Mission

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.
As indicated later in this Annual Report, PRC programs were firing on all cylinders in 2013. The Precambrian field camp had to turn away nearly twenty applicants as we attracted a record 42 applicants for our maximum enrollment of twenty four. Nine of the 24 students came to us from colleges that had not previously been represented at the PRC camp, and once again, our 2013 crop of students came from all parts of the United States. We implemented several programmatic changes to enhance both safety and teaching effectiveness. Five outstanding geologic maps were produced and published by the PRC in areas spanning a wide range of geological environments in northeastern Minnesota. As in years past, our previous years’ field camp students presented the results of their capstone mapping projects at the Institute on Lake Superior Geology, which was held in Houghton, Michigan last May.

Our sponsorship and mentoring in UMD’s student chapter of the Society of Economic Geologists has led to record numbers of members (25) in its third year. With the help of PRC funding, three undergraduate and three graduate students accompanied the PRC Directors to participate in the 2013 Prospectors and Developers Association of Canada meeting in Toronto in March. We also assisted in planning and guiding an incredible week-long field trip for ten UMD-SEG students to visit geological highlights and mine sites in Arizona.
during UMD’s April spring break. In the fall, we helped plan, lead and finance an SEG field trip to the exceptional mining district in our backyard – the Mesabi Iron Range.

For the third year in a row, the PRC took the lead in planning and organizing the very popular Minnesota Minerals Education Workshop, which was held in Hibbing, Minnesota, last June. The three day meeting, which included both short courses and field trips, attracted 70 K-12 Earth Science teachers and involved some 30 volunteers.

Finally, this year’s professional workshop (the PRC’s 6th) on the topic of Cu-Ni-PGE deposits in the Lake Superior region was a great success and earned a considerable (~$40K) profit for the PRC. The workshop was attended by 62 international participants and involved 26 different lecturers and field trip leaders. It included two days of short course lectures (24 talks) held at UMD and five days of field trips that included visits to the Eagle Mine in Michigan, the Cu-Ni deposits of the Duluth Complex, and the Lac des Iles Pd mine outside Thunder Bay. Part of the success of the workshop has to be attributed to the promotional support provide by the Society of Economic Geologist in advertising the workshop in their quarterly newsletter and their website.

The only programmatic disappointment this year has again been the failure to generate sufficient interest in a professional field course. We offered a one-week advanced field course on mapping mafic layered intrusions that focused on two intrusions of the Duluth Complex, but it was not sufficiently subscribed to be run. The course was scheduled to take place in October immediately after the Cu-Ni-PGE workshop. Unfortunately, this followed our first unsuccessful attempt to run a professional field course in 2012, which was focused on mapping Archean volcanic terrains prospective for lode gold deposits. We have concluded from these two unsuccessful attempts that, as they say, timing is everything. The downturn in the minerals industry that started in 2012 first hit the gold producers and prospectors, and then spread to the entire minerals exploration industry by 2013. We haven’t quit on the idea of running professional field courses, and our corporate partners, as well as our Board of Advisors, still believe this is a needed program for the industry. We’ll just have to wait until the timing is right.

Because of the downturn in the minerals exploration industry, many of the PRC’s longtime industry supporters have informed us that they will not be able to make their annual membership contributions this year. Some of this decrease in external funding has been offset by establishing new external supporters (such as the Minnesota section of the SME), having a profitable professional workshop, and receiving a grant from the Iron Range Resources and Rehabilitation Board to support our outreach program to K-12 Earth Science teachers. Still, this has not been enough to balance the losses incurred due to a decrease in membership contributions from over $100K in 2011 to $62K this past year.

We have been attempting to right our financial ship this year with various cost cutting measures, and unfortunately, we have also had to cut back on our support of students by suspending our research grant program. Financial support for graduate students is now limited to those students being supported by our Industry Sponsorship of Student Research program.

Finally, we would like to report that UMD’s Department of Geological Sciences was successful in hiring a new economic geology faculty member to replace the retiring Dr. Ron Morton last year. Dr. Christian Schardt, from Freiberg, Germany, joined the UMD Department of Geoscience faculty in September, 2013. He has an MS from the University of Minnesota and a PhD from the University of Tasmania. His research has focused on field studies and modeling of fluid flow in VMS and other hydrothermal ore deposit systems. Christian is very interested in becoming more familiar with northern Minnesota geology and ore deposits by way of assisting in the Precambrian field camp and other PRC programs. We expect that his name will appear frequently in future PRC annual reports.

Thanks to all the companies and individuals (Al MacTavish!) who have continued to support us through this financially challenging time. We hope that the financial health of the minerals industry will improve in the near future, and that corporate supporters will soon reinstate their important financial support of our programs.
The seventh Precambrian Research Center field camp took place between July 7 and August 16, 2013. For the fourth straight year, the field camp was attended by 22 students who represented 16 different colleges from across the United States and Canada. Nine students came from schools that had not sent a student to the Precambrian field camp before. We have had a total of 67 different schools represented in camp over the past seven years.

The 2013 field camp faculty has remained largely unchanged from years past. The principal instructors were PRC Directors Jim Miller, George Hudak, and Dean Peterson with assistance from Phil Larson (Duluth Metals), Nigel Wattrus (UMD Department of Geological Sciences), Marsha Patelke (NRRI-UMD), and Mark Severson (Teck American). For the capstone projects, Mark Jirsa and Terry Boerboom of the Minnesota Geological Survey again led projects along with Jim and Dean. George Hudak unfortunately needed to cut short his involvement during the last three weeks of camp due to management commitments at the NRRI. Teaching assistants for the 2013 camp were 2012 field camp alum and current UMD graduate students Sarah Sauer and Mike Doyle.

As in the past, the first four weeks of camp were devoted to teaching fundamental observation and mapping skills that are best suited to mapping in glaciated Precambrian shield terranes. This was accomplished through eight 2-3 day exercises based out of Duluth (weeks 1 & 2) and Ely (weeks 3 & 4). The first day of camp was spent teaching students about wilderness safety and how to use their compasses (orienteering and brunton).

A few changes from years past included breaking the group into two sets in the first week. Each subset alternated working two days each on the field geophysics exercise and the preliminary mapping exercise of the basal Midcontinent Rift section. Working in smaller groups in Week 1 greatly improved the effectiveness of both exercises. Another major change was to add an extra day to complete the Duluth Complex mapping exercise at Spirit Mountain in Week 2. Students always struggled to get enough mapping in over two days to truly understand the geology and structure of this area. We eliminated one day from the North Shore exercise, and focused on performing detailed sketching of roadcuts along the shore as well as field descriptions of volcanic and intrusive rocks associated with the North Shore Volcanic Group and Beaver Bay Complex. During our one night stay on the North Shore, we enjoyed an evening of camping at Tettegouche State Park which enabled everyone to test their camping gear (and hone their cooking skills!) prior to their capstone exercise.
The third and fourth weeks of camp were once again based out of Vermilion Community College in Ely. Exercises completed during this period of camp were modified from past years as well. For the two-day Mesabi Iron Range project, we devoted one day to core logging at the MN Department of Natural Resources Core Library in Hibbing and a second day to a tour of the Cliffs Thunderbird taconite mine and Fairlane processing plant in the central Mesabi Range. Since we didn’t get our annual canoe safety training in at Wolf Ridge, we opted to have a local Ely outfitter conduct a short training program at Miners Lake – an old iron ore pit. The students practiced their paddling strokes throughout the day as they mapped the greenstone and iron formation geology exposed on the pit walls of the lake. And as we’ve done at Wolf Ridge for years, we ended the session with dunking the canoes and practicing T-rescues. At the end of the third week, we moved our mineralized Duluth Complex mapping exercise north to the Nickel Lake area where the students mapped a Cu-Ni-PGE mineralized gabbroic mafic dike that cross cuts earlier anorthositic rocks. In the fourth week, the location of the greenstone exercise was moved from Soudan Underground Mine State Park to the area near the junction of Highway 1 and Mud Creek Road that contains exposures of greenstone, iron formation, felsic volcanics, and both mafic and felsic intrusive rocks.

Four capstone projects were conducted this year in various geological settings that had not previously been mapped in any detail. These were:

- Hanson Lake Area (Jirsa) – mapped by canoe, Late Archean metasedimentary rocks in the BWCAW west of the Gunflint Trail.
- Pine Mtn Area (Boerboom) – mapped by overland traverses, Mesoproterozoic volcanics and intrusion of the Midcontinent Rift along the central Gunflint Trail.
- Lake Three Area (Miller) – mapped by canoe and overland traverses, a troctolitic intrusion of the Duluth Complex in a recently burned area at the south end of Lake Three in the BWCAW.
- Gafvert Lake Area (Peterson) – mapped by overland traverses volcanoclastic units of the Gafvert Lake Volcanic sequence east of Lake Vermilion.

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/.

2013 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
- Terry Boerboom
  Minnesota Geological Survey
  Univ of Minnesota
  Expertise: Geologic Mapping, Igneous Petrology
- 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:
- Sarah Sauer
  2012 PRC Alum
- Mike Doyle
  2011 PRC Alum
Field Camp Student Comments

“I came hoping to learn how to map. I left actually knowing how.”

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 have learned more in the 6 weeks of this camp than I have in all of geology.”

“After coming out of a field camp in Montana, I thought I knew what to expect. I was completely wrong! This field camp was an amazing experience and the close group of instructors was top notch.”

“I was worried that not being familiar with the regional geology would put me at a disadvantage, but I soon realized that I was on the same level as everyone else. I learned so much, it’s daunting to even think about it.”

“I was hoping to get a different view on geology than just carbonates. This camp was a mapping-based, strenuous, hard-rock, economic geology focused camp and I loved every minute of it.”

“It blew my mind!!”

What are some enduring understandings from this experience?

“Geologic maps are never really finished or correct.”

“Grain size, color, texture, rock name.”

“Humility about field geology due to an appreciation of all that is involved in doing it well.”

“Take good notes – you will probably never be back here.”

“The raw experience gained, combined with the confidence this camp nurtures.”

“The outcrops are neither representative nor random.”

“Northern Minnesota woods are not that scary.”

“Raw geologic data is not collected by planes and satellites. Raw data is collected by men and women who are passionate about geology in the field.”
Students

Mark Baumgardner
Wayne State (MI)

Jordan Benningfield
NW Missouri State

Nathan Brown
Virginia Tech

Paul Fix
U of Wisc-Stevens Pt

Stephen Ginley
U of Maryland

Jack Graham
U of Wisc-Milwaukee

Matt Grotte
U of Minnesota Duluth

Alan Jacobson
U of Wisc-Milwaukee

Jamie Kendall
Swathmore College, PA

Sara Kozmor
SUNY-Binghamton

Mitchell May
Eastern Kentucky

Steve Moorhead
Wayne State (MI)

Connor Mulcahy
Hope College (MI)

Claire Ostwald
Boston University

Ann Marie Prue
U of Wisc-River Falls

Dan Romanelli
Washington State

Lauren Schraeder
Wayne State (MI)

Nathan Schnirer
Univ of Cincinnati

Roger Schulz
U of Wisc-Eau Claire

John Smith
Virginia Tech

Aaron Summers
NW Missouri State

Justin White
NW Missouri State

Mike Doyle
2012 PRC Alum

Sarah Sauer
2012 PRC Alum
A primary objective of the PRC has been to provide financial and advisory support to graduate and undergraduate students conducting field-based research on the Precambrian geology of the Lake Superior region. This has been accomplished in the form of graduate research assistantships and research grants, which have been available to undergraduate or graduate students from any school provided that the student research involves some aspect of Precambrian geology. These scholarships have largely been funded by annual corporate and individual membership contributions to the PRC Foundation, as well as profits gained from professional workshops.

The PRC realizes that its financial health closely follows the ups and downs of financing in the minerals industry. As we are all aware, 2013 has been a difficult year for the minerals industry, and the financial situation of the PRC mirrors this trend. As a result of a reduction in corporate membership contributions during 2013, the PRC had no other choice than to suspend offering up to five $1,000 research grants for studies of Precambrian geology this past year, except to current UMD graduate students. Unfortunately, given the current lack of funding, we have been forced to temporarily suspend offering graduate research assistantships in the upcoming 2014-15 academic year that aren’t directly funded through our Industry Sponsorship of Student Research (ISSR) program (see below).

Listed below and to the right are recipients of PRC graduate research assistantships provided in 2013 that were funded from PRC membership contributions (GRA’s funded through the ISSR program are listed on the next page).

**Aubrey Lee, MS candidate**

UMD Advisor: Jim Miller
GRA term: Spring 2013 semester
Thesis Title: Petrographic and Geochemical Study of the Seine Bay - Bad Vermilion Lake Mafic Layered Intrusion, Mine Centre, Ontario, Canada
Expected Completion Date: Summer 2014

**Adam Leu, MS candidate**

UMD Advisor: Jim Miller
GRA term: Fall 2013 semester
Thesis Title: Geology and Petrology of the Wilder Lake Intrusion, Duluth Complex, NE Minnesota
Expected Completion Date: Summer 2014

**Industry Sponsorship of Student Research**

Although general membership contributions to the Precambrian Research Center have declined over the past year, we have been able maintain support for graduate student research by soliciting direct sponsorship of Masters-level graduate studies at UMD by exploration and mining companies. This support is established through a Memorandum of Understanding between the PRC and the company that formulates the objectives of the project, a timetable, confidentiality stipulations, and the level of company support negotiated between the company, the student, the PRC directors, and the student’s academic advisor. No indirect costs are involved, and all funds go directly to support the student and their research. Companies are encouraged to contribute the total amount of agreed-upon support to the PRC by the onset of the project period. The PRC is then responsible for distribution of that support to the student and vendors. The company receives financial and progress reports on a quarterly basis during the duration of the contract.

Possible components of sponsorship include:

**Graduate Research Assistantship** - includes support for 1/2-time salary, fringe benefits, and tuition waiver during the academic year (Sept.-May). For Masters students, GRAs are usually awarded during the second year of studies. For the 2013-14 academic year, cost for a GRA at UMD was approximately $30,000.

**Analytical Expenses** - companies cover the costs of analytical services and data acquisition (such as thin section preparation), lithogeochemistry, isotope chemistry, assay analyses, mineral chemistry, radiometric dating, paleomagnetic analyses, etc.
**Field Expenses** - travel, room and board associated with field studies.

**In-kind Support** - companies agree to share data, material (e.g., core), and services that pertain to the research project.

**Employment** - companies agree to employ the student for part of the duration of the contract. Ideally, this would occur during the summer between the student’s 1st and 2nd year.

**2013 Industry Support of Student Research Projects**

**Teck**

Sponsor: *Teck American*, Spokane, WA  
Student: *Paul Fix*, Stevens Point, WI

Advisors: Tamara Diedrich (Barr Engineering; UMD adjunct faculty), Jim Miller (UMD associate professor)

Project Title: Characterization of Secondary Mineral Controls on Metal Mobility from Weathered Duluth Complex, Mesaba Deposit

Support Level: $68,000. Covers GRAs for 2013-14 and 2014-15 academic years and analytical fees and professional travel costs

Term of Support: September 2013 - May 2015

**Duluth Metals Ltd**

Sponsor: *Duluth Metals Ltd*, Toronto, ON  
Student: *Craig Caton*, Spokane, WA

Advisors: Penny Morton (UMD professor), Jim Miller (UMD associate professor), Dean Peterson (Duluth Metals, UMD adjunct professor)

Project Title: Petrogenesis and metallogenesis of the southern part of the Bald Eagle Intrusion, Duluth Complex, Minnesota

Support Level: $31,205. Covers GRA for 2012-13 academic year and SEM analytical costs; also includes in-kind support and 2012 summer employment

Term of Support: January 2012 - May 2013

**Twin Metals Minnesota**

Sponsor: *Twin Metals* Minnesota, St. Paul, MN  
Student: *Alex Steiner*, Terre Haute, IN
The sixth professional workshop organized by the Precambrian Research Center was held October 6-13, 2013 and was attended by an international mix of 67 participants, mostly from the minerals industry. The workshop also involved the expert contributions of 30 short course instructors and field trip leaders. The workshop included two days of invited short course talks on the attributes of magmatic sulfide deposits, especially those occurring in the western Lake Superior region, and five days of field trips, including visits to the Eagle Ni-Cu-PGE Mine near Marquette, Michigan, and the Lac des Illes Pd mine outside Thunder Bay, Ontario. The PRC welcomed the Society of Economic Geologists as a cosponsor of this year’s workshop.

As with previous PRC workshops on greenstone belt volcanology and mineralization (2008), mafic layered intrusions (2009), Precambrian iron formations (2010) and silica sand resources in the upper Midwest (2012), 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 this workshop was to familiarize participants with 1) the geological setting, mineralogy, textures, geochemistry and geophysical attributes of magmatic ore deposits, 2) how such deposits are explored, mined, processed, and remediated, and 3) the types and characteristics of Cu-Ni-PGE deposits that occur in the Lake Superior region.

The two days of short course lectures included talks by 20 internationally recognized experts on magmatic sulfide deposits. The topics and lecturers were:

**Short Course I: Attributes of Magmatic Sulfide Deposits**
- Classification and Metallogenic Models - **Tony Naldrett**, Emeritus Professor of Economic Geology, U. Toronto
- Mineralogy and Textures - **Sarah-Jane Barnes**, Professor, Canada Research Chair Magmatic Ore Deposits, U. Quebec-Chicoutimi
- Geochemistry - **Ed Ripley**, Professor, Indiana University, Bloomington
- Geophysical Attributes - **Alan King**, Geoscience North Ltd. (formerly Chief Geophysicist, Vale Global Exploration)
- Exploration Strategies - **Dean Peterson**, Senior VP of Exploration, Duluth Metals Ltd.
- Options for Mining - **Vern Baker**, President, Duluth Metals Ltd.
- Processing and Beneficiation - **Louis Cabri**, Cabri Consulting Inc. (formerly with Canada Centre for Mineral & Energy Technology)
- Mineral Economics - **Henry (Rick) Sandri**, President, Pathfinder Minerals and Vermilion Gold
- Environmental Mitigation – **Jacob Waples**, Principal Geochemist, Golder Associates

**Short Course II: Cu-Ni-PGE Deposits in the Lake Superior Region**
- Geology and Mineral Deposits of the Midcontinent Rift - **Jim Miller**, Precambrian Research Center, University of Minnesota Duluth
- Maturi/Birch Lake Cu-Ni-PGE deposit, Duluth Complex - **Dean Peterson**, Duluth Metals Ltd. and Precambrian Research Center
October 2013

- **Mesaba Cu-Ni-PGE deposit, Duluth Complex** - Mark Severson, Teck American
- **NorthMet Cu-Ni-PGE deposit, Duluth Complex** - Andrew Ware, PolyMet
- **Potential for PGE reef deposits, Duluth Complex** - Jim Miller, UMD/PRC
- **Great Lakes Nickel Cu-Ni-PGE deposit, Crystal Lake Gabbro, Ontario** – Rob Cundari, Ontario Geological Survey
- **Marathon Cu-Ni-PGE Deposit, Coldwell Complex, Ontario** - David Good, Stillwater, Canada
- **Tamarack Ni-Cu-PGE deposit, Minnesota** - Dean Rossell, Rio Tinto-Kennecott
- **BIC Cu-Ni-PGE deposit, Michigan** - Dan Foley, Rio Tinto-Kennecott
- **Thunder Bay North Ni-Cu-PGE deposit, Current Lake Intrusion, Ontario** - Al MacTavish, Panoramic Resources
- **Seagull Ni-Cu-PGE deposit, Ontario** - Geoff Heggie, Panoramic Res.
- **Rare Metal Mineralization in Carbonatitic and Alkaline Intrusions** - Shannon Zurevinski, Ontario Geological Survey
- **Pd Mineralization in the Archean Lac des Iles Complex, Ontario** – John Corkery, North American Palladium

**Field trip visits included:**
- **Copperwood Cu-sulfide deposit, Ironwood, MI, Orvana Minerals** – core display
- **Caledonia Native Cu Mine, Ontonagon, MI, Red Metal Minerals** - underground mine tour
- **Eagle Ni-Cu-PGE Underground Mine, Marquette, MI, Lundin Mining** – underground mine tour
- **Humboldt processing plant/Core Shack, Ishpeming, MI, Lundin Mining** – plant tour & core display
- **Tamarack Ni-Cu-PGE deposit, Tamarack, MN, Rio Tinto-Kennecott** - core display
- **NorthMet Cu-Ni-PGE deposit, Hoyt Lakes, MN, Polymet Mining** – core display, plant & tailings basin
- **Mesaba Cu-Ni-PGE deposit, Babbitt, MN, Teck American** – core display
- **Maturi Cu-Ni-PGE deposit, Ely, MN, Twin Metals Minnesota** – core display
- **Lac des Iles Pd Mine, Thunder Bay, ON, North American Palladium** – minesite tour & field exposures
- **Thunder Bay North Cu-Ni-PGE deposit, Thunder Bay, ON, Panoramic Resources** – core display
- **Seagull PGE deposit, Thunder Bay, ON, MinFocus/Black Panther/Panoramic** – core display
- **Marathon Cu-Ni-PGE deposit, Marathon, ON, Stillwater Canada** – core display
- **Thunder Intrusion, Thunder Bay, ON, Rio Tinto-Kennecott** – field exposures

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
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 in 2011 and 2012, the PRC served as the lead organizer for the 2013 Minnesota Minerals Education Workshop (MMEW) held June 18-20 at Hibbing Community College. A total of 74 participants attended the 16th annual MMEW, the sixth highest attendance for the popular workshop. Attendees were mostly K-12 Earth Science teachers from throughout Minnesota, but also included college educators, students, and non-teachers. The workshop involved 23 instructors and volunteers from various academic institutions, K-12 schools, state agencies, as well as mining, exploration and geo-engineering companies. An impressive slate of field trip stops were offered thanks to the involvement of 21 staff from local mining companies (Cliffs Natural Resources, US Steel, Magnetation, Essar Steel, and Hawkinson Construction), the Minnesota Department of Natural Resources Hibbing office, and NRRI’s Coleraine Minerals Research Lab.

The first day of the workshop was devoted to participants attending four out of 17 short course offerings on a variety of geologic and mineral resource topics. Teachers were presented with educational resources at the end of the day, which included gifts of pen magnets, Mesabi Range maps, a collection of Minnesota rocks and minerals, and a jump drive loaded with a variety of teacher resources. The second and third days of the workshop were devoted to field trips highlighting the geology and mineral resources of the western Mesabi Range and included visits to NRRI’s Coleraine Minerals Research Lab, U.S. Steel’s KeeTac mine and taconite processing plant, MN DNR’s Hibbing Drill Core Library, and Cliff’s HibTac mine and reclamation areas, new Essar taconite plant under construction near Naswauk, the new Magnetation operation near Bovey, and finally the Hawkinson Aggregate operation near Grand Rapids.

Next year, the PRC is partnering with the MN Department of Natural Resources in organizing the 17th annual MMEW to be held at Southwest Minnesota State University in Marshall.
Mentoring - SEG Student Chapter at UMD

The PRC again served as advisor and financial supporter of the UMD-Society of Economic Geologists student chapter, now in its third year. At the end of 2013, the chapter had 25 active members compared to 15 in 2012. Activities of the UMD-SEG student chapter that were co-sponsored by the PRC in 2013 included:

**Students Sponsored to Attend 2013 PDAC** The PRC and the Department of Geological Sciences provided funding for six UMD-SEG students (3 undergraduates and 3 graduates) to attend the Prospectors and Developers Association of Canada convention in Toronto last March. While at the meeting, the PRC directors and the students visited Antofagasta’s Toronto headquarters where the PRC was generously presented with a membership check for $25,000, making Antofagasta the top contributor to the PRC in 2013.

**Spring Break Field Trip to New Mexico and Arizona** PRC director, Jim Miller accompanied 10 UMD-SEG students on a weeklong field trip to geological and mining sites in northwestern New Mexico and northern Arizona. Highlights of the trip included visits to Valles Caldera, El Mapais Volcanic Field, Petrified Forest, Sedona Red Rocks, Jerome VMS Deposit (led by explorationist extraordinaire Paul Lindberg!), Prescott Area, Bagdad Cupporphyry, Grand Canyon, Dinosaur Tracks, Canyon de Chelley and Ship Rock.

**Fall Field Trip to the Western Mesabi Range** The PRC took the lead in organizing a weekend field trip for UMD-SEG to mining operations along the Western Mesabi Range. The PRC also provided funding to cover lodging expenses for the trip. Highlights of the trip included visits to Cliffs Hibbing Taconite Mine, U.S. Steel’s Keewatin Taconite mine and processing plant, Essar Steel’s taconite processing plant under construction, Magnetation’s new operation reprocessing historic iron ore tailings, and Hawkins Construction’s aggregate operation. Ten economic geology students from the University of Wisconsin Eau Claire joined the UMD students for the trip.

2013 Institute on Lake Superior Geology

PRC-affiliated students, faculty, and staff were well represented again at the 59th Annual Institute on Lake Superior Geology (ILSG) held May 8-11, 2013 in Houghton, Michigan. A number of PRC-supported students (Lee, Canton, Dyess) presented the results of their graduate research and 2012 PRC field camp students presented field maps from their capstone projects.

**Oral presentations by PRC-affiliated participants:**
- Aubrey Lee and Jim Miller, The Igneous Stratigraphy of the Bad Vermilion Intrusion, Mine Centre, Ontario, Canada: Which Way is Up?

**Poster Presentation by PRC-affiliated participants:**
- Craig Canton, Crystalization of Chrome Spinel in the Southern Troctolite Zone of the Bald Eagle Intrusion, Duluth Complex, Northeastern MN
- Jonathan Dyess and Vicki Hansen – Application of LiDAR to resolving regional tectonic and glacial fabrics in glaciated terrane: An example from an Archean granite-greenstone belt in NE Minnesota
- Jonathan Dyess and Vicki Hansen – Structural and Kinematic Analysis of the Shagawa Lake Shear Zone and Snowbank Lake Stock, Superior Province, NE Minnesota
- Ellen Fehrs, Edward Kenny, John Kuchma, Sarah Sauer, William Sylvester, and George Hudak, Bedrock Geologic Map of the Putnam Lake Area, St. Louis County, NE Minnesota – Precambrian Research Center Capstone Project
- Katrina Korman, Suzanne Craddock, Michael Doyle, Jessica Walter, Aubrey Lee, and Mark Jirsa Geologic mapping of Neoarchean and Paleoproterozoic rocks near Ester Lake by students of the Precambrian Research Center’s 2012 field camp – Precambrian Research Center Capstone Project
- Aubrey Lee, and Jim Miller, Field, Petrographic, and Geochemical Study of the Bad Vermilion Intrusion, Mine Centre, Ontario, Canada
- Adam Leu, Lionel Djon, Emily LaPietra, Zach Martin, Ricardo Martinez, and Jim Miller, 2012 Precambrian Field Camp Mapping in the Wilder Lake Intrusion, Lake County, Northeastern Minnesota – Precambrian Research Center Capstone Project
2013 PRC Corporate and Individual Members

Funds to support the various PRC programs are sought from a number of public and private sources. In addition to base funding provided from the Natural Resources Research Institute and the College of Science and Engineering at the University of Minnesota Duluth, the most important source of working capital for PRC activities comes from corporate and individual memberships. Funds from these sources largely go toward subsidizing costs of the Precambrian field camp and providing research assistantships and grants to students. Below is a list of the PRC members for 2012 and their annual level of support. In addition to these annual memberships, corporate support also comes in the form of direct sponsorship of student research.

This year we welcome two new members to the Precambrian Research Center – the Iron Range Resources and Rehabilitation Board (IRRBB) and the Minnesota Section of the Society of Mining, Metallurgy and Exploration (SME). The IRRBB awarded the PRC with a workforce development grant to support our outreach activities related to the Minnesota Minerals Education Workshop (see page 10) and to support training of students through the Precambrian field camp. The SME-MN professional organization not only provided financial backing to the PRC this past year, but also provided the PRC with a free booth at their annual conference held April, 2013 in Duluth.

<table>
<thead>
<tr>
<th>2013 Members</th>
<th>Membership Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antofagasta</td>
<td>Diamond</td>
</tr>
<tr>
<td>Newmont Mining</td>
<td>Platinum</td>
</tr>
<tr>
<td>Iron Range Rehabilitatin &amp; Reclamation Board</td>
<td>Platinum</td>
</tr>
<tr>
<td>Rio Tinto - Kennecott Exploration</td>
<td>Gold</td>
</tr>
<tr>
<td>Anglo American</td>
<td>Gold</td>
</tr>
<tr>
<td>SME - MN Section</td>
<td>Copper</td>
</tr>
<tr>
<td>Idea Drilling</td>
<td>Copper</td>
</tr>
<tr>
<td>Al MacTavish</td>
<td>Nickel</td>
</tr>
<tr>
<td>Rolf Westgaard</td>
<td>Zinc</td>
</tr>
<tr>
<td><strong>Total Membership Contributions</strong></td>
<td><strong>$61,800</strong></td>
</tr>
</tbody>
</table>
Financial Statement
January - December 2013

INCOME
Natural Resources Research Institute Allocation  50,000  14.9%
Precambrian Field Camp Tuition (22 students)  66,953  19.9%
Professional Workshop Income  112,554  33.5%
Corporate & Individual Memberships  61,700  18.4%
Industry Sponsors of Student Research  44,432  13.2%
Total 335,639

EXPENSES
Salaries (excluding Field Camp)  94,721  21.4%
Precambrian Field Camp  115,160  26.0%
Professional Workshop  72,481  16.4%
Student Support (GRA, Grants, Industry Sponsorships)  82,492  18.6%
Travel & Misc. Expenses  18,349  4.1%
Carry Forward Expenses from 2012  59,343  13.4%
Total 442,547

Year-end Balance (106,908)
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.

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

UMD Position - Howard Mooers, 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

The 2013 PRC Board of Advisors meeting was held at the Toronto Hilton on Monday, March 4th. This was the fourth time that the annual BoA meeting was held during the Prospectors and Developers Association of Canada (PDAC) convention, which most BoA members routinely attend. In addition to most standing board members, emeritus board members Tony Naldrett, Dave Groves, and Greg Stott were also in attendance.

During the meeting, PRC directors, Miller, Hudak, and Peterson briefly reported on the 2012 PRC programs, which were summarized in the 2012 Annual Report. There was also a discussion of plans for a Professional Workshop on Cu-Ni-PGE deposits in the Lake Superior region and a Professional Field Course on mapping mafic layered intrusions, both scheduled for October 2013. As reported on page 9, the workshop was a great success, but the field course did not generate enough interest to run. There was also a discussion about plans at UMD to expand its programs in economic geology. One aspect of this was a search for a new economic geology faculty position which resulted in the successful hire of Dr. Christian Schardt in August 2013. Another was planning for the establishment of a Center for Mineral Resources at UMD. This is still in the planning stages. Finally, a considerable amount of time was spent discussing the financial troubles that surfaced in 2012 and the difficulty the PRC has experienced in fundraising.

Unfortunately the financial problems that began in 2012 became worse in 2013 such that the March 2014 Board of Advisors meeting at the PDAC was cancelled to save on expenses. We plan to have a teleconference BoA meeting sometime in the spring 2014.
Last year we anticipated that 2013 would be a year of innovation and change. We projected a positive outlook of new ideas for PRC programs. As we documented throughout this report, the programs of the PRC remain robust and vital. However, the financial realities of the minerals industry that so generously provided us with a significant percentage of our financial support have required that we make some hard choices. In light of the diminished financial support we anticipate from the minerals industry during these trying times, the PRC will continue to function, but with reduced scholarship offerings relative to previous years. Our top priorities for the coming year are to 1) bring our financial situation into balance, 2) preserve the viability of our flagship program – Precambrian field camp, 3) maintain our leadership in several programs (MMEW); and 4) if possible, offer reduced scholarship opportunities for qualified students.

Given the reality of reduced corporate sponsorships, it is imperative that the PRC work toward reducing costs while simultaneously seeking out new (and renewed) revenues. In addition to continuing the cost savings measures we have adopted in 2013 (devoting less PRC staff time to outreach activities, suspending student research grants, limiting awards of graduate research assistantships to those directly sponsored by industry contracts), we plan to make additional changes to cut costs. Preserving the high quality and affordability of the Precambrian field camp is a paramount goal of the PRC as we move through this rough patch. Developing an affordable field camp that teaches students the special skills required to map geologically and logistically challenging Precambrian terrains of the Canadian Shield is why the Precambrian Research Center was created in 2007. The PRC will maintain running the “most unique field camp in North America.” As we seek to keep the quality and effectiveness of the field camp intact, we nevertheless will constantly evaluate where we can save costs without compromising quality. Currently, tuition and fees paid by the students cover about 60% of the actual costs of field camp. Perhaps the hardest cuts to make as we try to achieve fiscal balance are those that directly affect students. It is because of these hard cuts, which directly impact student research that is worthy of support, that we intend to redouble our efforts to raise funds for student research when this economic downturn reverses.

So while we hunker down to preserve what is best about the PRC programs, we can take a page from Charles Darwin. We will prepare to adapt and adjust to the new realities, so that when the recovery comes, and the new niches reveal themselves, we will be poised to take full advantage of them and prosper. We will survive because we will be the fittest.