

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

No. 65 June 11, 2007

From the Editor

Well, as you will see, the submissions to this edition of Ashfall were a little slim and I was reduced to writing an article myself. While I hope that you will find the update on research into the Midcontinent Rift rocks around Thunder Bay interesting, I would prefer to be including articles by other VIPers. Hopefully with another season of fieldwork getting underway there will be a bunch of new articles flooding into my inbox.....don't make me beg!

At the annual meeting in Yellowknife we announced the winners of this years Gélinas awards. You can read the citations for this outstanding crop of students in this edition, as well as responses from the students themselves, none of whom were able to attend the meeting. In order to encourage attendance by our award winners at future meetings it was decided that we would offer \$200 per winner to help with travel costs. It was also decided at the annual meeting that we would increase the VIP membership fee to \$10 next year, but keep it free for students.

Details of VIP sponsored activities for the Quebec City 2008 GAC MAC can be found at the end of the newsletter.

The Division bank account is pretty healthy at the moment with a balance on December 31, 2006 of \$4857.50 (full details can be found on page 3).

Some of you may recall that in Ashfall #63 I mentioned that the Home Reef submarine volcano near Tonga had erupted producing some fairly impressive pumice rafts. These pumice rafts have now reached Australia, having been reported on beaches in Southern Queensland and NSW in March, 2007. A journey of 3400 km in about 8 months. Also in the news, the BBC have reported that an eruption of Santorini may have triggered a tsunami, wiping out an ancient civilisation on Crete and spawning the legend of Atlantis. Details of the Santorini eruptions can be found on the Global Volcanism Program web site.

Finally I would like to include a plug for the Large Igneous Province Commission and their "LIP of the Month". This is a very comprehensive site that is a good starting point for any LIP-related information.

Have a great summer and I look forward to hearing from you all in the Fall!



This stunning panoramic photograph from Ol Doinyo Lengai carbonatite volcano was taken by Marco Fulle. To quote from the web site "As a result of the air's humidity the fresh black ash gradually changes to white. On its left, the deeply black hornito T58B has just ended a paroxysmal eruption. The whole Lengai North Crater is visible in this panorama. From left to right: East rim overflow just below Kitumbeine volcano on the horizon; pyramidal hornitos T45, T37B and T37 and sharp hornito T47 just below Lengai's summit; hornito T40 partially hidden by Stephane; crater C on the north crater rim just between Stephane and Gelai volcano on the horizon". For more stunning photos visit Stromboli online.



2007 GÉLINAS AWARDS

Every year the Volcanology and Igneous Petrology Division of the Geological Association of Canada presents three medals for the most outstanding theses, written by Canadians or submitted to Canadian universities, which comprise material at least 50% related to volcanology and igneous petrology. A gold medal is awarded for the best Ph.D. thesis, a silver medal for the best M.Sc. thesis and an antique copper medal for the best B.Sc. thesis. Nominated theses are evaluated on the basis of originality, validity of concepts, organization and presentation of data, understanding of volcanology and petrology, and depth of research.

Gold medal - Ben Kennedy

This year several Ph.D. theses were nominated for the Leopold Gélinas Gold Medal, and all of them were excellent and would deserve the award. Unfortunately, the committee had to select only one.

The thesis which won the Gélinas Gold Medal is the thesis by Ben Kennedy from McGill University entitled "Magmatic Processes associated with the Development of Large Silicic Calderas" supervised by John Stix. This is an outstanding thesis, which proposes and tests ideas and concepts which are important for the field of volcanology. It is a combination of fieldwork, experiments and theory.

The first chapter of his thesis is a study of the classic ring dike structure in New Hampshire. Ben demonstrates the caldera origin of the structure and makes important new insights into the magmatic plumbing system. He documented that an injection of mafic magma not only rejuvenated the system, but also melted the cumulate or crystal mush. The second chapter is a study of another classic caldera locality (Lake City caldera in Colorado). Here Ben documented a complex sequence of magmatic events related to caldera collapse and subsequent resurgence. He shows the connection between collapse and resurgence by the mobilization of resident magma and the intrusion of new magma, demonstrating that these events must have been very closely linked in time. Chapter 3 is an innovative analogue experimental study which shows that caldera subsidence is not only connected to magma mixing in the chamber but actually is the driving force for mixing and stirring of the magma. He compares and contrasts single-block and multiple-block collapse, showing that the latter is a much more efficient mechanism to stir magmas in the chamber and destroy chemical zonation. Finally, the last chapter is a conceptual and theoretical treatment of caldera development. Ben's hypothesis and numerical modelling suggests that

partial melting of a crystal mush in a magma chamber by intrusion of basalt leads firstly to underpressure (instead of overpressure) and subsequently to failure of the chamber's roof forming a caldera - *Citation by Jarda Dostal*

Ben's response

I would like to thank everyone at the GAC and the VIP section for awarding me the Gélinas gold medal for my Ph.D. thesis. I would have loved to be there to collect it in person. I would especially like to thank those who actually read it, it grew quite overweight over the years, it was hard enough to move it let alone read it, Thanks again.

Silver Medal - Patricia Nadeau

The Silver Medal Gélinas winner for the best MSc thesis in Volcanology and Igneous Petrology goes to Patricia Nadeau of Simon Fraser University of British Columbia, supervised by Glyn Williams-Jones, Diana Allen and Kirstie Simpson. Her thesis is titled "A multi-parameter investigation of volcanic plume behavior and resultant environmental impact at a persistently degassing volcano, Masaya, Nicaragua". The objective of the thesis was to investigate the behavior of boundary layer gas plumes and examine the effects of local topography and regional trade winds. Patricia undertook a thourough study of the SO₂ flux downwind of the Masaya volcano and demonstrated that along-axis dilution of the plume leads to underestimates of total SO, emissions. Patricia also demonstrated that accurate measurements of plume speed were necessary in order to correctly estimate the gas flux. Two journal publications and a book chapter have been prepared from the thesis, an outstanding effort. Congratulation Patricia! - Citation by Pete Hollings

Patricia's response

I would like to express my gratitude to the Volcanology and Igneous Petrology section of the Geological Association of Canada for selecting my M.Sc. thesis as this year's Gélinas Silver Medal recipient.

I'm honored to have been chosen and to be included with the impressive likes of past recipients; it is quite a privilege to have my name on the same list of medal winners as both of my previous supervisors, Glyn William-Jones and John Stix. To that end, I'd also like to thank Glyn, my M.Sc. supervisor at Simon Fraser University. Without his help, guidance, and support, my thesis wouldn't have been nearly as deserving of this award.

Unfortunately, as I am now well into my Ph.D. at Michigan Technological University, I was unable to personally accept the medal in Yellowknife. However, though I am no longer studying in Canada, Michigan Tech often collaborates with Canadian volcanologists, and I look forward to working with my Canadian colleagues again in the future.

Thank you again - Patricia Nadeau

Bronze medal - Marc Rinne

The 2007 Bronze Gélinas Medal for the best B.Sc. thesis in Volcanology and Igneous Petrology goes to Marc Rinne of the Geology department at Lakehead University. His thesis, supervised by Pete Hollings, is entitled "Petrography and Genesis of the Big Lake Ultramafic Complex and Associated PGE Mineralization, Marathon, Ontario", and investigates the processes responsible for the formation of a layered ultramafic intrusion and its related PGE mineralization. Through a comprehensive petrographic and wholerock geochemical study, Marc showed that the mineralization, which occurs as reefs within two peridotite units, clearly

formed by orthomagmatic processes related to injection of more primitive magmas into the reservoir. His detailed petrographic work also points towards at least two mixing events and that the Big Lake Ultramafic Complex is almost certainly overturned. Marc did an excellant job and went well beyond what is typical of an Honours thesis – he most certainly deserves this medal. Congratulations, Marc! - *Citation by Glyn Williams-Jones*

Marc's response

I am thrilled and honoured to receive the Leopold Gélinas Bronze Medal. As a student and an aspiring researcher it is encouraging to receive this level of recognition for a research project that has already been very rewarding in its own right. I am very grateful for the efforts of Jarda Dostal and Glyn Williams-Jones in making this award available to students such as myself.

In all fields of geology I'm sure we can identify at least one mentor who is especially skilled in bending learning curves in our favour, and in this vein I will make special mention of Pete Hollings and supervising geologists of MetalCORP Limited.

Finally, for the award, I would like to extend a general thanks to the Volcanology and Igneous Petrology Division.

If you know of a student you would like to nominate for the 2008 Gélinas awards please visit the awards section of the VIP web site for details and deadlines.

2006 Volcanology and Igneous Petrology Division Financial Summary		
\$4,230.57		
Credits \$ 1,192.00 \$ 433.31		Debits
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The geology of the Mesoproterozoic Midcontinent Rift: updates and advances

Pete Hollings, Lakehead University

The ~1.1 Ga Mesoproterozoic rocks of the Midcontinent Rift (MCR) of North America are interpreted to be an aborted continental rift (e.g., Van Schmus and Hinze, 1985). There have been various studies of the igneous rocks including the petrology and geochemistry (Sutcliffe, 1987; Nicholson and Shirey, 1990); geophysical characteristics (Behrendt et al., 1990; Hinze et al., 1992); and geochronology (Davis and Sutcliffe, 1985; Davis and Paces, 1990; David and Green, 1991; Heaman and Machado, 1992). The majority of these studies have dealt particularly with the large volumes of mafic magmas deposited between 1107 and 1096 Ma, with an emphasis on the US side of the border. Figure 1 summarises the geology and geochronology of the MCR as it was known about five years ago. As a result of a number of recent studies our understanding of the geology, particularly the Logan sills (LS on Fig. 1) has changed considerably. Much of this new information was derived as a result of the Lake Nipigon Regional Geoscience Initiative (LNRGI), which was conceived in 2002 as a means to generate economic stimulus in the area of the Nipigon Embayment through a program of geological mapping and geophysical surveying. Key objectives were to acquire a better understanding of the geology, stratigraphy, metallogeny and regional tectonic setting of the Proterozoic rocks in the Nipigon region. As a result of the LNRGI



Diabase sills on the shores of Lake Nipigon.

over 40 geological units were dated using U/Pb methods (Heaman and Easton, 2007), more than 1000 whole rock analyses undertaken (Hollings et al., 2007) and four new 1:50,000 geological maps produced (Hart and Magyarosi, 2004; Hart, 2005a; MacDonald, 2004; MacDonald et al., 2005). Many of the results of the LNRGI will be published in a forthcoming special issue of Canadian Journal of Earth Sciences, consequently I will just highlight some of the key findings related to the igneous rocks.

The Nipigon Embayment, a region of Proterozoic rocks centered on Lake Nipigon, Ontario, extends for approximately 150 kilometres north of Lake Superior (Fig. 1). The Embayment is defined by a series of mafic sills and older

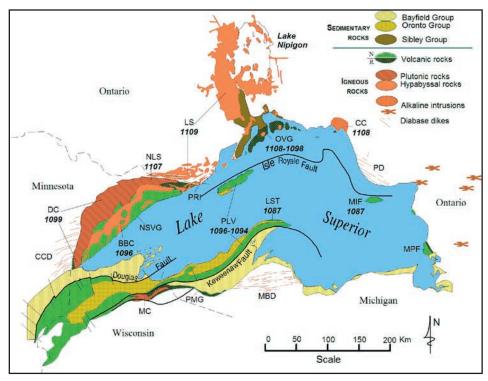


Figure 1. Map summarising the geology of the Midcontinent Rift prior to the Lake Nipigon Region Geoscience Intiative. The Logan sills (LS) are shown as a single homogenous unit found to the north and south of Thunder Bay with an age of ~1109 Ma. Map courtesy of Jim Miller, Minnesota Geological Survey.

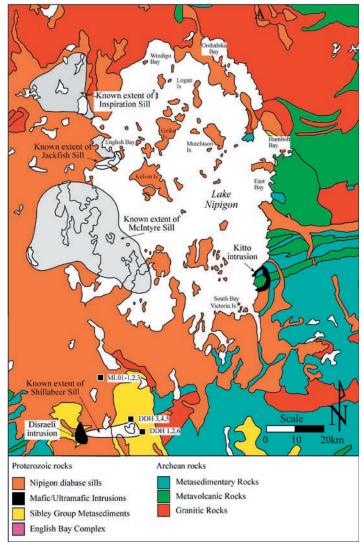


Figure 2. Simplified geological map showing the new subdivisions of the intrusive suites in the vicinity of the Nipigon Embayment. Modified from Hollings et al. (2007a).

clastic and chemical sedimentary rocks of the Sibley Group (e.g., Franklin et al., 1980). Sutcliffe (1987) estimated that the total volume of mafic rocks within the Nipigon Embayment was in excess of 10,000 km³. The geology of the Nipigon Emabyment is summarised in Hart and MacDonald (2007). The relationship of the Nipigon Embayment to the Midcontinent Rift underlying Lake Superior has been the subject of debate with many speculating that the Embayment may have formed as a failed arm of the Midcontinent Rift (e.g., Sutcliffe, 1991).

Figure 1 shows the Logan sills as a single homogenous unit with an age of 1109 Ma. The detailed geochemical and isotopic studies undertaken as part of the LNRGI have revealed that at least five geochemically distinct igneous suites can be recognized within the embayment (Fig. 2). In addition new geochronological data which have shown that the diabase sills and mafic/ultramafic intrusions in the vicinity of Lake Nipigon are in fact the oldest expression of igneous activity associated with the Midcontinent Rift (~1106 to 1115 Ma; Heaman and Easton, 2007).

The dominant rock type within the embayment are the Nipigon diabase sills which make up the majority of the outcropping sills (Fig. 2). At least two and possibly three distinct Nipigon sills have been recognised in outcrop and drill core where they are at least 150m thick (Hart and Mac-Donald, 2007). The Inspiration sills are located in the north west corner of the embayment and likely form a single sill that is somewhat older than the main pulse of intrusive magmatism (Heaman and Easton, 2007). The McIntyre sills are found in the west central portion of the Embayment. In addition to the diabase sills two ultramafic sills (Jackfish and Shillabeer) have also been recognised within the embayment. These ultramafic sills may be genetically related to the four larger ultramafic intrusions (Seagull, Kitto, Hele and Disraeli). The ultramafic intrusions include some of the oldest components of the rift (~1117 Kitto intrusion; Heaman and Easton, 2007)

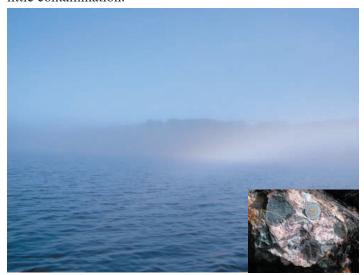
Radiogenic isotope data for the sills can be used to evaluate the source regions and emplacement histories of these sills. The ϵNd_T of all the sill suites are consistently negative (-0.5 to -6.5) but show coherent variations both within and between suites (Hollings et al., 2007b). The negative ϵNd_T values can be interpreted as the result of contamination of a plume-related mantle source by older crustal material. The Sr_i values (0.7032-0.7068) for the sills indicate that at least two distinct contaminants are required: a source with strongly negative ϵNd_T and lower Sr_i , likely Archean metasediment or granite, and one with elevated Sr_i , likely sedimentary rocks of the Proterozoic Sibley Group.

Many of the ultramafic intrusive units, including the Seagull, Kitto, Hele and Jackfish sills, are emplaced in the vicinity of large faults that cross cut the Nipigon Embayment. The Black Sturgeon fault runs approximately north-south along the west shore of Lake Nipigon and apparently has a long history of activity in the area. Rogala et al. (2007) have suggested that the Black Sturgeon fault may have formed one of the bounding faults for the half-graben



Tortoiseshell jointing on a flow top of a Nipigon sill

into which the Sibley metasedimentary group was deposited between 1300 and 1500 Ma. Furthermore, Hollings et al. (2004) have observed that the ~1540 Ma English Bay anorogenic granite-rhyolite complex on the north west shore of Lake Nipigon is also intruded along the Black Sturgeon fault (Fig. 2) and have suggested that it may have been emplaced along this crustal scale feature. This implies that these long-lived crustal fracture systems may have been constantly reactivated over 500 m.y. The least contaminated of the ultramafic sills (Jackfish) has also been emplaced along the Black Sturgeon fault (Fig. 2) and Hollings et al. (2007b) have suggested that movement along these crustal scale structures early in the history of the rift may have allowed the rocks to move through the crust with relatively little contamination.



Approaching Rabbit Island through the early morning mist. Inset shows an example of the diatreme/breccia exposed on Rabbit Island.

The research undertaken as part of the LNRGI inspired a number of other research projects on the rocks of the MCR. These included an Honours thesis that investigated the genesis of an unusual diatreme/breccia located on Rabbit Island in the middle of Lake Nipigon (Lane, 2005). The breccia had been described as a carbonatite diatreme but Lane (2005) concluded that it was in fact a carbonate-rich



Pahoehoe flow top in the Osler basalts on Wilson Island

breccia consisting of clasts of Nipigon diabase that had undergone extensive alteration.

Research has also taken place on the Osler Volcanic group located on the islands along the north shore of Lake Superior (OVG on Fig. 1). The Osler Group comprises a ~3km thick sequence of basaltic flows and sedimentary rocks dated at between 1108 and 1105 Ma. Hollings et al. (2007c) have shown that mafic flows at the base of the sequence comprise OIB-like basalts with εNd_T values of +0.3. Up sequence, the basalts display increasing light rare earth element enrichment with negative Nb anomalies and εNd_T values -3 to -5. This has been interpreted to be the result if increased crustal contamination possibly as a result in changes in the extensional regime of the rift causing longer residence times in the crust.

Towards the end of the LNRGI Mark Smyk (Ontario Geological Survey) and I undertook a helicopter traverse over the islands on the north shore of Lake Superior (Fig. 3). We had two objectives - sample some of the large mafic dykes that cropped out on the islands for dating and investigate the nature of the "stratovolcano" reported on Simpson Island (Sutcliffe and Smith, 1988). The dating did not work out too well as we did not manage to recover much datable material but the St. Ignace Island complex has generated some interesting data.

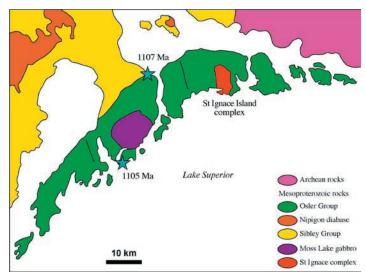


Figure 3. Regional geology map showing the extent of the exposed portion of the Osler Group and the location of the St. Ignace Island Complex. Modified from Giguerre (1975).

The St Ignace Island complex (SIC) consists of a gabbroic to anorthositic ring dyke, which encloses quartz-feld-spar porphyritic volcanic rocks (Sutcliffe and Smith 1988; Giguere 1975). Sutcliffe and Smith (1988) described the volcanic component of the SIC as intercalated plagioclase-glomeroporphyritic basaltic rocks, quartz-feldspar-phyric rhyolite flows and fragmental rocks. The pink to grey, rhyolitic rocks in the core of the SIC are dominantly quartz-phyric, with rare pyroxene and feldspar phenocrysts set in a fine-grained to glassy groundmass. They commonly contain wispy to amoeboid, mafic (basaltic?) inclusions, which are

typically plagioclase-phyric. Preliminary geochemical and geochronological data from the complex suggest that the rhyolites may represent young crustal melts intruded ~1089 Ma (Smyk et al., 2006). The textural evidence suggests that the mafic and felsic magmas were coeval. The presence of xenocrystic zircons in the rhyolites and elevated U/Th ratios, more consistent with zircons derived from a mafic source, supports this theory. We are continuing to study this suite of rocks with radiogenic isotope studies underway in order to investigate the magma sources.



Nebulitic contacts between andesite and rhyolite in the St. Ignace Complex

Finally (well, not really, as there are a lot more questions than answers) Mark and I have started to investigate the dykes and sills that are found south of Thunder Bay. We began this study while planning a field trip for the 2007 Institute on Lake Superior Geology meeting. As we tried to plan out our field stops it quickly became clear that our understanding of the geology was pretty confused (Smyk and Hollings, 2007). Geochemical data from the sills in Thunder Bay itself and a small number of analyses from sills to the south of town suggests that what was left of the Logan sills (Fig. 1, now restricted to the sills south of Thunder



Mark Smyk at the contact between a Pigeon River dyke and Rove metasedimentary rocks. Note that the Rove sediments have been deformed by the intrusion of the dyke.

Bay) may be an oversimplification as there are hints that there may be more than one geochemically distinct sill in the area (Hollings et al., 2007d). We are also working on the dyke suites south of town in order to resolve some outstanding questions. In addition to the sills, three dyke suites are recognised south of Thunder Bay - Pigeon River, Cloud River (aka Arrow River) and Mt Mollie (Fig. 4). The dykes typically consist of ophitic diabase that may be plagioclaseporphyritic. A typical, non-porphyritic olivine diabase consists of approximately 60% plagioclase (zoned labradorite; An 55-70), 20% augite + hypersthene, up to 15% olivine and up to 5% magnetite, ilmeno-magnetite and sulphides (Geul 1970, 1973). The dykes are primarily distinguished on the basis of their orientation but geochronological data, generated as part of the LNRGI, yielded ages of ~1078 Ma and ~1140 Ma for two dykes of the Pigeon River swarm, suggesting things may be a little more complex. Preliminary geochemistry from the dykes suggests little difference between the Pigeon River dykes of different ages (Hollings et al., 2007d) and consequently further work is planned.

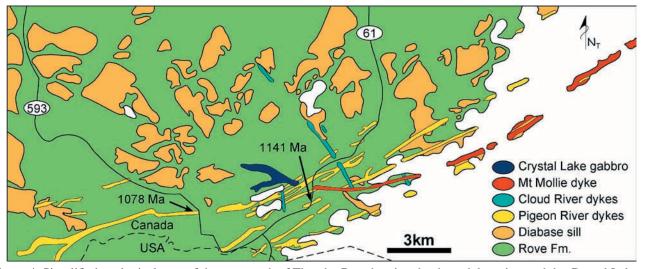


Figure 4. Simplified geological map of the area south of Thunder Bay showing the three dyke suites and the Crystal Lake gab-

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Meeting Announcements

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) strikeslip 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 moredetails



GAC-MAC 2008

The Volcanology and Igneous Petrology Division is sponsoring the following activities at the Quebec City meeting, May 26-28, 2008.

Special sessions

- 1. Bimodal volcanism: petrogenesis and tectonic setting-Convenors: Jaroslav Dostal and Brendan Murphy
- 2. Anorthosites to rapakivi g ranites: a tribute to the Career of Ronald F. Emslie Convenors: Mike A. Hamilton,

James S. Scoates and Tapani Ramo

Short Courses

Submarine volcanism and mineralization: modern through ancient - Convenors: Brian Cousens and Steve Piercey

Pre-Meeting Field Trip

Effusive and explosive subaqueous volcanism in the Abitibi greenstone belt - Leaders: Wulf Mueller, Real Daigneault, Vital Pearson and Damien Gaboury

For more details visit the web site



Ores and Orogenesis

The Arizona Geological Society is sponsoring the Ores & Orogenesis in Tucson, Arizona from 24 to 30 September, 2007. The conference is focused on tectonics, geologic evolution, and ore deposits in the circum-Pacific region. The conference will consist of four days of talks and posters, pre-meeting and post-meeting field trips and short courses, a core shack, a vendor exhibit hall, luncheon speakers, short courses and workshops, a reunion night, and a banquet honoring Bill Dickinson. The meeting seeks to attract industry, academic and government geologists as both technical presenters and attendees. The Ores & Orogenesis Symposium aims to be one of the premier events of 2007 for both the tectonics community and for economic geologists. Topics of interest to VIP members include:

- Hot topics and new technologies in tectonics
- Proterozoic geology symposium
- Plate tectonics and island arcs
- Circum-Pacific orogenesis
- Porphyry systems, epithermal systems, and volcanichosted massive sulfide deposits

Visit the meeting web site for more information

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