Sustainable Mineral Resources Development: Critical Issues for Canada's North

Vesicle cylinder in basalt flow of the Osler Volcanics, Wilson Island, Lake Superior. Photo courtesy of Pete Hollings

Pahoehoe textured flow tops in the 1.1 Ga Osler Volcanics, Wilson Island, Lake Superior. Photo courtesy of Pete Hollings

- Northeast Canada and Greenland: Geology, correlations, and resource potential
- Comparative planetary geology: Terrestrial analogues to Mars in the Arctic
- International Polar Year Research

Pre- and post-conference short courses and workshops include:

- The Geology of Gem deposits
- Remote Predictive Geological Mapping,
- Oceanic Volcanism and Mineralization
- Application of Till and Stream Sediment Heavy Mineral and Geochemical Methods to Mineral Exploration in western and northern Canada will be presented.
- Towards an Integrated Future in Geoscience Education and Outreach
- Mineral Deposit Models and Regional Exploration Symposium and Workshop

Six field trips are also planned in conjunction with the meeting:

- Transect through the Southwestern Slave Craton
- Pine Point and Hay River Area: Middle and Upper Devonian Carbonates
- Yellowknife Geoheritage, Emphasizing Submarine Volcanic Eruptions, Unique Sedimentary Deposits, and Continental Glaciation
- A Geological Transect of Trans-Hudsonian Orogen from the Superior Craton to the Rae Craton: Geology of Northern Quebec, Baffin Island, and Western Greenland.

Archean Terranes

The Volcanology and Igneous Petrology Division has agreed to be one of the main sponsors of the Archean symposium, "A Global Comparison of Archean Terranes". The symposium will take place from August 19th-25th, and involves a two-day conference at the University of Western Ontario and a 3-day fieldtrip in the Abitibi greenstone belt. The Abitibi belt of the Superior Province, Canada, is the largest and best-studied greenstone belt in the world. Komatiites, and mafic and felsic volcanic rocks ranging in age from 2724-2703 Ma, late-Archean (2690-2670 Ma) strike-slip basin deposits, and 2710-2686 Ma turbidite deposits are well-exposed throughout the volcanic belt. The 3-day field trip will provide an opportunity to visit critical outcrops and discuss significant issues with respect to Archean processes, including volcanic sequences, sedimentary successions, geochemistry, structural geology, geochronology, early life, ancient crustal evolution, mineral deposits, impact events, and the state of the early atmosphere. Igneous rocks will be one of the main focuses of the fieldtrip, with special emphasis on the physical volcanology of basalts, komatiites and rhyolites. These volcanic deposits represent a variety of depositional settings, such as ocean floors and plateaus, and caldera complexes. The past Chair of the Volcanology and Igneous Petrology Division, Wulf Mueller (UQAC), Real Daigneault (UQAC), and Vital Pearson (CONSOREM and UQAC) will be leading the fieldtrip. The Archean symposium is being organized by Patricia Corcoran (University of Western Ontario), a member of the Volcanology and Igneous Petrology Division, and a past winner of the Leopold Gelinas Gold Medal.

Contact Patricia Corcoran at pcorcor@uwo.ca for more details

Hornblende megacrysts in an andesitic dyke, liw Liw Creek, Baguio District, Philippines. Photo courtesy of Pete Hollings

Institute on Lake Superior Geology

The 53rd Annual meeting of the ILSG will be held in Lutsen, Minnesota on May 10 & 11, 2007 with field trips both before and after. Proposed field trips include the North Shore Volcanic Group, the Duluth Complex and the Proterozoic dykes and intrusions associated with Midcontinrnt Rift. Visit the ILSG website for more details.

Please send contributions to the next Ashfall to peter.hollings@lakeheadu.ca.

Geothermal activity near the El Tatio geyser field in Northern Chile. Photo courtesy of Amy Shute