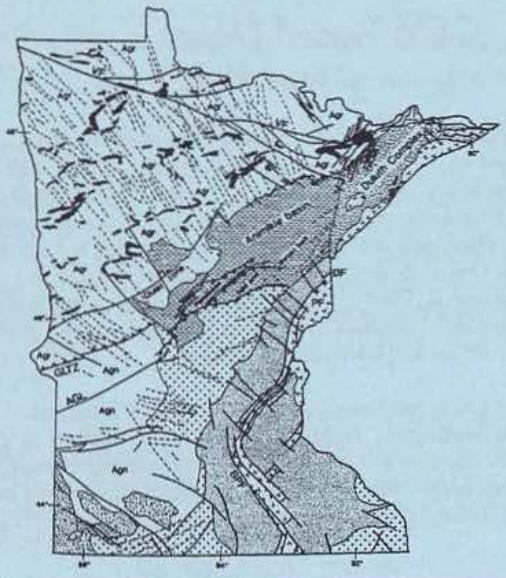

GEOLOGICAL SOCIETY OF MINNESOTA

NEWS

SUMMER 1999
VOLUME LIII NO. 2
http://www.geo.umn.edu/orgs/gsm/

Contents

SUMMER FIELD TRIP EDITION

When you spend enough time outside, it doesn't seem like outside anymore.

"Nature is always hinting at us.
It hints over and over again.
And suddenly we take the hint."
- Robert Frost -

by Gail Marshall

-1st Field Trip-
Twin Cities Glaciers and River Valleys

Date: Saturday, May 15, 1999

Leader: Carrie Patterson, senior scientist at the Minnesota Geological Survey.

HIGHLIGHTS:

One day field trip in the greater metro area that will examine prominent landforms of the Superior and Des Moines lobes, the last two lobes to have covered the area, and the postglacial development of the Minnesota and Mississippi Rivers. Stops will include a discussion on Paleozoic strata and their control on river history, the Minnesota and Mississippi River confluence, and Glacial River Warren.

Contact Gail at (612) 894-2961 for more information.

Agate Days

in Moose Lake, Minnesota
Sat.-Sun., July 17-18
Gem and Mineral Show at the Moose Lake High School: Sat.- 10 a.m. to 5 p.m. and Sun.- 10 a.m. to 4 p.m.

For more information contact:
Tom Olsen - Chrm. (218) 384-4961

1999 Minnesota State Fair Booth

See page 4

Announcements

The 1999 GSM Directory has been at the printers for the requisite length of time. That means they will be in your mailbox shortly, so look for them. Everyone with paid dues prior to April 1 will be listed.

Please notify the Membership Chair of all errors or omissions in the new Directory. Corrections will be published in the Fall Newsletter.

When all else fails, give us a call. We're listed in the phonebook:
GSM (612) 724-2101

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 Bruce Goetteman, 16125 Delarma Drive, Carver, MN 55315-9673. Phone: as listed above, or e-mail: again, as listed above.

Officers: Sylvia Huppler, *President*; William Robbins, *Vice President*; Bruce Goetteman, *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 Goetteman, 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 April 17th.

Rick Uthe discussed the program for the lecture series for 1999-2000. The theme is the Evolution of Phanerozoic Life on Earth, the last 540 Ma (million years). It sounds fascinating, and everything is "set" except for the location for the lectures. We will not know until possibly sometime in July where we shall meet. The University is dealing with the complication of needing more rooms in service at any one time, since the U will be on a semester schedule this fall instead of the quarter period. GSM will definitely notify all members as soon as possible. We hope that when the available room is selected, we will have a semipermanent location and will not need to move often.

Don Swensrud, Alex Lowe, and Dave Christianson will form a committee of three to consider the feasibility of starting a "Park and Ride" project for the Monday night lectures. The cost of parking everywhere, including the University, has gone up. The group will consider a meeting place at a free parking area with a few members then acting as shuttle drivers to transport members to the University.

The first field trip of May has been scheduled for May 15th. All members will receive notices of this and future field trips in the mail. The two one-day trips planned will be concerning glaciers and river valleys, and hydrology and ground water resources. One two-day trip will be to the to the Tower Sudan Mine, and one will be to the Baraboo, Wisconsin area.

Katy Paul is our new Editor of the Newsletter. Bruce Goetteman announced that we have 143 paid members. Doug Zbikowski announced that the first series of Geologic markers has been finalized.

Marlys Lowe and Goldie Johnson have been working with the Archives. Marlys will keep the current collection at her house, and the rest will be stored at the Minnesota Geological Survey.

Doug Zbikowski brought the rock and mineral collection to show members. This beautiful collection is used as the display for the school outreach program in the Metro area. The GSM contributed $1500 to the cost of the collection, and the University of Minnesota Department of Geology and Geophysics contributed $1500. It is stored at the U. of M., from where it is transported to the various elementary schools that have requested the program.

The annual Kimball Memorial Banquet was held on April 26th. Unfortunately, Dr. Robert Johnson of the U. of M. Geology Department was ill and unable to give the lecture. Dean Kjerland gave a very interesting talk on his trip to the Rock Elm disturbance in Pierce County, Wisconsin, the location of a major meteor impact site 7 km in diameter. He will write an article for a future newsletter, describing a fossil he discovered there.

The last series of lectures has been fascinating and absorbing. Hope to see many of you at the summer field trips.

Sylvia Huppler, President

You know you're a geologist when... you use your peanut butter and jelly sandwich to explain folding and crustal deformation.

Tri-State Geological Field Conference Guidebooks

The Geology Department at the University of Wisconsin at Eau Claire hosted a combined meeting of the 61st Annual Tri-State Geological Field Conference and the University of Wisconsin System Geological Field Conference on Sept. 25-27, 1998. Copies of the 92 page guidebook may be purchased for a limited time from the UWEC Geology Department. Guidebook field trip stops are in Eau Claire, Chippewa, and Dunn Counties.

The cost per guidebook is $2.50 if picked up at the UWEC Geology Department, or $5.00 if the guidebook is to be mailed. Guidebooks may be obtained by sending a check to UWEC Dept. of Geology, #133-688 at the following address:

Geology Field Conference
Dept. of Geology, UW-Eau Claire
Eau Claire, WI 54702

All orders must be prepaid. Be sure to clearly indicate a mailing address if you wish to have the guidebook sent to you. If you have any questions, please contact Nancy Amdahl (amdahlnj@uwec.edu, 715-836-3732). Person picking up copies at the Geology Dept. should contact Nancy before making the trip to ensure that copies are available!

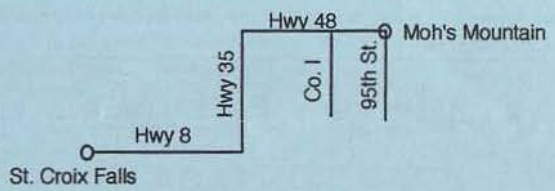
ICE AGE TRAIL
Indianhead Chapter
National Trails Day Hike
June 5, 1999

For an enjoyable Saturday in June, plan on signing up for a hike guided by Adam Cahow, PhD. Dr. Cahow is a retired Professor of Glacial Geology from U of WI Eau Claire. In additon, there will be afternoon carpools to other geologic features in NW Polk Co. This is a great geology experience, and the scenery isn't too bad, either.

Registration is at Moh's Mountain from 9 - 10 am. The hike begins at 10 sharp.

For more information, contact Herb Lundberg in Stillwater. His phone is: (651) 439-0462. He can also be reached via email: HLundb 6162@aol.com.

Or contact Cora Dversdall of Frederic, WI. Her email address is: edgelong@win.bright.net.



Before you head out there...
Experienced tips & **A**dvice
that will make your next field trip your best ever!

Whether you participate in a GSM field trip with a group, or go on your own to explore new sites, planning ahead can make the difference between a pleasureable experience, and a bad memory. The following list can provide helpful reminders to make your trip more enjoyable.

CLOTHING: Dress comfortably and practically. Layer clothing to help adjust to the changing temperatures throughout the day. Sturdy walking shoes or hiking boots are a must. Wear a hat to protect from the sun or rain (or flies). Bring along lightweight raingear: a waterproof jacket with hood, or pick up a disposable plastic poncho to carry in your pack.

FOOD/DRINK: Bring lunch. Packable foods such as dried fruit, nuts, snack bars, carrot sticks, pita bread, cheese sticks, pretzels, all make good snacks. Don't forget to bring a plastic bag for trash, wrappers, etc. Bring plenty of water. (Some 'fanny packs' have a bottle holder built-in; or use a backpack with bottle holder pockets on the sides.) Disposable hand wipes in foil packets come in very handy for clean-up.

EQUIPMENT: Plastic bags (zipper closure) or other specimen containers, tissue paper or newspaper to wrap delicate specimens, labels (masking tape works well), indelible felt-tip pen for labeling specimens, notebook, pen, magnifier, rock pick/hammer, mini-first aid kit, insect repellant.

OPTIONAL: Compass, camera, binoculars, jack-knife, map, tissues/handkerchief, field guide, canvas bag for carrying rock specimens, sturdy plastic to sit on, extra socks, ibuprofen/aspirin.

Summertime Fieldwork

by bruce goetteman

Lake Superior Agates. For some folks, this phrase inspires dreams of finding kilos of this semi-precious gemstone. For others, it means an occasional "Ooh, look, an agate." Still, for some rockhounders who toil away without much luck, agate hunting in Minnesota may seem like easy pickings.

Not to discourage anyone, but these images may not be entirely accurate. That said, there are still some excellent reasons to go into the field.

The reason I do so much rockhounding is not simply to find more agates. It is, almost literally, everything but that. On a typical tour, I often see more wildlife than I see people. When that happens, I consider it to be a true measure of a successful outing. Some days I see more avifauna than agates. For example, one morning I saw 6 eagles perched above the shores of a horseshoe lake. I can easily recall every wild turkey sighting. However, a lot of the agate finds just kind of run together in my memory.

I am routinely entertained by families of chickadees flirting in the trees, and routinely startled by the sudden tumble of rock settling to an angle of repose when I am concentrating too hard on my field identification. Frequently, I hear a single crow calling, connecting with its family members, and another more distant, mechanical moan of a train whistle beckoning. There have been 30 crows together in one fly-over. To mention the ducks and geese would require exponents.

Just one more: I have enjoyed sunsets that make a better case for creationism than William Jennings Bryan.

Reasons for getting out into the field are countless, the experiences endless. Still for many, there is the find.

NEWS FROM CYBERSPACE

Following are a few sites Alex Lowe visited and thought were interesting:

http://www.ucmp.berkeley.edu/exhibit/geology.html

A visitor can find out more about how geological time scales are constructed by clicking on a time scale such as Cenozoic in the geological time scale, and they will be transported to the stratigraphy page. Or one can click on any of the eras to find out about some of the organisms that lived during those times and how we came to learn about them.

http://www.geolab.unc.edu/Petunia/IgMetAtlas/mainmenu.html

This web page was constructed to aid in the study of thin sections of rocks.

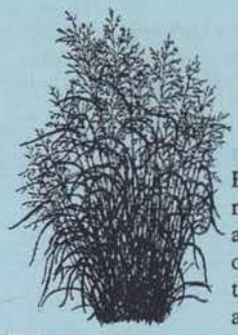
1999 MINNESOTA STATE FAIR

August 26 - Labor Day September 6

This is an early reminder that the Geological Society of Minnesota will again have a booth at the State Fair this year. Even though the fair seems quite a ways off, we will soon begin preparation for staffing the booth. You may see me carrying around a calendar at the field trips and asking folks to sign up. Later on, we will begin to make telephone calls to all members again asking folks to sign up. There are three shifts a day and we need two people per shift. Take a moment right now to check your calendar for August. If you have a preference for working the Fair, you are welcome to call me now.

We've done some "face lifting" of the booth which includes newly painted panels (by Paul Lemke) and we are looking for a piece of carpeting approximately $10' \times 10'$ (in the event you may have such a piece or know of someone who does) in either green or brown to resemble the earth. Carpeting will enhance the booth as well as make it more comfortable to stand on. We have acquired a rock box and slides as a permanent part of the display table (from Doug Zbikowski). If you have interest in planning or set up of the booth, please join us. I can be reached at 651-699-9812 or leave a message.

Judy Hamilton
Chair, State Fair Booth



ANIMAL, VEGETABLE, OR MINERAL?

by Katy Paul

By eating balanced diets, we humans make sure that we ingest adequate amounts of vitamins and minerals. Many of the minerals humans need come from the vegetables we eat, and the vegetables accumulate these minerals from the soil. This ability that plants have, to extract minerals from soil, is vital to the plants' survival. But plants also take up minerals that they don't need. And now humans are developing ways to exploit the ability of plants to extract minerals from the soil, for purposes that are not nutritional.

Deliberately using plants to accumulate elements from the soil is called phytoremediation. Plants that are particularly efficient at extracting minerals from the soil are known as hyperaccumulator plants. Researchers have shown that these "metal-scavenging" plants can accumulate lead, uranium, cesium, strontium, chromium, zinc, selenium, manganese, calcium, cobalt, and iron from the soil, and store these metals in their above-gound shoots and leaves. Then, the plants can be harvested, burned, and the metals can be recovered.

Phytoremediation is a new technology that is being tested in field trials as a method of cleaning soils that have been contaminated with toxic metals, such as lead, cadmium, zinc, nickel, or radioactive isotopes such as uranium or cobalt. Scientists are attempting to identify plants that are exceptionally good at extracting metals from the soil. By searching for key plant genes, and bio-engineering efficient hyperaccumulator plants, scientists hope to develop plants with improved rates of metal uptake, which would make phytoremediation a practical and economical solution to cleaning up landfills, mining sites, nuclear waste dumps, or any contaminated site.

One such hyperaccumulator plant is pennycress, a wild herb that grows on soils that are rich in zinc and nickel. (Prospectors have long recognized certain plants as indicators of the presence of metal ore.) But pennycress is slow growing and typically grows to only 8 to 12 inches. By cross breeding with other strains of metal-storing pennycress, plant geneticists are attempting to produce a high-yielding, fast growing plant that could be used to remove zinc from contaminated soil. Pennycress has been tested in field trials right here in our own back yard at the Pig's Eye Landfill in St. Paul.

Scientists in New Zealand have discovered that some plants will even soak up tiny amounts of gold. In laboratory tests, Indian mustard plants were grown in pots of soil that contained 4 parts per million of gold. Then, ammonium thiocyanate was added to the soil, to make the gold soluble. (This chemical is used in traditional gold mining and contains cyanide.) The plants died within a week from absorbing the chemical, but not before they also absorbed some of the gold. The dead plants were harvested and burned, and the resulting ash was found to contain 150 parts per million of gold. Obviously, this type of biomining is not economically feasible right now. And harmful chemicals cannot be spread on the ground, due to the damage they would cause to the environment. But, perhaps one day, plants might be used to extract gold from ore or mine waste.

Traditional mining techniques include processes that crush the ore, and then extract the minerals, such as gold or copper, by the application of chemicals, or high heat. These methods unfortunately, have created undesirable effects in the environment, and have caused mining operations to become quite controversial. In recent years, mining companies have been working to become more environmentally friendly, and have enlisted the aid of certain types of bacteria. Thiobacillus ferooxidans is a bacterium that is naturally present in some sulfur-containing materials, such as copper sulfide minerals. It oxidizes the sulfide material, which releases acid, and an oxidizing solution of ferric ions — which can wash out metals from crude ore. The metal can then be collected and the sulfuric acid can be recycled.

Using bacteria in mining can be economical, but large-scale operations would be even more practical. However, this bioprocessing releases a great deal of heat, which can then kill the bacteria and stop the process. So the search is on for a form of bacteria that thrives in an acidic, metal-rich, toxic environment — that is also very hot. Bacteria that thrive on the ocean floor on hydrothermal vents (black smokers) might just be the answer. These bacteria survive in temperatures up to 100 degrees Celsius or higher, and certainly seem to do well in highly oxidative environments. Black smokers provide homes for some of the densest concentrations of life known on the seafloor. Some deep-sea vent bacteria appear to be capable of extracting metals from the hydrothermal fluids — a desirable characteristic to offer to the future of biomining technology.

Phytoremediation and biomining will be important technologies in the next millennium. In 1995, the first international conference devoted to phytoremediation was held at the University of Missouri, attracting hundreds of plant physiologists, biochemists, ecologists, soil scientists, and others. Research is being done by Universities, mining companies, various government agencies (EPA, DOD, DOE), chemical companies (Dupont), and new companies are starting up every year. It will be interesting to watch this new technology develop.

In Memoriam

Rocky Franklinite, the long time and well known mineral collector, of Stone Road in the Mineville area of Minnesotaite died yesterday of severely clogged arterites in his diamond pipes. He was bornite here 77 years ago.

Rocky was admitted to the Granite State Hospital on Thursday complaining of gastrolithic discomformities after a meal of crystal lattice, graptolites, and earth crust. He had been treated with Pepto-Bismuth and alkali seltzer for acid-rock stomach. According to Dr. Bruce Cite, despite the hospital's best efforts, Rocky's cats-eyes turned to greenstone in his headframe and he metamorphosed early Friday.

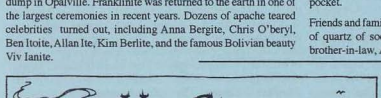
The funeral was held Monday at the Lustrous Memorial mine dump in Opalville. Franklinite was returned to the earth in one of the largest ceremonies in recent years. Dozens of apache teared celebrities turned out, including Anna Bergite, Chris O'beryl, Ben Itoite, Allan Ite, Kim Berlite, and the famous Bolivian beauty Viv Ianite.

The grave shaft near the brookite was piled high with rock flours, including hematite roses and green ockites. A mahogany obsidian beryl served as a cryptomelene as Rocky was returned to the fault zone of his alteration.

The Reverend Marc Asite started the eulogy with a prehnite, going on to describe Rocky as a wonderful humite, with a tremendous apatite for olivine. His road metal never became paved with goldstone, but he brought the joy of adularia to many a jaded admirer, regardless of crystal class. Even as a sometimes abrasive old miner, he served as a lodestone for thousands of tumbling followers.

Rocky is survived by his vein mate of 44 collecting seasons, Cas Siterite, his dog, Stilbite, and three grand pebble-pups, James Onite, Cris Tobalite, and Will Emite, with one more in the gem pocket.

Friends and family met after the reclaiming burial for refreshments of quartz of soda niter and pudding stone at the home of his brother-in-law, Al Abaster.



[What follows is an excerpt of an e-mail report received by Doug Zbikowski from James Acworth, Conservation Management Advisor, Mt. Cameroon Project, Limbe]

Maybe you've already heard that Mt. Cameroon is erupting as of Sunday night [March 28th] at about 8pm. There had been a number of earth tremors reported in Buea on Saturday (which shook down two houses in Bokwaongo), and on Sunday Limbe was shaking too. People came out of the Atlantic Beach hotel because the rooms were rattling so much! By 8:20 p.m., as we walked home from a friend's house, we could clearly see the eruption up on the left hand flank of the mountain, popping and spitting plumes of flame and lava up over the ridge for all to see. The rumblings were easily audible from Limbe, and various people said they could smell the sulphur.

After peering through binoculars for half and hour in Limbe, we all wanted to get a better view, so we jumped into a couple of Land Rovers and drove down the West Coast. From there, depending on the perspective and the cloud cover, one could clearly see the mouth of the crater, and the lava burning its way down across the grassland. It seemed to be coming from the same place as the last eruption in 1982, which started on the Western flank at about 2,800 meters altitude, and whose lava flow headed southwest, towards Bakingili, but I am not yet certain. It is still difficult to see where the lava might go to, but most likely, towards the less populated West Coast. Last time, Bakingili was evacuated, but the lava never reached the village, stopping at about 1,200 meters.

Over the past 150 years, the mountain has erupted approximately every 20 or so years, and with the last one in 1982, many of us pyromaniacs have been wondering whether we would be lucky enough to witness one while here.

In 1922, a lava flow wiped out a swath of forest and plantations up to 2 - 3 kilometers across, from 1,600 meters, running into the sea, and set fire to an area which was a great deal bigger than that. Many of the biggest lava flows on the Mountain seem to have come down the Western flank, which is perhaps why few people have chosen to live there. And all the villages are at sea level, in close reach of a canoe if things get 'hot'.

Of course the traditional hypotheses are already abounding - most eruptions are supposed to be the result of the mountain being angry. Ephaa'sa'Moto, half-stone half-man - the "god" of the mountain, follows local events closely and has always added timely and sobering punctuations to the region's historical calendar (the last eruption coincided with the death of the highly respected former Paramount Chief of Buea). Perhaps Ephaa'sa'Moto is angry with the natives, who have willingly sold most of their land and are sitting back and watching everybody else convert their forests to farms!

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Location: 4.20N, 9.17E
Elevation: 13.428 ft (4095 m)
Last Updated: April 5, 1999
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Mount Cameroon is a stratovolcano located in the nation of Cameroon, 180 miles west of the capital of Yaounde. This volcano is also known locally as Mount Faka and "Chariot of the Gods." It is one of Cameroon's main tourist attractions. Thousands of people participate in a race up its rocky slopes each year. It is the highest peak in West and Central Africa. Cameroon has erupted five times this century. Its most recent eruption is noted above.

EARTHQUAKE!!!

Part II

by Katy Paul

[Part I of Earthquake!!! recounted eye-witness reports describing the effects of the New Madrid earthquakes of 1811-1812. Many people reported streams of matter being thrown up, as high as 30 feet into the air, and spouts of sand and water gushing from fissures in the earth.]

Fractured rock, as found in many parts of the western United States, may absorb energy from earthquake waves and thus reduce the geographical extent of damage from a major earthquake. In areas where geological formations stretch unbroken for hundreds of miles, as in portions of the eastern United States, vibrations may travel great distances with much of their initial destructive potential intact. Additionally, in the region of the epicenter of the 1811 and 1812 earthquakes, there is a thick cover of alluvium, containing layers of water-saturated sand. The combination of poor soil conditions in the epicentral regions, and of low attenuation of surface-wave energy is responsible for the damage and felt areas being about 100 times greater than those of earthquakes of the same magnitude in western North America.

The surficial geology in the epicentral region of the New Madrid earthquakes is ideal for producing large surface displacements, fissures, and landslides. The thick silty, sandy, river alluvium of the major river valleys in the region is particularly suited for the production of the strange phenomena called sand blows, or sand volcanoes. The many eye witness accounts that recorded, large amounts of mud, sand, stone, and water being "thrown up", were in fact, describing a phenomenon known as liquefaction. Earthquake vibrations in poorly consolidated soil, where ground water exists close to the surface, will cause soil to lose its cohesion and behave as a liquid. The pressure of the water in between particles of soil or sand (known as pore water) rises with the passage of waves from an earthquake. The more powerful an earthquake, the more intense its associated ground motion is likely to be, and therefore, higher pressure is created in the pore water. Upon liquefaction, pore water pressure increases several fold within seconds. The pore water pressure, carrying the full weight of overlying soil and water, can hydraulically fracture an overlying fine-grained cap and lead to the venting of large quantities of sediment and water to the ground surface, forming sand volcanoes. When liquefaction occurs on slopes, large masses of soil may flow downslope, either in liquefied form, or as large blocks of still-cohesive soil, sliding on an underlying, liquefied layer of soil. Lateral spread, in which blocks of soil at the surface slide sideways, can also be caused by liquefaction of an underlying layer.

During the New Madrid earthquakes, liquefaction occurred over a huge region. Today, aerial views of some regions clearly show isolated white spots scattered far across the land where sand was vented onto the dark-colored clay soil.

In 1974, networks of seismometers were set up in the Missouri bootheel and surrounding areas, in hopes of finding clues to the origin of the New Madrid quakes. Thousands of microquakes that were subsequently recorded revealed a zigzag fault pattern that roughly parallels the Mississippi River at the junction of Kentucky, Missouri, Tennessee, and Arkansas. Some geologists studying the New Madrid seismic zone believe that the North American continent began to tear apart approximately 600 million years ago. When the rift eventually closed, it left a weak zone, which continues to be squeezed at a relatively rapid rate. Eugene S. Schweig of the University of Memphis and the U.S. Geological Survey, believes that the strain that builds up in the earth there could store enough energy to power a magnitude 8 earthquake about every 400 to 1,100 years.

In 1990, self-proclaimed earthquake forecaster, Iben Browning, predicted that a major earthquake would strike the New Madrid seismic zone on, or about, Dec. 3, 1990. The only outcome of his prediction was an increased nervousness of some residents of the area. As much as people would like to be forewarned of impending earthquake disasters, there is no way to predict when the next great quake may strike. It may happen in 800 years, or 8. What can be predicted however, is that the next major earthquake in this no longer sparsely populated region will cause massive destruction, injury, and death. Perhaps the next great quake will not come during any of our lifetimes, but as long as humans continue to live in the New Madrid seismic zone, the likelihood of major devastation with the next earthquake will only increase.

You know you're a geologist when...*you hope to die in a pyroclastic flow, (just to experience it.)
*you total your car because you were gawking at a road cut.

Finis *The 1998-1999 program theme of Physical Geology and Climate Change has presented a host of opportunities to learn more about climate and how geology can influence climatic changes. Here is a brief summary of the last lecture from that series.*

Climate Variations: Space and Time Scales

Keeping with the theme of the 1998-1999 Program, the April 12th Lecture, presented by Kathy Klink (U of M, Geography Dept.), detailed the various methods researchers use to track climate variations over time, and why climates vary. Over the past 140,000 years or so, evidence of climate change is left as proxy records: pollen in lake sediments, coral, ice cores. By studying the proxy records, scientists have learned that during the last interglacial period, temperatures were approximately 4°C higher than today. And during the last 10,000 years, the climate has been relatively stable, with temperatures much less variable than during the last glacial period.

In addition to proxy records, observation records were begun around the middle 1800's. Since that time, global temperatures have risen 0.3 - 0.6°C. There was a much cooler period, called the Little Ice Age, which lasted from 1450-1850. Records show that global temperatures are influenced by many factors, and have gone up and down many times over the years. And regional climatic variability does not always match global change.

Climate varies due to climatic forcing factors: radiation from the sun, sunspots, volcanic activity (dust in the air blocks out solar radiation and causes a drop in temperature), and Milankovich cycles (the eccentricity in the earth's orbit, precession - the distance between the earth and the sun, and obliquity - the degree of tilt of the earth).

Another factor in climate variability is climatic feedback. Surface reflectivity, called albedo, can contribute either a positive or negative feedback. The albedo feedback from ice, clouds, and water vapor, can effect the amount of infrared radiation absorbed by the atmosphere, and thus the temperature. Anthropogenic activity (humans) contributes to the climate variations by the addition of CO_2 and other trace gasses to the atmosphere. Even urbanization can cause temperature variations on a regional scale.

The complexity of the climate system makes it very difficult to attribute the causes of climate variability to a specific factor. It is likely that orbital variations, solar variability, volcanism, and anthropogenic activity all play a role in influencing climate.

MPLS MN 554 05/13/99 23:46 ISS #13

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