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

PRECAMBRIAN RESEARCH CENTER PROFESSIONAL WORKSHOP SERIES

***Short Course & Field Investigations of Physical Volcanology,
Structural Geology, and Hydrothermal Alteration***

associated with

VMS and Lode Gold Deposits in Archean Greenstone Belts

October 5 – October 12, 2008

***University of Minnesota Duluth
Duluth, Minnesota***

Sponsored by:
**Precambrian Research Center
Department of Geological Sciences
Natural Resources Research Institute**

www.d.umn.edu/prc/workshops

About the Workshop

The workshop is designed for professional geologists and graduate students working with and/or interested in hydrothermally altered and/or metamorphosed Precambrian volcanic rocks associated with submarine volcanic-associated mineralization, as well as structurally deformed and hydrothermally altered rocks associated with mesothermal-type lode gold deposits. Emphasis will be placed on the physical and field characteristics of rocks associated with these deposits, as well as the theoretical concepts associated with the genesis of these ore systems.

The workshop will lead off with an informal icebreaker and lecture on the evening of October 5. A two-and-one-half-day long short course involving lectures and labs will be conducted in the Department of Geological Sciences at the University of Minnesota Duluth on October 6 - 8. Three days of field investigation in the Sturgeon Lake area (northwestern Ontario VMS), the Rainy River area (northwestern Ontario gold), and the Western Vermilion district (northern Minnesota VMS and gold) concludes the workshop on October 9 -11. Participants will return to Duluth the morning of Sunday, October 12.

Workshop Instructors

- **Ron Morton** - Professor, Dept. of Geological Sciences, University of Minnesota Duluth
Research Interests: Physical volcanology, volcanogenic massive sulfide VMS mineralization, and hydrothermal alteration of greenstone belts in northwestern Ontario and northern Minnesota.
- **George Hudak** - Associate Professor, Dept. of Geology, University of Wisconsin Oshkosh
Research Interests: Field-based volcanic facies and hydrothermal alteration mineral facies mapping associated with Neoproterozoic VMS and epithermal gold deposits; variations in mineral chemistry across ancient submarine hydrothermal alteration zones; geochemistry of Precambrian volcanic rocks and associated hydrothermal alteration zones, and mineralization.
- **Dean Peterson** – Senior Research Associate, Natural Resources Research Institute, UMD
Research Interests: Economic geology, geological mapping, Precambrian geology, mineral potential modeling, and three-dimensional modeling of ore systems including mesothermal-gold, epithermal-gold, volcanogenic massive sulfide, copper-nickel-PGE in the Duluth Complex, high-grade copper-PGE veins beneath the Sudbury Igneous Complex, and copper-gold-molybdenum porphyry deposits.
- **Harold Gibson** – Director, Mineral Exploration Research Centre, Laurentian University, Sudbury, ON
Research Interests: submarine volcanic processes and deposits, impact structures and breccias, hydrothermal alteration and fluid characteristics, volcanogenic massive sulphide (VMS) deposits, epithermal precious metal deposits, mesothermal gold deposits, Ni-Cu-PGE deposits, and diamonds.

Short Course (Sunday, October 5 – Wednesday, October 8)

Three days of instruction will involve lectures and laboratory sessions on the topics listed below. Study materials will include lecture notes, hand specimens, thin sections, and chemical analyses of a variety of altered and metamorphosed volcanic, volcanoclastic, and epiclastic rocks associated with VMS mineralization, as well as structurally deformed and altered supracrustal and intrusive rocks associated with Precambrian lode gold deposits. Numerous classic mineralized regions will be discussed during the course and showcased in the labs, including:

Noranda, Quebec	Timmins, Ontario	Kirkland Lake, Ontario
Winston Lake, Ontario	Sturgeon Lake, Ontario	Snow Lake, Manitoba
Kuroko, Japan	Flin Flon, Manitoba	Wawa, Ontario
Vermilion District, Minnesota	Hemlo, Ontario	Kirkland Lake, Ontario
Bousquet, Quebec		

Participants will receive a short course volume that will include lecture and lab notes and pertinent background information and articles.

Sunday, October 5: Icebreaker and Introductory Lecture (Morton, Hudak, Gibson, Peterson)

Lecture: Introduction to short course and field trips; components of submarine volcanic centers and recognition of synvolcanic structures and synvolcanic intrusions

Monday, October 6: Physical Volcanology, Alteration & Geochemistry of Submarine Lava Flows (Gibson, Morton, Hudak)

Lectures: Components of submarine volcanic centers; submarine mafic and felsic lavas – physical volcanology, geochemistry and hydrothermal alteration

Lab: Physical characteristics of submarine lavas; physical and mineralogical characteristics of hydrothermally altered submarine lavas in VMS mineralizing systems

Tuesday, October 7: Physical Volcanology, Alteration & Geochemistry of Submarine Volcaniclastic and Epiclastic Rocks (Morton and Hudak)

Lectures: Eruptive processes, depositional mechanisms, and physical characteristics of submarine volcaniclastic and epiclastic rocks; submarine calderas and mineralization; hydrothermal alteration of submarine volcaniclastic and epiclastic rocks

Lab: Physical characteristics of mafic, intermediate, and felsic volcaniclastic and epiclastic rocks and peperites; Physical and mineralogical characteristics of hydrothermally altered submarine volcaniclastic and epiclastic rocks and peperites associated with VMS mineralizing systems

Wednesday, October 8: Structural Geology and Alteration Associated with Mesothermal Lode Gold Deposits (Peterson)

Lectures: Introduction to lode gold deposits; description of the lode-gold ore deposit model, structural geology and timing associated with lode gold deposits; alteration associated with lode gold deposits

Lab: Evaluation of geological maps with emphasis on identifying elements that indicate favorable conditions for gold deposition “building geological maps, taking geological maps apart into their basic elements, building new maps of lode gold potential”

Note: Participants will leave UMD at 2:00 pm to travel by bus to Ignace, Ontario

Field Trip (Thursday, October 9 – Sunday, October 12)

A three-day long field trip will investigate the well-preserved, hydrothermally altered and metamorphosed volcanic rocks which host VMS and lode gold deposits within the Wabigoon and Wawa subprovinces of the Superior Province (see figure below). Participants will receive a guidebook for the field trip.

Thursday, October 9

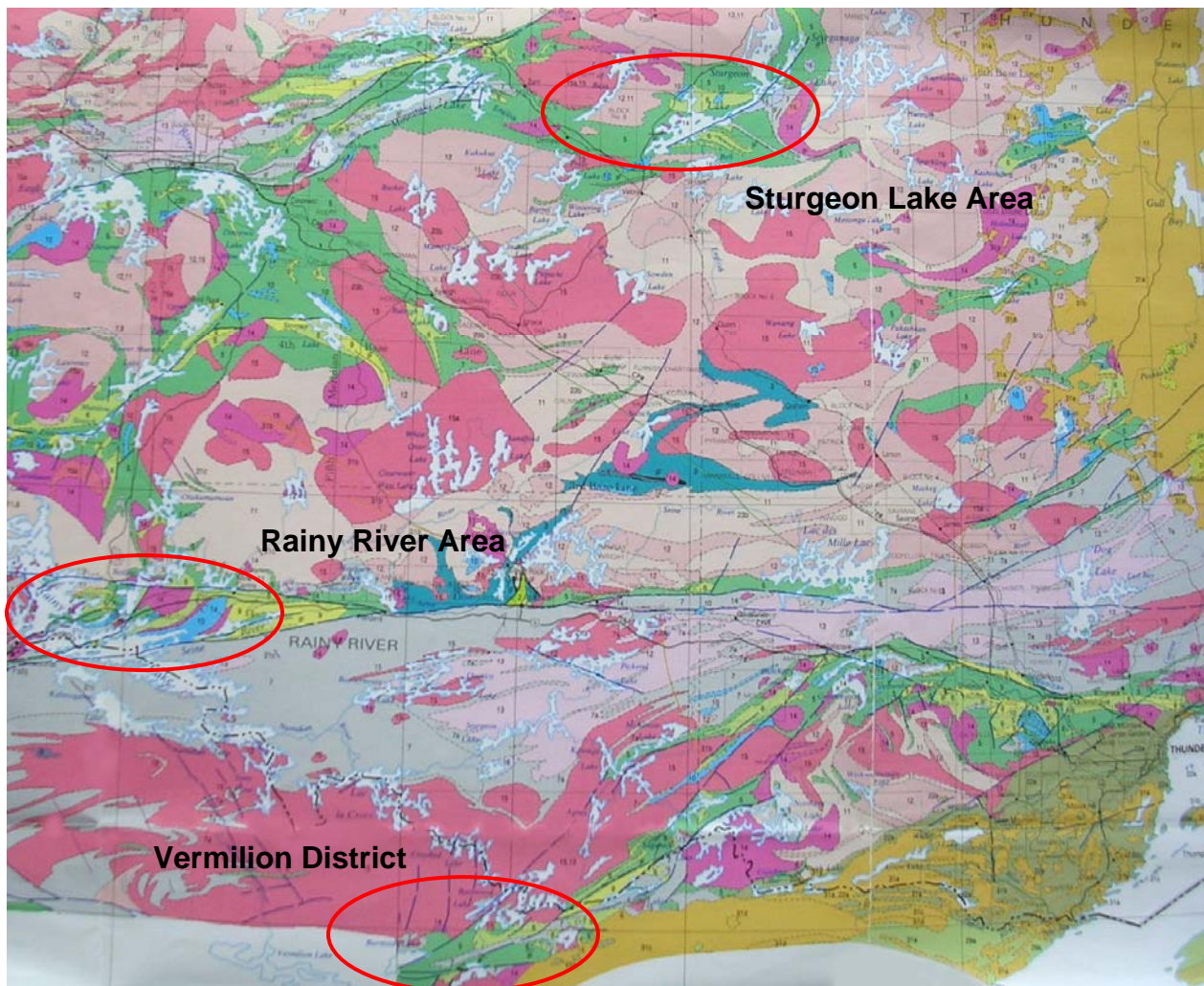
In the Sturgeon Lake area of northwestern Ontario, one of the world's best preserved mineralized Neoproterozoic caldera complexes will be investigated. Features that will be investigated include caldera-collapse associated meso- and megabreccia deposits, voluminous subaqueously deposited felsic tuffs and lapilli tuffs, well preserved mafic-intermediate pillow lavas, pillow breccias, hyaloclastite and peperites, submarine lava domes and dome-associated breccia deposits, and replacement-style volcanogenic massive sulfide mineralization. Additionally, various alteration mineral assemblages and their spatial relationships to synvolcanic fault zones will be observed and evaluated.

Friday, October 10

The second day of the field trip will be devoted to viewing the geologic setting lode gold deposits within poorly exposed rocks of the Rainy River district of the Wabigoon Subprovince. Due to thick overburden cover and a paucity of outcrop, much of the geological interpretation of the Rainy River area has been based on the aeromagnetic data, geological mapping, and rotation drilling carried out in the late 1980's by the Ontario Geological Survey (OGS), and on data collected from over 700 reverse circulation drill hole completed by Nuinsco Resources Limited between 1994 and 1999. The OGS program resulted in the discovery of a high level of pristine gold grains in Richardson Township. The trip intends to view the products of an advanced exploration program by Rainy River Resources in Richardson Township.

Saturday, October 11

In the Vermilion District of northeastern Minnesota, a Neoproterozoic, mafic-intermediate, lava flow-dominated submarine volcanic sequence will be studied. Geological studies suggest that this succession is representative of a submarine succession deposited in increasingly deeper water during the transition from an arc to back-arc environment. As such, field evidence for evaluating ancient water depth interpretations (flow facies, volcanoclastic strata, alteration and mineralization styles) will be discussed. Field trip stops will evaluate exceptionally well-preserved pillow lavas, sheet flows, peperites base-metal enriched exhalites and Algoma-type iron formations. Additionally, regionally extensive semi-conformable (quartz-epidote) and localized disconformable (chlorite-sericite) alteration zones will be visited. The well-exposed Mud Creek Road area of the Vermilion hosts several of the classic styles of lode gold mineralization, including: 1) pyritic shear zones, 2) auriferous quartz-carbonate veins in felsic intrusive rocks, and 3) sulfidized iron formation. The Mud Creek Shear Zone is analogous to classic major shear zones in Ontario (Destor-Porcupine, Kirkland Lake-Cadillac Break). The field trip will investigate all of these features and how they are interrelated.



Portion of the Bedrock Geology of Ontario map (OGS Map 2542) showing the field trip area locations.

Travel to Canada

To avoid any complication at the U.S.-Canadian border, all participants are required to carry a valid passport during the field trip. According to the Western Hemisphere Travel Initiatives ([WHTI](#)) regulations from the US Homeland Security Department, US-Canadian border crossings by land require US and Canadian citizens to present a government-issued photo ID, such as a driver's license, **along with** proof of citizenship, such as a passport, birth certificate, or naturalization certificate.

Workshop Schedule

Sunday, Oct. 5 - Participants arrive in Duluth; check in to hotels; reception and introductory lectures

18:00-21:00 Welcoming Reception at the Inn on Lake Superior (Hors d'oeuvres provided, cash bar)
Introductory Lecture

Monday, Oct. 6 – Physical Volcanology/Alteration of Lava Flows & Associated VMS Mineralization

7:45-8:00 Participants transported by van from hotels to UMD
8:00-12:30 Lectures and Lab – Submarine Mafic and Felsic Lava Flows and VMS
12:30-13:30 Lunch break (UMD dining center)
13:30-16:30 Lectures and Lab – Alteration of Submarine Lava Flows and Mineralization
16:30 Participants transported by vans back to hotels

Tuesday, Oct. 7 – Physical Volcanology/Alteration of Volcaniclastic Rocks & Associated VMS Mineralization

7:45-8:00 Participants transported by van from hotels to UMD
8:00-12:00 Lectures and Labs – Submarine Volcaniclastic Rocks and VMS
12:00-13:00 Lunch break (UMD dining center)
13:00 -17:00 Lectures and Lab – Alteration of Submarine Volcaniclastic Rocks and Mineralization
17:00 Participants transported by vans back to hotels
18:00 Banquet at North Shore restaurant

Wednesday, Oct. 8 – Structure, Alteration, and Mineralization Associated with Lode Gold Deposits

7:45-8:00 Participants transported by van from hotels to UMD
8:00-13:00 Lectures and Lab – Lode Gold Deposits
13:00-14:00 Lunch break (UMD dining center)
14:00 Participants load busses
18:00-19:00 Dinner* in Thunder Bay, Ontario
22:00 Check in to Silver Dollar bunkhouses, Sturgeon Lake, Ont.

Thursday, Oct. 9 – Field Trip: Day 1 – Sturgeon Lake VMS Field Trip

7:00 – 8:00 Breakfast (provided)
8:00-16:00 Sturgeon Lake Field Trip (lunch provided)
16:00-18:00 Drive to Dryden, Ontario
18:00-19:00 Dinner* at Dryden Restaurant
19:00-21:00 Drive to Fort Francis, Ontario: check in to Fort Francis motel

Friday, Oct. 10 – Field Trip: Day 2 –Rainy River Gold Field Trip

7:00 – 8:00 Continental Breakfast at Fort Francis motel
9:00-16:00 Rainy River area field trip (lunch provided)
16:00-18:30 Drive to Lake Vermilion, check in at Fortune Bay Casino Hotel
18:30-19:30 Dinner* at Fortune Bay Casino Hotel

Saturday, Oct. 11 – Field Trip: Day 3 – Vermilion District VMS and Gold Field Trip

7:00-8:00 Breakfast at Fortune Bay (provided)
8:00-9:00 Overview lecture on Vermilion District geology
9:00-17:30 Vermilion District field trip (lunch provided)
18:30-20:00 Banquet dinner at Fortune Bay Casino Hotel

Sunday, Oct. 12 – Participants leave Fortune Bay Casino Hotel at 7:30 am, arrive in Duluth by 9:30 am

* at participants' expense

Registration and Fees

Registration for this hands-on workshop is **limited to 22 participants** with preference given to PRC members*. Three slots at a discounted rate will be reserved for students enrolled in MS or PhD programs (see requirements below). All other participants will be accepted to the workshop on a **first come – first serve basis** contingent upon receipt of the registration form and full payment of the workshop fee.

Total Workshop Fee: **\$1650 USD (\$1100 for Students, limit 3)**

Registration deadline: **September 19, 2008.**

Final Notice of Acceptance: **September 22, 2008**

Cancellation Deadline: **September 29, 2008**

The workshop fee includes:

- Copy of short course volume and field trip guidebook
- Certificate of Attendance indicating contact hours
- Van transport between Downtown Duluth/Canal Park hotels and UMD
- Welcoming reception Sunday evening (10/5)
- Banquet dinner Tuesday evening (10/7)
- Lunches and morning coffee breaks during short course (10/6 – 10/8)
- Four nights lodging during the field trip (10/8 - 10/11)
- Field trip transportation (by mini-coach bus)
- Breakfasts, lunches and refreshments during field trip (10/8 - 10/12)
- Banquet dinner Saturday evening (10/11)

Participants will be responsible for all other meals not indicated above, as well as their hotel accommodations in Duluth and transportation to and from Duluth.

Graduate Student Registrants

Up to three graduate students enrolled in accredited M.S. or Ph.D. programs in Canadian or US colleges during the 2007-2008 academic year may attend the workshop at a discounted registration rate of \$1100. Student registrations must be accompanied by:

- a letter by the student briefly describing how the workshop pertains to their thesis research and their career goals.
- a letter of recommendation from their thesis advisor commenting on the qualifications of the student and the usefulness of this workshop to the student's thesis research.

Students registrations do not initially require payment of fees. If more than 3 students register, the three most qualified students will be chosen and notified by **September 22**. Upon notification of acceptance into the workshop, students will be expected to pay the registration fee (and tuition costs, if requested) by **September 29**.

College Credits and Tuition

Registrants have the option of receiving 2.5 undergraduate credits from the University of Minnesota Duluth for participating in this workshop and submitting brief reports.

Course Name: GEOL 5095, Sec. 241 - Special Topics: Precambrian Volcanic Rocks, Hydrothermal Alteration, and Associated Mineral Deposits

Instructor of Record: Prof. Ron Morton, UMD Department of Geological Sciences

Tuition Fee: \$233.90 (\$88/credit for tuition; \$5.56/credit for UMD Technology and Services fee)

Requirements: To receive full credit for the course, participants must:

1. Participate in all aspects of the short course and field trip
2. Submit a 2- to 3-page reflection paper on each of the three short course sessions
3. Complete a 2-page summary of the relationship between alteration and mineralization within VMS and lode gold deposits.
4. Complete a course evaluation form

Requirements 2-4 must be submitted to the instructor by December 15, 2008 to receive Fall 08 credit.

Notice of Acceptance and Cancellation Policy

Upon receipt of completed registration form and full payment, a preliminary notice of acceptance will be sent. If the course fills before the registration deadline, you can request to be put on a waiting list and your check held. Because a limited number of PRC members have priority for the course at any time before the registration deadline, it is possible (but unlikely) to be bumped from the workshop by a PRC member, especially for late registrants. A final notice of acceptance to the workshop will be sent by **September 22**.

A full course refund is given if notice of cancellation is received by **September 29**. Our program obligations make it necessary to assess a charge equal to one-half of the course fee for later cancellations. No course refund is possible after the course begins on October 5.

About Duluth

Duluth, the world's largest freshwater inland port, is located at the western tip of Lake Superior, midway between the Twin Cities of Minneapolis / St. Paul and the Canadian border. Nestled in the hills overlooking the largest of the Great Lakes, the city offers breathtaking scenery and serves as the gateway to abundant recreational opportunities

Persons desiring additional information about Duluth can call the Duluth Convention and Visitors Bureau at 1-800-4-DULUTH (438-5884) or visit their website (<http://www.visitduluth.com/>). Persons desiring additional information about Minnesota can call the Minnesota Office of Tourism at 888-TOURISM (868-7476) or visit their website at <http://www.exploreminnesota.com/>.

Air and Ground Transportation to and from Duluth

Daily flights into Duluth International Airport (www.duluthairport.com/) are provided by Northwest Airlines with up eight flights daily arriving from Minneapolis-St. Paul and two from Detroit. Transportation from the airport to area hotels and motels is available by taxi at reasonable rates and some hotels provide shuttle service (check with your hotel). Rental cars may also be obtained at the airport from Alamo, Avis, Budget, Hertz, and National.

If you are flying out of Duluth on Sunday, October 19, we will be returning from the field trip by 9:30 AM and will drop participants off at the airport. This will allow participants to catch nonstop Northwest Airline flights to Minneapolis scheduled to depart at 10:49 AM and 12:40 PM and an early afternoon nonstop flight to Detroit which departs at 1:25 PM.

Hotel Accommodations

Participants are expected to reserve and pay for their own hotel accommodations for the time (3 nights) we will be in Duluth - Sunday night (10/5) thru Wednesday morning (10/8). For ease of collecting and transporting people to and from UMD by van, we request that you book accommodations in one of the Downtown/Canal Park area hotels listed below at least for the first four nights. The locations of these hotels are shown on the map below. The Inn on Lake Superior, the location of the Sunday night reception, has a block of 15 rooms reserved for the workshop at a negotiated rate (\$106 + tax). These rooms will only be held until **September 5** and you must request the "**PRC Workshop**" rate. Rates listed for other hotels are not guaranteed and are subject to change. Be aware that this is "color season" in northern Minnesota and other conference are in town that week, so book your accommodations as soon as possible.

Downtown/Canal Park (see map)

Quoted Rate (Sun-Wed)

Inn on Lake Superior*	218/726-1111	888/668-4352	\$106 (PRC Workshop rate)
Canal Park Lodge	218/279-6000	800/777-8560	\$116 /Cityview
Hampton Inn	218/720-3000	800/426-7866	\$89/Cityview; \$109/Lakeview
The Suites at Waterfront Plaza Hotel	218/727-4663	877/766-2665	\$105 (some restrictions)
Comfort Suites	218/727-1378	800/517-4000	\$134 /Lakeview
Radisson	218/727-8981	800/333-3333	\$71
Holiday Inn	218/722-1202	800/477-7089	\$79

* Rooms blocked for "PRC Workshop" until September 5.

Google Earth Map of the Downtown/Canal Park area of Duluth showing motel locations



For More Information

Questions about registration or accommodations?

Contact **Jim Miller** – 218/720-4355, mille066@umn.edu

Questions about the short course, field trips, or college credits?

Contact **Ron Morton** – 218/726-7218, rmorton@d.umn.edu

or **George Hudak** – 920-424-4463, hudak@uwosh.edu

or **Dean Peterson** – 218-7820-4393, dpeters1@nrri.umn.edu

Registration Form

(Please fill out one form per registrant)

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VMS and Lode Gold Deposits in Archean Greenstone Belts***

University of Minnesota – Duluth

Duluth, Minnesota

October 5 - 12, 2008

Name _____

Affiliation _____

Address _____

City _____ State/Prov _____ Zip/P Code _____ Country _____

Day Phone () _____ FAX No. () _____

E-Mail _____

Check here if this registration is to be applied to a PRC Membership reservation (see www.d.umn.edu/prc/memberships for details)

Indicate Duluth hotel accommodations for October 5 - 8 stay, if known: _____

Registration and Tuition Fees

\$1650 Workshop Fee (professional) _____

\$1100 Workshop Fee (student; must attach recommendation letter) _____

\$234 Tuition (2.5 undergraduate credits; optional) _____

Total Fees _____

Please enclose a check made payable to:

“University of Minnesota Duluth”

Mail Registration Form and Payment to:

Jim Miller, Administrative Director
Precambrian Research Center
Natural Resources Research Institute - UMD
5013 Miller Trunk Highway
Duluth, MN 55811 USA



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