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**Precambrian
Research Center**

Annual Report



Mission



"The rocks are the final court of appeal" Francis Pettijohn

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*Mission:
To provide
education,
training and
support in
Precambrian
field studies
for the next
generation of
geoscientists.*



THE PRECAMBRIAN RESEARCH CENTER WAS ESTABLISHED IN 2007 TO SATISFY AN URGENT, LONG-TERM NEED WITHIN THE PRIVATE AND PUBLIC SECTORS OF THE GEOLOGICAL COMMUNITY FOR GEOSCIENTISTS SKILLED IN GEOLOGICAL MAPPING AND THE STUDY OF PRECAMBRIAN GEOLOGY. THE CENTER'S GOALS ARE TO TRAIN GEOSCIENTISTS IN MODERN METHODS OF GEOLOGICAL MAPPING AND MAP MAKING IN GLACIATED PRECAMBRIAN TERRANES OF THE CANADIAN SHIELD. AS SHOWN IN OUR LOGO, THE CANADIAN SHIELD MAKES UP ALMOST HALF OF THE NORTH AMERICAN CONTINENT. SUCH TERRAINS OF LOW-LYING ANCIENT ROCKS FORM THE CORES OF ALL CONTINENTS AND ARE EXTREMELY IMPORTANT TO GLOBAL SOCIETY BECAUSE THEY HOST A LARGE PERCENTAGE OF THE WORLD'S MINERAL RESOURCES.

THE PRECAMBRIAN RESEARCH CENTER IS MANAGED AS A COLLABORATIVE EFFORT BETWEEN TWO GEOSCIENCES INSTITUTIONS AT THE UNIVERSITY OF MINNESOTA DULUTH – THE NATURAL RESOURCES RESEARCH INSTITUTE AND THE DEPARTMENT OF GEOLOGICAL SCIENCES. TRAINING IN FIELD METHODS PARTICULARLY SUITED TO PRECAMBRIAN TERRANES IS PROVIDED THROUGH A VARIETY OF PROGRAMS INCLUDING THE PRECAMBRIAN SUMMER FIELD CAMP, PROFESSIONAL WORKSHOPS, GRADUATE STUDENT ADVISING, AND VARIOUS MAPPING AND PRECAMBRIAN GEOLOGY COURSES OFFERED AT UMD. INSTRUCTORS FOR THESE PROGRAMS INCLUDE A CONSORTIUM OF EXPERIENCED PRECAMBRIAN FIELD GEOLOGISTS FROM THE UNIVERSITY, AS WELL AS FROM THE MINNESOTA GEOLOGICAL SURVEY, OTHER ACADEMIC AND GOVERNMENTAL INSTITUTIONS, AND PRIVATE INDUSTRY.

Letter from the PRC Directors



Jim Miller



George Hudak



Dean Peterson

F

our years and going stronger than ever! The Directors at the Precambrian Research Center (PRC) are happy to report yet another successful year in 2010. In fact, it's fair to say that we even exceeded our own expectations given the uncertain economic climate, a diminished emphasis on field work in more and more undergraduate geosciences programs, and cuts in educational and training opportunities for both college students and professionals. Despite these seemingly bleak conditions, we continue to draw ever increasing applicants for our field camp, as well as a healthy group of international participants to our professional workshops. Based on the feedback we have received, those who have participated in our programs have been as enriched by these experiences as we have.

Thankfully, 2010 saw a rebound in exploration activities, both locally and globally, which has been spurred largely by mineral commodity prices that have returned to or exceeded pre-recession levels. We were encouraged that several former PRC field camp students had not only finished their Master's degrees this year (Dan Costello, Steve Hoaglund, and Shelby Frost), but had also successfully obtained employment in the exploration industry. Discussions with many exploration geologists from the U.S. and abroad, as well as with our exceptionally talented Board of Advisors, clearly affirms a principal motivation for the PRC's reason to exist – to satisfy a real and dire need for well-trained field geologists. The mission of the PRC - to provide education, training, and support in field studies for the next generation of geoscientists - has never been more essential than it is today.

During 2010, we continued to improve and expand our five basic core programs – Precambrian field camp, professional workshops, student assistantships and grants, mapping and geology courses offered at UMD, and outreach activities. As we look forward to 2011, our plans are to continue to improve and expand these programs. One improvement we can announce now is the hiring of Marsha Patelke to be the Manager of the PRC beginning in January 2011. Marsha, a staff scientist with the Natural Resources Research Institute, will be responsible for logistical planning and management for the field camp, professional workshops, and other PRC activities. With her expertise in sedimentology and stratigraphy of iron formations, Marsha will also continue to assist teaching part of field camp as she has for the past three years. We are very excited to have Marsha play a bigger role on the PRC team.



Marsha Patelke

The showpiece of our programs, the Precambrian field camp, was once again extremely successful. With an incredibly talented pool of applicants from all parts of the United States, we strapped up our boots and decided to accept 22 students (two more than our planned "maximum" of 20). These students hailed from 18 different universities and colleges from all parts of the United States. Our decision to increase enrollment couldn't have worked out better – eight projects and five exceptional capstone maps later, this bumper crop of Precambrian savvy geologists has already succeeded in adding to our understanding of the world's fascinating Precambrian geological terranes. For example, several of the capstone maps (see back cover) have identified new geological features which are the basis for new graduate studies, and two of these maps are



being utilized extensively in the development of Minnesota's newest state park. And as always, as noted in the student field camp quotes, the experience for students was more than just academic: "It helped me narrow down what I want to do with my career. I think I could be an economic geologist, be a field mapper, and enjoy that for the rest of my life," said one student.

In addition to the field camp, the PRC conducted its most successful professional workshop to date. Titled "Geology, Mineralogy and Genesis of Precambrian Iron Formations," the workshop included two days of short course lectures by internationally and regionally known experts on Precambrian iron formations, as well as four days of field excursions to key locales featuring a wide variety of iron formation characteristics and elements in Wisconsin and Minnesota. Nearly 50 participants from nine different countries representing the mining/exploration industry, government, and faculty and students from academia, made for an exceptionally diverse group participating in stimulating conversations both on and off the outcrops.

We also continued to increase our commitment to providing graduate students both advising and funding for work on Precambrian geology research projects. At the present time, PRC Directors Miller and Hudak are advising or co-advising 10 students on a wide variety of field-based geological problems in the United States and Canada. In 2010, the PRC provided a graduate research assistantship to an MS student at UMD (Dan Foley) and provided nearly \$5,000 in student research grants to support six graduate and undergraduate students from across the United States in their research on a wide variety of field-based Precambrian geology topics.

The Geological Maps course (GEOL 3000) was once again a success, and continues to influence many students to pursue field-based studies on a wide variety of topics in both Precambrian and Phanerozoic rocks. We look forward to exposing more students to the challenges and rewards associated with field geology in future offerings of this course. We are also deeply involved in developing the Exploration and Mining Geology track that will become a reality in the Department of Geosciences at UMD next Fall. PRC directors Miller and Hudak will co-teach the Geologic Maps course in Fall 2011 and will co-teach a new course in Minerals Exploration in Spring 2012.

Our outreach programs continue to increase and diversify. Over the past several months, nearly all of the PRC staff have been involved in the coordination and planning for the national Geological Society of America meeting, which will take place in Minneapolis in October, 2011. Over a dozen field trips associated

with Precambrian geology and mineral deposits in both the United States and Canada will be offered during this meeting. The PRC has also taken on the role of organizing the very popular Minnesota Minerals Education Workshop (MMEW), now in its 14th year, for up to 90 K-12 earth science teachers. PRC directors Hudak and Miller have been named to the Board of Directors for the Minnesota Center for Minerals Resource Education, which oversees the MMEW. A three-day MMEW workshop will be held in June 2011 and will include both short courses and field trips on a wide variety of geological and mining industry-related topics. Finally, PRC directors continue to be involved in the Society of Economic Geologists Mentoring Program and plan to assist with the establishment of a Society of Exploration Geophysicists student chapter at UMD in 2011.

The improvement in the economic climate resulted in an increase of over 25% in corporate and individual PRC memberships in 2010 relative to 2009. With over \$57,000 in donations from our members, we were able to successfully fund student research projects and keep the costs of our field camp competitive with other field camps, no doubt leading to the success of our programs. We are particularly thankful to our new PRC corporate members, the Prospectors and Developers Association of Canada and Golder Associates, and our new PRC individual members, Chris White and William Gardner. We also want to thank returning corporate members, Duluth Metals and Teck American. Special thanks goes to our long-standing supporters: Anglo American, Newmont, Cliffs Natural Resources, Tom Gardner and Al MacTavish. Over the coming year, we intend to expand our fundraising efforts with the hope of both increasing and diversifying our membership.

In 2011, we intend to improve on our success in 2010. We've already been contacted by a large number of students seeking information about our summer field camp, and once again expect to fill our enrollment capacity at 24. With our key roles in the upcoming MMEW workshop and national GSA meeting, we are looking forward to the opportunity for increased visibility of our various programs at both the state and national levels. We are excited about further developing the collaborations we've established with our Canadian colleagues, in particular, by offering our first "international" capstone project at next year's field camp. And as always, we welcome the opportunity to add new corporate and individual members.

Thanks to everyone who has supported us in the past, and to all of the participants in our various programs. We're excited about the opportunities that lie ahead in 2011!

Precambrian Field Camp

The fourth Precambrian Research Center Field Camp took place between July 4 and August 14, 2010. This field camp class was our largest to date, and comprised 22 students from 18 different universities from all regions of the United States. In addition to the PRC directors, the 2010 field camp faculty included Terry Boerboom (Minnesota Geological Survey), Mark Jirsa (Minnesota Geological Survey), Phil Larson (Cliffs Natural Resources), Nigel Watrus (UMD Department of Geological Sciences), Marsha Patelke (NRRI-UMD), and Mark Severson (NRRI-UMD). Lucy Mulvey (an alumnus of the 2009 PRC Field Camp) did an outstanding job as teaching assistant for the course.

As in the past, we continued to focus on training students the fundamental field mapping skills that are taught at most field camps, as well as providing specialized training in skills that are needed to efficiently and effectively map in glaciated Precambrian shield terranes. Exercises that expose students to core logging, surficial (glacial) mapping, mineral prospecting techniques, underground (drift) mapping, magnetic and gravity geophysical surveying and interpretation, metamorphic grade recognition, identification and interpretation of polyphase deformational structures and fabrics, and recognition of economic mineralization and associated alteration remained essential and unique components of our program. As well, during their capstone projects, students learned the process of transforming field observations and interpretations into high quality geological maps and professional presentations utilizing various software tools including ArcMap, Microsoft Excel, Microsoft Word,

Microsoft PowerPoint, Adobe Illustrator, Adobe Photoshop, AutoCAD and Surfer.

The first four weeks of camp encompassed eight mapping projects in Neoproterozoic, Mesoproterozoic, and Paleoproterozoic terranes in northeastern Minnesota that encompassed a wide variety of igneous, sedimentary, metavolcanic and metasedimentary rocks and associated mineral deposits. Based on student feedback in 2009, the 2010 field camp



included some minor curriculum changes. The geophysics (magnetic and gravity) and greenstone mapping exercises underwent minor modifications that enhanced the productivity of the students as well as the quality of their results. An unplanned change occurred during the Lake Superior shoreline mapping exercise of week 2 as a result of inclement weather – only the second time an assignment has had to be modified due to weather in four years of camp! With our collective experiences teaching the field camp, these adjustments went smoothly. Once again, the students produced excellent work.

During the fifth “Capstone Mapping” week of camp, students and staff broke out into five field parties to conduct mapping projects in various geologic settings in northeastern Minnesota. Of

particular significance this year was our first underground mapping project conducted at Soudan Underground Mine State Park. Two capstone maps produced during the 2010 field camp extend previous field camp mapping in the BWCA, one added to ongoing mapping by the Minnesota Geological Survey along the North Shore of Lake Superior, and another focused on mapping in Minnesota’s newest park - Lake Vermilion State Park. During the final week of camp, students digitally compiled their field data, developed geologic map interpretations, and produced summary PowerPoint presentations. On the last day of camp, capstone maps and presentations were shown to PRC faculty, professional industry and government geologists, and other invited guests. The five new capstone maps are illustrated on the back cover of this annual report. These maps and their associated PowerPoint presentations can be downloaded from the PRC website: www.d.umn.edu/prc/fieldcamp.

Our 2010 field camp students, like alumni of previous PRC field camps, continue to contribute to both academia and industry. Of the 22 students who participated in the 2010 field camp, 14 are completing their undergraduate degrees (including many applying to graduate geology programs), six are completing their first year of graduate school (including the University of Minnesota Duluth, University of Wisconsin-Milwaukee, the Colorado School of Mines, and Illinois State University) and two are currently employed in industry. Three of our 2010 field camp alumni have applied to UMD for graduate school starting in the fall of 2011.



Students



Ryan Birkemeier
U of MN-Duluth



Tyler Boley
MN State Mankato



Brittnee Brannan
U Texas-Permian Basin



Ben Brooker
Illinois State



Eric Carlson
Idaho State



Ryan Doucette
St. Norbert (WI)



Max Hadley
U of Cincinnati (OH)



Corey Holton
U of Arizona



Kyle Kubitz
U of WI-River Falls



Aubrey Lee
U of MN-TC



Levi Markwood
Slippery Rock (PA)



Jeff Olson
U of WI-Eau Claire



Charlie Parent
U of MN-Duluth



Molly Partridge
Winona State (MN)



Rita Pierce
U of Alaska



Amy Radakovich
St. Norbert (WI)



Damon Rhodes
Central Missouri St



Andrew Ritts
Carleton (MN)



Eric Scheurer
U of Maine



Ernie Thalhammer
Buffalo State (NY)



Alex Tomlinson
U of Cincinnati (OH)



Alli Vallowe
Virginia Tech

2010 Field Camp Staff

Principal Instructors:

George Hudak

Natural Resources Research Institute
Univ of Minnesota Duluth
Expertise-Volcanology, Economic Geology, Geologic Mapping

Jim Miller

Dept. of Geological Sciences
Univ of Minnesota Duluth
Expertise-Igneous Petrology, Econ Geology, Geologic Mapping

Dean Peterson

Duluth Metals Ltd.
Expertise-Economic Geology, Geologic Mapping

Associate Instructors:

Terry Boerboom

Minnesota Geological Survey
Univ of Minnesota
Expertise-Geologic Mapping, Igneous Petrology

Mark Jirsa

Minnesota Geological Survey
Univ of Minnesota
Expertise-Geologic Mapping, Structural Geology

Phil Larson

Cliffs Natural Rsrc (currently Duluth Metals, Ltd.)
Expertise-Quaternary Geology, Geologic Mapping

Marsha Patelke

Natural Resources Research Institute
Univ of Minnesota Duluth
Expertise-Sedimentology/Stratigraphy

Mark Severson

Natural Resources Research Institute
Univ of Minnesota Duluth
Expertise-Economic Geology, Geologic Mapping, Core Logging

Nigel Wattrus

Dept. of Geological Sciences
Univ of Minnesota Duluth
Expertise-Seismic Geophysics

Teaching Assistant:

Lucy Mulvey

Dept. of Geology and Geophysics, Univ of Minn
BS Geology received Dec. 2010; 2009 PRC Field Camp Student

Field Camp Student Comments

“CONFIDENCE! I am so much more confident in the field.”

At the end of the field camp, students were asked to anonymously evaluate their experience by answering a series of questions. Here are some of their comments.



How did this camp meet your initial expectations?

“I didn't know what to expect. I certainly didn't expect it to be so much fun!”

“Expected a lot of work and it was. Expected to learn a lot and I did. Did not expect economic geology to be the focus, but am excited to have a better idea of how to locate ore deposits.”

“Exceeded my expectations (especially after hearing what my friends said about their field camp experience). My choice helped me gain more experience in geology that is different to that I've seen previously.”

“No expectations going in, but was shocked with how awesome it was. I had an amazing experience overall.”

“Surpassed expectations. Came in feeling kind of confident and now feel I can take on any problem in the field. Also, just the relationships I made, professional and personal, made the experience that much better.”



How do you think this camp will help you with your career goals?

“To put it simply, it will show all of my employers that I not only have a standard education, but that I am also comfortable outdoors where the rocks are. It will make me a more flexible prospective employee.”

“I have become more interested in economic geology and made several contacts. I hope to have a career that includes mapping.”

“Contacts, friends and knowledge: all will allow me to go far and succeed.”

“I have a much brighter outlook on my future now. My skill set is so awesome and my toolbox is huge! I don't think I should have issues finding jobs.”

“It helped me narrow down what I want to do with my career. I think I could be an economic geologist, be a field mapper, and enjoy that for the rest of my life.”

“This gives me a leg up. I now have experience that most graduating geologists don't have.”

“This camp helped me figure out what I really enjoy. I hadn't mapped before and I really love it.”

What are your enduring understandings from this experience?

“How to use a brunton, how to describe rocks, how to identify rocks and minerals, how to map outcrop, how to spend late nights working on a project even if it's not due the next day.”

“The more rocks I see and the more time spent in the field, the better the geologic interpretations will be.”

“It's all about solving the puzzle.”

“How to stay organized in the field. How to work effectively with others.”

“Be neat. Take good notes.”

“I will always understand that I should have gone to school here. You're all amazing teachers and people.”



Student Research Assistantships & Grants

A primary objective of the Precambrian Research Center is to provide financial and advisory support to graduate and undergraduate students conducting field-based research on the Precambrian geology, primarily in the Lake Superior region. This support comes in the form of graduate research assistantships, which are limited to UMD graduate students in their second year of study, and research grants, which are available to undergraduate or graduate students from any school. The extent to which the Center can provide such support will vary based on the annual level of corporate and individual membership contributions.

Graduate Research Assistantships

Two quarter-time graduate research assistantships for the 2010-11 school year were awarded to **Dan Foley** and **Mike Totenhagen** (both are 2009 PRC field camp alum). Both Dan and Mike were to receive their GRAs in the coming spring semester, but Mike took a full-time position in January with Arcelor Mittal at the Minorca Taconite Mine near Virginia, MN. He plans to complete his Master of Science thesis on "Characterization of Gangue Minerals in the Biwabik Iron Formation at the Thunderbird Taconite Mine, Eveleth, Minnesota" sometime this summer.

Dan Foley is making good progress on his thesis on the "Petrology and Cu-Ni-PGE Mineralization of the Bovine Igneous Complex, Baraga County, Northern Michigan." Analytical support for Dan's Master's project is coming from Kennecott Eagle Minerals (a subsidiary of Rio Tinto). Kennecott Eagle also hired Dan last summer as a geological assistant. The PRC-GR award for this spring semester provides Dan salary support while he focuses exclusively on his thesis research.



Dan Foley

Chris White, recipient of a 2007-08 graduate assistantship, defended his Master of Science thesis in June, 2010. His thesis is entitled: "The Petrology, Petrogenesis, and Metallogeny of the South Kawishiwi Intrusion in the Nokomis Deposit Area, Duluth Complex, Northeastern Minnesota." Chris is currently working for Cardero Iron Ore as a project geologist on titanium prospects in the Duluth Complex.

Student Research Grants

The Precambrian Research Center awarded about \$5,000 in research grants to six students in 2010 to support their graduate research on a variety of field-based Precambrian geology topics. The students, their college, the award amount, the use of the grant, and the topic of their research are listed below.

Michael DeVasto, University of Wisconsin-Milwaukee, Master of Science Candidate

Award: \$1,000 of thin sections for Master's thesis

Research Topic: Quantifying the relationship between geochemical and microtextural changes across small-scale granitic shear zones near Mountain, WI

Robert Mahon, Idaho State University, Master of Science Candidate

Award: \$1,000 for thin sections and field expenses

Research Topic: Geologic Map of the Saddle Peak Hills 7.5' Quadrangle and Sedimentology and Age Constraints of the Meso-Neoproterozoic Pahump Group, Death Valley, California

Nicholas Swanson-Hysell, Princeton University, PhD Candidate

Award: \$1,000 for field expenses

Research Topic: A stratigraphic approach to determining the paleointensity of the late Mesoproterozoic geomagnetic field during a period of rapid latitudinal plate motion, Mamainse Point, Ontario.

Dan Foley, University of Minnesota Duluth, Master of Science Candidate

Award: \$925 for field expenses

Research Topic: Petrology and Cu-Ni-PGE Mineralization of the Bovine Igneous Complex, Baraga County, Northern Michigan

Matt Chaffee, University of Minnesota Duluth, Master of Science Candidate

Award: \$575 for travel expenses

Research Topic: Petrographic and Geochemical Study of the Hybrid Gabbro associated with the Current Lake Intrusive Complex, Magma Metal's Thunder Bay North Property

Stephanie Theriault, University of Minnesota Duluth, Master of Science Candidate

Award: \$610 for thin sections

Research Topic: Mineralogy, Spatial Distribution, and Isotope Geochemistry of Sulfur in the Biwabik Iron Formation, Minnesota

Workshops

PROFESSIONAL WORKSHOP ON PRECAMBRIAN IRON FORMATIONS-OCTOBER 2010

The third and most well-attended professional workshop organized by the Precambrian Research Center was conducted over six days this past October on the topic of the "Geology, Mineralogy and Genesis of Precambrian Iron Formations." With over a century of iron mining in the state that is still going strong, this topic seemed an obvious choice. As with previous PRC workshops on greenstone belt volcanology and mineralization (2008) and mafic layered intrusions (2009), this workshop was designed to provide a forum for professional geologists, academic researchers, and students to learn from experts about current research and field studies being conducted on a vital component of Precambrian geology.

The goal of the workshop was to familiarize participants with the stratigraphy, mineralogy, textures, internal structures, geochemistry, and geo-metallurgy of both Lake Superior-type and Algoman-type iron formations, as well as with current genetic models proposed for their formation. The workshop included two days of short course lectures by 16 internationally and regionally renowned experts on Precambrian iron formations. The topics and lecturers were:

1. *Classifying and Understanding Precambrian Iron Formations as Sediments*, Bruce Simonson, Oberlin College, OH
2. *Depositional Controls on Iron Formation Associations: Examples from the Canadian Shield*, Phil Fralick, Lakehead Univ, ON
3. *Biogenetic Influences on Iron Formation Genesis*, Russell Shapiro, California State-Chico
4. *Hydrothermal Influences on Iron Formation*, Jan Peter, Geological Survey of Canada
5. *Algoma-type Iron Formations: Overview of Occurrence and Origin*, Phil Thurston, Laurentian University, ON
6. *Overview of Lake Superior-type Iron Formations*, Richard Ojakangas, University of Minnesota-Duluth
7. *Stratigraphy of the Biwabik Iron Formation, Mesabi Range, Minnesota*, Mark Severson, Natural Resources Research Institute, UMD
8. *The Negaunee Iron Formation, Marquette Range, Michigan*, Tom Waggoner, Consultant, Negaunee, MI
9. *Geology of the Gogebic Iron Formation, MI and WI*, Bill Cannon, U.S. Geological Survey, Reston, VA
10. *Mineralogy of Iron Formations: Primary, Diagenetic, and Metamorphic*, Kase Klein, University of New Mexico
11. *Thermal Metamorphism of Iron Formations*, Peter McSwiggen, Consultant, Minneapolis, MN
12. *Geochemistry of Algoma-type Iron Formations: An Example from the Abitibi Greenstone Belt*, Geoff Baldwin, Laurentian University, ON
13. *An Fe Isotope Perspective on Iron Formation Genesis*, Brian Beard, University of Wisconsin-Madison
14. *Origin of Iron Formation-hosted High-grade Iron and Manganese Deposits and their Paleo-environmental Significance*, Nic Beukes, University of Johannesburg, South Africa
15. *Geo-metallurgy of Iron Formations*, Rod Johnson, R. Johnson and Associates, Negaunee, MI
16. *Economic Geology of Iron Formations*, Richard Fink, Cliffs Natural Resources, Cleveland, OH



The workshop also included four days of field excursions on the classic iron formations of the Lake Superior area led by local experts.

- Field Trip 1 *The Western Gogebic Iron Range in WI*
Leaders: Bill Cannon (USGS), Phil Fralick (Lakehead)
- Field Trip 2 *Geology of the Central Mesabi Range, MN*
Leaders: Mark Severson (UMD-NRRI), Richard Ojakangas (UMD), Phil Larson (Cliffs NR), Peter Jongewaard (Cliffs NR)
- Field Trip 3A *Geology of the Eastern Mesabi Range, MN*
Leaders: Mark Severson (UMD-NRRI), Tom Campbell (Cliffs NR), Jeff Bird (Cliffs NR)
- Field Trip 3B *Geology of the Soudan Iron Formation, MN*
Leader: Dean Peterson (Duluth Metals Ltd.)
- Field Trip 4 *Geology of the Gunflint Iron Formation and the Sudbury Impact Layer, Northeastern MN*
Leaders: Mark Jirsa (Minnesota Geol Survey), Phil Fralick (Lakehead)

The workshop was attended by 47 participants from nine different countries and included a good mix of industry professionals (31), government staff (6), academics (5), and students (5). All participants received a DVD with copies of the Powerpoint lectures, field trip guidebook, and recommended journal articles. The guidebook from the workshop (and previous workshops) can be downloaded from the PRC website: www.d.umn.edu/prc/workshops/Guidebooks

For a summary of this and previous workshops, go to: www.d.umn.edu/prc/workshops

Board of Advisors



At its inception, the Precambrian Research Center established a Board of Advisors whose role is to offer advice and counsel to the PRC directors on its programs. The Board serves as a vehicle for communication and interaction between the PRC, academia, geological surveys, and the mineral industry. In addition to being ambassadors in the larger geological community, the board provides fresh and objective viewpoints on strategy, curriculum, funding opportunities, collaborative educational opportunities, and research programs.

At the end of 2009, the make-up of the Board was updated and expanded. In addition, the location of the annual board meeting was changed to coincide with the Prospectors and Developers Association of Canada (PDAC) convention held each March in Toronto. The first board meeting to be held at the PDAC last March was a great success with 11 of our 14 advisors in attendance.

2010 PRC Board Members

NRRI Position - **Donald Fosnacht**, Director, Center for Applied Research and Development

UMD Position - **Ron Morton**, Head, Department of Geological Sciences

MGS Position - **Harvey Thorleifson**, Director, Minnesota Geological Survey

USGS Position - **William Cannon**, Geologist, U.S. Geological Survey - Reston

Canadian Survey Position - **Greg Stott**, former Chief Geologist, Ontario Geological Survey

First Academic Position - **Harold Gibson**, Professor, Director-Minerals Exploration Research Centre, Laurentian University

Second Academic Position - **Mark Hannington**, Professor, Goldcorp Chair in Economic Geology, University of Ottawa

Third Academic Position - **Bruce Marsh**, Professor of Igneous Petrology, Johns Hopkins University

First Consultant Position - **James Franklin**, formerly Chief Scientist, Geological Survey of Canada

Second Consultant Position - **Jon Scoates**, formerly Chief Geologist, Manitoba Geological Survey

Third Consultant Position - **Dave Peck**, President, Peck Geosciences & Exploration Corporation

First Industry Position - **Dave Groves**, Chief Geologist, Newmont Mining Corporation

Second Industry Position - **Vern Baker**, President, Duluth Metals Ltd.

Third Industry Position - **Ron Graber**, General Mgr – Resource Technology, Cliffs Natural Resources

Former Members: PRC Board of Advisors

Anthony (Tony) Naldrett - Emeritus Professor of Geology, University of Toronto (2006-2010)

Odin Christensen - Former Chief Geologist, Newmont Mining Corporation (2006-2010)

Alan Bailes - Senior Geologist (retired), Manitoba Geological Survey (2006-2010)

Alar Soever, President and Director, Wallbridge Mining Company Ltd. (2006-2010)

NEXT PRC WORKSHOP - OCTOBER 2012



Cu-Ni-PGE Deposits in the Lake Superior Region

Because the PRC staff will be heavily involved with the running of the 2011 national Geological Society of America meeting to be held in Minneapolis next October (see Other Activities), we will not be organizing a professional workshop next fall. Instead, the PRC is planning to host its fourth professional workshop in October 2012 on the topic of Cu-Ni-PGE deposits associated with the Midcontinent Rift in the Lake Superior region. Check the PRC website for details and updates.

Other Activities

OUTREACH – MINNESOTA MINERALS EDUCATION WORKSHOP

Another important function of the PRC is to conduct outreach activities intended to educate the general public and K-12 educators about Lake Superior area geology and mineral resources. As reported in the 2008 annual report, the PRC took the lead in organizing the 12th annual Minnesota Minerals Education Workshop (MMEW) that was held in August, 2008 at Vermilion Community College in Ely. The PRC has taken the lead again in organizing the 14th annual MMEW to be held in June, 2011 at the Mesabi Range Community and Technical College in Eveleth, Minnesota.

The MMEW is a three-day workshop that offers K-12 earth science teachers educational resources, lesson plan ideas, and information on Minnesota's geology and mineral resources. It involves one day of short courses and two days of field trips highlighting local geology and mineral resources. It has consistently been popular with earth science teachers, attracting 50 to 80 teachers per year, in large part because of its low cost (\$30 – 40 registration), short time frame, instruction by experts in Minnesota's geology and resources, and free curriculum materials (e.g., rock & mineral samples, posters, lesson plan ideas, ...).

For the first 12 years, the MMEW was organized and staffed by volunteers from various governmental agencies, college geology departments, mining industries, professional organizations, and K-12 schools. In 2009, an official non-profit entity was created – the Minnesota Center for Mineral Resource Education, which serves as an advisory and oversight board and a vehicle for raising funds from industry for the annual production of the MMEW. PRC directors, Jim Miller and George Hudak, are both serving three year terms on the this Education Board. Jim is Vice Chair for Operations and is the principal organizer for the MMEW. George is on the Board representing the Natural Resources Research Institute.

Planning for the June 2011 workshop in Eveleth started in September and registration will begin soon. Over 20 volunteers have provided their time and

expertise in planning, organizing, and producing the upcoming workshop. K-12 teachers will be able to choose four from among 17 different short course classes being offered by various geoscience professionals and educators. Morning classes offer a variety of basic to advanced geology topics and afternoon classes focus largely on mineral resource, mining, and reclamation topics. Two days of field trips will visit the former LTV taconite mine now owned by PolyMet, the United Taconite pit and processing plant near Eveleth that is operated by Cliffs Natural Resources, a gravel pit in the area, and other geologic and mining sites of interest in the central Mesabi Range.

To learn more about the upcoming MMEW meeting, check out the website at: www.MMEW.org.

FIELD CAMP PROMOTION

With the good word about the PRC Precambrian field camp being spread by former students, promotion of the camp with visits to upper Midwest colleges and universities has been curtailed. The only promotional visit was made by Jim Miller, who travelled to southeastern Minnesota last February to speak to Winona State University students about the camp and about Minnesota's mineral resources. The visit interested three students to enroll in the 2010 field camp, though two later backed out because of scheduling conflicts.

We trust that word-of-mouth and field camp posters, which were again distributed to 235 U.S. and Canadian schools in late December, will be sufficient advertising to fill the camp in 2011, as it did in 2010.

2011 NATIONAL GSA MEETING, MINNEAPOLIS

The PRC Directors and staff are deeply involved in the planning, organizing and production of the 2011 National GSA meeting to be held in Minneapolis, October 9-12, 2011. Jim Miller and George Hudak are chair and co-chair, respectively, of the field trip committee. Along with two other co-chairs and a GSA Field Trip coordinator, the committee met regularly throughout 2010 to develop a slate of 46 field trips that will be offered before, during, and after the meeting.

PRC directors and staff will also be directly involved leading field trips on Precambrian geology and economic geology. The trips involving PRC staff (**in bold**) include:

- Classic Precambrian Geology of Northeastern Minnesota–**Jirsa**, Green
- Sudbury Ejecta Layer in the Western Lake Superior Region–**Jirsa**, Fralick, Weiblen
- North Shore Volcanic Group–Green, **Boerboom**
- Greenstone Belts of the Western Superior Province–**Hudak**, Heine
- Differentiated Layered Intrusions of the Duluth Complex–**Miller**
- Paleoproterozoic Orogen of East-Central Minnesota–**Boerboom**, Holm, Van Schmus
- Cu-Ni-PGE Deposits of the Duluth Complex–Patelke, **Severson**, **Peterson**
- Mesabi Iron Range–Ojakangas, **Severson**, Cliffs
- VMS Deposits of the Southern Canadian Shield–**Hudak**, Smyk
- Anatomy of a Mineralized Intrusion - the South Kawishiwi Intrusion–**Peterson**, Freiberg, Boerst

In addition, Jim Miller will co-chair a topical session on the "Geology and Mineral Deposits of the Midcontinent Rift."

SOCIETY OF ECONOMIC GEOLOGISTS

As has been the case for the past several years, George Hudak remains a mentor for the Society of Economic Geologists. As well, Hudak reviewed two manuscripts submitted to the Society's refereed journal *Economic Geology*.

CONFERENCES/WORKSHOPS

The Directors of the PRC and PRC-supported students routinely attend conferences, symposia, and workshops to 1) promote the PRC, 2) learn about new research in our respective areas of interest, especially as it relates to field mapping, 3) give talks about the PRC or our research, and 4) lead field trips on Precambrian geology. Some of the conferences attended in 2010 include: Prospectors and Developers Association Convention, March, Toronto, ON - All three PRC directors attended the PDAC and distributed 2009 PRC



annual reports and flyers advertising the 2010 workshop on Precambrian Iron Formations to exploration company representatives. Hudak and Miller also assisted at the State of Minnesota booth throughout the convention.

NW Ontario Prospectors Association, April, Thunder Bay, ON – Jim Miller attended this two-day regional prospectors meeting to promote the PRC, and particularly the Precambrian iron formation workshop.

56th Annual Institute on Lake Superior Geology, May, International Falls, MN – All PRC directors and affiliated staff attended this two-day meeting. As in past years, the capstone maps (4 total) completed as part of the 2009 field camp were presented at the poster session. In addition, PRC-supported students, Steve Hoaglund and Shelby Frost, gave an oral and poster presentation, respectively, on their M.S. thesis research.

11th International Platinum Symposium, June, Sudbury, ON – Jim Miller attended this four-day international conference held every 3-4 years and presented, along with James Scoates (UBC), a workshop on the "Petrographic Attributes of Mafic Layered Intrusions". He also was co-leader of a six-day post-symposium field trip on "Cu-Ni-PGE Deposits in Mafic Intrusions on the Lake Superior Region". Dean Peterson gave an oral presentation titled "Magmatic Ore Deposits in the Mid Continent Rift."

Teaching in the Field Workshop, August, Bozeman, MT – Jim Miller attended this four-day National Science Foundation-sponsored workshop held at Montana State University. He presented a talk entitled "A Field Mapping Exercise to Emphasize the Interpretive Nature of Bedrock Geologic Maps in Glaciated Terranes," served on a panel discussing "Cross-cutting Issues that Affect Field Instruction" and was leader of a working group on field safety.

Geological Society of America Meeting, October-November, Denver, CO – Jim Miller attended a two-day workshop on "Field Safety Leadership."

Memberships

CORPORATE AND INDIVIDUAL MEMBERSHIPS

One of the major sources of funding for the educational programs of the Precambrian Research Center is corporate and individual membership donations. With the minerals industry standing to be the prime beneficiary of the Center's mission (training and support to students in modern field methods and map-making) we look to the minerals industry to serve as its principal benefactor. Each year, we actively solicit mineral resource companies and professional individuals to donate tax-deductible contributions to a gift fund held by the College of Science and Engineering at the University of Minnesota Duluth. Monies from this fund are used exclusively to benefit students through subsidies to the Precambrian field camp, supporting graduate research assistantships, and funding student research grants. Membership levels are listed in the table below. The main benefit of a membership to donors is the reservation of slots in annual professional workshops, which typically limit attendance to 20-30 participants.

Membership Level	Membership Type	Annual Contribution	Benefits		
			Annual Report	Workshop Reservations	Board of Advisors
Diamond	Corporate	>\$20,001	X	5	1
Platinum	Corporate	\$20,000-10,001	X	3	
Gold	Corporate	\$10,000-5,001	X	2	
Copper	Corporate	<\$5,000	X	1	
Palladium	Individual	>\$5,001	X	1	1
Titanium	Individual	\$5,000-2,001	X	1	
Nickel	Individual	\$2,000-501	X	1 per year	
Zinc	Individual	<\$500	X		

PRECAMBRIAN RESEARCH CENTER MEMBERS

	Current Membership Level	Most Recent Contribution	Status
Corporate Members			
Anglo American plc	Platinum	August 09	Member since 4/07
Newmont Mining Corp	Copper	August 09	Member since 5/07
Cliff's Natural Resources	Copper	February 09	Member since 8/07
Prospectors and Developers Association of Canada	Copper	September 10	New Member
Golder Associates	Copper	September 10	New Member
Individual Members			
Tom Gardner	Palladium	December 10	Member since 5/07
Al MacTavish	Nickel	July 10	Member since 4/07
Chris White	Zinc	May 10	New Member
Bill Gardner	Nickel	May 10	New Member

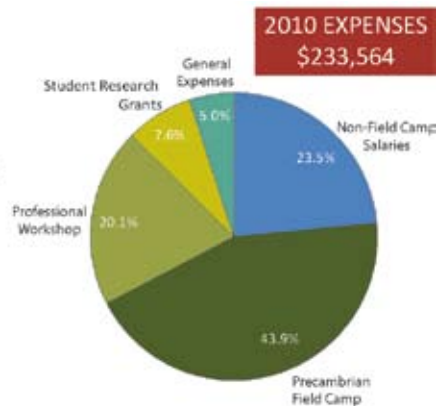
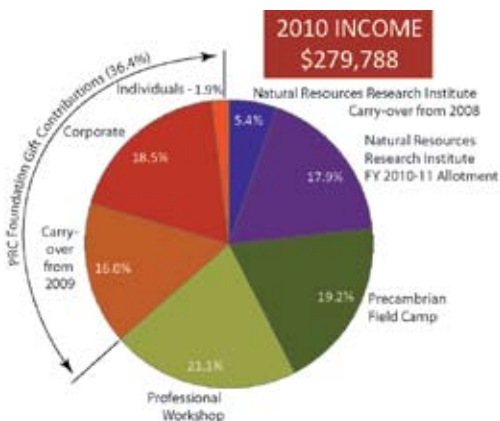
Financial Statement (January - December 2010)

INCOME

Natural Resources Research Institute Allocation		
Carry-over from 2009	15,033	5.37%
FY 2010-11 Allocation	50,000	17.87%
Precambrian Field Camp Tuition (22 students)	53,798	19.23%
Workshop Registration	59,100	21.12%
PRC Foundation Gift Contributions		
Carryover from 2010	44,707	15.98%
2010 Corporate Contributions	51,900	18.55%
2010 Individual Contributions	5,250	1.88%
TOTAL INCOME	279,788	

EXPENSES

Directors Salaries (excluding Field Camp)	54,808	23.47%
Precambrian Field Camp	102,483	43.88%
Professional Workshops	46,875	20.07%
Student Assistantships and Grants	17,659	7.56%
General Expenses (Promotion, Travel, Supplies)	11,739	5.03%
TOTAL EXPENSES	233,564	
YEAR END BALANCE	26,224	



Looking Ahead

As the PRC enters its fifth year, we are pleased that our essential programs, field camp and professional workshops, are popular and successful. We are also thankful that our core corporate and individual sponsors have continued to support our current efforts. New sizeable membership contributions received in early 2011 bode well for increasing that support in the coming year. This success and support gives us the opportunity to grow our other programs (student grants, geologic mapping/exploration courses, and outreach) and to explore new programs. This success has also allowed us to recently hire Marsha Patelke for the part-time position of PRC Manager. Marsha will be in charge of logistical planning and management of the field camp and professional workshops – tasks previously carried out by Jim Miller.

Expanding our student financial aid programs of graduate research assistantships (GRA) and student research grants has always been dependent on our success in fundraising. We feel good that we have been able to provide at least one GRA per year and about \$5,000 in student research grants, but would like to be able to double those levels of support. One new means of financing student research that we initiated this year is to seek out company support for a student's graduate project, whereby the company conveys that support to the PRC Foundation as a tax-deductible contribution. Depending on the agreed-upon level of support, the PRC handles the financial transactions related to graduate research assistantship support, tuition, analytical expenses, and travel costs. Such an arrangement has been established with Magma Metals Limited of Thunder Bay, Ontario for their support of Matt Chaffee's Master



ad to 2011

of Science thesis project on their Thunder Bay North property. We hope to use this as a model to attract other company support for our students.

Another way that the PRC supports students is through mentoring. With most PRC directors and staff being Society of Economic Geology members or fellows, we have recently promoted the establishment of an SEG student chapter among UMD's geology undergraduates and graduates with several informational meetings. When UMD's chapter is certified, it will be only the 11th chapter among U.S. schools – more disheartening evidence of the diminished status of economic geology in much of academia – but also a positive sign of UMD's and the PRC's commitment to this important geological discipline.

Plans for growing PRC's involvement in teaching mapping- and exploration-related courses will take shape next fall when the new "Exploration and Mining Geology" curriculum track will be inaugurated in the Department of Geological Sciences at UMD. This curriculum track builds on the very robust and rigorous curriculum requirements for a Bachelor of Science in geology by requiring six additional courses focused on economic geology. These courses, which will be offered every other year, include: Geologic Maps, GIS, Probability and Statistic, Economic Geology, Minerals Exploration, and Minerals Processing. The latter three courses are also available to graduate students. PRC Directors, Jim Miller and George Hudak, will be co-teaching the Geologic Maps and Minerals Exploration courses in the next academic year.

Our role in public outreach will expand next year when the PRC takes

the lead in hosting the 14th Annual Minnesota Minerals Education Workshop (MMEW). The MMEW is a three-day summer workshop for K-12 earth science educators that offers short courses and field trips focused on the geology and mineral resources of Minnesota. Past workshops have attracted between 55 and 85 teachers from throughout the state. The PRC is slated to serve as the principal organizer of the MMEW through 2013. PRC Directors Miller and Hudak will continue to serve their terms as Vice Chair of Operations and Director, respectively, for the Minnesota Center for Minerals Resource Education. As well, Hudak will continue to serve as a mentor for the Society of Economic Geology.

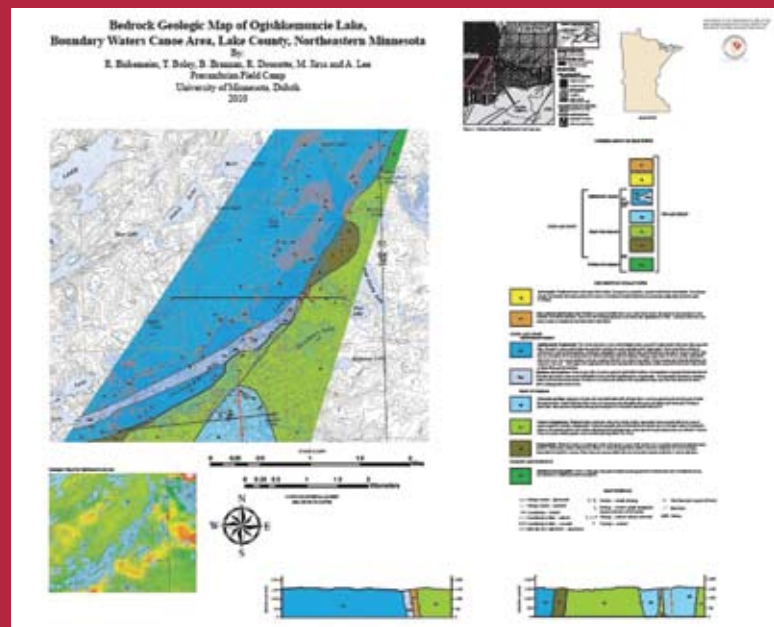
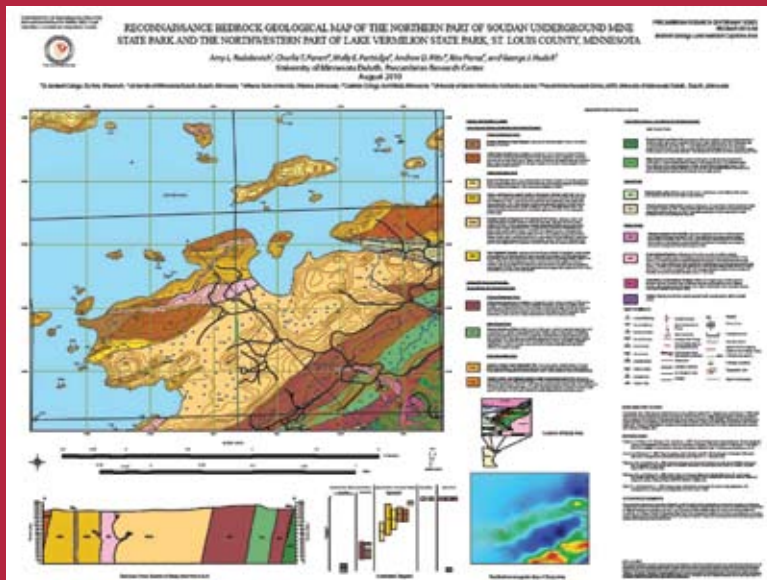
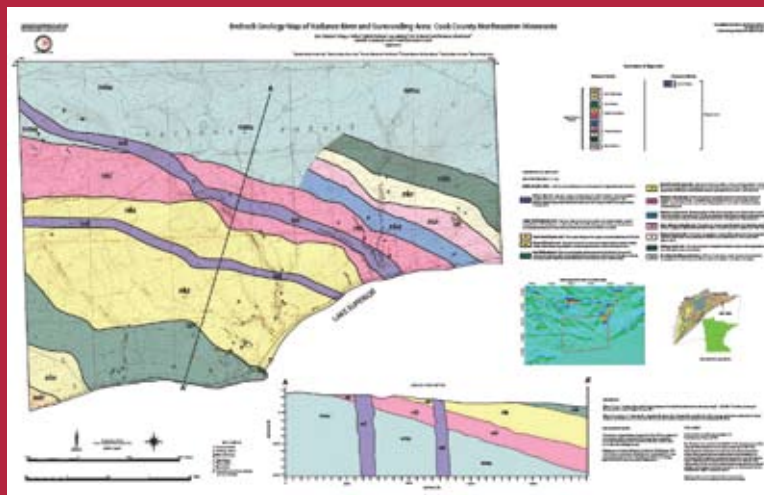
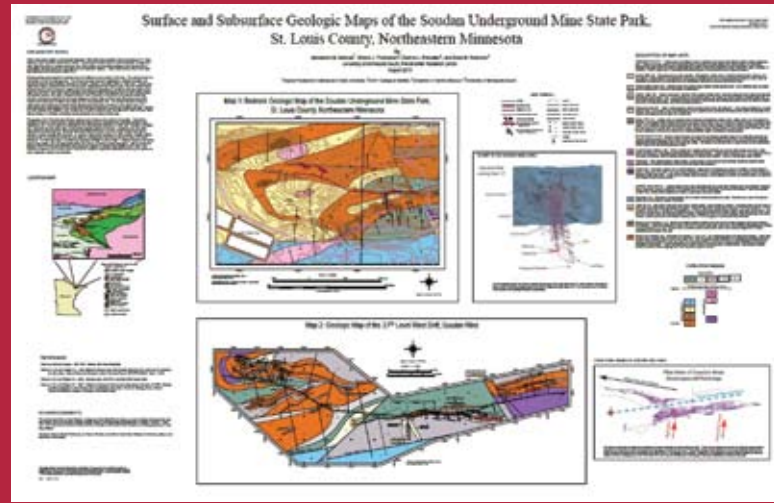
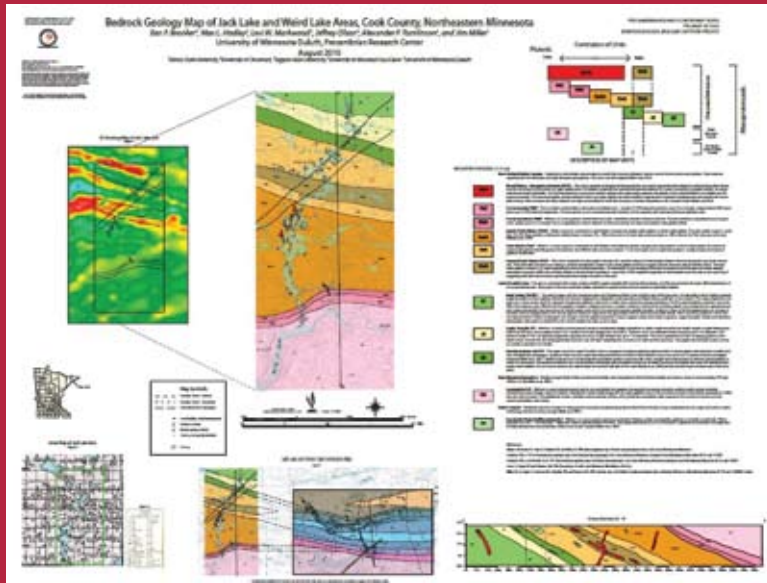
As for new program directions, we have are looking into developing an advanced field camp geared toward new professional geologists and graduate students. This idea was strongly supported by our PRC Board of Advisors at last year's meeting in Toronto. We envision a two-week camp that would be run in May each year. We are looking to begin the first camp, perhaps in 2012, with a greenstone belt focus. Subsequent camps will emphasize different geological settings (e.g., layered intrusions, shear-zones, ...) and geographic locations in the southern Canadian Shield. We plan to involve expert mappers from throughout the U.S. and Canada and to coordinate the running of this camp with colleagues at Lakehead and Laurentian universities. After we get this off the ground, we may run two or more camps a year in the spring and/or fall. Initial reaction to this professional field camp idea has been very positive and we expect this to be a very popular program among the minerals exploration industry. As with our professional workshops, we will reserve slots in these camps for our PRC members. We plan to have further discussions about organizing

and advertising this endeavor with our Board of Advisors in March.

Another possible area of growth is contracting with exploration companies to develop specialized field-oriented (mapping, drill core logging, etc.) programs specifically tailored to companies' needs. The PRC has been approached by one company to provide customized field training for some of their staff geologists. Another company has inquired about the possibility of having PRC staff and PRC-trained students contract for short-term field mapping. Such mapping contracts would provide significant sources of additional income for other PRC programs. However, pursuing such work in the near term in Canada, where much of our contract work could be focused, will require reallocation of staff time and acquiring professional licensure (e.g. P. Geo. Licenses).

So with the exploration and mining industry booming once again, we anticipate a productive and successful 2011, both for PRC's programs and our students. One area of concern is the loss of income that will result from suspending our annual professional workshop this fall. This is necessary because of the heavy involvement of the PRC staff in the 2011 national Geological Society of America meeting in Minneapolis next fall. Last fall's Precambrian Iron Formation workshop earned the PRC over \$12,000 for student programs. Hopefully, increased efforts at fundraising will offset this loss. As mentioned above, a couple of sizeable contributions from new members in early 2011 bode well.

We look forward to reporting to you this time next year on the PRC's progress in 2011.



www.d.umn.edu/prc