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 geoscience 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.
The words that best describes the operational status of the sixth year of the PRC are “stable” and “records.” Although 2012 saw no significant programmatic changes, we held steady or set records for the numbers of students, professionals, and K-12 teachers engaged in our educational programs. We also held steady at a high level of corporate and individual membership support. We had only one disappointment--a failed attempt to start a professional field camp--but we are committed to trying again next year, because we think it is a really, really good idea.

For the third year in a row, the Precambrian field camp, our flagship program, attracted 22 students from 16 different schools, including our first Canadian. We were excited to have several capstone projects focus on mapping outstanding exposures in the Boundary Water Canoe Area Wilderness that was intensely burned in the Fall of 2011. Read further about the great projects from last summer’s camp. And for next year’s camp, we have received a record 37 applications for the 24 available slots by the January 25 early registration deadline! Eight new schools are represented in the 2013 class. We are looking forward to implementing some significant changes to several of the exercises next year that we think will greatly improve their effectiveness. We also plan to offer five capstone projects again, possibly including a project in Ontario.

For our annual professional workshop this year, we partnered with the Twin Cities subsection of the Society of Mining, Metallurgy, and Exploration (SME) to put on a two-day conference in October on Silica Sand Resources of Minnesota and Wisconsin. You may ask why the PRC would be involved in a workshop on Cambrian and Ordovician sandstone formations. Well, the obvious answer is that the quartz grains are Precambrian! There currently is a boom in silica (frac) sand exploration and mining in the upper Midwest due to increased demand by the oil and gas industry for hydrofrac drilling. Still, we did not know how many people the technical session and one-day field trip would attract. We budgeted for 100 attendees for the technical session and 80 for the field trip. Final numbers were 322 for the short course and 120 for the field trip (we had to turn away 50 from the field trip). Read on for more details about the most successful PRC workshop to date, and the protesters who came to politely voice their opposition. Next October’s workshop will be a 7-day conference on the Cu-Ni-PGE Deposits of the Lake Superior region.

Another great success in terms of participants was the PRC-organized Minnesota Minerals Education Workshop held in Winona. This 3-day conference was the 15th annual MMEW, which has attracted between 50 and 86 K-12 science teachers in the past. The Winona meeting attracted a record 96 participants. We are again in the planning stages for hosting the 16th annual MMEW at Hibbing Community College, to be held next June. Participants will again have a choice of among 16 different short course topics on Minnesota’s geology and resources and will attend two days of field trips focused on the western Mesabi Range.

One of the disappointments of the past year has been the failure to generate enough interest in our first offering of a professional field course. Directors
Precambrian Field Camp

The sixth Precambrian Research Center field camp took place between July 8 and August 18, 2012. For the third straight year, the field camp was attended by 22 students who represented 16 different colleges from across the United States and Canada. The 2012 field camp faculty included the PRC Directors Jim Miller, George Hudak, and Dean Peterson, as well as Mark Jirsa (Minnesota Geological Survey), Phil Larson (Duluth Metals), Nigel Watrous (UMD Department of Geological Sciences), Marsha Patelke (UMD-NRRI), and Mark Severson (UMD-NRRI). Adam Leu and Aubrey Lee (alumni of the 2011 and 2010 PRC Field Camps, respectively) were outstanding teaching assistants for the course.

As in the past, students were taught fundamental mapping skills that are similar to those taught at most field camps, but we continued to focus the bulk of our training on specialized skills that are required to efficiently and effectively map in glaciated Precambrian shield terranes. During the first four weeks of camp, these essential and unique components of our program included:

- diamond drill core logging,
- surficial (glacial) mapping,
- mineral prospecting techniques,
- magnetic and gravity geophysical surveying and interpretation,
- metamorphic grade recognition,
- identification and interpretation of polyphase deformational structures and fabrics,
- underground mapping, and
- recognition of economic mineralization and associated alteration.

Five capstone projects (see maps on the back cover) required students (and faculty!) to complete their remote field mapping and rapidly (less than 2 weeks!) transform their field observations and interpretations into high quality, published geological maps. The resulting professional presentations utilized a variety of software tools including ArcGIS, Microsoft Excel, Microsoft Word, Microsoft PowerPoint, Adobe Illustrator, Adobe Photoshop, AutoCAD and Surfer.

The eight mapping exercises completed during the first four weeks involved a wide variety of igneous, sedimentary, metasedimentary, metavolcanic, and intrusive rocks that comprise the complex and well-preserved Neoarchean, Mesoproterozoic, and Paleoproterozoic terranes in northeastern Minnesota. Minor changes once again took place in the curriculum based on previous student feedback and field logistics. A more significant change was caused by historic late June storms and associated flooding that devastated our Thomson field area, typically our first mapping exercise. We switched the project to map an area just west of Duluth that includes Paleoproterozoic sedimentary rocks and Mesoproterozoic lava flows and intrusive rocks associated with the Keeweenawan Rift. We liked the results so much that we have decided
to make this project a permanent introductory exercise of the
camp. Another highlight was that the PRC was again given
the opportunity by the Minnesota Department of Natural
Resources to conduct detailed geological mapping at Soudan
Mine State Park for our greenstone mapping project during the
fourth week of camp. This mapping built on previous capstone
mapping projects conducted in 2010 at Soudan Mine State
Park, and 2010 and 2011 in neighboring Lake Vermilion State
Park. The PRC is nearing completion of a new, detailed (1:5000
scale) geological map of Soudan Underground Mine State Park
and Lake Vermilion State Park that should be available later this
year on the PRC website.

During the fifth week of camp, students and faculty continued
the annual tradition of dispersing across northeastern
Minnesota to conduct their capstone mapping projects in
previously unmapped or poorly mapped areas. Five capstone
mapping projects located in northeastern Minnesota (including
three which took advantage of recently burned regions of the
Superior National Forest and Boundary Waters Canoe
Area Wilderness resulting from the Pagami Creek Fire) were
conducted:

• **Reconnaissance bedrock mapping of Archean geology**
  in the Ester Lake area: Under the direction of Mark
  Jirs, this project set out into the Boundary Waters
  Canoe Area off the Gunflint Trail to map the contact
  relationships between the Archean Saganaga tonalite
  and related sedimentary rocks of the Knife Lake Group,
  and to evaluate the continuity of stratigraphy between
  suspected fault-bounded sedimentary units.

• **Bedrock mapping of the Wilder Lake Intrusion:**
  Returning to his now intensely burned PhD thesis map
  area, Jim Miller supervised a capstone project that
  mapped incredibly well-exposed inland gabbro outcrops
  of the Wilder Lake Intrusion – one of the most distinct
  mafic layered intrusions in the Duluth Complex. The
  project also served as the initiation of mapping for Adam
  Leu’s MS thesis project on the geology and petrology of
  the WLI.

• **Bedrock mapping of anorthositic rocks of the Duluth
  Complex in the Forest Center area:** This capstone
  project, under the direction of Dean Peterson, set out to
  map newly created exposures of the anorthositic series
  of the Duluth Complex created by the Pagami Creek fire.
  This work resulted in documenting lithologic variations
  within the anorthositic series, and showed the utility of
  using LiDAR digital elevation data as a base for detailed
  geologic mapping.

• **Detailed bedrock mapping of the Duluth Complex in
  the Lake Two area:** This was the first capstone project
  supervised by Mark Severson. Located in an area of the
  Boundary Waters Canoe Area affected by the Pagami
  Creek fire, the project focused on detailed mapping
  excellent exposures of the complex relationships
  between the anorthositic and troctolitic series of
  the Duluth Complex in the inland region surrounding
  Lake Two.

• **Bedrock mapping of greenstone geology in the Putnam
  Lake area:** Under the direction of George Hudak, this
  capstone project accomplished the most detailed
  mapping to date of Archean mafic volcanic rocks,
  Algoma-type banded iron formations, and intermediate-
  to mafic composition syn- and post-volcanic intrusive
  rocks within the south limb of the Tower-Soudan
  Antcline. This project also utilized LiDAR digital
  elevation data as a base map, specifically for efficiently
  finding outcrop locations in heavily vegetated parts of
  greenstone belt terranes.

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, the five capstone maps were presented
to the PRC faculty, minerals industry professionals, and
other invited guests at a ceremony at the Natural Resources
Research Institute. The five new capstone maps are illustrated
on the back cover of this annual report. The maps and
accompanying final PowerPoint presentations for each of the
capstone projects can be downloaded from the PRC website:
www.d.umn.edu/prc/fieldcamp/.

Of the 22 students that completed the 2012 PRC Field Camp,
most went back to complete their undergraduate geology
degrees at their respective colleges and universities. Several
of these students are applying for graduate studies in the
geological sciences. Three of the 2012 field camp alumni are
currently employed in the minerals industry. As is usually the
case, several of our 2012 field camp alumni have applied to
UMD to initiate their graduate studies in economic geology
next Fall.

The PRC faculty and staff, along with industry, government, and
academic professionals, were once again astonished by the
efforts, skills, and hard work of the 2012 field camp students.
It appears to have paid off, as most students felt that the camp
gave them the confidence and skills that will allow them to be
successful and make big contributions to the geosciences (see
“Student Comments,” p. 8). We are looking forward to working
with what looks to be another outstanding crop of 2013 field
camp students who wish to develop their mapping skills in the
nuances of Precambrian terranes.
Students

2012 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:
- Mark Jirsa
  Minnesota Geological Survey
  Univ of Minnesota
  Expertise: Geologic Mapping, Structural Geology
- Phil Larson
  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 Assistants:
- Aubrey Lee
  2010 PRC Alum
  UMD MS candidate
- Adam Leu
  2011 PRC Alum
  UMD MS Candidate
Field Camp Student Comments

“I am no longer 'a geology student' but now a GEOLOGIST. My confidence has grown 15-fold.”

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?

“It exceeded my expectations. I could not have even fathomed what I accomplished.”

“I heard great things so I had high expectations, and you guys still exceeded them! Awesome job!”

“Far and above!!! The amazing amount of energy and enthusiasm that Dean and George and Jim brought to this just rubs off on everyone. We all feel that way now, too!”

“I had no idea I’d learn so much when I signed up for this course. It totally blew me away with how thoroughly the instructors teach field methods.”

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

“The skills I learned here are way above most of my peers. I know these skills will help me grow.”

“We have been given the field skills to excel in industry and now the confidence to take on the tough tasks of the future.”

“Taught me very beneficial skills that are needed and few others have.”

“I want to be a field geologist or exploration geologist. Everything I’ve learned in camp is pertinent to my future career.”

What are your enduring understandings from this experience?

“Field geology is very important. You can only do so much behind a computer. The real work is in the field.”

“Mapping and confidence with a brunton.”

“An understanding of the importance of detailed field mapping to any geological process. You have to get out and physically see the rocks.”

“I learned everything I know about field geology in the last 6 weeks.”

“I am not as bad of a geologist as I thought I was.”
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 (GRAs), 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 varies based on the annual level of corporate and individual membership contributions.

The PRC awarded Graduate Research Assistantships for the full 2012-2013 academic year to Craig Caton and Aubrey Lee. Two single semester GRAs were awarded to Adam Leu and John Dyess for the Fall semester of 2012. Each of these students also received $1,000 PRC Student Research Grants, which are available to students from any academic institution to further support their graduate research on a variety of field-based Precambrian geology topics.

Craig Caton is currently working on completing his MS thesis titled “Petrogenesis and Metallogenesis of the Southern Troctolite Zone of the Bald Eagle Intrusion, Duluth Complex, Northeastern Minnesota.” His work seeks to determine the parent magma composition, emplacement, venting, crystallization, compaction, and mineralization history of this potentially economic intrusion. Craig’s research expenses and graduate research assistantship are being funded by Duluth Metals Ltd. as part of the Industry Support of Student Research program (see next column).

Aubrey Lee is in the process of completing her MS degree on a study titled “Petrographic and Geochemical Study of the Seine Bay – Bad Vermilion (SVVB) Lake Mafic Layered Intrusion, Numax Resources Inc. Mine Centre Property, Ontario, Canada.” This field and laboratory study includes generation of a new, detailed geological map for the prospect, and has the goals of establishing the lithological and chemical stratigraphy of the intrusion, gaining a better understanding of the emplacement and crystallization history of the magma chamber, and fully characterizing the mineralogic, textural, chemical attributes of Fe-Ti oxide layers and their genesis. Aubrey’s research is being funded by Numax Resources, Inc.

Adam Leu is completing his first year in the master’s degree program at UMD, and is in the process of gathering and interpreting field, petrographic, and geochemical data for his study “Geology and Petrology of the Wilder Lake Intrusion, Duluth Complex, NE Minnesota.” His project, which is largely funded by the USGS’s EDMAP program, aims to verify and evaluate the origin of some of this intrusion’s enigmatic petrologic attributes by conducting detailed field mapping, petrographic study, mineral chemical analysis, and litho-geochemical analysis, as well as further establishing the cumulative stratigraphy over the intrusion’s 10 kilometer strike length.

Jon Dyess is currently in his third year of his Ph.D. research titled “Structural and Kinematic Analysis of the Shagawa Lake Shear Zone and Snowbank Lake Stock, Superior Province, NE Minnesota.” Jon’s study represents a multi-scale and multi-pronged approach to the evaluation of tectonic fabrics within the Shagawa Lake shear zone (Vermilion District, Minnesota) aimed at understanding the deformational history of the Shagawa Lake shear zone, including interactions of the shear zone with the Snowbank Lake stock.

Industry Sponsors of Student Research

The Precambrian Research Center was again successful in soliciting an exploration company for direct support of graduate student research at UMD. In March 2012, Duluth Metals Ltd agreed to contribute $30,000 to the PRC Foundation in order to fund a graduate research assistantship for MS candidate Craig Caton for the 2012-13 academic year. In addition, Duluth Metals agreed to cover all analytical and petrographic expenses related to his petrologic study of the Bald Eagle intrusion of the Duluth Complex.
After a one-year hiatus in order to concentrate on the National Geological Society of America meeting in Minneapolis, the PRC stepped out of its comfort zone by offering a conference on the Silica Sand Resources of Minnesota and Wisconsin in October, 2012. Mining of high-purity silica sand rock formations has been conducted in the upper Mississippi River Valley for over a century. However, the boom in domestic oil and gas exploration over the past decade, largely spurred by increased use of hydraulic fracturing techniques, has driven a new mineral rush in Minnesota and Wisconsin for deposits of what the industry calls “Northern White Sand.” By virtue of its nearly pure quartz composition, friability, and coarse grain size, this resource is considered an ideal “frac sand” for use as a proppant in oil and gas exploration and extraction.

In the face of this rush to expand current operations and develop new mines, this conference was organized in order to satisfy an urgent need among the public, media, government regulatory agencies, and energy and mineral resource industries for credible information about this industry.

The PRC partnered with the Twin Cities section of the Society of Mining, Metallurgy, and Exploration (SME) to organize and promote the conference. It was held in conjunction with the Midwest Groundwater Association Meeting at the Earle Brown Heritage Center in Brooklyn Park, MN. It was kicked off with a welcoming banquet highlighted by a talk on the booming domestic oil and gas industry.

Outside the facility, about two dozen protesters bused up from Winona, MN politely voiced their opposition to silica sand mining. The next day, a technical session of invited talks by 17 experts from industry, government and academia touched on various aspects of silica sand resources. After being delayed for about an hour by more protesters on the third morning, a long field trip day showcased several mining and processing operations in western Wisconsin with best practices in the industry. The highlight of the field trip was observing a blast at Preferred Sands operation in Blair, WI.

The interest in the topic of silica sand was evident not only by the protesters it attracted, but also by the impressive number of registrants (322) for the technical session. Participation in the field trip was limited by the capacity of two coach buses and involved 120 attendees. The meeting also attracted 16 corporate sponsors and 16 exhibitors. The conference received generally favorable press coverage from print and radio media. The conference was a financial success for the PRC and the SME-TC which will help to support both organization’s educational programs and support for students.
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 it did in 2011, the PRC served as the lead organizer for the 15th Annual Minnesota Minerals Education Workshop (MMEW) held June 19-21, 2012 at Winona State University in southeastern Minnesota. A record total of 96 participants, composed primarily of K-12 earth science teachers from throughout Minnesota, attended the three-day workshop. The workshop involved 28 volunteers from various academic institutions, K-12 schools, state agencies, and mining and geo-engineering companies.

On the first day, participants attended four of 16 short course offerings on a variety of geologic and mineral resource topics. The courses were taught by volunteers from local academic institutions, K-12 schools, state agencies, and mining and geo-engineering companies. The second and third days of the workshop were devoted to field trips highlighting the geology and mineral resources of the area around Winona. Two busloads of participants toured Mystery Cave near Forestville as well as sites in SE Minnesota illustrating karst topography, fossiliferous limestone, quartz sandstone formations, and glacial till deposits. On Thursday, sites were visited along the Mississippi River Valley between Trempeleau and Alma, Wisconsin, that included overviews of the valley, a lock and dam operation, a coal-fired powerplant, and an aggregate quarry.

The PRC is also taking the lead in organizing the next MMEW to be held at Hibbing Community College next June. Field trips for the 16th annual workshop will focus on the geology and mineral resources of the western Mesabi Range. To learn more about the upcoming MMEW meeting, check out the website at: www.MMEW.org.
The PRC again served as advisor and financial supporter of the UMD-Society of Economic Geologists student chapter, now in its second year. At the end of 2012, the chapter had 15 active members. Activities of the UMD-SEG student chapter that were co-sponsored by the PRC in 2012 included:

Students Sponsored to Attend 2012 PDAC – The PRC and the Richard Patelke Scholarship funded five UMD-SEG students (2 undergraduates and 3 graduates) to attend the Prospectors and Developers Association of Canada convention in Toronto last March. The PRC will continue to use funding provided by the PDAC for this purpose each year.

Fall Field Trip to Upper Michigan – The PRC provided funding to cover lodging expenses for seven UMD-SEG students, as well as three students from Wayne State University (Detroit), for a weekend field trip to the Marquette, Michigan area. Highlights of the trip included visits to the Rio Tinto’s Eagle Ni-Cu-PGE deposit core shack and a tour of Empire and Tilden iron mines operated by Cliffs Natural Resources.

Plans for a 2012 spring break field trip to New Mexico and Arizona had to be postponed due to a lack of funds. However, after being awarded funding from the SEG foundation in July, plans are moving forward with a Spring Break 2013 field trip in conjunction with the student chapter at New Mexico Tech.
PRC-affiliated students, faculty, and staff were well represented at the 58th Annual Institute on Lake Superior Geology (ILSG) held May 18-21, 2011 in Thunder Bay, Ontario. PRC director Jim Miller was awarded the Goldich Medal, which is given out annually to a geoscientist who has made particularly noteworthy and meritorious contributions to the understanding of Lake Superior geology and mineral deposits.

Oral presentations by PRC-affiliated participants included:

Chaffee, M.1, Miller, J.1, Hollings, P., Heggie, G., MacTavish, A., and Bandli, B.

Petrographic and geochemical study of the hybrid rock unit associated with the Current Lake Intrusive Complex, Magma Metals’ Thunder Bay North Property

Brooker, B.2,4 and Miller, J.1

Geology and petrology of a Mesoproterozoic layered mafic intrusion in portions of the Brule Lake and Cherokee Lake 7.5’ Quadrangles, northeastern Minnesota

Swanson-Hysell3, N., Burgess, S., Maloof, A., and Bowring, S.

Temporal context of the Mamainse Point succession: a record of magmatic activity and fast plate motion across the “latent stage” of Midcontinent Rift development

Thalhamer, E.3,4 and Czech, D.

Analyzing ductile shear zone network geometries in the Grassy Portage Sill, Rainy Lake Region, Northwestern Ontario, Canada

Poster presentations by PRC-affiliated participants* included:

Craddock, S.4 and Craddock, J.

Strain variations in carbonates across the Proterozoic Grenville Orogen

Goscinak*, C.2 and Hansen, V.

Quartz Fabric analysis of the Kawishiwi Shear Zone, NE Minnesota

Hudak, G.3, Monson Geerts, S., Zanko, L., Severson, A., Severson, A. and Bandli, B.

The Minnesota Taconite Workers Health Study: Environmental Study of Airborne Particulates - 2012Update

Jirsa, M.1

Bedrock geologic map of the Crane Lake and Brule Narrows 30’X60’ quadrangles, Quetico subprovince, northern Minnesota


Reconnaissance geologic mapping of Neoarchean rocks in the central Boundary Waters Canoe Area Wilderness by students of the Precambrian Research Center’s 2011 field camp.

Lee, A.3,4, Albers, P., Miller, J.1, Severson, M.1 and Deen, T.

Bedrock Geologic map of the Seine Bay/Bad Vermilion Lake intrusion, Mine Centre, Ontario

Miller, J.1, Brooker, B.4, Asp, K.4, Leu, A.4, Parisi, A.4 and Sletten, D.4

2011 Precambrian Field Camp Mapping in the Sawbill Lake Area, Cook County, Northeastern Minnesota

* Recipients of Best Student Paper Awards
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 PRC 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. Since 2009, the PRC Board of Advisors has held its annual meeting during the Prospectors and Developers Association of Canada (PDAC) convention held each March in Toronto.

This year, we bid a heartfelt thank you to three exiting board members Jon Scoates, Bill Cannon, and Mike Nemitz. We greatly appreciate their guidance and advice and we are glad to know that we can continue to seek their counsel and expertise as needed in the future.

We also welcome the advice and counsel of three new board members:

Rick Sandri consults in the field of mineral economics and will assume the Consulting/Junior Position formerly held by Jon Scoates, who has been on the PRC board since its founding. Rick is a professional Mineral Economist and currently runs Vermillion Gold as president, and StoneBridge Analytics, a natural resource consulting firm. Previously, as president of Duluth Metals, he managed the discovery of the Nokomis deposit of the Duluth Complex. With over 30 years of exploration and mining experience in over 80 countries, he brings a strong operational business perspective to the PRC with a focus on the economic and financial aspects of project development.

Michael Ressel, is Chief Geologist of North American exploration for Newmont Mining Corp. Michael fills the Industry Position vacated by Mike Nemitz, who has been reassigned to Australia. In his current position, he contributes to evaluations of grassroots through advanced exploration projects, helps guide regional exploration focus, is involved in developing training and mentoring programs in both mines and exploration, and liaises with university-sponsored research. Previously, Michael worked in mine geology, development, and exploration for Carlin-type gold, epithermal Au-Ag, porphyry Cu-Au, gold skarn, and Archean orogenic gold deposits principally in the U.S., Canada, and West Africa. Michael has a Ph.D. in economic geology from the University of Nevada, Reno and is a co-recipient of the Brian J. Skinner Award for outstanding paper published in the journal Economic Geology in 2006.

Bruce Lipin is an emeritus scientist at the U.S. Geological Survey stationed in Reston, VA who has filled in for Bill Cannon at board meetings for the past 3 years. This year we have invited Bruce to be Bill’s permanent replacement on the board. After receiving his Ph.D. at Penn State, Bruce joined the USGS in 1974 as a NRC post-doctoral fellow to study lunar basalts. In 1976 he joined the Branch of Eastern Mineral Resources of the USGS where he specialized in global chromium and platinum deposits and conducted research on the Stillwater Complex of Montana. During his time with the USGS, Bruce was Chief of the Branch of Eastern Mineral Resources from 1984-1989, Associate Chief of the Office of Mineral Resources from 1993-1996, Project Chief of the Mineral Database Project in 1997 and in 2004, he joined the Global Mineral Resource Assessment project.
Board of Advisors

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 - Bruce Lipin, Emeritus Scientist, U.S. Geological Survey
Canadian Survey Position - Mark Smyk, Regional Manager, NW Resident Geologist Program, 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 - Paul Spry, Professor of Economic Geology, Iowa State University
First Consultant/Junior Position - James Franklin, Franklin Geosciences
Second Consultant/Junior Position - Rick Sandri, President, Vermilion Gold
Third Consultant/Junior Position - Dave Peck, Head of Exploration, North American Palladium
First Industry Position - Michael Ressel, Chief Geologist, North America, Newmont Mining Corporation
Second Industry Position - Vern Baker, President, Duluth Metals Ltd.
Third Industry Position - Ron Graber, General Manager– Resource Technology, Cliffs Natural Resources

“Emeritus” PRC Board of Advisors

Anthony (Tony) Naldrett - Emeritus Professor of Geology, University of Toronto (2006-2009)
Odin Christensen - Former Chief Geologist, Newmont Mining Corporation (2006-2009)
Alan Bailes - Senior Geologist (retired), Manitoba Geological Survey (2006-2010)
Alar Soever - President and Director, Wallbridge Mining Company Ltd. (2006-2010)
Dave Groves - Former Chief Geologist, Newmont Mining Corporation (2009-2011)
Bruce Marsh - Professor of Igneous Petrology, Johns Hopkins University (2006-2011)
Mike Nemitz - Senior Exploration Geologist, Newmont Mining (2011-2012)
Jon Scoates - Former Senior Geologist, Manitoba Geological Survey (2009-2012)
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 to provide training and support to students in modern field methods and mapping, 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 Swenson 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.

We are sincerely grateful to our corporate and individual members, who in 2012 contributed $83,500 in support of PRC programs and students. We would especially like to welcome two new members – Idea Drilling and North American Palladium.

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<td>North American Palladium</td>
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<tr>
<td>Gold</td>
<td>$10,000-5,001</td>
<td>Rio Tinto-Kennecott Expl.</td>
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<td>Cliffs Natural Resources</td>
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<tr>
<td>Copper</td>
<td>&lt;$5,000</td>
<td>Prospects and Developers Association of Canada</td>
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<td></td>
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<td>Idea Drilling</td>
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<td></td>
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<td></td>
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<td>Barr Engineering</td>
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<tr>
<td>Individual Memberships</td>
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<tr>
<td>Palladium</td>
<td>&gt;$5,001</td>
<td>Tom Gardner</td>
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<td>Titanium</td>
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<tr>
<td>Nickel</td>
<td>$2,000-501</td>
<td>Dean Peterson</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dave Groves</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Al MacTavish</td>
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<tr>
<td>Zinc</td>
<td>&lt;$500</td>
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<td>Corporate Sponsor of Student Research</td>
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</tr>
<tr>
<td>Sponsor</td>
<td>Amount</td>
<td>UMD Student</td>
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<td>Duluth Metals</td>
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<td>Craig Caton</td>
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### INCOME

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<tr>
<th>Description</th>
<th>Amount</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Carry-over from 2011</td>
<td>2,134</td>
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<tr>
<td>Natural Resources Research Institute Allocation</td>
<td>40,000</td>
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<tr>
<td>Precambrian Field Camp Tuition (22 students)</td>
<td>72,790</td>
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<td>Professional Workshop Income</td>
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<tr>
<td>PRC Foundation Gift Contributions</td>
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<tr>
<td>Corporate Memberships</td>
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<td>Industry Sponsors of Student Research</td>
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<td><strong>TOTAL INCOME</strong></td>
<td><strong>314,021</strong></td>
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### EXPENSES

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<tr>
<th>Description</th>
<th>Amount</th>
<th>Percentage</th>
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<tr>
<td>Salaries (excluding Field Camp)</td>
<td>65,310</td>
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<tr>
<td>Precambrian Field Camp</td>
<td>135,407</td>
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<td>Professional Workshop</td>
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<td>Student support (GRA, Grants, Industry Sponsorships)</td>
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<td>General Expenses</td>
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<td><strong>TOTAL EXPENSES</strong></td>
<td><strong>373,365</strong></td>
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</table>

**YEAR END BALANCE** (59,343)

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### Financial Statement

*(January - December 2012)*

#### INCOME Graph
- 23.9% Corporate Memberships
- 12.7% Carry-over from 2011
- 23.2% Precambrian Field Camp Tuition
- 27.3% Professional Workshop Registration

#### EXPENSES Graph
- 24.3% Professional Workshop
- 17.5% Non-Field Camp Salaries
- 36.3% Precambrian Field Camp

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2012 INCOME $314,021

2012 EXPENSES $373,365
Whereas we characterized the past year as one of stability with growth, we foresee 2013 to be one of innovation and change in several program areas. This prospect for change comes not only from planned modifications and additions to our current programs, but also from changes occurring within the Department of Geological Sciences and the Natural Resources Research Institute which jointly oversee the operation of the PRC.

Precambrian Field Camp - As of the late-January early registration deadline, a record 35 applications were received for the 24 slots open for the summer field camp. The buzz about the PRC camp is obviously building. The eight training exercises held during the first four weeks will be generally the same, however each exercise will be tweaked in order to improve the efficiency and effectiveness of the field camp experience. We will report to you next year on the success of these changes. Plans for 2013 capstone mapping projects during the fifth week include:

- George Hudak hopes to revisit his PhD field area to lead a capstone mapping project within the mineralized Sturgeon Lake Caldera Complex in northwestern Ontario.
- Terry Boerboom of the Minnesota Geological Survey returns after a two-year hiatus to lead a capstone project on the North Shore volcanics.
- Mark Jirsa, also of the MGS, returns to the Archean terrane west of Saganaga Lake off the Gunflint Trail and adds to his reconnaissance mapping of last summer.
- Jim Miller returns to the Pagami Creek burn area (and his PhD stomping grounds) to map a poorly defined troctolite intrusion in the Duluth Complex exposed south of Lake Three.
- Dean Peterson will focus his capstone project on better defining the structural boundary between the Archean Quetico and Wawa subprovinces in the northern Lake Vermilion area.

Professional Workshop - Planning is well underway for a week-long professional workshop in October (6th-13th) on “Copper-Nickel, and Platinum Group Metal Deposits of the Lake Superior Region”. The workshop, which will be co-sponsored by the Society of Economic Geologists (SEG), will involve two days of short course lectures from prominent geoscientists and five days of field trips to regional Cu-Ni-PGE deposits. The first
day’s lectures will be keynoted by Prof. Tony Naldrett, who will overview the types of magmatic sulfide deposits, to be followed by talks describing their geologic, mineralogical, geochemical and geophysical attributes and other summarizing techniques for their exploration, mining, processing and remediation. The second day of lectures will focus on descriptions of various Cu, Ni, and PGE deposits and prospects in the Lake Superior region. Five days of field trips will include visits to Rio Tinto’s new Eagle Ni-Cu-PGE mine and processing plant in Upper Michigan, the Caledonia native Cu mine near Ontonagon, MI, and North American Palladium’s Lac des Iles Mine near Thunder Bay. In addition, mineralized drill core will be displayed from Orvana’s Copperwood copper sulfide deposit (MI), Rio Tinto’s Tamarack Ni-Cu-PGE deposit (MN), Duluth Complex Cu-Ni-PGE deposits (PolyMet’s NorthMet, Teck’s Mesaba, and Twin Metal’s Nokomis), and from Ontario, Panoramic’s Thunder Bay North PGE-Cu-Ni deposit, Stillwater Canada’s Marathon Cu-Ni-PGE deposit, and MinFocus’ Seagull prospect.

Professional Field Course – Undaunted by our unsuccessful attempt to launch the first PRC professional field course last October, we are getting a head start in planning and advertising a field course on “Mapping Mafic Layered Intrusions” for October, 2013. Because of the linkage between Cu-Ni-PGE deposits and mafic layered intrusions (MLI), we are offering the field course immediately following the workshop (Oct. 13th-20th). Focusing on two intrusions comprising the greater Duluth Complex in northeastern Minnesota, the Layered Series at Duluth and the Sonju Lake Intrusion, the course will teach field methods best suited to delineating the lithostratigraphy and internal structures of MLI.

Outreach – Minnesota Minerals Education Workshop – Planning is also underway for planning the 16th annual Minnesota Minerals Education Workshop to be held at Hibbing Community College next June (18th-20th). This will be the third year that the PRC has taken the lead in organizing this popular three-day workshop that seeks to educate K-12 Earth Science teachers about Minnesota’s geology and mineral resources.

New Faculty Hire in Economic Geology at UMD – The PRC is involved in the current search for an economic geologist to fill an assistant professor faculty position in the Department of Geological Sciences. The entry-level position is being created by the retirement of Dr. Ron Morton in May 2013. We are hoping to find a bright, ambitious candidate with experience in field studies of Precambrian geology and ore deposits and with interest in being involved in the Precambrian field camp and other PRC programs.

Center of Excellence in Mining and Minerals Exploration at UMD – Planning discussions are currently underway among the main departments/institutes within the University of Minnesota Duluth that have strong ties with the minerals industry, to establish a Center of Excellence focused on mining and minerals exploration. For the past 50 years, UMD has been providing critical human and intellectual capital to the century of mining that occurs on our doorstep – the Mesabi Iron Range. With taconite mining expected to continue for another half century and the nascent Cu-Ni industry poised to take off for a similar period, UMD’s role in the growth of this world class mining district will become even more critical. The educational goal of this Center is to coordinate and integrate curriculum that will produce engineers and scientists who are well-educated in specific fields related to exploration and mining, but who also have a broad appreciation of the mining cycle – exploration, resource assessment, mining, mineral processing, and environmental remediation. The Center’s research goal is to promote collaborations among faculty and students of different disciplines and the minerals industry, for the benefit of society locally and globally. The planning group will have discussions with interested faculty and local minerals industries over the coming year to better define the goals, objectives, and organizational structure of the center. Stay tuned.

Fundraising Changes – Now that the PRC has established a core group of corporate and individual members who have repeatedly made generous annual contributions, we are looking to modify our fundraising practices. Rather than having PRC directors make direct appeals annually to these companies, we will use the development office in the Swenson College of Science and Engineering to contact our long-standing members. The directors’ involvement with our member companies and individuals will focus more on conveying interesting programmatic information and on linking member companies with PRC-trained students for employment. The directors will continue to be involved in seeking out new members.

As you can see we have a number of ambitious goals for the coming year. We look forward to reporting on the successful accomplishment of these and other aims in next year’s report. All the best for a safe, prosperous, and productive 2013.