

GEOLOGICAL SOCIETY OF MINNESOTA

NEWS

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Annual Fall Meeting

Monday, September 27, 5 PM
 Old Country Buffet
 3000 White Bear Ave.
 Maplewood, MN
 Need directions? Call (612) 724-2101

INTRODUCING: 1999 - 2000 LECTURE SERIES

EVOLUTION OF PHANEROZOIC LIFE ON EARTH:
 THE LAST 540 MILLION YEARS

In the geologic time scale, four eons are recognized: the Hadean, Archean, Proterozoic, and the Phanerozoic. The Phanerozoic eon encompasses the last 540 million years of the earth's history, and the evolution of life forms, some of which are still living and some which are extinct. If the entire 4.6 billion year lifetime of the earth were compared to a 24-hour day, we could say that the Phanerozoic eon began at approximately 8:20 p.m. with the appearance of the first animals. (Humans appear on the scene at about ten minutes to midnight.)

The first period in the Phanerozoic eon is called the Cambrian, which is known for its abundance of shelled animals, sponges, corals, and trilobites. Beginning with the Cambrian period, the lecture series will explore the origin and evolution of ancient life, and we will also take a look at how plate tectonics influenced these life cycles.

Some life forms have remained almost unchanged for 600 million years. Other organisms, such as trilobites, graptolites, and dinosaurs, that once were incredibly successful in terms of numbers and longevity, have been eliminated from the record and are no longer represented by living forms. To learn more about the extinctions, evolutions, and diversity of life, join us in our tour through the Phantastic Phanerozoic!!

Did you see the '99-'00
 Lecture Schedule?
 Yup. And I've marked all
 18 Events on my calendar.



Announcements

Field Trip # 4: Sept 18th
Leader: Roger Miller from the U of M, will lead a tour with the topic "Geology of the Twin Cities". Watch your mailbox for the next notice.

It's Membership Renewal Time. Send your membership dues to the little address listed at the bottom of the box below.

GSM NEWS

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The purpose of this newsletter is to inform the members and friends of the activities of the Geological Society of Minnesota. *GSM News* is published four times a year: February 15, May 15, August 15, and November 15. It welcomes unsolicited Geology and Earth Science related articles and photographs. Deadline for article submission is three weeks before the date of publication. Send all material for *GSM NEWS* to: Geological Society of Minnesota c/o Katy Paul, 6901 West 84th Street, Bloomington, MN 55438. Phone: as listed above, or e-mail: again, as listed above.

Officers: Sylvia Huppler, *President*; William Robbins, *Vice President*; Bruce Goettelman, *Treasurer*; Jean Hosterman, *Secretary*.

Directors: In addition to the officers listed above; David Christianson; Steve Erickson; Paul Lemke; Marlys Lowe; Gail Marshall.

Send all GSM membership dues, change of address cards, and renewals to the GSM Membership Chair: c/o Bruce Goettelman, 16125 Delarma Drive, Carver, MN 55315. Membership levels are: \$10 for full-time Students, \$20 for Individuals, or \$30 for Families.



GSM Board News

The GSM board met on the afternoon of July 10th at the beautiful lake home of Goldie Johnson. We spent a lovely day there, and after the dinner meeting there were boat rides for those interested.

Bruce Goettelman, Treasurer, announced that the books have been audited; our thanks to Katy Paul. Marlys Lowe announced that the archives are now stored at the Survey. Galen O'Conner said that the last field trip of this summer will be on the geography of the Twin Cities, mostly St. Paul, and will be led by Roger Miller. Judy and her group have plans well in hand for the state fair. Doug Zbikowski reported on Phase two marker sites and the Outreach project. Rick Uthe was not present, since he was out Utah way, making plans for the field trip in 2001.

Sister Joan Kain has secured the rest of her financing for the videotape, "Staking a Claim in Brownstone on the South Shore of Lake Superior" which will be produced from her slide presentation. The slides are of nine cities in Minnesota, Wisconsin, and Michigan, and include the city of Duluth. The GSM had agreed in 1998 to provide \$500 in matching funds, when the rest of her financing was secured. The Northern Great Lakes Museum and Visitor Center in Ashland, Wisconsin is undertaking this project. We will have a copy in our video collection.

A nominating committee of Dwight Robinson, Marlys Lowe, and Judy Hamilton will present nominees for the board at the September banquet meeting, and the members will vote their approval at that time.

I was delighted to receive a call from Kathy Ohler, Department of Geology and Geophysics Administrator at the U. of M., who informed me that we could meet in room B-75 of Amundson Hall for the fall semester. This has been the favorite for many of the lecturers as well as the GSM members. Sign up sheets for committees will be passed around in October and November. Do sign up for your favorite activity of the GSM. The more people on the committee, the better the outcome, and new ideas are always appreciated and needed. The next board meeting will be Saturday, October 9th, at 1:00, at the home of Marlys Lowe. New officers will be elected to serve for one year starting in January.

See you at the State Fair!

Sylvia Huppler, President

Murphy's First Law:

If anything can go wrong, it will — even on a field trip.

Pattie's Premise: The enthusiasm of any one under the age of 18 on a field trip with their parents expires at the beginning of the sixth minute at the site.

GSM Rockers Set New Record!

by Doug Zbikowski

A special "thank you" to Mother Nature for the just-in-time delivery of a heat-wave crushing cold front the night before the GSM rock-box building party! The morning of Saturday, July 31 was actually beautiful. What a change from the over 100 degrees of the day before. It was a great temperature for working . . . and boy, did the rocks fly!

Aside from the recent weather, this year was especially worrisome because the Mn/DOT rock crusher is broken and we were short of sample-sized pieces of several types of rock (including hematite, which is tough to break). Thankfully, our GSM line-up of heavy hitters kept the malls busy. Those major-leaguers were: Bill Robbins, Roger Knutson, Tom Schoenecker, and Steve Erickson. Smashing job guys!

The rest of the team prepared the plastic boxes, and after awhile everyone got a chance to fill the boxes. Margaret Rodina, Katy Paul, Martha Mayou & her husband Dave, Gerry Paul, and the party host Doug Zbikowski helped to keep the production lines moving at record speed. In about four hours, 198 rock boxes were built! With such blazing speed in a construction zone it was no wonder that two Band-Aids were needed!

After the work, there was cold watermelon and homemade pizza to satisfy the hungry troops. Our deepest thanks to this crew for an outstanding performance in GSM's fourth year at building rock boxes for school teachers. Thousands of kids will be turned-on to Minnesota's Geology through this effort. Many thanks!

STATE FAIR BOOTH

The State Fair is getting close! It begins August 26 and runs through Labor Day, September 6. This is our most important event for generating new members. This is where most people first find us, and with their membership, further develop their interest in and knowledge of geology.

This year we have newly painted wall panels (thanks to Paul Lemke), our own rock box and "thin section" slide set, as used in classroom presentations (thanks to Doug Zbikowski) and (hopefully — I'm working on it) a piece of carpeting to make standing in the booth more comfortable.

The public loves our booth because so much of it is hands-on. Last year we gave out 3500 brochures and answered at least twice as many questions.

If you have ideas, please call me (651-699-9812). We'll see if they can be incorporated. In the meantime, if you have not been contacted to work a spot in the booth, please call Alex Lowe (651-451-6853). We need everyone to pitch in for at least one spot. The shifts are divided into 3 shifts a day: 9:00 am - 1:00 pm, 1:00 p.m. - 5:00 p.m., and 5:00 p.m. - 9:00 p.m. with two people working each shift. Thanks in advance.

NOTE: If people ride a Metro Tranist bus to the fair, they will receive a coupon good for \$2 off the admission price.

— Judy Hamilton

GSM Membership Renewal Time

It's renewal time for almost everyone's membership in the GSM. Our membership year begins October 1. For those subscribing after April 1, their membership is graciously extended through Sept. 30 of the following year. If you are not certain of your membership anniversary, check the address label on this newsletter. It has the expiration date printed in the upper corner.

In an effort to both attract new members and encourage existing members to renew, the membership committee has embarked on a bold new venture. As a gift for your new or renewal membership of \$30 or more, plus \$5 postage & handling, we'll send you our new Stearns County Granite Collection.

This set consists of a specimen of the mineral microcline and five granite specimens commonly found in Stearns County, Minnesota. They are packaged with a descriptive key in a handsome, six-compartment, polystyrene box.

Specimens include St. Cloud "red" granite, Reformatory "gray" granodiorite, Rockville granite, Richmond granite, and diabase. Their average size is 2" x 2".

The supply is limited, so renew now!



There's Platinum in Them Thar Hills!

by Jim Miller, Minnesota Geological Survey, 2642 University Avenue W,
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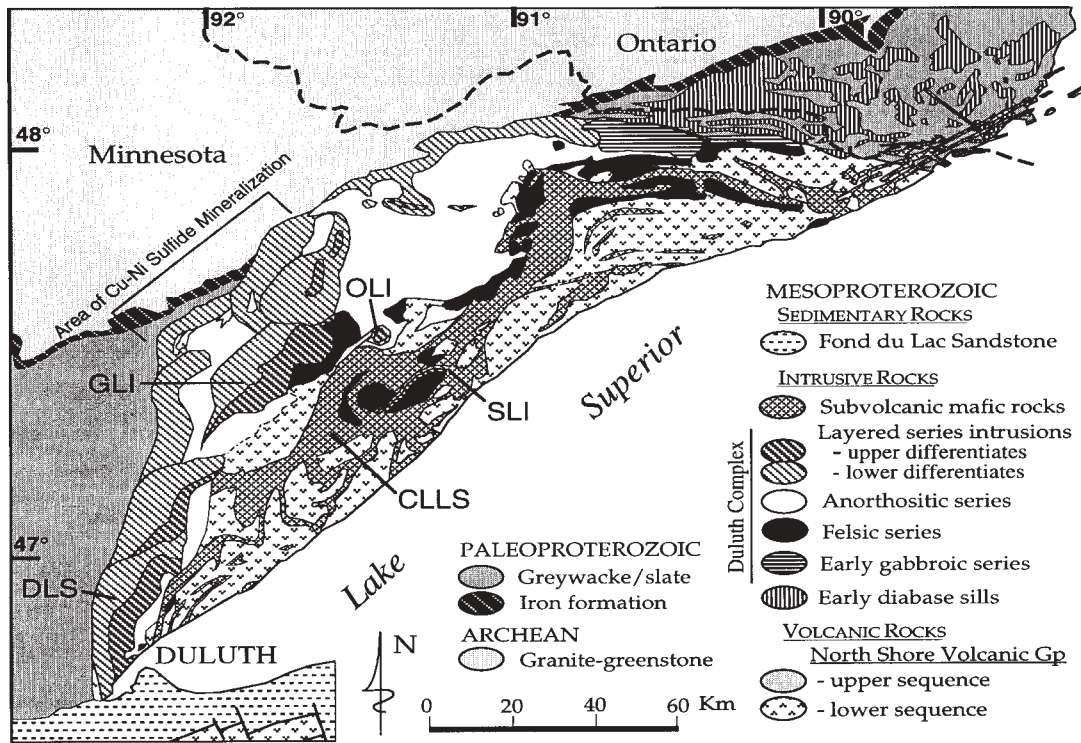
Gold has indeed fallen on hard times. Not only is the gold standard a thing of the past, but countries around the world are selling off their reserves. The new precious metal at the turn of the millennium is platinum and its cousins (palladium, osmium, rhenium, rhodium, and iridium), collectively known as the platinum group elements or PGEs. Demand for PGEs has increased steadily in the past decade. An indication of this can be seen in the doubling of the stock market price of palladium over the past five years (now comparable to platinum in price at ~\$350/oz). The increased demand for PGEs results from their growing use in high-tech electrical applications and in autocatalytic converters. The adoption of stricter air quality standards worldwide has fueled the accelerating need for catalytic converters. Market speculation may also be playing a role because the potential use of fuel cells to power electric cars would further increase demand for PGEs (see article in Nov. 23, 1998 issue of Newsweek). More than 80 percent of the world's demand for PGEs is supplied by only two sources, the Bushveld Complex of South Africa and the Noril'sk district of western Siberia. Access to these resources may hinge on the future political stability of these countries. The only domestic production of PGEs is from the Stillwater Complex in Montana, which supplied about 10 percent of the world's palladium and less than 5 percent platinum and other PGEs in 1997. These facts, together with anticipated shortages in supply in the near future, have revitalized the search for domestic PGE deposits.

PGE deposits are invariably associated with mafic igneous intrusions and are of two general types. In the first type, exemplified by the Noril'sk deposit, the PGEs are associated with high concentrations of copper-nickel (Cu-Ni) sulfides in the margins or feeder zones of mafic intrusions. PGE deposits of the second type are exemplified by the Bushveld and Stillwater complexes, and are termed stratiform PGE deposits or PGE reefs. PGE reefs occur as thin (1-3 m) conformable horizons within layered intrusions. The reefs typically contain minor (<5 percent) sulfide, although some reefs are associated with chromite seams that contain

almost no sulfide (e.g., the UG2 reef in the Bushveld Complex).

Exploration for PGE-reef deposits in Minnesota has concentrated almost exclusively on the northwestern margin of the Duluth Complex (Fig. 1). This is an area of extensive Cu-Ni sulfide mineralization that holds potential for Noril'sk-type PGE deposits. More than 200 km of drill core was acquired during exploration for Cu-Ni sulfide deposits between the 1950's and 1970's. This core is now stored at the DNR core library in Hibbing. Since the 1980's private companies and public agencies, notably the Natural Resources Research Institute (NRRI) have reevaluated this drill core to assess the potential for PGE mineralization. These studies have revealed higher-than-normal concentrations of PGEs, and have, in turn, resulted in new exploration activity in the northwestern part of the Duluth Complex. PGE-reef deposits have not previously been an exploration target in the Duluth Complex and related intrusions of northeastern Minnesota. This is because until recently all known PGE-reef deposits were associated with intrusions such as the Bushveld and Stillwater complexes, that are composed of layered igneous rocks which include a lower ultramafic unit (olivine + pyroxene), and upper mafic unit (pyroxene + plagioclase). The PGE reefs in the Bushveld and Stillwater complexes are located near the transition from ultramafic to mafic rock units.

Intrusions of the Duluth Complex formed from *tholeiitic* magmas, which typically do not produce significant volumes of ultramafic rock. In other words, the Duluth Complex seemed to be the wrong type of layered intrusion to host PGE-reef deposits. This mindset changed significantly, however, with the discovery in 1991 (Bird and others, *Economic Geology*) of a palladium+gold reef in the upper part of the Skaergaard intrusion of East Greenland—the mother of all tholeiitic layered intrusions. Subsequent work has shown that the PGE reef in the Skaergaard, called the Platinova reef,



corresponds to a horizon where iron sulfide became saturated in the silicate magma. When sulfide becomes saturated, it exsolves (unmixes) from the silicate magma as small droplets of Fe-S-O (iron, sulfur and oxygen) liquid, which then settle through the magma because of their higher density. Because PGEs strongly prefer sulfide liquid over silicate magma, the descending droplets of sulfide liquid scavenge metals, including PGEs, from the magma. Although not all geologists agree with this “magmatic” model for the creation of PGE reefs, it seems to explain the Platinoval reef quite well. Based on data from the Skaergaard, and on theoretical considerations of sulfide and PGE behavior in mafic magmas, some general criteria can be used to evaluate the potential for PGE-reef mineralization in tholeiitic intrusions. These are:

- (1) The parent magma is initially sulfide-undersaturated.
- (2) The parent magma has a high initial PGE concentration and/or experiences a considerable amount of fractional crystallization to build up metal concentrations prior to sulfide saturation.

Figure 1. Geology of the Duluth Complex and related Mesoproterozoic rocks of northeastern Minnesota. Intrusions discussed in the text are: DLS-Layered Series at Duluth, SLI-Sonju Lake intrusion, GLI-Greenwood Lake intrusion, CLLS-Cloquet Lake layered series, and OLI-Osier Lake intrusion.

3) The initial segregation of sulfide liquid is triggered by a process that promotes a high silicate/sulfide melt ratio.

At the time of the Platinoval discovery, the Minnesota Geological Survey (MGS) was conducting a mapping project in the Duluth area. Then, between 1993 and 1995, MGS received funding from the State Legislature’s Minerals Coordinating Committee to evaluate the potential for PGE-reef mineralization in the Layered Series at Duluth (DLS, Fig. 1). This study revealed some anomalously high PGE concentrations associated with sulfide mineralization. More significantly, it also showed that the general criteria (above) for PGE reef formation were fulfilled, and that a favorable horizon may occur in the medial part of the DLS. These results, while interesting, were hardly enough to

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convince the State or industry to accept the political risk associated with drilling a test hole in the Spirit Mountain Ski Area near Duluth.

A more fundamental problem with using the DLS as a test case to evaluate the PGE-reef potential of Duluth Complex intrusions, is that it evolved as a fairly complex, open-magmatic system in comparison to the simpler, more closed magma system of the Skaergaard. However, the Sonju Lake intrusion near Finland (Fig. 1) was formed in a simple, closed system, and was targeted as the ideal intrusion in which the potential for PGE deposits could be better evaluated.

This past winter, the MGS was funded by the MCC to conduct a geochemical survey of the Sonju Lake intrusion. The results of this study, which were first reported at the recent ILSG meeting held in Marquette, Michigan this past May (Miller, 1999 ILSG Proceedings), revealed that appreciable PGE-reef mineralization is probably present approximately 800 m above the base of the 1.2-km-thick intrusion. These results show patterns that are remarkably similar to the Skaergaard (Fig. 2) in terms of proportional distance above the base of the intrusion, the gabbroic composition of the host rock, and evidence for the effectiveness of PGE removal from the magma system. Because sample spacing was on a scale of tens of meters for the Sonju Lake intrusion, and a typical PGE reef would be meter-scale in thickness, core drilling and systematic geochemical sampling are necessary to establish the peak grade, thickness, and lateral continuity of the PGE reef. Exploration interest has definitely been piqued by these results and it is likely that such drilling will occur in the near future.

The presence and discovery of horizons favorable for PGE reefs in both the open-system DLS and the closed-system Sonju Lake intrusion opens up all the well-differentiated, Midcontinent Rift-related intrusions in the Lake Superior region as potential targets for this heretofore unexplored type of mineralization. Several poorly exposed intrusions have been identified in a new interpretation of the central Duluth Complex just published by the MGS (Miller and Chandler, 1999, MGS miscellaneous map M-101). These include the Greenwood Lake intrusion and the Osier Lake intrusion, as well as parts of the Cloquet Lake layered series (Fig. 1).

If an economically viable PGE reef is discovered in northern Minnesota in the near future, there is no doubt that a debate will ensue over new mining in northern Minnesota. The debate will be interesting in that one cannot imagine a more environmentally friendly ore deposit. This type of deposit would be mined in an underground operation, and involve a low volume of excavated material. The ore would have a naturally low sulfide content compared with most other metal deposits, thus minimizing sulfur dioxide emission problems related to smelting. And perhaps most significantly, the use of PGEs in catalytic converters would help clean up the air. The more widespread use of platinum-catalyzed fuel cells could eventually make the internal-combustion engine obsolete. Fuel up and stay tuned. ◇

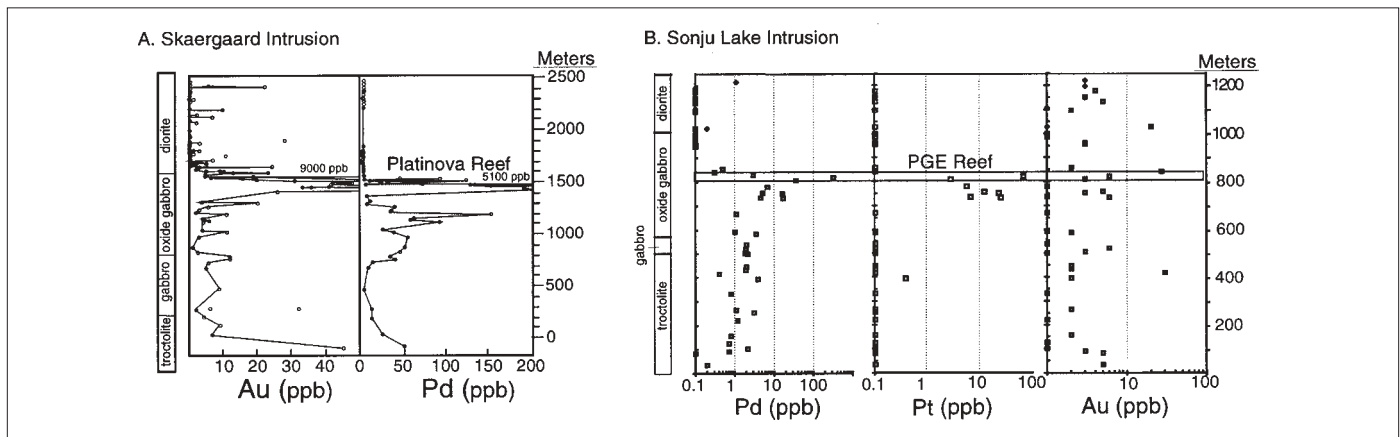


Figure 2. Stratigraphic variations in PGE and Au concentrations in the Skaergaard Intrusion of east Greenland (A) and the Sonju Lake intrusion of northeastern Minnesota (B). Horizontal scale shows concentrations in parts per billion (ppb). Vertical scale shows distance above base of intrusion in meters. Au-gold, Pd-palladium, Pt-platinum.



FALLING ROCK CHANGES HISTORY IN DULUTH

by Doug Zbikowski

Duluth Harbor has served the Upper Midwest as a gateway to world commerce for over a century. In 1955, the Geological Society of Minnesota erected a marker on highway 61 at an observation area named Rest Point, which overlooked the harbor and Lake Superior. The plaque revealed the formation of the Lake Superior basin, mentioned its geologically recent glacial scouring, and described the harbor and Minnesota Point. It stated that the volcanic activity associated with the basin occurred “more than 600 million years ago”. This, of course, is true; but we now can pin it down more closely at 1.1 billion years ago.

At some time along the life of the bronze plaque, road construction took place nearby that involved blasting rock. The construction crew neglected to protect the plaque from the resulting aerial bombardment and falling chunks of rock smashed two

large gouges into the plaque, making the text unreadable in one. Maybe this fallout was an omen from Mother Nature that she wanted a new geological biography.

Later, the damaged plaque was moved a short distance to the (then new) Thompson Hill Travel Information Center (I-35 at Hwy. 2, southwest Duluth). It was mounted on a lakeside balcony overlooking the harbor and the expanse of Lake Superior. This location has proved to be probably our most-read plaque site in the state. During the summertime, travelers are reading it (less gouged text) almost continuously at times. If they ask the staff at the desk why the plaque has those gouges, they are routinely told that it was struck by lightning. Anyway, next summer you will find a new plaque, which will read as below.

GEOLOGY OF DULUTH HARBOR

Lake Superior is situated over the Midcontinent Rift, which is a rupture in the North American continent that formed a great rift valley from the Lake Superior region southwest to Kansas about 1.1 billion years ago. For about 20 million years as the rift valley opened, basaltic lavas erupted into it, accumulating to a thickness of up to 20 kilometers in the Lake Superior region. After the rifting and volcanic activity ended, the great thickness of dense basalt here depressed the crust into a trough-shaped basin. As the depression formed, it was filled in by sediment eroded and washed in from the surrounding heights. Ultimately, the sedimentary deposits reached a thickness of many kilometers.

Over the past two million years, glaciers more than a kilometer thick have repeatedly advanced along the buried trough and scoured out much of the soft sedimentary rock that once filled it. The harder, erosion-resistant volcanic rocks along the margins of the trough now form the rocky coastline of much of Lake Superior.

Ten thousand years ago, as the glacial ice in the basin melted west to east, water ponded in front of the ice almost to the level of this marker to form Glacial Lake Duluth. Eventually, the ice melted out of the eastern lake basin and a drainage way opened to the lower Great Lakes. When the eastern outlet first formed, it was lower in elevation than today and drained the lake to 60 meters below its present level.

Relieved of the great weight of this glacial ice, the earth's crust has been slowly rising. The rate of rebound is fastest where the load of ice has been most recently removed. Thus, the northeastern lake basin and its eastern outlet are rising faster, thereby tilting the basin toward the southwest and flooding the mouth of the St. Louis River. Duluth harbor, which was formed by this submergence, has been enlarged by the formation of Minnesota Point, a baymouth bar sand deposit washed there by easterly waves and shore currents transporting beach sand from Wisconsin.

Erected by the Geological Society of Minnesota
in partnership with the
Minnesota Department of Transportation
and the Minnesota Geological Survey

1998

Allen's Axiom: An agate will orient itself to be sawn so that the ugliest portion of its interior is exposed.