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**P r e c a m b r i a n
R e s e a r c h C e n t e r**

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

Just over three years after establishing the Precambrian Research Center (PRC), we're happy to report that we are gaining a nationwide reputation as a leader in field-based geological educational programs. Over the past year, we gave presentations at many regional and national meetings and our center was mentioned in several research articles discussing new field-based educational programs. We are now drawing field camp students from all regions of the United States, as well as workshop participants from all over the globe. It has been great to see how our ideas for developing better field mappers, concentrating in mineral-rich Precambrian terranes, have been received by industry, government and academia.

2009 began under a cloud of economic uncertainty and diminished mineral exploration activity worldwide. By the end of the year, increased consumer confidence and demand had produced significant rebounds in (and in some cases, record) metal prices, and exploration activities once again began to expand. Based on the number of student recommendation requests we've recently received from industry, it is apparent that our field-savvy students are once again in high demand. With this in mind, we will continue to provide education, training, and support in field studies for the next generation of geoscientists.

During 2009 we continued to develop and improve upon our five basic programs. The centerpiece of the PRC programs, the Precambrian field camp, was once again a great success! For the first time, our field course was filled to its maximum of 20 students. It's clear that our talks at local universities and colleges, our

presentations at regional and national meetings, our field camp posters (which are sent to all geosciences programs in the U.S. and Canada), and word of mouth from field camp alumni are getting the word out on our program. Our students this year came from across the United States, including New England, the middle Atlantic States, the deep south, the Pacific northwest, as well as the Midwest. It seemed like it took only moments for this talented group to mesh into a highly-tuned working machine focused on understanding field mapping and field geology...they were a pleasure to work with! As one student put it "I have so much left to learn (about field geology), but I think I have the tools now to start." Their capstone maps (featured on the back cover) are testaments to their hard work and emerging field and map-making skills.

In addition to a full field camp, the PRC had two other noteworthy accomplishments in 2009. The first occurred in May when the PRC hosted the 55th Annual Institute on Lake Superior Geology meeting in Ely, Minnesota. Seven field trips and a two day-long technical meeting were attended by 235 participants. Most were witness to great field trips, outstanding oral and poster presentations by professionals and students alike, and an exceptionally informative and humorous banquet presentation by Dr. Marvin Marshak of the Physics Department at the University of Minnesota. In October, the PRC conducted its third professional workshop "Field, Petrographic, and Mineralization Characteristics of Mafic Layered Intrusions." Jim Miller coordinated this workshop which



included numerous presentations on, and virtual field trips of, classic mafic layered intrusions throughout the world. In addition, several field trips investigated the features of several Duluth Complex intrusions. Nine instructors, 21 geosciences professionals, and two graduate students participated in this six-day long workshop (described in more detail on page 10).

With the field camp running ever more smoothly, and as we gained further experience running professional workshops, we've had time to reflect on how we can improve our established programs. In December, the field camp faculty got together and offered suggestions for improving field camp logistics and field camp mapping exercises. Over the next few months we'll be implementing these changes and developing mapping projects in areas we have never mapped in detail. Another major implementation was increasing the number of individuals on our PRC Board of Advisors (see page 11). We are looking forward to fresh ideas and suggestions from our newly expanded board during our Board Meeting at the 2010 Prospector and Developers Association of Canada (PDAC) Meeting.

Another welcome change to the management of the PRC, which occurred this past November, is that George Hudak has joined the Economic Geology Group at the UMD Natural Resources Research Institute. As part of this appointment, George will devote a quarter-time to PRC activities. With the three PRC directors now living and working in the same location, it provides us with greater opportunity for improved collaboration as we move forward with our programs.

We continued our commitment to outreach activities by agreeing to take on leading roles in education and mentoring to the public and K-12 educators. As reported on page 12, the PRC is planning to take a major role in managing the very popular Minnesota Minerals Education Workshop for K-12 earth science teachers. The MMEW is a 3-day workshop that has been held each summer for the past 12 years and has attracted 50-90 teachers. The Geologic Maps course at UMD (Geol 3000) continues to be a success, and has clearly been influencing many students to pursue field-based geological studies and research projects. In addition, PRC faculty are serving as advisors or co-advisors for 10 current M.S. graduate students.

One disappointment from the past year has been the decline in fundraising through corporate and individual memberships. Clearly, this was caused in part from the tough economic times over the past year. Nevertheless, donations from our members totaled over \$41,000, which continued to allow the PRC to provide both undergraduate and graduate students with research scholarships for their projects in Precambrian terranes. We intend to redouble our fundraising efforts in the coming year now that the minerals industry appears to be rebounding.

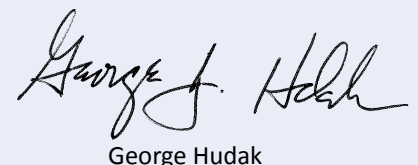
Looking forward to this coming year, we've already been contacted by a large number of students about the summer 2010 field camp. We expect to once again reach the enrollment capacity of 20 students. The PRC will continue to participate in the development of the new Mining and Mineral Exploration options in the Geology Department at the University of Minnesota Duluth, and look forward to

its implementation in the coming year. We are also looking forward to putting on our fourth professional workshop in October, 2010. With significant input from both industry and academia, and with an exceptional line-up of expert instructors, this week-long field- and laboratory-based workshop on the geology and genesis of Precambrian iron formations should be both educational and exciting for all involved. We look forward to adding new corporate and individual members, as well as applying for grants to various organizations for developing new and creative means of teaching field geology and researching Precambrian rocks. And we are especially looking forward to establishing educational programs and research projects with our Canadian colleagues to the north!

We're looking forward to another great year – in the meantime, get involved in one of the PRC's programs to get first word on our news!



Jim Miller



George Hudak



Dean Peterson

Precambrian Field Camp

The third Precambrian Research Center Field Camp took place between July 5 and August 15, 2008. It was attended by 20 students from 18 different universities throughout the United States (see the following page). In addition to the PRC directors, instructors for the 2009 camp included Terry Boerboom (MN Geological Survey), John Goodge (UMD), Mark Jirsa (MN Geological Survey), Phil Larson (Cliffs Natural Resources), Marsha Patelke (NRRI-UMD), and Mark Severson (NRRI-UMD). Steve Hoagland (an alumnus of the inaugural 2007 PRC field camp and current Master's degree candidate at UMD) and Eric Stifter (an alumnus of the 2008 PRC field camp) served as teaching assistants for the field course.

Several small but significant changes were made to the 2009 curriculum based on student feedback and our experiences during the 2007 and 2008 field camps. The geophysics exercise (magnetics) and the greenstone mapping project were modified and several new capstone areas across northeastern Minnesota were selected. PRC faculty agreed to start field camp one week earlier in July to ensure that the students could stay in the UMD dorms during the final week of the camp. With another year of experience under our belts, we had a much better feeling for what both students and faculty could expect to accomplish during the intensive six-week-long field camp.

As in the past, the 2009 field camp included geological mapping at a wide variety of scales (1:250 to 1:24,000) and in a wide variety of Proterozoic and Archean terranes in northeastern Minnesota. We continued to focus on training students in fundamental mapping skills taught at most field camps, as well as specialized skills necessary to effectively and efficiently map in glaciated Precambrian shield terranes. Such skills included core logging, surficial (glacial) mapping, mineral prospecting techniques, underground (drift) mapping, magnetic and gravity geophysical

surveying, metamorphic grade recognition and description, identification and interpretation of polyphase deformational structures and fabrics, recognition of economic mineralization and associated alteration, and bush and lake navigation techniques, logistics, and safety. The last week focused on transforming field data into high quality geological maps and professional presentations using various computer software programs, including ArcView, Microsoft Excel, Microsoft Word, Microsoft PowerPoint, Adobe Illustrator, Adobe Photoshop, AutoCAD and Surfer.

Students once again participated in eight mapping exercises over the first four weeks of the camp. While in the Duluth area during the first two weeks of the camp, students completed mapping exercises at Thomson Dam, Spirit Mountain, and along the Lake Superior shoreline near Finland, as well as a gravity and magnetic survey near Duluth. With the third and fourth weeks of the camp based out of Vermilion Community College in Ely, students participated in several projects within the Biwabik Iron Formation along the Mesabi Range, the Cu-Ni-PGE mineralized zone at the basal contact of the Duluth Complex underground mapping at Soudan Mine State Park, and within the Neoproterozoic Vermilion Greenstone Belt. During the fifth week, students and faculty dispersed across northeastern Minnesota, mostly into the Boundary Water Canoe Area Wilderness, to conduct five capstone mapping projects. After returning to Duluth (and taking well-needed showers), students worked at digitally compiling their capstone field data and constructing geologic maps in the UMD Geology Department computer lab.

Five geological maps were produced from this year's capstone projects. On the final day of field camp, the students summarized their capstone mapping results by displaying their maps and giving PowerPoint presentations to the PRC faculty, industry geologists, government geologists, and other invited guests.

The capstone project maps (which are illustrated on the back cover of this annual report) and associated PowerPoint presentations can be downloaded at the PRC website:
www.d.umn.edu/prc/fieldcamp

The success of our program has always been measured by the success of our students. Of our 2007 students, several remain employed in the mineral exploration industry, several have recently completed, or are in the final stages of completing, their M.S. degrees, and at least one continues to pursue his Ph.D.. From our 2008 field camp, one student is completing his Master's degree in economic geology, one is completing his first year of his Master's degree program at the University of Minnesota Duluth, another is starting her Master's Degree program at Lakehead University (Thunder Bay, Ontario), and several are applying for admittance into Master's degrees programs at various prestigious universities in the United States .

Our 2009 field camp alumni have continued our previous classes' tradition of excelling in industry and academia. Five students are in master's degree programs (including three students in the Geology Department at UMD, one student in the Geological Sciences program at Colorado School of Mines, and one student in the Department of Earth and Planetary Sciences at Harvard University). One student is currently participating in a study of volcanic features on Mars as part of a NASA geology internship. Several students are currently applying for graduate studies as they complete their undergraduate geology degrees. Most recently, two students were hired as exploration geologists with Duluth Metals, Ltd.

Based on the 10 applications received by the end of January, many students from schools not previously represented in the camp, we are expecting our fourth field camp to be full this summer.



Students



Sam Blakely
U of Puget Sound (WA)



Brooke Fahrenkrog
U of W – Eau Claire



Cara Leithauser
U of MN-Duluth



Lucy Mulvey
U of MN - TC



Aaron Rowland
U of W – Eau Claire



Amy Brown
Sul Ross Univ (TX)



Dan Foley
Gustavus Adolphus (MN)



Aaron Magnuson
Winona St (MN)



Bob Nowak
College of Wooster (PA)



Mike Totenhagen
No Dakota State



Lee Copp
Wayne State (MI)



Penny Greer
U of So. Indiana



Andrew McCarthy
Colby College (ME)



Matt Pendleton
U of MN - TC



Tabitha Watson
Tulane (LA)



Dalyce Creighton
U of W-Milwaukee



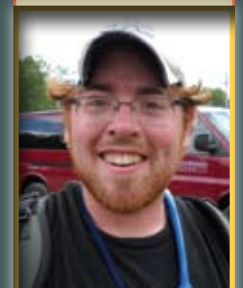
Steven Jaret
U of TN - Knoxville



Kevin McGinn
Temple (PA)



Cabin Ross
St. Thomas (MN)



Joe Zeitler
U of No. Iowa

Field Camp Student Comments

"Thank you so much for setting up this camp. It was a great educational experience that is truly unique!"

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

How did this camp meet your initial expectations?

"Surpassed my expectations by: so many instructors, the quality of information taught, the great accommodations, AWESOME classmates, and the high level of dedication of the instructors."

"I was nervous that I wouldn't have a strong enough background to do what I needed to do, but you guys did an excellent job of walking us through everything."

"The projects were perfectly challenging and expectation of products was realistic and ambitious."

"I knew it would be challenging and it was very much so, but I didn't expect to gain so much and learn as much as I did; I am walking away with a lot of confidence."

"Outstanding information with a highly supportive staff."

"The workload made us focus and brought the group together as one unit very quickly."

"It made me realize that I like mapping a lot more than I initially thought I did."

"This camp was everything I expected and more; it's the faculty that made it."



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

"A true taste of what it is like to be a field mapper."

"This camp will give me an "edge" other undergraduates won't have."

"It provided me with a specific Precambrian-style mapping skill set."

"This experience has definitely given me the confidence to apply anywhere and feel like I could handle whatever they throw at me."

"My mapping skills and confidence in my work has improved exponentially."

"I think I'm far better prepared (for an exploration job) than I had ever dreamed I could be before I took this camp."

Other Comments

"I learned to trust my instincts."

"It was nice how much the instructors gave of their time."

"Ely was amazing and a great opportunity for all of us to become a "family"."

"Every geology student needs to have an experience like this."

"You never know what you'll come across in the field; keep your eyes and notebook open!"

"I have so much left to learn (about field geology), but I think I have the tools now to start."





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 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

Although two students were eligible for a PRC graduate research assistantship for the 2009-10, they chose to accept other assistantship offers. Four eligible students are applying for one assistantship that is being offered to the upcoming 2010-11 academic year.

As reported in last year's annual report, the Precambrian Research Center awarded UMD graduate student **Tom Johnson** with a Graduate Research Assistantship for the 2008-2009 academic year. Tom successfully defended his M.S. thesis in September, which is entitled: *Structural, Kinematic, and Hydrothermal Fluid Investigation of the Murray Shear Zone, Northeastern Minnesota with Implications for Gold Mineralization*. Tom is an alum of the inaugural 2007 Precambrian field camp. He is currently employed with a civil engineering firm in the Duluth area.

Recipient of a 2007-08 graduate assistantship, **Chris White**, is scheduled to defend his M.S. thesis in spring 2010. Chris' thesis is entitled: *Magmatic Evolution and Cu-Ni-PGE Mineralization of the South Kawishiwi Intrusion in the Nokomis Deposit Area, Duluth Complex, Northeastern Minnesota*. Chris is currently employed as a project geologist with an exploration company evaluating titanium resources in the Duluth Complex.

Student Research Grants

The Precambrian Research Center awarded approximately \$4,000 in grants to seven students in 2009 to support their undergraduate or 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 is listed below.

Melissa Hage, University of Tennessee-Knoxville, Ph.D. Candidate
Award: \$1000 for thin sections for Ph.D. thesis
Research Topic: The Effects of Metamorphism on the Petrology and Geochemistry of ~1.9 Ga Gunflint Iron Formation, Minnesota and Ontario

Evan Finnes, University of Minnesota-Twin Cities, M.S. Candidate
Award: \$1000 for thin sections and field expenses
Research Topic: AMS Study of Duluth Complex Igneous Intrusions

Shelby Frost, University of Minnesota Duluth, M.S. Candidate
Award: \$1000 for thin sections
Research Topic: Effects of Contact Metamorphism by the Duluth Complex on Proterozoic Footwall Rocks in Northeastern Minnesota

Dan Costello, University of Minnesota Duluth, M.S. Candidate
Award: \$134 for thin sections
Research Topic: Geology and Petrology of the Tuscarora Intrusion of the Duluth Complex, Gillis Lake 7.5' Quadrangle, Northeastern Minnesota

Eric Stifter, University of Minnesota Duluth, Undergraduate Senior Research Project
Award: \$457 for whole rock analyses
Research Topic: Cyclical Phase Layering in the Duluth Complex at Duluth – Evidence for Periodic Magma Venting from a Shallow Staging Chamber

Ryan Dayton, University of Minnesota Duluth, M.S. Candidate
Award: \$111 for whole rock analyses
Research Topic: Quantifying Assimilation vs. Fractional Crystallization using Sm-Nd, Lu-Hf and Pb isotope systems: The Geochemical Evolution of the Sonju Lake Intrusion, Finland, MN

Workshops



Professional Workshop on Mafic Layered Intrusions October 2009

The Precambrian Research Center successfully conducted its second professional workshop in October, 2009 entitled: "Field, Petrographic, and Mineralization Characteristics of Mafic Layered Intrusions." The workshop was attended by 21 participants, who came mainly from exploration, mining, and geo-engineering companies working in the Lake Superior region. Two graduate students also participated in the workshop. The workshop included lectures on various topics related to mafic intrusions, lab sessions featuring virtual field trips, samples, and thin sections of renowned mafic layered intrusions, and several field trips investigating intrusions of the Duluth Complex. Nine geologists, well known for their work with mafic layered intrusions, served as instructors for the workshop: Roger Cooper (Lamar University, TX), Michael Easton (Ontario Geological Survey), Chusi Li (Indiana University), Bruce Marsh (Johns Hopkins University), Jim Miller (University of Minnesota Duluth), Ed Ripley (Indiana University), James Scoates (University of British Columbia), Jon Scoates (consultant, retired from the Canadian Geological Survey and the Manitoba Geological Survey), and Mark Severson (University of Minnesota Duluth). Dean Rossell of Rio Tinto gave an evening banquet presentation on the Eagle deposit of Upper Michigan during workshop.

Monday, October 5

Lecture 1: Mafic Layered Intrusions: Stratigraphic Nomenclature and Terminology (Scoates and Scoates)
Lecture 2: Layering in Mafic Layered Intrusions: Examples from the Stillwater Complex (Cooper)
Lab 1: Skaergaard Intrusion (Severson and Miller)
Lab 2: Stillwater Complex (Cooper)

Tuesday, October 6

Lecture 3: Genesis of Ni-Cu Sulfide Deposits in Dynamic Magma Conduits: Fundamental Controls and Examples from Noril'sk and Voisey's Bay (Li)
Lecture 4: Sulfide Mineral Assemblages and Textures In Magmatic Cu-Ni-PGE Occurrences (Ripley)
Lecture 5: Deuteric Alteration and Metamorphism of Mafic Layered Intrusions (Easton)
Lab 3: Voisey's Bay (Li and Ripley)
Lab 4: Duke Island (Ripley and Li)
Lab 5: East Bull Lake Intrusive Suite (Easton)

Wednesday, October 7

Field Trip 1 – Igneous Stratigraphy of the Duluth Layered Series (Miller)

Thursday, October 8

Lecture 6: Petrology of Mafic Layered Intrusions and Magma Dynamics (Marsh)
Lecture 7: Geochemistry of Mafic Layered Intrusions (Miller)
Lab 6: Ferrar Sills (Marsh)
Lab 7: Bird River and Fox River Sills (Scoates and Scoates)

Friday, October 9

Field Trip 2 – Investigation of the Cu-Ni-PGE-Mineralized Partridge River Intrusion in Drill Core (Severson)

Saturday, October 10

Field Trip 3 – Igneous Stratigraphy of the Sonju Lake Intrusion (Miller)

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

Workshop on Iron Formations Planned for October 2010

The PRC is currently planning to host its third professional workshop next fall with the tentative title of "Geology, Mineralogy, and Genesis of Precambrian Iron Formations" Check the PRC website for details and updates.



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 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.

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. Previous meetings were held in conjunction with the Institute on Lake Superior Geology meetings, which unfortunately, few advisors were able to attend. The first board meeting in Toronto will be held on March 8th, 2010 with the majority of our 14 advisors expected to be 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**, Senior Geologist, U.S. Geological Survey - Reston
- Canadian Survey Position* - **Greg Stott**, Chief Geologist, Ontario Geological Survey
- First Academic Position* - **Harold Gibson**, Prof, Director-Minerals Exploration Rsrch Centre, Laurentian Univ
- Second Academic Position* - **Mark Hannington**, Prof, Goldcorp Chair in Economic Geology, Univ 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* - **Alar Soever**, President and Director, Wallbridge Mining Company Ltd.
- Third Industry Position* - **Ron Graber**, General Manager - Resource Technology, Cliffs Natural Resources

Former PRC Board of Advisor Members

- 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)

Principal Instructors:

- George Hudak**
Dept. of Geology
Univ of Wisconsin Oshkosh
- Jim Miller**
Dept. of Geological Sciences
Univ of Minnesota Duluth
- Dean Peterson**
Natural Resources Research Institute
Univ of Minnesota Duluth

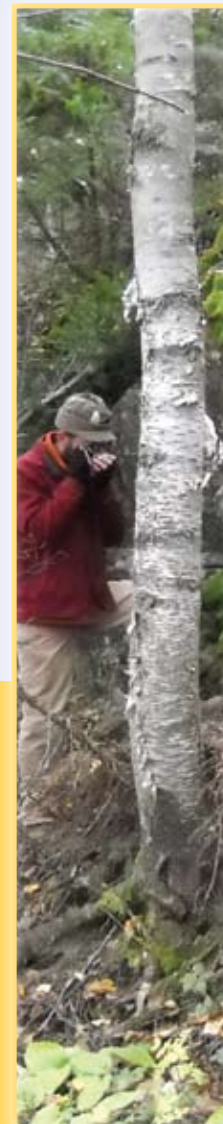
Associate Instructors:

- Terry Boerboom**
Minnesota Geological Survey
Univ of Minnesota Twin Cities
- John Goode**
Dept. of Geological Sciences
Univ of Minnesota Duluth
- Mark Jirsa**
Minnesota Geological Survey
Univ of Minnesota Twin Cities
- Phil Larson**
Cliffs Natural Resources
- Marsha Patelke**
Natural Resources Research Institute
Univ of Minnesota Duluth

- Mark Severson**
Natural Resources Research Institute
Univ of Minnesota Duluth
- Nigel Wattus**
Dept. of Geological Sciences
Univ of Minnesota Duluth

Teaching Assistants:

- Steve Hoagland**
Dept. of Geological Sciences
Univ of Minnesota Duluth
- Eric Stifter**
Dept. of Geological Sciences
Univ of Minnesota Duluth



2009 Field
Camp Staff

Other Activities

55th Annual Institute on Lake Superior Geology

The PRC served as organizer and host for the 55th annual Institute on Lake Superior Geology (ILSG), which was held May 5-10, 2009 in Ely, Minnesota. This regional meeting focuses on the geology of the Lake Superior region, in particular the Precambrian. It's held each spring at different locations throughout the region, in both the U.S. and Canada, hosted by various government or academic institutions. With a two-day technical meeting of oral and poster presentations at its core, the great attraction of the ILSG meetings are the multiple pre- and post-meeting field trips that highlight the local geology of the host site. They typically attract a healthy mix of academic, government, and industry geoscientists and are a particularly welcoming venue for geology students to present the results of their research. Visit the ILSG website at: www.lakesuperiorgeology.org

Last year 235 participants attended, making it the third best attended ILSG meeting in its 55 year history. Seven field trips highlighted various aspects of the geology and ore deposits in the Ely area. Most trips were filled to capacity with a cumulative total of 325 field trip attendees. During the two-day technical session, 21 talks and 24 posters were presented. Forty-five geology students attended the meeting with 18 giving oral or poster presentations. More than half of the students received financial aid to defray travel and registration expenses with funds provided by meeting registrants and several corporations and organizations.

The PRC directors served as the main organizing committee. Jim Miller planned meeting and field trip logistics, promotion, fundraising, and registration; George Hudak organized the technical program and managed student travel and

best paper awards; and Dean Peterson compiled the field trip guidebook. Julie Anne Heinz, an executive office administrator at the Natural Resources Research Institute, provided valuable assistance with meeting registration and planning. Jim, George, and Dean also led field trips for the meeting on the following topics:

- "Cu-Ni deposits of the Duluth Complex" co-led by Dean;
- "Tour of the Soudan Mine and Physics Laboratory" co-led by Dean;
- "Architecture of an Archean Greenstone Belt: Stratigraphy, Structure, and Mineralization" co-led by Dean and George; and
- "Geology of the Lake One Troctolite by Canoe" led by Jim.

In addition, Dean Peterson gave an oral presentation at the technical meeting entitled: "The Nokomis Cu-Ni-PGE Deposit, Duluth Complex, Minnesota."

Adding to the exposure the PRC received by organizing the 55th ILSG meeting, all student-generated maps from the 2008 field camp capstone mapping projects were presented as posters at the meeting. These included:

Jirsa, M., Cowan, H., Kowalik, J., and Niedermiller, J.

- *Geologic Mapping of Neoproterozoic Rocks Near Paulsen Lake, Boundary Waters Canoe Area Wilderness, by Students of the Precambrian Research Center's 2008 Field Camp*

Stifter, E., Wartman, J., Gibbons, J., Kane, K., Murphy, L., Carlson, A., Mason, T., Hudak, G. and Peterson, D.

- *Bedrock Geologic Map of the Disappointment and Ima Lakes Area, Lake County, Northeastern Minnesota*

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 last year's annual report, the PRC took the lead in organizing the 12th annual Minnesota Minerals Education Workshop (MMEW) that was held in August, 2008 in Ely. The MMEW is a three-day workshop that offers K-12 earth science teachers educational resources, lesson plans 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 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, ...).

In 2009, however, the workshop had to be cancelled, in part, because the loss of one of its key contributors, the Minnesota Department of Natural Resources. The planning, financial management, and conduct of the workshop had always been run by an ad hoc group of volunteers from various state agencies, universities (especially UMD), industry interests, as well as assistance from K-12 teachers themselves. The loss of the DNR involvement compelled a rethinking of how the MMEW would be managed and sustained going forward.

The remaining stakeholders in the MMEW decided that a more formal organizational structure was needed to keep the popular workshop alive. Consequently, a new non-profit organization was established in mid-2009, called the Minnesota Center for Mineral Resource Education, and PRC directors, Jim Miller and George Hudak, have agreed to serve a three-year term



as workshop planning chairs starting in 2011. The first MMEW meeting to be organized by the PRC is planned for June of 2011. We will report next year on our progress.

PRC promotion

School Visits: Visits to upper Midwest colleges and universities to promotion the 2009 field camp began in the fall of 2008 and continued into 2009 with a visit by Jim Miller to the University of Wisconsin-Eau Claire in February. The visit interested two UWEC students to enroll in the 2009 field camp. This past November, Dean Peterson gave a seminar at the Colorado School of Mines on "The Nokomis Cu-Ni-PGE Deposit, Duluth Complex, Minnesota." In addition, Dean spent the day talking with geology and mining engineering students about the PRC and career prospects in the minerals industry.

Given the full enrollment in last summer's camp and a decrease in outside funding, the directors decided to largely suspend the annual "PRC field camp tour" this past fall and winter. Hopefully, word of mouth and field camp posters that were distributed to all US and Canadian schools in early January will be sufficient advertising to fill the camp again in 2010.

Conference Presentations: The Directors of the PRC routinely give talks at Regional, National, and International meetings related to the importance of field mapping on various scientific matters and promote the PRC. The venues for these talks and presentations in 2009 included:

- Prospectors and Developers Association of Canada
- Society of Mining Engineers, MN Chapter
- Cold Regions Engineering Conference
- U.S. Geologic Survey
- Bureau of Land Management
- American Geophysical Union
- Geological Society of America



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. The minerals industry stands to be the prime beneficiary of the Center's mission to provide training and support to students in modern field methods and map-making, therefore 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
Individual Members			
Tom Gardner	Palladium	September 09	Member since 5/07
Al MacTavish	Nickel	February 09	Member since 4/07
Richard Patelke	Nickel	January 09	Member since 8/07

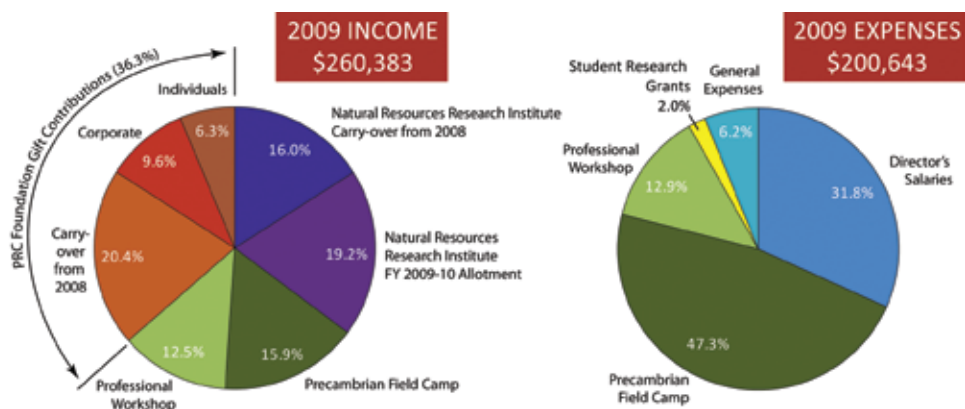
Financial Statement (January - December 2009)

INCOME

Natural Resources Research Institute Allocation		
Carry-over from 2008	41,636	16.0%
FY 2009-10 Allocation	50,000	19.2%
Precambrian Field Camp Tuition (20 students)	41,365	15.9%
Workshop Registration	32,675	12.6%
PRC Foundation Gift Contributions		
Carryover from 2008	53,207	20.4%
2009 Corporate Contributions	25,000	9.6%
2009 Individual Contributions & Anonymous Match	16,500	6.3%
TOTAL INCOME	260,383	

EXPENSES

Directors Salaries (excluding Field Camp)	63,770	31.8%
Precambrian Field Camp	94,825	47.3%
Professional Workshops	25,813	12.9%
Student Assistantships and Grants	3,772	2.0%
General Expenses (Promotion, Travel, Supplies)	12,463	6.2%
TOTAL EXPENSES	200,643	
YEAR END BALANCE	59,740	



Looking Ahead

Despite challenging economic times, diminished opportunities for field geologists in mineral exploration, and fiscal challenges at universities, the Precambrian Research Center did well in 2009. As we look forward to 2010 and beyond, we have gained the confidence that with hard work, good planning, and maintaining our focus on field-oriented geological studies, we can weather severe storms.

As we enter our fourth year, we will continue to focus on what we do best – training geoscientist in modern methods of geological mapping and map-making in the Canadian Shield, as well as providing outreach and promotional activities to foster a better understanding of the unique and complex geological environment in which we live. Utilizing our University of Minnesota Duluth faculty, Natural Resources Research Institute staff, Minnesota Geological Survey scientists, and suggestions from our Board of Advisors, we are pushing ahead with implementing improvements to our current program.

Several items stand out as priorities. We've already received applications for our fourth summer field camp (several months before deadline), and it appears that we will once again have a full course of 20 students from all over North America. Several of our field projects will be modified, including a new location for greenstone belt mapping. The new mapping area will have significantly more structural complexity to be more consistent with prospective areas for shear zone hosted mesothermal gold deposits. Five new capstone field areas have been identified that will merge with areas mapped in recent capstone projects to develop new regional perspectives and interpretations. Several projects will be in regions not mapped in detail in recent years. We also hope to complete our



d to 2010

first underground capstone mapping project! Stay tuned....based on our students' previous efforts, these are going to be outstanding contributions to understanding Minnesota's Precambrian geology.

We are also eager to put on our fourth professional workshop "Geology, Mineralogy, and Genesis of Precambrian Iron Formations." Iron formations have provided the foundation of the mineral wealth in the Lake Superior region for well over 100 years. We have lined up an outstanding group of world-renowned experts to lecture on both Archean banded iron formations (BIFs) and Proterozoic granular iron formations (GIFS) including classifications, terminology, tectonic and depositional settings, biological and hydrothermal influences, primary and secondary mineralogy, effects of metamorphism and supergene processes, descriptions of iron formations in the Lake Superior region, and the geometallurgy, geochemistry and economic geology of iron formations. Four full days of field trips to evaluate classic iron formation localities on the Gogebic Range, Mesabi Range, Vermilion Range, and Gunflint ranges are also planned. This should be an exceptional overview of these economically important and incredibly complicated geological systems, and will be of value to exploration and mining geologists of all abilities and experience levels. More information about the workshop can be found at www.d.umn.edu/prc/workshops. Plans are already in the works to put on another iron formation workshop in 2011 that will focus on ore processing and metallurgy .

We are also excited about expanding and adding several new members to the PRC Board of Advisors from industry,

government, and academia. We look forward to their suggestions and contributions in the coming year. Several hail from prestigious academic institutions and government agencies in Canada -- it's only appropriate since we're focusing our studies on the Canadian Shield. We are looking forward to planning and developing new cross-border partnerships for both teaching and research with well regarded institutions such as the Mineral Exploration Research Centre (Laurentian University, Sudbury, Ontario) and the Canadian Shield Research Institute (University of Ottawa, Ottawa, Ontario). This will allow students and professionals alike further opportunities to experience and understand the wide variety of rocks and geological processes that formed the core of our North American continent. Partnerships such as those we intend to develop also allow us the opportunity to learn from a larger group of well-seasoned Precambrian geoscientists. We look forward to the opportunity to get rid of the many "border faults" on our geological maps!

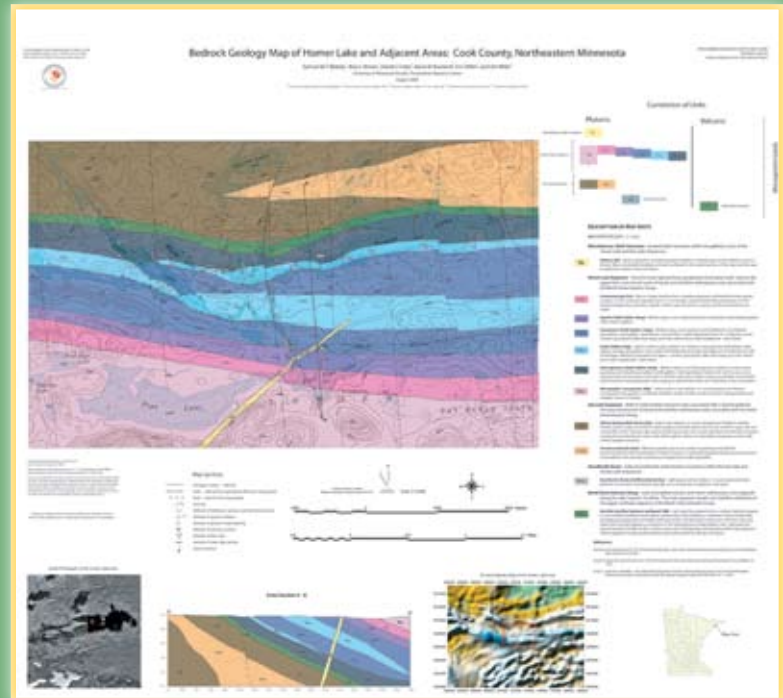
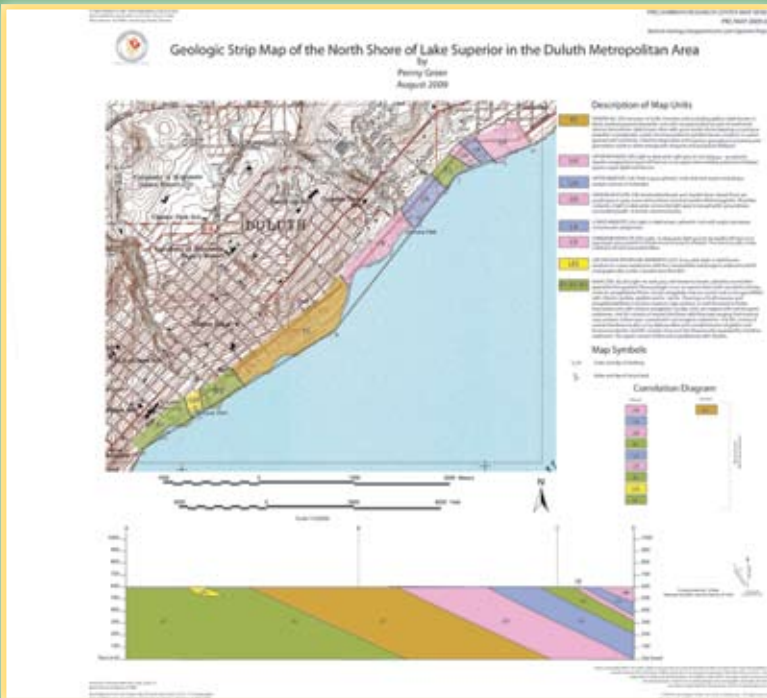
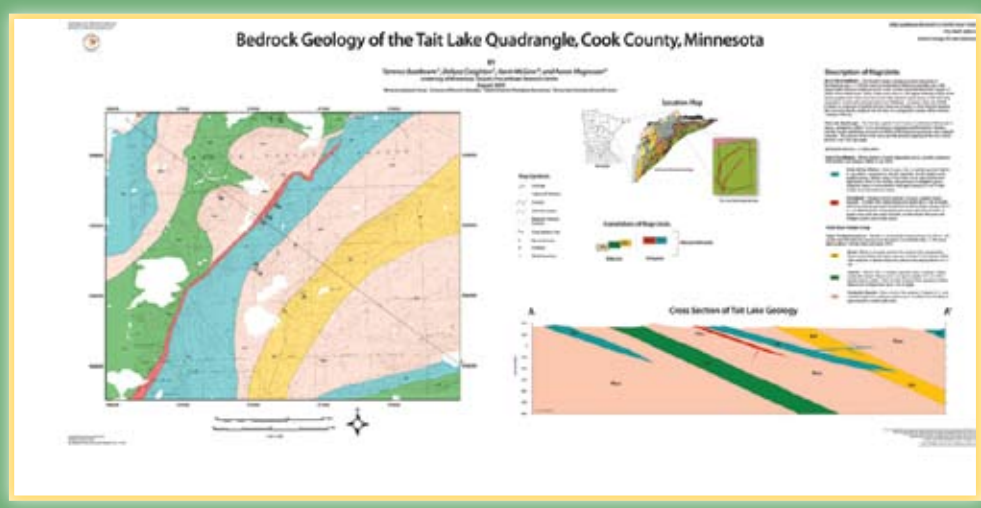
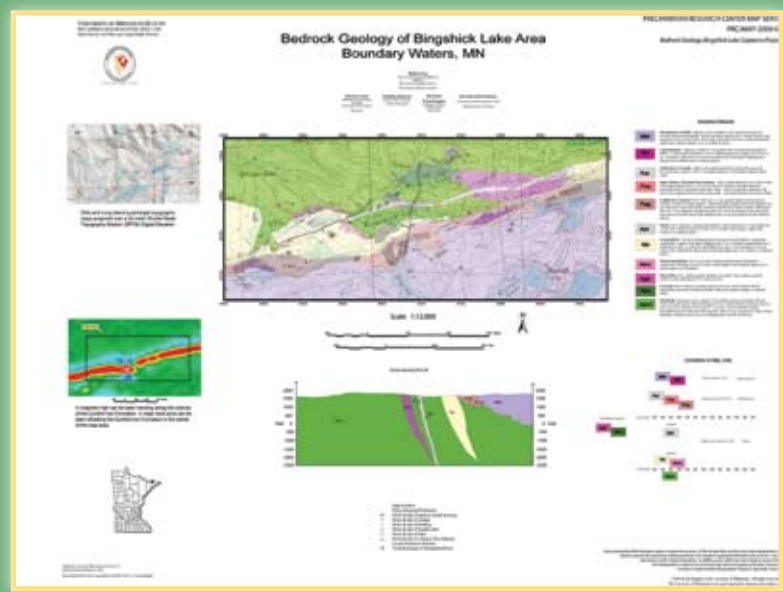
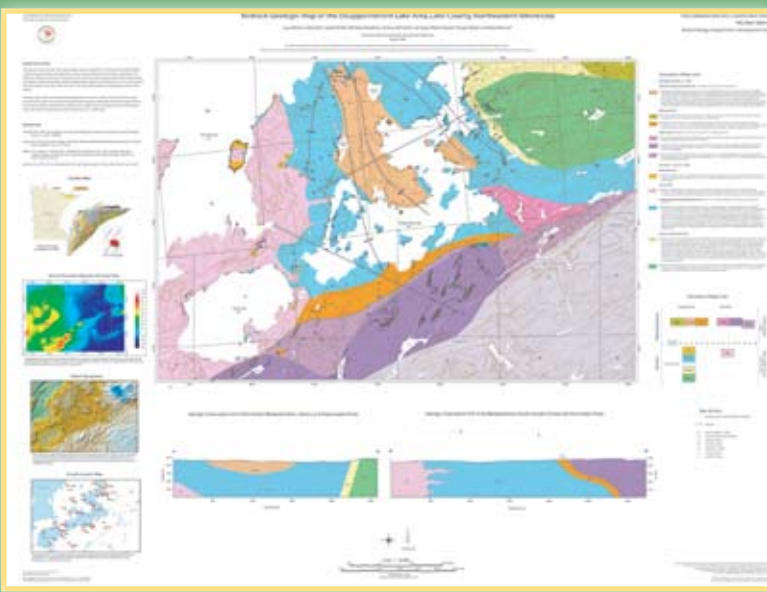
Perhaps our hardest challenge is to develop new and creative ways of financing our PRC activities. Let us first say that we are extremely grateful to the Natural Resources Research Institute for providing the PRC with a baseline of funding. And in spite of the poor economic conditions of the past year, we have continued to obtain significant financial support from both industry and individual members. The support that we've received from Anglo American PLC, Newmont Mining Corp, and Cliffs Natural Resources, as well as contributions from Tom Gardner, Al MacTavish, and Richard Patelke has enabled us to offer a significant

number of student research grants and keep field camp costs down. We can't thank our current and past members enough for their vital support. Over the coming year, we will work aggressively to solicit tax-deductible membership contributions from the minerals industry and individuals, with the goal of raising at least \$100,000. This level of support will be enable us to continue to subsidize about half the costs of our field camp (~\$40,000), provide two graduate research assistantships for the 2010-2011 academic year (\$56,000), and offer a number of student research grants (\$1,000 each). We are also planning on submitting grant proposals to various professional organizations and government funding agencies to enable us continued success in developing our programs.

As we have done since the inception of the PRC over four years ago, we continue to look forward to hearing from our ever-growing list of PRC alumni. We take great pride in hearing the many success stories our students have shared, and we look forward to even better stories as our former students become established geosciences professionals.

In closing, as we strive for a "green economy," it will be vital that geoscientists have extensive knowledge of Precambrian rocks...after all, Precambrian rocks hold much of the mineral wealth necessary to make the "green economy" a reality. Once again, all of us at the Precambrian Research Center look forward to doing our share to educate the current and future generation of Precambrian field geologists, as well as the public, on the importance and beauty of Precambrian geological systems.

Here's to an exciting and successful 2010!



www.d.umn.edu/prc

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