

# Minnesota Geological Survey

## NEWSLETTER

SEP 27 1985

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VOLUME 1, NUMBER 1 SUMMER, 1985

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MINNESOTA GEOLOGICAL SURVEY, UNIVERSITY OF MINNESOTA  
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## RECENT OIL AND GAS EXPLORATION IN MINNESOTA

An exploration effort aimed at rocks more than a billion years old is changing the history of oil and gas exploration in Minnesota. For the first time major national and international energy companies are involved, and they are evaluating rocks which traditionally have been considered much too old to bear oil or gas.

The search is centered on a structure known as the Midcontinent rift system. This narrow linear feature, which extends from Lake Superior to Kansas, originated as a fracture in the earth's crust a little more than a billion years ago. The forces which caused the splitting eventually waned, but not before lava flows and complex crustal movement had created a wide central valley flanked by highlands. The rift valley was eventually filled by sands and muds derived by erosion of the bordering highlands. The valley was also the site of temporary lakes formed in meanders cut off from river channels or by damming of river sections. These lakes also received sediment, and the sequence of sediments in the rift valley eventually reached thousands of feet in thickness. Crustal movements in the rift zone since then have created a rather complex juxtapositioning of the lava flows and sediments. In east-central and southeastern Minnesota, the lava

flows are called the Chengwatana Volcanic Group and the sediments are known as the Solor Church Formation, Fond du Lac Formation, and Hinckley Sandstone (Fig. 1).

Several conditions must have been met for oil or gas to have formed in the rift. There must have been sediments rich in organic material—nature's source of oil. These sediments must have been subjected to a certain range of pressure and temperature to produce oil from the organic material. It is also necessary that proper rock types and rock relationships existed to accumulate and hold any oil produced. Geologists originally felt that insufficient life existed a billion years ago to create organic-rich sediments. However, research centered on a lake sediment deposit in Michigan has shown that some of the deposits in the rift supported algae and fungi populations of sufficient magnitude to result in organic-rich bottom sediments. Parts of the correlative Solor Church Formation in Minnesota also contain thin layers of organic-rich sediment, but recent research by J.R. Hatch of the U.S. Geological Survey and G.B. Morey of the MGS has shown that these rocks have been subjected to temperature extremes that would negate their suitability as oil source beds.

(Continued on page 7)

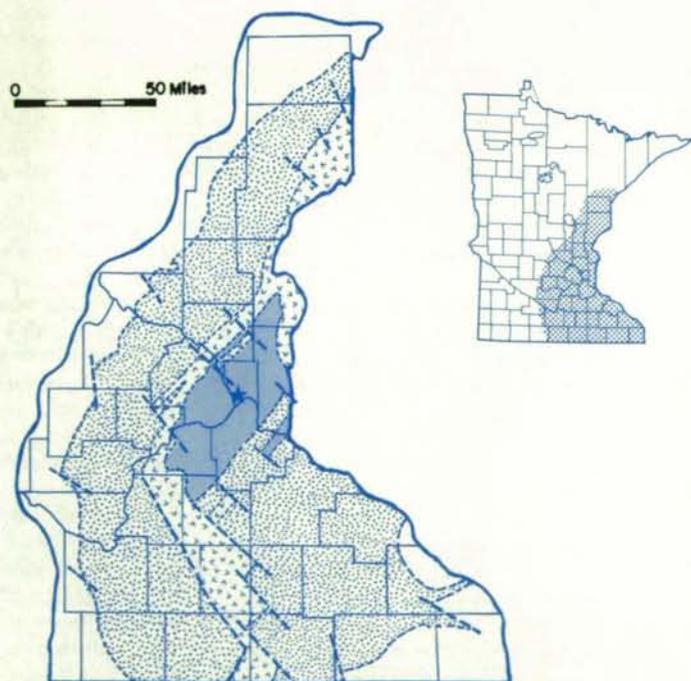


Figure 1. Schematic geologic map of the Midcontinent rift system in southeastern Minnesota. Stipple, Fond du Lac Formation and Hinckley Sandstone, undivided; pattern, Chengwatana Volcanic Group; shading, Solor Church Formation.

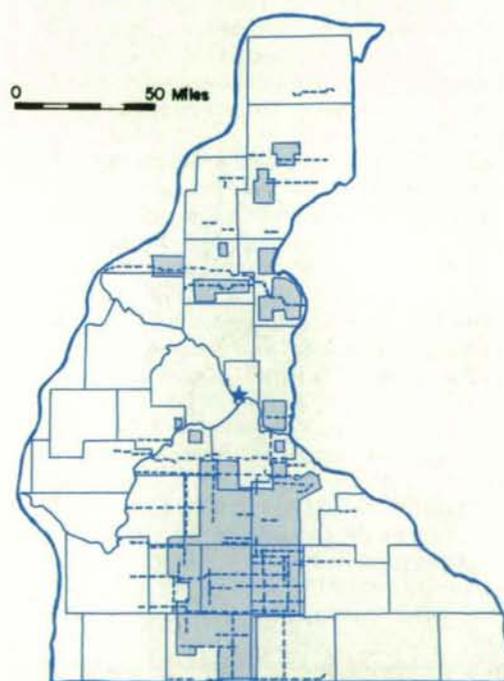


Figure 2. Areas of extensive oil and gas leasing and seismic testing in southeastern Minnesota. As of early 1985, some 480,000 acres had been leased (in shaded areas). Dashed lines show the location of approximately 1000 line-miles of seismic exploration.



## DIRECTOR'S COLUMN

This newsletter is a revival of one begun in the 1960s and published annually until 1970, when it was interrupted by severe constraints on funding and a change in directors. While the newsletter may have been dormant, the Minnesota Geological Survey has not. As with other Rip Van Winkles, this newsletter awakens now to a vastly different world of geological activities in Minnesota. At this point it is not as important to chronicle the details of these changes, as it is to use this perspective to review the role of the Survey in the life of the state over the past 113 years and look forward to our future role.

I see five very distinct eras in the life of the Minnesota Geological Survey. The first, the Winchell era, started in 1872 with an act of the Legislature directing the Regents of the University to establish a geological survey as a means of bringing the scientific resources of the University to bear on the exploration and development of the natural resources of what was then a frontier state. Newton Horace Winchell, the first director, was a man of great energy and ability. He built a geological survey which was internationally recognized as one of the leading geological organizations of its time. The broad outlines of Minnesota geology were delineated. The iron ranges were discovered and mapped within the limits of then existing technology, and the basis was laid for one of the great triumphs of classic geology, the unraveling of the stratigraphic succession in the Precambrian Shield of the Lake Superior region, which was the first great success in deciphering geologic history in the enigmatic Precambrian basements of the continents.

Second came a dormant era following Winchell's retirement in 1898. The organization he had built was assimilated into the Department of Geology, which he had founded. The Survey was dormant for about a decade, but during this period Van Hise and Leith produced their great synthesis, 'Geology of the Lake Superior Region' (U.S. Geological Survey Monograph 52), building heavily on the groundwork of the Winchell survey.

The third era I would call the academic era. About 1910 the Survey was reactivated with a small 'state special' appropriation, roughly equivalent to a professor's salary at the time, given to the Department of Geology to support research by students and faculty on Minnesota geology. The Survey continued in this mode for roughly 50 years, during which a remarkable amount of geology was done on this very modest base, but as one can imagine, not in the organized, programmatic mode we now find increasingly necessary to meet the demands of major resource and policy issues, as well as further scientific discovery.

Closely interwoven with the operation of the Survey during this period was the development of one of the world's major tools for geological research. Professor A.O. Nier of the Department of Physics with Samuel Goldich of the Department of Geology developed the mass spectrometer for the radioisotopic age-dating of rocks and minerals and began to put numbers, some of them astonishing, to the billions of years represented by the sequence of rock formations that Winchell had started to put in stratigraphic and paragenetic order 50 years earlier.

The fourth era of the Survey began when Elmer Anderson became governor. He foresaw that the future development and protection of Minnesota's resources required a more systematic and modern data base of geological information. Upon the retirement of Professor George Schwartz, who had guided the Survey in its academic mode for decades, Dr. Paul Sims, a leading specialist in Precambrian geol-

ogy and mineral deposits in the United States Geological Survey, was brought in as director with an appropriation large enough to start building a small professional staff and to start systematic geologic mapping of the state. Sims, partly supported by funds from the Iron Range Resources and Rehabilitation Board, made outstanding contributions to the modern geologic mapping of the Vermilion district in northern Minnesota. The staff he started building includes G.B. Morey, the present Chief Geologist of the Survey, Bruce Olsen, who directs much of the work on environmental geology and water resources in southern Minnesota, John Mossler, and Bruce Bloomgren.

The culmination of Sims's work came with the centennial of the Minnesota Geological Survey in 1972. A centennial volume, 'The Geology of Minnesota' by Sims and Morey, synthesized a hundred years of geological investigation and is a major contribution to the literature of the geology of North America.

A decision in 1973 by the state legislature to greatly curtail mineral-resource-related research at the University of Minnesota led to drastic curtailment of the staff and funding for the Survey, and this led Sims to return to the United States Geological Survey, where he has continued to do major research on the geology of the Lake Superior region.

The fifth and present era of the Survey in retrospect began with my appointment as director, August 1, 1973. In order to retain even a vestige of the Survey organization built by Sims over the preceding decade, it was necessary to become far more aggressive in seeking outside grants and contracts to perform geological investigations to meet the needs for geological information felt by federal, state, and local agencies. From this point forward, outside grants and contracts have become a significant component of Survey funding.

Several major themes have guided the Survey since 1973. First is the recognition that further progress in understanding the geology of Minnesota is dependent on a strong attack on subsurface geology. From one end to the other Minnesota is heavily blanketed by glacial drift. Bedrock outcrops are adequate for conventional geologic mapping in limited areas which provide tantalizing windows into bedrock geology that is hidden throughout most of the state. Even the geology of the glacial drift is very complex and cannot be understood without a massive data base of subsurface information. There is still much to be learned from conventional geologic mapping on surface outcrops, but repeatedly we reach the point of diminishing returns, where advances in knowledge are frustrated by the inability to project our geology across the state in anything but the broadest outlines without ways to look into and beneath the drift. For this reason much of Minnesota remains a geologically unexplored frontier.

Our attack on subsurface geology is twofold. We are engaged in an intensive and continuing campaign to collect logs and, where possible, cuttings and samples from water well drilling and engineering test boring. We now have a data base running into hundreds of thousands of logs, which is increasingly valuable to us, to state and local agencies and to the civil engineering industry. The other thrust is to combine geophysics with a limited but significant number of geologically targeted test holes drilled by us or the Minnesota Department of Natural Resources to carry the Precambrian bedrock geology and overlying glacial drift stratigraphy across Minnesota. In this we have had magnificent support from the Legislative Commission on Minnesota Resources, which has funded what is probably the most outstanding program of high-resolution aeromagnetic mapping performed in the United States. As we follow up with test drilling, gravity mapping and geochemistry on the samples from drilling, working in close coordination with the Department of Natural Resources, it is clear that we are in the midst of a new age of discovery in Minnesota geology.

Another major theme has been the development of a strong program in engineering and environmental geology and hydrogeology to meet the constantly escalating demands for geologic knowledge from the increasing pressure that modern society is putting on its resources and environment. Our work on the engineering geology of the Twin Cities Metropolitan Area has been cited in the authoritative McGraw-Hill Handbook of Geology and Civil Engineering as a model to be followed by urban areas throughout the world, and we are conducting one of the largest experiments in the world on sea-

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# DIRECTOR'S COLUMN

(Continued from page 2)

sonal storage of thermal energy in geologic media as a means of capturing heat in the summer to use in the winter, thus conserving fossil fuel. To meet the needs of county and local governments we have developed a county atlas program to supply the need for geologic information at the county and local level. Several counties have joined with us enthusiastically on a cost-sharing basis to produce atlases. Atlases for Scott and Winona Counties have been published.

After two biennia of stringency in the University budget, which entailed significant attrition in our staff, we are starting the 1985-87 biennium with solid state appropriations which compensate in part for the fact that sources of federal grants and contracts on which we have relied in recent years are dwindling; nevertheless, we look forward to the future with considerable optimism. Over the last few years a number of legislative seminars and state and local conferences

have been held on the development and wise use of Minnesota's resources. Without exception the continued development of the geological data base needed to address these needs has been identified as a top priority. The iron mining industry is under severe stress due to world market factors which are likely to persist, but we do not believe that the mining industry in Minnesota must become another Rip Van Winkle, destined to drop off to sleep for decades. Minnesota is more to be looked on as a sleeping giant, slumbering under a blanket of glacial drift, beneath which the potential for a diversified mining industry is waiting to be discovered. Our job is to peel back that blanket and arouse the giant. We are confident that investment in Minnesota's geology is an investment in Minnesota's future.

Matt Walton, Director

## PROJECT UPDATES

### GEOPHYSICS

#### Aeromagnetic Survey

V. Chandler

In 1978 the MGS began a large-scale geophysical program funded by the Legislative Commission on Minnesota Resources (LCMR). Paramount to this activity is a program to acquire low-altitude, high-resolution aeromagnetic data over the entire state. These data, which are stored on a digital base, have been acquired to fulfill the following objectives: (1) to further the Minnesota Geological Survey's mission in detailed mapping of the Precambrian bedrock; (2) to provide data that would assist in mineral evaluation and regulation of state-owned lands; (3) to provide academic institutions with high-quality geophysical data for studies on Precambrian geology; and (4) to encourage mineral exploration in the state by providing private companies with detailed geophysical data at low cost.

To date, high-resolution aeromagnetic data have been gathered over northeastern and east-central Minnesota, and surveying is now in progress over the west-central part of the state. The current data set, which is one of the largest of its kind in the world, is available to the public in several digital and analog forms.

#### Aeromagnetically Targeted Drilling

D. Southwick, G. Meyer

To meet the need for accurate data on geophysically defined targets, a portion of the LCMR funding is being used for shallow drilling. To date, the drilling has focused in central Minnesota where four distinct, con-

trasting groups of Precambrian basement rocks come together in a poorly understood manner. Some of these rocks may have economic mineral potential, so the understanding of the regional bedrock geology has both scientific and practical value. Thirty-nine holes have been drilled, primarily in Todd, Cass, and Morrison Counties. The primary objective is to obtain a sample of bedrock at each site. A secondary objective is to collect information about the unconsolidated, glacially deposited sand and gravel aquifers.

#### Downhole Geophysical Logging

D. Setterholm, B. Bloomgren, B. Olsen

In cooperation with the Minnesota Department of Health, MGS has access to a downhole geophysical logging system. Current capabilities include natural gamma, caliper, single-point electric and casing-collar locator tools. The system provides additional information for the interpretation of well cuttings or core, and permits investigation of well construction and bedrock geology in existing wells. Currently MGS has approximately 500 logs from various parts of the state, representing rocks as old as Archean to as young as Pleistocene.

#### Additional Geophysical Activities

V. Chandler, J. Miller, P. McSwiggen, B. Bloomgren, M. Jirsa, graduate student R. Ferderer

The MGS is also involved in a number of smaller geophysical projects. A rock properties file (with updated density and magnetic susceptibility values) is available in a computer data base. Paleomagnetic measurement of Keweenaw dikes in the Cloquet and Grand Portage areas is underway, and a gravity survey over the Hibbing 2° sheet has revealed a wealth of detail over an area of recent exploration interest. Significant progress has also been made toward completing a structural study over the northwestern Duluth Complex. This study consists of grid processing, modeling, and rock magnetism

studies and is sponsored by the Minnesota Department of Natural Resources. MGS graduate students are working with high-resolution aeromagnetic data Werner deconvolution and grid processing over the Great Lakes tectonic zone. Werner deconvolution is an automated interpretation technique which determines magnetic anomaly source parameters such as depth, dip, and magnetization. Work has also recently been initiated on a gravity and magnetic modeling study of the St. Croix horst.

### PRECAMBRIAN GEOLOGY

G. Morey, D. Southwick, J. Mossler, M. Jirsa, D. Setterholm

The Minnesota Geological Survey is working in cooperation with the U.S. Geological Survey on the Midcontinent Strategic and Critical Minerals Program. The study area includes the southern half of Minnesota. Isopach, structure, and lithofacies maps are being prepared, as well as a Precambrian bedrock geologic map, a tectonic map, and geologic cross sections. Topical projects include evaluation for economic sedimentary manganese deposits and Athabasca-type uranium deposits.

Restudy of the Precambrian Sioux Quartzite in light of modern sedimentology indicates that the Sioux is primarily a redbed sequence which was deposited from braided streams on a deeply weathered land surface of moderate relief. Deposition is interpreted to have taken place in several fault-bounded basins in a cratonic setting, rather than as a continuous blanket sand in a marine shelf setting as previously inferred. With deposition in a cratonic setting, economic Athabasca-type uranium deposits and Witwatersrand-type paleoplacer deposits in the Sioux are possible.

### HYDROGEOLOGY

R. Kanivetsky, B. Palen

In addition to ground-water monitoring at the ATEs project (see Engineering and En-

(Continued)

## PROJECT UPDATES

(Continued from page 3)

vironmental Geology) the MGS hydrogeology team has been working on two additional projects. The aquifer recharge project estimates ground-water recharge rates in Minnesota from observation well records and precipitation and air-temperature records from nearby weather stations. Recharge is affected by soil type and overburden lithology, depth to the water table, and land use.

The greenhouse effect project extrapolates the relationships between precipitation, evaporation, and recharge, with various environmental scenarios of increased air temperature and changes in rainfall to the year 2015. This is a joint project with the Hubert Humphrey Institute of Public Affairs, which provided the scenarios based on recent literature. The project also involves an attempt to verify the predictions by comparing them with reported recharge rates in western states that have precipitation and temperatures similar to the scenarios.

## GEOCHEMISTRY AND GEOCHRONOLOGY

R. Lively

The geochemistry lab analyzes alpha-emitting radioactive isotopes within the  $^{238}\text{U}$  decay series in the rocks and waters of Minnesota. Current projects include studying speleothem growth over the last 350,000 years in the Upper Midwest. It appears that speleothems formed during interglacial and postglacial periods, and remained dormant during glacial times, even though the glaciers did not cover the caves where the samples were collected.

Other ongoing research involves the study of stromatolites in hard-water lakes of western Minnesota. Recent attempts to date the calcite in the stromatolites by the U-series technique appear promising. The lab is also measuring the sedimentation rate in Minnesota lakes over the past 100 to 150 years through the use of  $^{210}\text{Pb}$  dating. The lab is also studying indoor radiation environments, primarily the isotopes of radon and radon daughter products.

## COMPUTER OPERATIONS

T. Wahl, M. Kuhns

The past year has seen substantial growth in computer utilization at the Survey. Because computers can analyze large amounts of data quickly, and can perform mundane and repetitive tasks, their use frees geologists for the more creative and innovative aspects of research. The computers currently being utilized are the CDC Cyber 845, the Cray-1, and VAX 11/780, all of the University of Minnesota Computer Center; and the PRIME 850 and computer graphics capabilities of the

Planning Information Center, State Planning Agency.

The two major areas of computer activities are data-base development and analysis of geophysical data. The eventual goal is an integrated Geographic Information System (GIS) of geologically related data.

Additional services provided include special purpose applications programming, consulting and assistance for staff geologists, and providing data in response to information requests from outside consultants, well drillers, county planners, and state and federal agencies.

## STRATIGRAPHIC GEOLOGY

J. Mossler, D. Setterholm

The MGS has completed a study of the sedimentology of the Middle Ordovician Platteville Formation. Research indicates that the Platteville was deposited in a quiet subtidal environment on a shallow marine shelf. Low rates of sedimentation characterize the lower part of the formation. Limestone beds in the upper part of the Platteville are separated by shale beds which thicken southwestward toward the Transcontinental Arch. The increased detrital sedimentation was probably caused by uplift of the arch during deposition of the Platteville. X-ray analyses indicate a progressive increase of dolomite content (vs. limestone) toward the north and northeast. The diagenetic fabric of the carbonates suggests that the offshore marine rocks went from the marine phreatic zone into the deeper connate zone without significant exposure.

The Cretaceous rocks of Minnesota are also being studied. Information compiled from the literature and from water well drill holes has been plotted on maps to show the pre-Cretaceous topographic surface and the apparent thickness of the Cretaceous rocks. The exploration model of W.F. Cannon and E.R. Force indicates some potential for occurrences of sedimentary manganese in Minnesota. This should provide increased interest in the Cretaceous rocks of the state for some time to come.

## QUATERNARY GEOLOGY

H. Hobbs, G. Meyer

Research is continuing on subsurface stratigraphy using information from test drilling. Stratigraphy has been recognized by field descriptions of color and texture, and microscopic identification of the very coarse (1-2 mm) sand fraction. Nine new till units have been recognized beneath the Wadena till in Todd County. New data indicate that the Wadena till is of northeastern rather than northwestern provenance as believed earlier, and a new radiocarbon date of 36,970 BP from wood above the till supports an early Wisconsinan age designation. The newly recognized Elmdale till may have been deposited by the first Pleistocene ice advance

into central Minnesota.

MGS is also involved in county-wide surficial mapping, focused primarily on southeastern Minnesota. Recent field work in Winona County has revealed evidence of at least two glaciations separated by a long span of time. The earlier glaciation predates the deep stream dissection which now dominates the landscape bordering the Mississippi River. Mapping of Olmsted County is being used to further define the glacial climate model developed for Winona County.

Research on older glacial deposits and weathering residuum and younger loess and terrace deposits in southeastern Minnesota provides the focus for a paleomagnetic study. Evidence of a magnetic reversal in the older sediments remains elusive at the present time.

The MGS is also aiding the Twin Cities Office of the U.S. Bureau of Mines in its search for local clays to replace western states' bentonite in taconite binder.



Matt Walton (left) and Marc Hoyer inspect the Aquifer Thermal Energy Storage site on the St. Paul campus.

## ENGINEERING AND ENVIRONMENTAL GEOLOGY

### Aquifer Thermal Energy Storage (ATES)

M. Walton, M. Hoyer, J. Spletstoesser, R. Kanivetsky, M. Jirsa

The Aquifer Thermal Energy Storage experiment at the University of Minnesota has been underway since May 1980. It is part of the Underground Energy Storage Program of the U.S. Department of Energy. Together with the University Physical Plant and the U.S. Geological Survey, we are studying the feasibility of storing thermal energy in the Late Cambrian Franconia-Ironton-Galesville confined aquifer, about 590 feet beneath the St. Paul Campus. Heated water is injected into the aquifer and stored; the energy is subsequently recovered by means of a

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# PROJECT UPDATES

(Continued from page 4)

heat exchanger. Four short-term experimental cycles were completed by May 1985 to measure the amount of heat lost during storage.

## County Atlas Program

*B. Olsen, B. Bloomgren, H. Hobbs, R. Kanivetsky, J. Mossler*

Public awareness of the impact that local geologic and hydrologic conditions may have on the spread of ground-water contamination has prompted local government units to seek detailed geologic information. The county atlas program includes (1) data-base development of site-specific geologic and hydrologic reference information, (2) a series of maps or reports depicting county-wide geologic and hydrogeologic conditions, and (3) interaction between county staff and MGS personnel to bring geologic and hydrologic information to bear on local zoning or regulatory problems. Interpretive maps are probably most useful in making local land and water use decisions because few counties have staff expertise in the earth sciences or hydrology.

A geologic atlas for Scott County was published in 1982 and for Winona County in October 1984. Work is currently underway on an atlas for Olmsted County.

## Subsurface Data Program

*B. Olsen, B. Bloomgren, D. Setterholm*

High-quality subsurface geologic and hydrologic information has become an essential element in making wise decisions governing land and water use. MGS receives 500 to 800 telephone requests for subsurface data each year, in addition to having over 100 visitors use in-house files and staff expertise (telephone inquiries for subsurface data: 612-373-3591). Data bases include:

(1) Water well records—approximately 70,000 water well logs have been copied from contractors' files or received since record submission became mandatory in 1975. Approximately 5,000 to 9,000 new logs are received each year. Each well record includes a formation log, a description of well construction, and pumping information. The locations of about 45,000 wells have been field checked by MGS staff. A computer storage and retrieval system has been developed and about 30,000 located and interpreted logs have been entered. In addition, a state-wide water well data base is being developed with the cooperation of the Department of Natural Resources and the Health Department as part of the Land Management Information System.

(2) Engineering soil borings records—approximately 25,000 soil borings logs are on

file which include a lithologic description, blow count record, water table elevation, and engineering test results. About 10,000 of these logs have been entered into a computerized storage and retrieval system.

(3) Mineral exploration logs—over 20,000 records of test holes drilled for aggregate resource evaluation, metallic minerals exploration, and wildcat oil wells are available in manual files or report form. Assay data are available for many metallic mineral test holes and information from 3,000 logs in the Cuyuna mining district has been computerized.

(4) Drill cuttings samples—over 2,000 sets of formation samples collected during drilling of water wells and test holes are housed in a permanent library. Approximately 50 to 100 new sample sets are acquired annually.

(5) Core samples—the Minerals Division of the Minnesota Department of Natural Resources and the U.S. Bureau of Mines each operate core-storage facilities. MGS maintains a small library of core primarily from

southeastern Minnesota and from test holes drilled for publicly funded projects.

## New Brighton Quadrangle

*B. Bloomgren, G. Meyer*

MGS is currently under contract with the Minnesota Pollution Control Agency (MPCA) to provide them with up-to-date bedrock geologic and surficial geologic maps for ground-water contamination studies. Information is being provided by the MPCA drilling program, the Twin Cities Army Arsenal Plant drilling program, and local water well drillers. MPCA consultants have also made available new data on Quaternary sediments for compilation into the surficial map and cross sections.

Both the Survey and the Planning Information Center (formerly LMIC) of the Minnesota Planning Agency have copies of all of the test hole and water well information in a computer data base. This allows the MPCA to attach their water quality analyses to a specific well being sampled. ■

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# STAFF NEWS

*John Spletstoesser* attended the National Geological Society of America convention in Reno in November 1984 where he presented a paper "Geologic studies in the Ellsworth Mountains, Antarctica—A 25-year journey from the unknown." In addition, John presented a paper and chaired a session at the North-Central Geological Society of America meeting in DeKalb, Illinois, April 25-26, 1985. The title of the paper was "Unusual erosional feature in sandstone, Falkland Islands—striations caused by penguin feet."

*Roman Kanivetsky* attended the Legislative Foresite Seminar February 6-9, 1985. Roman also chaired the session on applied hydrogeology at the American Institute of Hydrology Workshop in Minneapolis on May 16-17, 1985. Roman also conducted a seminar at the University of Minnesota on January 24, 1985 on the subject "Are we running out of ground water in Minnesota?"

*Tim Wahl* attended the Ninth Pecora Symposium on Remote Sensing, held in Sioux Falls, S.D., October 2-4, 1984. Interesting aspects of the meeting included possible applications for spatial information handling and image-processing techniques.

*Matt Walton*, MGS Director, participated in the American Institute of Hydrology Workshop held in Minneapolis on May 16-17, 1985. Dr. Walton took part in a special session on "Minnesota Problems and Solutions."

*Val Chandler*, resident geophysicist, attended the DNAG (Decade of North American Geology) conference in Denver in March. He also presented papers on the Kenora-Kabetogama dike swarm and paleomagnetism of the Cloquet and Grand Portage dikes at the International Dike Conference in Toronto on June 3-8, 1985. Val's paper on the "General aspects of the Minnesota Geological Survey aeromagnetic program and advantages of an image-processing approach" will appear in a special volume published by the Society of Exploration Geophysicists. Val recently taught a course in gravity and magnetic exploration at the University of Minnesota. The class highlight for the 42 students was a gravity survey field project across the Midcontinent anomaly.

*Dave Southwick*, Assistant Chief Geologist, recently attended the Institute on Lake Superior Geology annual meeting in Kenora, Ontario. Dave also taught a structural geology course at the University of Minnesota during the spring quarter, 1985.

*Jim Miller, Jr.* attended the Institute on Lake Superior Geology, Kenora, Ontario, and presented a paper on "Petrogenesis of anorthositic rocks of the Duluth Complex."

*Gary Meyer* presented his research on the Wadena till at the North-Central Section Meeting of the Geological Society of America in DeKalb, Illinois.

*Howard Hobbs* attended the North-Central Section Meeting of the Geological Society of America and presented a paper titled "Surficial geology of Winona County, southeastern Minnesota." Howard also testified at the Minnesota Department of Natural Resources Lake Pulaski hearing in the spring of 1985.

(Continued on page 7)

# FUNDING REPORT

## Fiscal Year Ending June 30, 1985

A State Special appropriation from the Legislature provides operating funds (salaries, benefits, supplies, travel, etc.) for the Survey. These appropriations are made by the State Legislature on a biennial (24-month) schedule. State appropriations for fiscal year 1985 included \$681,700 for general expenses and \$376,500 from the Legislative Commission on Minnesota Resources (LCMR) for special projects. In addition to the Legislative appropriations, contracts and grants support a variety of projects. For FY 1985 the total funds from all sources approached \$1.33 million. The contracts and grants listed below were active in the fiscal year ending June 30, 1985, and many will carry over into the next fiscal year and longer.

### Federal Contracts and Grants

- "Midcontinent Strategic Minerals Mapping," U.S. Geological Survey.
- "Structural Analysis of an Archean Greenstone/Granite Terrane in Northern Minnesota," National Science Foundation. (In cooperation with University of Minnesota Department of Geology and Geophysics.)
- "Aquifer Thermal Energy Storage," Battelle Pacific Northwest Laboratory.
- "Field Logistics, Beardmore Area, Antarctica," National Science Foundation subaward through University of Maine.
- "COGEMAP," U.S. Geological Survey.

### State and Other Contracts and Grants

- "Global Greenhouse Projected Changes in the World's Climate on the Availability of Ground Water and Influences on Surface Water in Minnesota," University of Minnesota Hubert Humphrey Institute.
- "Winona County Geological Atlas," Winona County, Minnesota.
- "Geologic Suitability for Landfill Siting, Olmsted County, Minnesota," Olmsted County, Minnesota.
- "Electrical Resistivity Survey of Landfill Sites, Dakota and Carver Counties, Minnesota," Metropolitan Council of the Twin Cities.
- "Surficial and Subsurface Geology of the New Brighton 7½-Minute Quadrangle, Minnesota," Minnesota Pollution Control Agency.
- "Continued Surficial and Subsurface Geology of the New Brighton 7½-Minute Quadrangle, Minnesota," Minnesota Pollution Control Agency.
- "Public Sample Analysis Program," Minnesota Department of Natural Resources.
- "Lithochemical Analysis of Rock Units for Mineral Potential Evaluation," Minnesota Department of Natural Resources. (In cooperation with University of Minnesota-Duluth Geology Department.)
- "Relationship of Structural Geology of the Duluth Complex to Economic Mineralization," Minnesota Department of Natural Resources. (In cooperation with University of Minnesota-Duluth Geology Department and Natural Resources Research Institute.)
- "Review of Crystalline Rock Program-II," Minnesota Environmental Quality Board.
- "Review of Crystalline Rock Program-III," Minnesota Environmental Quality Board.
- "Digitizing Geophysical Data From Northeastern Minnesota," Minnesota Department of Natural Resources.
- "Aquifer Thermal Energy Storage District Cooling Project for Downtown St. Paul, Minnesota;" District Heating Development Company, St. Paul.
- "Olmsted County Geologic Atlas—Phase I," Olmsted County, Minnesota.

## State Legislature—1985-1987 Biennium

The State Special appropriation is \$895,300 for the first year of the 1985-1987 biennium. A slightly larger budget is expected for the second year. In addition, appropriations from the LCMR have been made for the biennium to support several special projects:

- "Aeromagnetic Mapping" \$800,000 for 24 months.
- "Lanesboro Watershed Management Techniques," \$255,000 for 24 months. This project is under the direction of Prof. E. C. Alexander, Jr., University of Minnesota Department of Geology and Geophysics, in cooperation with the University's College of Forestry, Agricultural Experiment Station and the Minnesota Department of Agriculture.
- "Age, Residence Times, and Recharge Rates of Groundwater," \$100,000 for 24 months. This project is under the direction of Prof. E. C. Alexander, Jr., University of Minnesota Department of Geology and Geophysics. ■

## MGS STAFF

What weighs 4,200 pounds, has 52 legs and lives as much as one-third of its life at 2642 University Avenue in St. Paul? Yes, that's right, the 26 full-time employees of the Minnesota Geological Survey, consisting of the scientists and support staff listed below. An additional nine part-time employees were on the payroll in May 1985.

Matt Walton, *Director*  
G.B. Morey, *Associate Director and Chief Geologist*  
David L. Southwick, *Associate Chief Geologist*

Douglas J. Bergstrom, *Geologist*  
Bruce A. Bloomgren, *Geologist*  
Val W. Chandler, *Geophysicist*  
Howard C. Hobbs, *Geologist*  
Marcus C. Hoyer, *Geologist*  
Mark A. Jirsa, *Geologist*  
Roman Kanivetsky, *Hydrogeologist*  
Mary Jo P. Kuhns, *Geologist*  
Richard S. Lively, *Geochronologist*  
Peter L. McSwiggen, *Geologist*

Gary N. Meyer, *Geologist*  
James D. Miller Jr., *Geologist*  
John H. Mossler, *Geologist*  
Bruce M. Olsen, *Geologist*  
Barbara M. Palen, *Geologist*  
Dale R. Setterholm, *Geologist*  
John F. Spletstoesser, *Geological Engineer and Program Manager*

Timothy E. Wahl, *Analyst/Programmer*  
Nancy H. Balaban, *Editor*  
Richard B. Darling, *Graphic Designer*  
Linda L. McDonald, *Senior Accounts Specialist*  
Jeanne B. Perrin, *Administrative Secretary*  
Lynn M. Swanson, *Librarian*

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## STAFF NEWS (Continued from page 5)

*Doug Bergstrom* is currently on leave of absence and has survived his first year of graduate study at the University of Delaware. His Master's program focuses on Cenozoic lacustrine rocks in western Nevada. Doug and G.B. Morey, Associate Director, are co-authors of the Northern MidContinent Region portion of "Correlation of Stratigraphic Units of North America" recently published by the American Association of Petroleum Geologists.

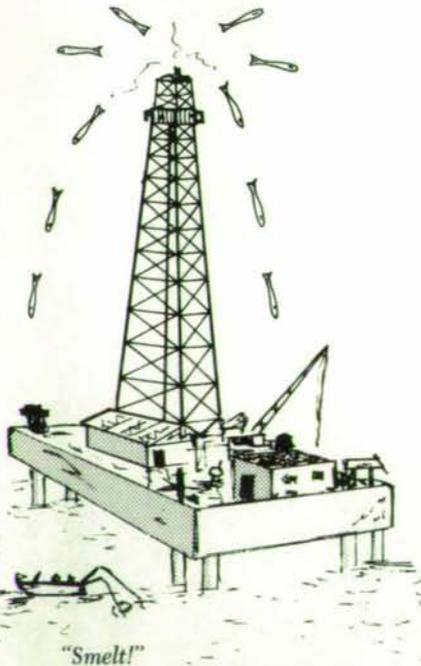
*Mary Jo Kuhns* co-authored a paper on the Cenozoic gravels in the Lewiston basin of Washington and Idaho as part of the "Cenozoic geology of Idaho"—Idaho Bureau of Mines and Geology Bulletin 26 edited in part by former MGS-er Bill Bonnichsen.

*Rich Lively* co-authored a paper presented by the senior author at the North-Central Section Meeting of the Geological Society of America in DeKalb, Illinois, on freshwater stromatolites. ■

## OIL AND GAS

(Continued from page 1)

An effort to find oil or gas typically begins with the leasing of large parcels of land on the basis of very preliminary information and a large-scale program of seismic testing. Both leasing and seismic work have taken place in Minnesota (Fig. 2) and will probably continue. The seismic testing is intended to identify the rift location and the types and relationships of the rocks within it. If results are favorable in light of the theory of oil production, test drilling may follow. So far Kansas is the only site of test drilling on the rift, but the exploration effort continues. Because of the age of the rocks and the lack of testing, the exploration effort on the rift must be considered a high-risk venture. However, it is certain to generate new data that will enhance our understanding of the geology of the Midcontinent rift system. ■



## ★ NEWS NOTES ★

### Geologic Sample Program

During 1984, the Minnesota Geological Survey initiated a Public Sample Program. Funded by the Minnesota Department of Natural Resources, this program identifies geologic samples submitted by the general public. The program was partially initiated as a result of increased gold exploration activity and heightened public interest. The MGS and DNR recognized the fact that amateur prospectors need access to technical assistance for successful exploration. In addition, the samples and detailed sample locations enable the MGS to expand the outcrop data base for the state.



### Survey Moves

As you have noticed if you tried to visit us or buy a topographic map at 1633 Eustis St., St. Paul, we are no longer there. In June, 1983 we created a major tectonic event and moved all rocks and personnel 2 miles south to 2642 University Ave., St. Paul. We are still off-campus, but in a University-owned building about a mile east of our earliest home in Pillsbury Hall. The new building is larger and we now have a core-storage facility and core laboratory. Our telephone numbers have remained the same, but some time within the next academic year University telephone numbers will change as a result of a major conversion to a different communications system. We'll keep you posted!



### Awards

On March 30, Sam Goldich received the University of Minnesota's "Outstanding Achievement Award." The awards ceremony was preceded by a seminar on current research by Department of Geology and Geophysics graduate students. Dr. Goldich's work in geochemistry was reviewed by one of Sam's former students, Gil Hanson of SUNY-Stony Brook. V. Rama Murthy, Acting Vice President of Academic Affairs, presented the award to Dr. Goldich at a special dinner in his honor.

Paul K. Sims, former MGS director now with the U.S. Geological Survey in Denver, received the Institute on Lake Superior Geology's 1985 Goldich medal. Dr. Sims was cited for major contributions to the geology of the Lake Superior region. The award was presented at a special ceremony at the Institute's 31st Annual Meeting in Kenora, Ontario on May 8, 1985. ■

# RECENT SURVEY PUBLICATIONS

GEOLOGIC ATLAS OF WINONA COUNTY, MINNESOTA, edited by N.H. Balaban and Bruce M. Olsen. 1984. 8 plates, scale 1:100,000 and smaller. (County Atlas Series C-2).

THE SEARCH FOR OIL AND GAS IN MINNESOTA, by G.B. Morey. 1984. 30 p. (Educational Series 6).

GEOLOGIC MAP INDEX OF MINNESOTA, 2nd ed., by Timothy E. Wahl, Mary Jo P. Kuhns, and G.B. Morey, 1985.

AGGREGATE RESOURCES INVENTORY, TWIN CITIES METROPOLITAN AREA, MINNESOTA, by Gary N. Meyer and Mark A. Jirsa. 1984. 16 p., 2 plates. (Information Circular 20).

SHADED-RELIEF AEROMAGNETIC ANOMALY MAP OF NORTHEASTERN AND EAST-CENTRAL MINNESOTA, by Val W. Chandler, Earl Nordstrand, and Steven Anderson. 1984. Scale 1:1,000,000. (Miscellaneous Map Series M-53).

SIMPLE BOUGUER GRAVITY MAP OF MINNESOTA, HIBBING SHEET, by Val W. Chandler, Mark A. Jirsa, and Rodney J. Ikola. 1985. Scale 1:250,000. (Miscellaneous Map Series M-56). This map supersedes Miscellaneous Map M-3, by R.J. Ikola, 1968.

PETROLOGY OF SOME LOGAN DIABASE SILLS, COOK COUNTY, MINNESOTA, by Norris W. Jones. 1984. 40 p. (Report of Investigations 29).

INTERFLOW SEDIMENTARY ROCKS IN THE KEWEENAWAN NORTH SHORE VOLCANIC GROUP, NORTHEASTERN MINNESOTA, by Mark A. Jirsa. 1984. 19 p. (Report of Investigations 30).

PRE-PENOKEAN IGNEOUS AND METAMORPHIC ROCKS, BENTON AND STEARNS COUNTIES, CENTRAL MINNESOTA, by George A. Dacre, Glen R. Himmelberg, and G.B. Morey. 1984. 16 p. (Report of Investigations 31).

SHORTER CONTRIBUTIONS TO THE GEOLOGY OF THE SIOUX QUARTZITE (EARLY PROTEROZOIC), SOUTH-WESTERN MINNESOTA, edited by D.L. Southwick. 1984. 74 p., 1 plate. (Report of Investigations 32).

QUATERNARY GEOLOGIC MAP OF THE MINNEAPOLIS-ST. PAUL URBAN AREA, by Gary N. Meyer. 1985. Scale 1:48,000. Color. (Miscellaneous Map Series M-54).

BEDROCK GEOLOGIC AND TOPOGRAPHIC MAPS OF THE MINNEAPOLIS-ST. PAUL URBAN AREA, by Bruce A. Bloomgren. 1985. Scale 1:48,000. Color; 2 plates. (Miscellaneous Map Series M-57).

Inquiries to Map and Publication Sales: (612) 373-0223.

## Branch Office, University of Minnesota, Duluth

The Department of Geology at the Duluth campus of the University maintains an office which distributes publications of the Minnesota Geological Survey, and someone is also available to answer inquiries on the geology of Minnesota. This office is located at 230 Mathematics-Geology Building, Department of Geology, University of Minnesota, Duluth, MN 55812. Telephone (218) 726-8275.

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## In The Lighter Vein

A fascinating announcement was seen recently about a symposium on meteorites to be held in Tokyo. A paragraph on accommodations available for registrants included information on a local institute guest house and the types of rooms and so on, and the delightful statement that "meals are not served, but you can cook yourself." (Or, I suppose, if you share a room with someone, you can cook each other!)

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