

MINNESOTA GEOLOGICAL SURVEY

1969

Minnesota Geological Survey
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Newsletter

UNIVERSITY OF MINNESOTA



MINNESOTA GEOLOGICAL SURVEY

Paul K. Sims, Ph.D., *Director*
Rudolph K. Hogberg, M.S., *Assistant to the Director and Geologist (On leave)*
George S. Austin, M.S., *Geologist (Resigned Sept. 15, 1969)*
Rodney J. Ikola, M.S., *Geophysicist*
Glenn B. Morey, Ph.D., *Geologist*
John H. Mossler, Ph.D., *Geologist*
Walter E. Parham, Ph.D., *Geologist*
Eugene C. Perry, Jr., Ph.D., *Geochemist*
Reta Bradley, B.S., *Geologist and Cartographer*

D.M. Davidson, Jr., Ph.D., *Geologist (part-time)*
James A. Grant, Ph.D., *Geologist (part-time)*
J.C. Green, Ph.D., *Geologist (part-time)*
R.W. Ojakangas, Ph.D. *Geologist (part-time)*

Virginia Williams, *Senior Secretary*
Claudia Colvin, *Senior Clerk-Typist*

Additional part-time staff consists of 4 faculty members and 3 graduate students of the Department of Geology and Geophysics, Minneapolis Campus.

The Minnesota Geological Survey has the responsibility for conducting investigations of the geology of Minnesota for the benefit of the citizens and industries of the State. It carries out this responsibility by geologic mapping of the rock strata, by research on the occurrence, quality, and usefulness of mineral resources, and by publication of the results.

A list of publications of the Minnesota Geological Survey is available upon request. Book reports include a bulletin series, special publication series, reports of investigations, educational series, information circulars, summary reports, reprint series, and miscellaneous reports. Maps include a State geologic map atlas, geologic map series, miscellaneous map series, and other maps and charts.

The Survey welcomes inquiries concerning any aspect of the geology of the State. Inquiries by mail should be addressed to:

Paul K. Sims, Director
Minnesota Geological Survey
University of Minnesota
Minneapolis, Minnesota 55455

The Survey offices are located in Pillsbury Hall and Jones Hall, Minneapolis Campus. Phones 373-3372, 373-4986, 373-4572. A branch office is located at the Geology Department, University of Minnesota, Duluth.

SUMMARY OF ACTIVITIES

The outlook for a base metal mining industry in the state was enhanced during the past year by the beginning of exploration in Minnesota's greenstone belts. The search for massive sulfide deposits of copper, zinc, and silver in the greenstone belts, together with continuing exploration for copper and nickel in the Duluth Complex, give the state a two-pronged chance of attaining a base metal industry. As in the past several years, geologic mapping, geophysical mapping, and research to aid the exploration were given a high priority in our program.

Significant progress was made during the year in knowledge of the sedimentary sequences of southern Minnesota. Studies of water well samples and of several deep cores, made available by Northern Natural Gas Company, have led to refinements in the nomenclature of the Precambrian "Red Clastics," the Paleozoic succession, and the Cretaceous of southwestern Minnesota. Clay mineralogy has proved to be a valuable tool in these studies, particularly for delineating units in the Cretaceous System and determining lateral variations in the Paleozoic strata. A major objective of the accelerated studies of the subsurface is to develop the geologic knowledge needed for ground-water-resource evaluations in southern Minnesota.

In another area of interest, the Survey continued to contribute directly to state-wide planning efforts of the State Planning Agency. A Survey representative was a member of the task force of the State Water Resources Coordinating Committee and was employed half-time by the State Planning Agency as a Mineral Resource Planner.

The 1969 State Legislature recognized our contribution to the state by increasing our appropriations for the coming biennium. The major increment is for state-wide surficial mapping. This program — to map the unconsolidated glacial deposits of the state at a scale of 1:250,000 — will complement the existing program to prepare a bedrock geologic map of the state. A major objective will be to gather data on the distribution, thickness, lithology, and age sequence of the glacial deposits, to aid water resource investigations and land-use planning being carried out by various units of the state government and by federal agencies. The surficial mapping

program will be coordinated with the state-wide soil mapping program and with the hydrologic studies of the Minnesota Department of Conservation and the U.S. Geological Survey, under the aegis of the State Planning Agency.

Additional funds for geologic mapping are provided for 1969-70 through a contract with the Minnesota Department of Conservation. The funds, transferred to the Conservation Department by the Iron Range Resources and Rehabilitation Commission, are to be used to accelerate geologic mapping in northern Minnesota, for the purpose of aiding copper-nickel exploration and the classification of state lands.

An important function of the Survey is to disseminate information about the geology of Minnesota. Eight geologic maps and reports were published during the year, and three maps were placed in open-files in order to make them available to the public at the earliest possible time. The Minnesota Department of Iron Range Resources and Rehabilitation assisted in publishing two book reports and one map. A special report was released in May on the geology and mineral potential of the proposed Voyageurs National Park in northern Minnesota, with the assistance of the Minnesota Resources Commission. The Survey has responsibility in the state for evaluating the mineral potential of areas that are being considered for restricted status.

In addition to publishing reports and maps, the Survey provides direct assistance to many organizations and individuals as a public service. As an example of this activity, this year the Survey assisted the Minnesota Department of Conservation in delineating areas of greenstone belts for mineral leasing. Such activities contribute directly to the state's economy.

The lack of adequate space on the campus continues to handicap Survey operations. The request to the University administration for a new building for the Survey and other units of the School of Earth Sciences was not acted upon by the 1969 State Legislature. Favorable support is needed if we are to expand our role in the growth and development of the state.

BUDGET

The Survey program is financed primarily by direct appropriations of the Minnesota State Legislature. Additional support is provided by University Support funds and by contracts and grants. The total monies available during fiscal year 1968-69 are listed below:

\$ 80,000 — State Legislative Special
40,413 — University Support funds
70,000 — Natural Resources Account
(geologic mapping)

8,300 — State Planning Agency (contracts)
10,850 — NSF Grant (E.C. Perry, Jr.)
3,580 — American Chemical Society Grant
(E.C. Perry, Jr.)
8,900 — Minnesota Department of Conservation
(contract)
2,500 — Iron Range Resources and
Rehabilitation Commission (contract)

\$224,543

A significant increase in funds is available for fiscal year 1969-70, largely as a result of recommendations by the Minnesota Resources Commission and a contract with the Minnesota Department of Conservation. The budget for 1969-70 follows:

\$ 88,000 – State Legislative Special
42,400 – University Support funds
80,000 – Geologic mapping
(Natural Resources Account)

30,000 – Surficial mapping
(Natural Resources Account)
*50,000 – Minnesota Department of Conservation
(contract)
15,000 – Other contracts and grants (estimated)
\$305,400

*Funds provided by Iron Range Resources and Rehabilitation Commission for purpose of accelerating geologic mapping in northern Minnesota.

STAFF NOTES

George S. Austin will resign on September 15, 1969 to complete graduate studies at the University of Iowa. He conducted a field trip for the general public in the Rochester area on October 5, 1968, and prepared an exhibit for the Minnesota Water Well Association annual meeting, held at the Hopkins House, Hopkins, Minnesota, January 21-22, 1969. He attended the annual meeting of the American Association of Petroleum Geologists in Dallas in April.

Bill Bonnichsen resigned in January, 1969 to accept a position as Assistant Professor of Petrology at Cornell University, Ithaca, New York. He will continue mapping and studies of the southern half of the Duluth Complex for the next few summers.

Reta Bradley is preparing a four-part booklet titled "A Guide to the Geology of Minnesota State Parks," which should be completed during the year.

Donald M. Davidson, Jr., Assistant Professor of Geology, University of Minnesota, Duluth, has completed geologic mapping of the Duluth Complex in the Perent Lake and Kawishiwi Lake quadrangles and now is studying the so-called "red rocks" of the complex.

James A. Grant has been appointed Associate Professor of Geology, University of Minnesota, Duluth. He will continue to work summers with the Minnesota Geological Survey.

J.C. Green, Associate Professor of Geology, University of Minnesota, Duluth, will be on sabbatical leave during academic year 1969-70. During much of the year he will be carrying out research sponsored by the Minnesota Geological Survey. In September, 1969 he will attend a Symposium on Volcanoes and their Roots at Oxford University, England.

R.K. Hogberg continued to represent the Survey on the task force of the State Water Resources Coordinating Committee of the State Planning Agency, and was employed half-time by the State Planning Agency as Mineral Resource Planner. He attended the SME fall meeting in Minneapolis in September, the joint AIME-University of Minnesota Mining Symposium in Duluth in January, the Northeastern Section of the Geological Society of America meeting in Albany, New York in March, the 5th Forum on Geology of Industrial Minerals in Harrisburg, Pennsylvania in April, and the Association of American State Geologists annual meeting in Tucson, Arizona in May. He has been granted leave beginning

August 1, 1969 but will continue to represent the Survey on the State Water Resources Coordinating Committee.

Rodney J. Ikola attended the annual meeting of the Society of Exploration Geophysicists in Denver in October, the AIME-University of Minnesota Mining Symposium in Duluth in January, and the Institute on Lake Superior Geology in Oshkosh, Wisconsin in May.

G.B. Morey completed studies of the Thomson Formation (with R.W. Ojakangas) and the subsurface "Red Clastics" during the year. He attended the AIME-University of Minnesota Mining Symposium in Duluth in January and the Institute on Lake Superior Geology in Oshkosh, Wisconsin in May.

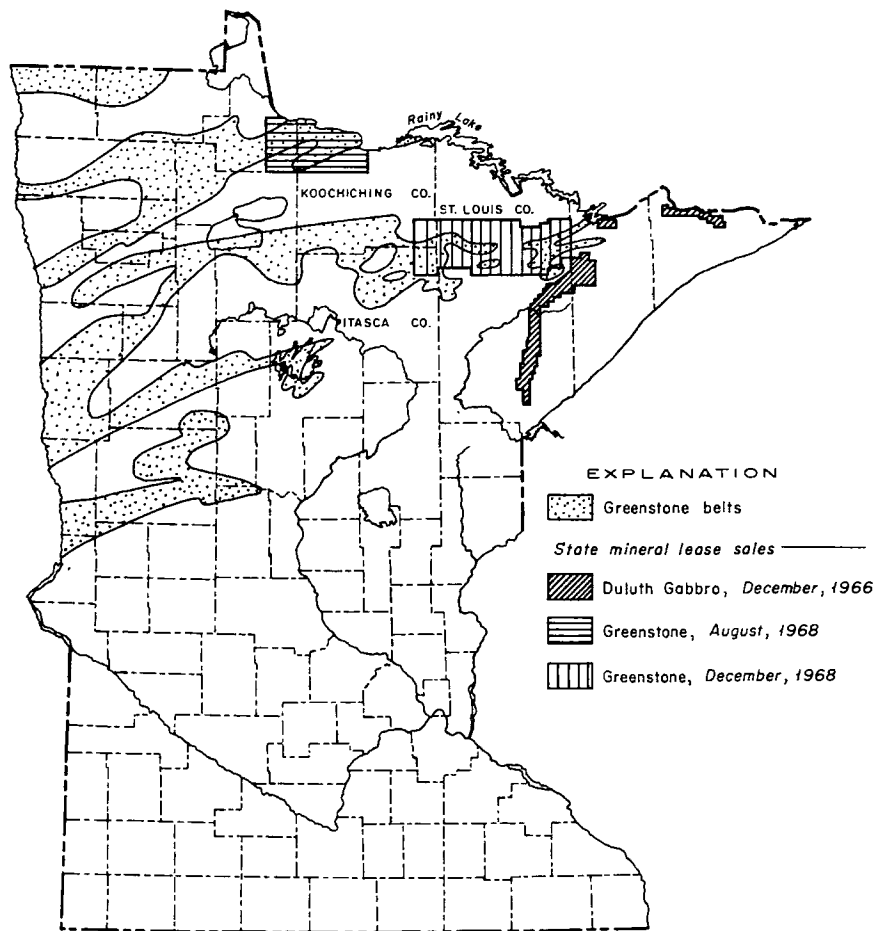
John H. Mossler has accepted an appointment as stratigrapher-sedimentologist with the Minnesota Geological Survey, effective September 15, 1969. He is completing requirements for the Ph.D. degree at the University of Iowa.

R.W. Ojakangas, Associate Professor of Geology, University of Minnesota, Duluth, is continuing studies of the Knife Lake Group and related graywacke sandstones, and has begun reconnaissance geologic mapping of the Roseau 1:250,000 map sheet.

W.E. Parham was awarded a grant from the University's Office of International Programs to attend the 1969 International Clay Conference in Tokyo, Japan in September, where he will present a paper entitled "Halloysite-rich Tropical Weathering Products of Hong Kong." Also, while in Hong Kong, he will study alteration of feldspar and mica in the humid tropics as related to infertile soils. He attended the Clay Minerals Society annual meeting at Indiana University in October, 1968, and was a judge of earth science projects at the annual State Science Fair in Minneapolis in April.

E.C. Perry, Jr. received a grant from the American Chemical Society to sample and study Early Precambrian cherts in the South Africa, India, and Australia shield areas. The collecting trip is related to a comprehensive study of oxygen isotope geochemistry of ancient cherts.

P.K. Sims continued as coordinator of the Federal-State cooperative topographic mapping program, financed by appropriations recommended by the Minnesota Resources Commission. He attended the annual meeting of the American Institute of Mining and Metallurgical Engineers in Washington, D.C. in February.



**MAP SHOWING DISTRIBUTION OF
VOLCANIC ROCKS IN NORTHERN
MINNESOTA**

EXPLORATION FOR BASE METAL SULFIDES IN MINNESOTA

New emphasis was given to the search for base metal deposits during the year by exploration begun in Minnesota's greenstone belts. Interest in the greenstone belts was stimulated by their similarity to productive greenstone belts (copper, zinc, silver, gold, nickel) in Canada and by the leasing of state lands.

For the fourth consecutive year exploration for deposits of copper and nickel in the Duluth Complex, northeastern Minnesota, continued at a high level. The International Nickel Company, Inc., American Metal Climax, Inc., Bear Creek Mining Company, United States Steel Corporation, Cleveland-Cliffs Iron Co., Humble Oil and Refining Co., Phelps Dodge Corp., W.S. Moore Company, Canadian Mining and Smelting Ltd., Duval Corporation, Newmont Exploration Ltd., New Jersey Zinc Co., and The Hanna Mining Company are holding leases and/or are conducting exploration programs. International Nickel Company, Inc. is evaluating the economic feasibility of mining its deposits adjacent to the South Kawishiwi River near Ely.

Activity in the greenstone belts was focused primarily

on two areas in which state lands were offered for leasing (see map on opposite page). In August, 1968, 50,000 acres in northwestern Koochiching County and 8,000 acres in adjacent Lake of the Woods County were leased to two companies: Humble Oil and Refining Co. and Texas Gulf Sulphur Co. In December, 1968, 60,000 acres in north-central St. Louis County, 21,000 acres in northeastern Itasca County, and 7,000 acres in southeastern Koochiching County were leased to six mining companies: Bear Creek Mining Company, The Hanna Mining Company, Humble Oil and Refining Co., The New Jersey Zinc Co., United States Steel Corporation, and W.S. Moore Company. Preliminary investigations of the several companies generally appear to be favorable.

Geologic mapping and research by the Minnesota Geological Survey has contributed directly to the current high level of interest by the mining industry. As an example, a geologic map of the Vermilion district and adjacent areas, published in the early part of 1968, delineated areas underlain by greenstone that now are being

explored by several companies. Also, in northwestern Cook County, geologic mapping along the base of the Duluth Complex, carried out since 1962, has stimulated exploration for copper-nickel deposits.

The Minnesota Geological Survey is continuing geologic mapping, gravity surveying, and research to aid base metal exploration. Geologic mapping is being carried out again this summer in the Vermilion district and adjacent areas to the west in the Duluth Complex. Because of the

interest of the mining industry in areas along the International Boundary in northwestern Minnesota, reconnaissance geologic mapping and gravity surveying were started in western Koochiching, Lake of the Woods, and Roseau counties in June. The Survey's work is being done largely on funds provided by the Natural Resources Account and a contract with the Minnesota Department of Conservation, Division of Waters, Soils, and Minerals.

Lectures and Public Addresses

- G.S. Austin –
Geologic data useful to the Minnesota Geological Survey:
Minnesota Water Well Drillers Association, Hopkins, January
- Bill Bonnicksen –
Status of developments for copper-nickel in northeast Minnesota:
Univ. Minn. Mining Symposium, Duluth, January
- Geology of southern part of the Duluth Complex, Minnesota:
Inst. Lake Superior Geology, Oshkosh, Wis., May
- D.M. Davidson, Jr. –
Felsic rock associations of the Duluth Complex:
Inst. Lake Superior Geology, Oshkosh, Wis., May
- James A. Grant –
Partial melting of common rocks as a possible source of cordierite-anthophyllite-bearing assemblages:
Geol. Soc. America, Mexico City, November
- A petrogenetic grid for the high grade metamorphism of pelitic rocks: American Geophysical Union, Washington, D.C., April
- R.K. Hogberg –
Industrials minerals of Minnesota:
SME Fall meeting, Minneapolis, September
- Aggregates and urban development:
North-central Commercial Aggregate and Ready-Mixed Concrete Producers Association, St. Louis Park, November
- Rodney J. Ikola
A regional gravity survey of the Duluth Complex and adjacent areas in northeastern Minnesota:
SME Fall meeting, Minneapolis, September
- A regional gravity survey of southwestern Minnesota:
Inst. Lake Superior Geology, Oshkosh, Wis., May
- G.B. Morey –
Archean sedimentation, Vermilion district, Minnesota:
Dept. Geology and Geophysics, Minneapolis, October
- Rejuvenated Precambrian faults as a cause of Paleozoic structures in southeastern Minnesota (with D.G. Rensink):
Inst. Lake Superior Geology, Oshkosh, Wis., May
- R.W. Ojakangas –
The Rainy Lake "greenstone" belt:
Inst. Lake Superior Geology, Oshkosh, Wis., May
- W.E. Parham –
Formation of halloysite from feldspar: Low temperature, artificial weathering versus natural weathering:
Ann. mtg. Clay Minerals Society, Bloomington, Ind., October
- Rock weathering in the humid tropics and its effect on man:
Geol. Soc. Minnesota, Minneapolis, March
- Present-day rock weathering in the humid tropics and its relationship to ancient weathering products in Minnesota:
Minn. Geotechnical Society, Minneapolis, April
- Mesozoic weathering in Minnesota and clay mineral formation: and Tropical weathering and lateritic soils:
NSF visiting lecturer, Univ. S.D., Vermillion, S.D., November
- P.K. Sims –
Future potential of the mineral industry in Minnesota: Missouri Basin Inter-Agency Committee mtg., Hibbing, September
- Early stages of evolution of the Minnesota segment of the Superior Province:
State Univ. New York at Stony Brook, October
- Base metal deposits in Minnesota:
Geol. Soc. Minnesota, Minneapolis, December
- The potential for new mineral discoveries in Minnesota:
AIME-Univ. of Minn. Mining Symposium, Duluth, January

Academic Assignments and Other Professional Responsibilities

G.B. Morey –

Department of Geology and Geophysics, University of Minnesota: Assistant Professor: Taught in conjunction with F.M. Swain, an undergraduate course in Stratigraphy and Sedimentology

W.E. Parham –

Department of Geology and Geophysics, University of Minnesota: Associate Professor

E.C. Perry, Jr. –

Department of Geology and Geophysics, University of Minnesota: Assistant Professor

P.K. Sims –

Department of Geology and Geophysics, University of Minnesota: Professor; member of Advisory Committee, University's Water Resources Research Center; Society of Economic Geologists: Chairman of Publications Committee; Economic Geology Publishing Company: Director and member of Executive Committee; North Star Research and Development Institute, Minneapolis: Board of Directors

HIGHLIGHTS OF MINNESOTA'S MINERAL INDUSTRY – 1968 (Furnished by Bureau of Mines, U.S. Department of Interior)

Mineral production in 1968 was valued at \$567.4 million, an increase of about 7 percent over that of 1967. The major reason for the increase was an 8 percent gain in value of iron ore shipments. Iron-bearing ores (including manganese ore) comprised 91 percent of the state's total mineral value. Increases were also indicated for clay (excluding fire clay), lime, sand and gravel, and stone. Output of abrasive stone, portland and masonry cement, fire clay, manganese ore, and peat decreased in quantity and value.

Iron ore was mined from the Cuyuna range, Mesabi range, and the Spring Valley district. About 98 percent of the iron ore produced in Minnesota, including the entire output of taconite pellets, was from the Mesabi range. All iron mining in 1968 was by open-pit methods.

United States Steel Corp. began full-scale operations early in 1968 at its 4.5 million-ton-per-year Minntac plant near Mountain Iron. The Hanna Mining Co. temporarily closed its National Steel Pellet Plant near Keewatin in

August and began construction of a new pelletizing section incorporating a traveling grate and rotary kiln. Construction was completed in the spring of 1969. Hanna operated its Butler Taconite Project near Nashwauk throughout the year. Other companies operating taconite pellet plants in 1968 were Erie Mining Co. at Hoyt Lakes, Eveleth Taconite Co. at Forbes, and Reserve Mining Co. at Silver Bay. With the completion of alterations at the National Steel Plant, Minnesota has an annual pellet capacity of about 32 million tons.

Jones & Laughlin Steel Corp. began production in April at its McKinley mine and concentrating plant. Near Buhl, United States Steel Corp. began stripping operations at its Twin City property, scheduled to be in operation in 1970 as part of the Sherman mine complex. Installation of additional ore washing facilities at the Sherman plant was completed early in 1968. The Hanna Mining Co. ceased mining operations at the South Agnew mine on the Mesabi range and the Rabbit Lake mine on the Cuyuna range.

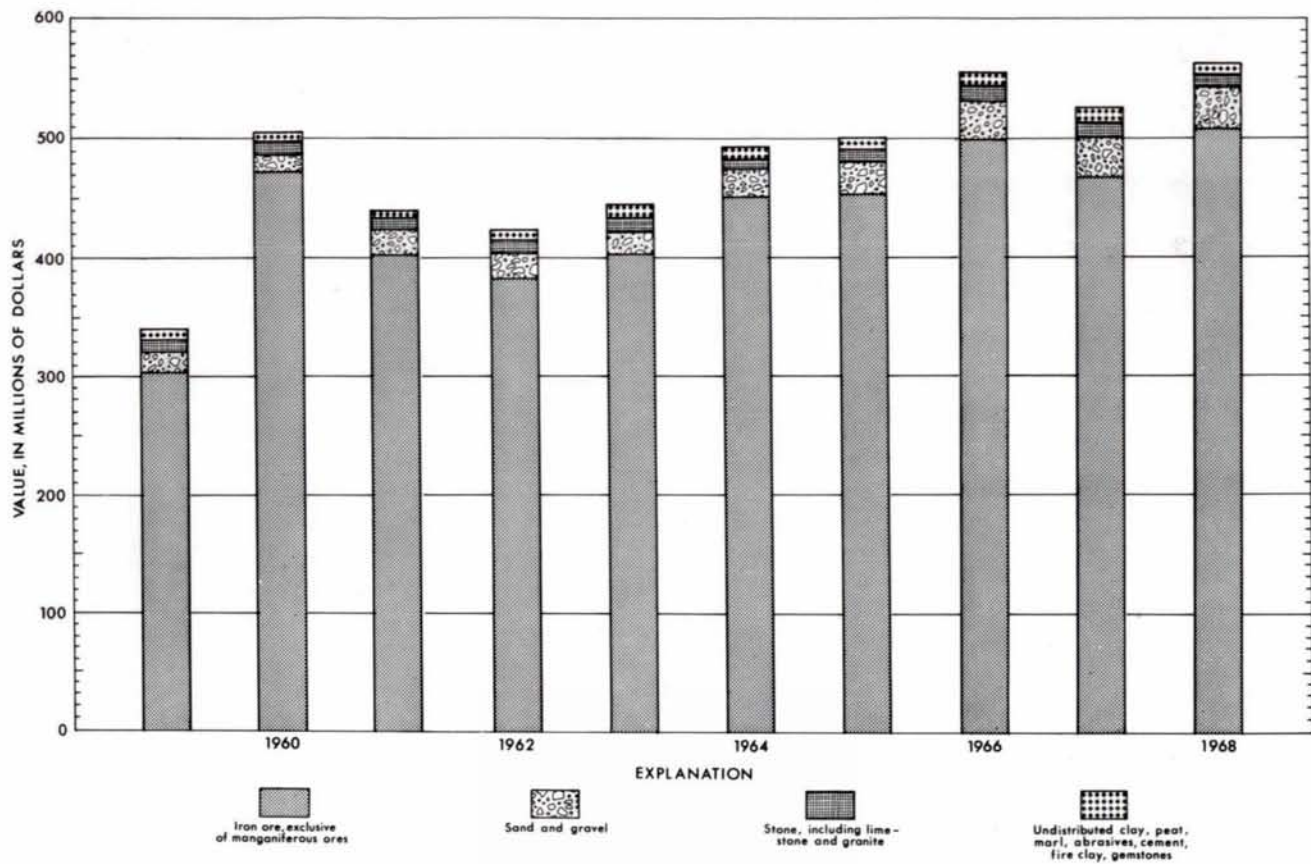
Mineral Production in Minnesota, 1967-68 ^{1/}

Mineral	1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays ^{2/} thousand short tons	228	\$342	240	\$359
Iron Ore (usable) thousand long tons, gross weight	49,457	468,623	51,275	508,814
Manganiferous ore (5 to 35 percent Mn) short tons, gross weight . .	236,753	W	191,846	W
Peat short tons . .	13,968	257	6,400	96
Sand and gravel thousand short tons .	41,212	33,132	44,674	36,414
Stone do .	4,160	11,442	4,427	13,045
Value of items that cannot be disclosed: Abrasive stone, cement, fire clay, gem stones, lime, and values indicated by symbol W	XX	9,530	XX	8,699
Total	XX	\$523,326	XX	\$567,427

W Withheld to avoid disclosing individual company confidential data. XX not applicable

^{1/} Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

^{2/} Excludes fire clay, included with "Value of items that cannot be disclosed."



VALUE OF MINERAL PRODUCTION 1959-68

PROJECTS

Current Projects

1. GEOLOGY OF CENTRAL PART OF DULUTH COMPLEX, Lake County W.C. Phinney
2. MINNESOTA'S CLAY MINERAL RESOURCES W.E. Parham
(Report on kaolin clay resources completed.)
3. GEOLOGY AND GEOCHRONOLOGY OF PRECAMBRIAN ROCKS,
Minnesota River Valley J.A. Grant
4. SEDIMENTOLOGY OF PRECAMBRIAN KNIFE LAKE GROUP R.W. Ojakangas
5. OXYGEN ISOTOPE FRACTIONATION STUDIES E.C. Perry, Jr.
6. GRAVITY INVESTIGATIONS IN MINNESOTA R.J. Ikola
(A network of base stations has been established. Gravity coverage will be
obtained for state as part of state geologic map project.)
7. GEOLOGY OF NORTH SHORE VOLCANIC GROUP J.C. Green
(A stratigraphic and petrologic study, in part financed by a grant from the National
Science Foundation.)

8. GEOLOGY OF THE VERMILION DISTRICT P.K. Sims, G.B. Morey,
(Includes mapping of the Ely quadrangle, by Green, and the R.W. Ojakangas, and
Shagawa Lake quadrangle, by Sims.) J.C. Green
9. ENGINEERING AND GLACIAL GEOLOGY OF MINNEAPOLIS-ST. PAUL AREA J.E. Stone
(Map of Centerville quadrangle completed.)
10. SUBSURFACE STRATIGRAPHY OF MINNESOTA G.S. Austin
(An accelerated study of the subsurface stratigraphy of Minnesota's
Paleozoic rocks, to provide data needed for hydrologic investigations.)
11. GEOLOGIC INVESTIGATIONS, SOUTH HALF OF DULUTH COMPLEX Bill Bonnichsen
(Reconnaissance geologic mapping in progress.)
12. GEOLOGY OF GRAND PORTAGE AND PIGEON POINT AREAS, Cook County P.W. Weiblen
(A reconnaissance investigation, to determine the structure and petrology
of the "Logan sills" and the Rove Formation and to evaluate the potential
for mineral deposits.)
13. GEOLOGY AND METAMORPHISM OF THE GUNFLINT IRON-FORMATION G.B. Morey
(Geologic mapping as part of a project being carried out in
cooperation with the U.S. Geological Survey.)
14. REMOTE SENSING – EVALUATION OF RADAR IMAGERY OF
MESABI RANGE AND ADJACENT AREAS Alta Walker
(Carried out in cooperation with USGS and NASA.)
15. GEOCHRONOLOGY OF MAFIC DIKE ROCKS, NORTHERN
MINNESOTA G.N. Hanson
(A cooperative project with field geologists of the MGS; emphasis
will be placed on dating of minerals.)
16. PETROLOGY AND ORIGIN OF GRANITIC AND METAMORPHIC
ROCKS IN AND ADJACENT TO WESTERN PART OF GIANTS
RANGE BATHOLITH S. Viswanathan

Projects Completed

1. GEOLOGY OF PRECAMBRIAN "RED CLASTICS" SOUTHEASTERN
MINNESOTA G.B. Morey
2. SAND AND GRAVEL RESOURCES, MINNEAPOLIS 15-MINUTE
QUADRANGLE R.K. Hogberg
3. PETROLOGY AND TITANIFEROUS MAGNETITE DEPOSITS OF THE
DULUTH COMPLEX, SOUTH LAKE QUADRANGLE AND ADJACENT
AREAS, Cook County H.D. Nathan
4. GEOLOGIC MAPPING OF TOWER 7½-MINUTE QUADRANGLE,
St. Louis County R.W. Ojakangas and
P.K. Sims
5. GEOLOGY OF PERENT LAKE AND KAWISHIWI LAKE QUAD-
RANGLES, DULUTH COMPLEX, Lake and Cook Counties D.M. Davidson, Jr.
6. SURFICIAL GEOLOGY OF MONTEVIDEO SE QUADRANGLE C.L. Matsch

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| 7. | GEOCHRONOLOGY OF THE MINNESOTA-ONTARIO BORDER REGION | S.S. Goldich and
G.N. Hanson |
| 8. | PARAGENESIS AND COMPOSITIONS OF SULFIDE AND ASSOCIATED
SILICATE MINERALS FROM MINERALIZED ZONE, DULUTH
COMPLEX | P.W. Weiblen |
| 9. | STRATIGRAPHY AND SEDIMENTOLOGY OF THE THOMSON FORMATION | G.B. Morey and
R.W. Ojakangas |

New Projects Begun Fiscal Year 1969-70

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|----|--|----------------|
| 1. | SUBSURFACE GEOLOGY OF TWIN CITIES BASIN
(An intensive study of the stratigraphy and lithofacies of the
subsurface Paleozoic rocks, to aid hydrologic studies.) | John Mossler |
| 2. | PLEISTOCENE GEOLOGY OF NEW ULM 1:250,000 SHEET | C.L. Matsch |
| 3. | AGES OF ROCKS ASSIGNED TO THE PENOKEAN OROGENY IN
MINNESOTA, WISCONSIN, AND MICHIGAN | S.S. Goldich |
| 4. | GEOCHRONOLOGY OF GIANTS RANGE BATHOLITH
(Financed by grant from National Science Foundation.) | G.N. Hanson |
| 5. | HYDROLOGY OF ST. LOUIS PARK AND VICINITY, Hennepin County | H.O. Pfannkuch |
| 6. | GEOLOGY OF LOGAN SILLS AND ASSOCIATED ROVE FORMATION,
HUNGRY JACK LAKE QUADRANGLE, Cook County | E. Mathéz |
| 7. | OSTRACODA OF THE DECORAH FORMATION | F.M. Swain |
| 8. | PALEONTOLOGIC STUDIES OF LATE CAMBRIAN AND EARLY
ORDOVICIAN ROCKS | G.F. Webers |

NEWS ITEMS

A branch office of the Minnesota Geological Survey was established on the Duluth campus of the University of Minnesota in April, 1969. The branch office was made possible by a cooperative arrangement in which three members of the UMD geology faculty rotate as representatives of the Survey. The branch office was established to facilitate liaison with the mining industry and to provide more effective geological services to the region.

The Lake Superior agate was established as the state gemstone by an act of the 1969 State Legislature. It was

selected because of its exceptional beauty and its rather wide distribution in gravel deposits throughout the eastern part of the state. The selection was strongly supported by state rock and mineral clubs.

Two other bills of interest to geologists were passed by the 1969 Minnesota Legislature: (1) H.F. 1207, concerning mineland reclamation and establishing an iron range trail and (2) S.F. 1966, authorizing the state to issue permits to prospect for, and leases to mine, certain minerals where mineral interest have been severed from surface interests.

STATE GEOLOGIC MAP ATLAS PROJECT

Preparation of a new state geologic (bedrock) map, which will consist of 11 separate sheets (scale 1:250,000), continued at about the same level during the year. Progress is summarized below and in the accompanying status map:

Two Harbors Sheet:

Project personnel: J.C. Green, W.C. Phinney, Donald Davidson, Jr., H.D. Nathan, Bill

Bonnichsen, P.W. Weiblen

Progress: 50% completed

Duluth Sheet:

Project personnel: G. B. Morey

Progress: 30% completed

International Falls Sheet:

Project personnel: David Southwick, R.W. Ojakangas

Progress: 30% completed

Stillwater Sheet:

Project personnel: G.S. Austin

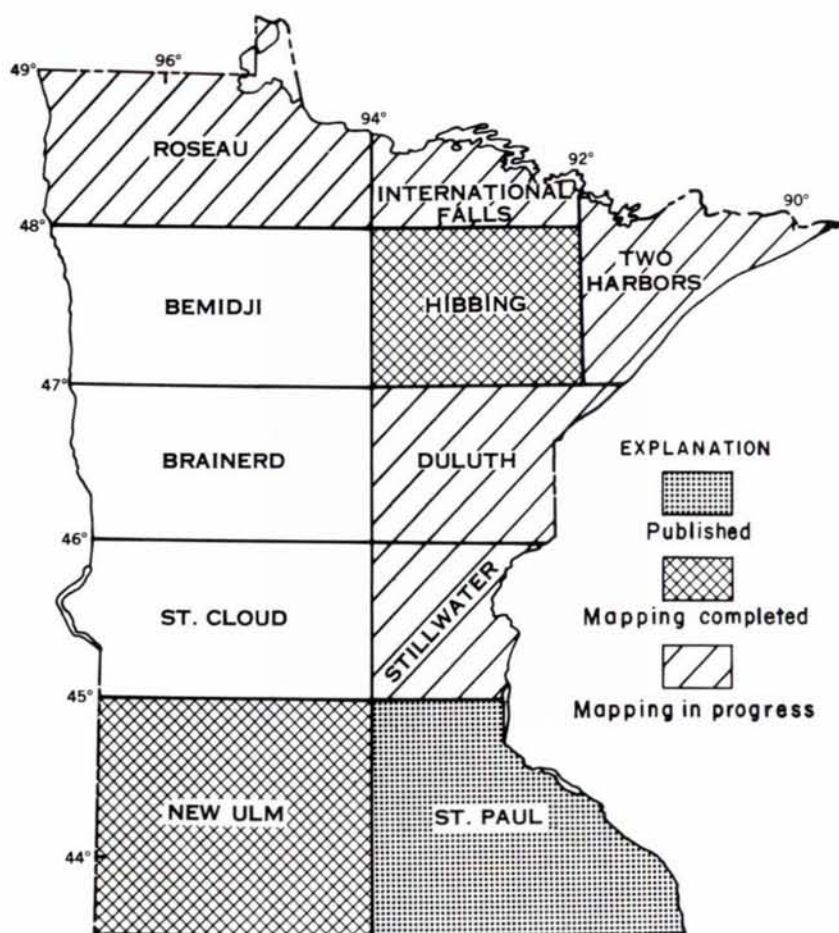
Progress: 25% completed

Roseau Sheet:

Project personnel: R.W. Ojakangas

Progress: Mapping begun June, 1969

The Hibbing and New Ulm sheets are expected to be published during fiscal year 1969-70. Morris T. Eng of the Division of Waters, Soils, and Minerals, Minnesota Department of Conservation, contributed by providing photo-geologic maps of selected areas.



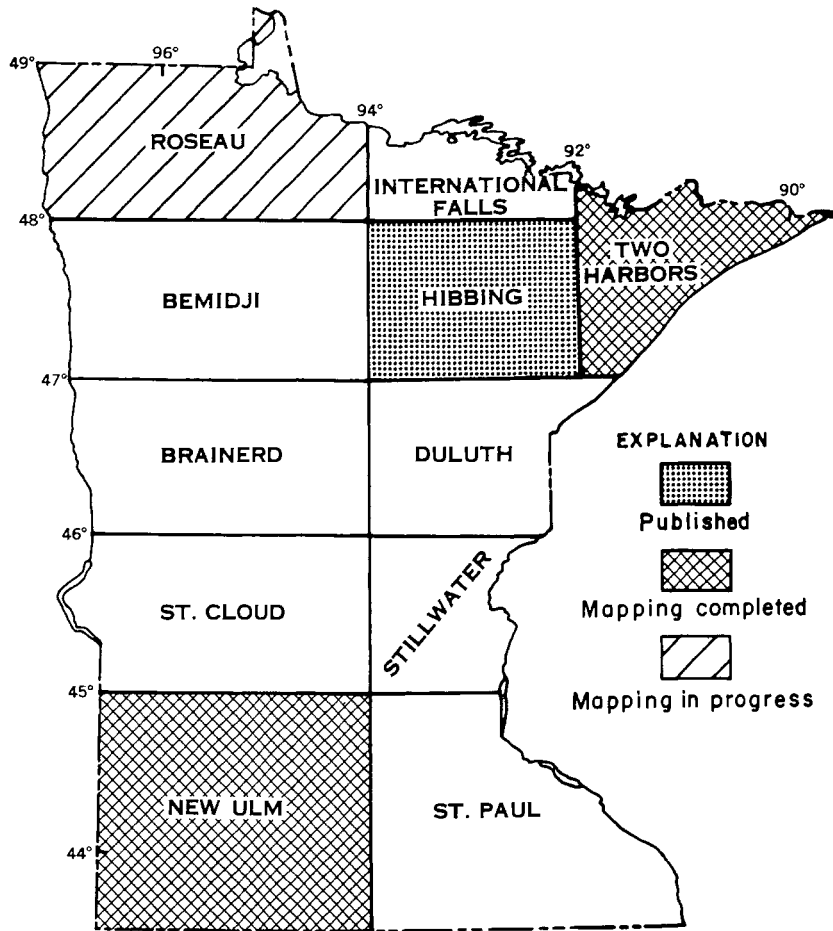
STATUS OF STATE GEOLOGIC MAP ATLAS, JUNE 30, 1968, (SCALE 1:250,000)

STATE GRAVITY MAP PROJECT

Gravity surveys are being carried out by R. J. Ikola concurrently with the State Geologic Map Atlas Project, to aid the geologic mapping and to provide basic data on regional gravity attraction. The data will be published mainly as simple Bouguer gravity maps. A gravity base-

station network has been completed and will soon be published.

The status of the gravity surveying is shown in the accompanying map.



STATUS OF STATE GRAVITY MAY ATLAS, JUNE 30, 1969, (SCALE 1:250,000)

MINNESOTA'S TOPOGRAPHIC MAPPING PROGRAM

Upon recommendation of the Minnesota Resources Commission, the 1969 State Legislature appropriated \$850,000 for the biennium for topographic mapping. This money is matched by Federal (USGS) funds on a 50-50 basis. Currently, the state is about one year behind schedule in the goal to complete topographic mapping by 1975 (See MORRC Report No. 7).

The status of the topographic mapping program is as follows:

- Percent of state covered by published topographic maps:
 - 1:24,000 scale (7½-minute quadrangles) – 34
 - 1:62,500 scale (15-minute quadrangles) – 31
- Percent authorized and in progress – 29
- Percent unmapped and not in program – 6

PUBLICATIONS 1968-69

Books and Reports

Special Publications

- SP-6, 1969, The cryptostome bryozoa from the Middle Ordovician Decorah Shale, Minnesota, by Olgerts L. Karklins, 120 p., 18 fossil plates, 11 figs. \$3.00
- SP-7, 1969, The Geology of the Middle Precambrian Rove Formation in northeastern Minnesota, by

- G.B. Morey, 62 p., 21 figs., 7 tables \$2.00
- SP-8*, 1969, Geology of Isaac Lake quadrangle, St. Louis County, Minnesota, by W.L. Griffin and G.B. Morey, 57 p., 8 figs., includes geologic map \$2.00

Reports of Investigations

- RI-9*, 1969, The Duluth Complex in the Gabbro Lake quadrangle, Minnesota, by W.C. Phinney, 20 p. \$0.50
- RI-10, 1969, Clay mineralogy, fabric, and industrial uses of the shale of the Decorah Formation, southeastern Minnesota, by W.E. Parham and G.S. Austin, 32 p. \$1.00

Reprint Series

- RS-12, 1969, Industrial minerals in Minnesota, by R.K. Hogberg Gratis
- RS-13, 1969, Formation of halloysite from feldspar: low temperature artificial weathering versus natural weathering, by W.E. Parham Gratis
- RS-14, 1969, Halloysite-rich tropical weathering products of Hong Kong, by W.E. Parham Gratis

Administrative Reports

- 1969+, The proposed Voyageurs National Park – its geology and mineral potential \$1.00

Maps

Miscellaneous Map Series

- Map M-6*, 1969, Geologic map of Embarrass quad-

- rangle, St. Louis County, Minnesota, by W.L. Griffin \$1.00

- Map M-7, 1969, Geologic map of Kawishiwi Lake quadrangle, Lake and Cook Counties, Minnesota, by D.M. Davidson, Jr. \$1.00

- Map M-8, 1969, Geologic map of Perent Lake quadrangle, Lake County, Minnesota, by D.M. Davidson, Jr. \$1.00

Open-file Maps

- Geologic map of Tower quadrangle, St. Louis County, Minnesota, by R.W. Ojakangas and P.K. Sims (map and 3 sections) \$1.00

- Geologic map of Long Island Lake quadrangle, Cook County, Minnesota, by G.B. Morey, P.W. Weiblen, J.J. Papike, and D.H. Anderson (map and 3 sections) . . . \$1.00

- Simple Bouguer gravity map of New Ulm 1:250,000 sheet by R.J. Ikola \$1.00

Order book reports and maps from Minnesota Geological Survey.

*Published in cooperation with Department of Iron Range Resources and Rehabilitation.

+Published in cooperation with Minnesota Resources Commission.

Publications by Staff in Scientific and Trade Journals

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- Bonnichsen, Bill, 1969, Status of developments for copper-nickel in northeast Minnesota: *Proc. 30th Ann. Mining Symposium, Univ. Minnesota*.
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- Winter, T.C., Bidwell, L.E., and Maclay, R.W., 1969, Water resources of the Otter Tail River watershed, west-central Minnesota: U.S. Geol. Survey Hydrologic Invs. Atlas, HA-296.

Reports and Maps Being Prepared for Publication

1. Geology of the Cloquet quadrangle, Carlton Co., Minnesota, by H.E. Wright, Jr., L.A. Mattson, and J.A. Thomas (will include colored geologic map).
2. Bedrock geology of the Tower quadrangle, St. Louis Co., Minnesota, by R.W. Ojakangas and P.K. Sims (will include colored geologic map).
3. Clay mineralogy and geology of Minnesota's kaolin clays, by W.E. Parham.
4. Geology of pre-Keweenawan rocks, Gabbro Lake quadrangle, Minnesota, by J.C. Green.
5. Geology and mineral resources of the Minneapolis 15-minute quadrangle, Minnesota, by R.K. Hogberg (will include colored geologic map).
6. Sediments and biogeochemistry of Minnesota Lakes, by F.M. Swain.
7. Glacial and vegetational history of northeastern Minnesota, by H.E. Wright, Jr. and others.
8. Stratigraphic and sedimentological aspects of Red Clastic Series in southeastern Minnesota, by G.B. Morey.
9. Stratigraphy of the Red Clastic Series in deep wells of southeastern Minnesota, by G.B. Morey.
10. Rejuvenated faults as a cause of Paleozoic structures, southeastern Minnesota, by G.B. Morey and D.G. Rensink.
11. Stratigraphy of the Lower Precambrian rocks in the Vermilion district, northeastern Minnesota, by G.B. Morey, J.C. Green, R.W. Ojakangas, and P.K. Sims.
12. Stratigraphy and sedimentology of the Middle Precambrian Thomson Formation, by G.B. Morey and R.W. Ojakangas.
13. Simple Bouguer gravity map of Minnesota and northwestern Wisconsin by Campbell Craddock, H.M. Mooney, and Victoria Kolehmainen (in color; scale 1:1,000,000).
14. Simple Bouguer gravity map of the Two Harbors sheet, by R.J. Ikola (scale 1:250,000).
15. Simple Bouguer gravity map of the New Ulm sheet, by R.J. Ikola (scale 1:250,000).
16. Geologic map of South Lake quadrangle, by G.B. Morey and H.L. Nathan.

GEORGE MELVIN SCHWARTZ GEOLOGICAL SURVEY FUND

The following alumni and friends of Professor Emeritus George Schwartz contributed to the Geological Survey Fund during the past year:

Carlson, Earl R.	Kamb, Hugo R.
Crosby, Garth M.	Quarforth, Kenneth R.
Dresser, Myron A.	Sand, Leonard B.
Dutton, Carl E.	Sandberg, Adolph E.
Gheith, Mohamed A.	Smith, Deane K., Jr.

Watkins, Vernon L.
Wayland, R.G.
Pfleider, E.P.

A major objective of the fund is to publish a volume titled "The Geology of Minnesota," which will be dedicated to Professor Schwartz and is scheduled for publication in 1972, the 100th anniversary of the Survey and the Department of Geology and Geophysics. Your contributions are invited.

OTHER GEOLOGIC ACTIVITIES IN THE STATE

Limnological Research Center, University of Minnesota

Although many of the projects of the Limnological Research Center are concerned most immediately with the biological aspects of lakes and their relations to water chemistry, geologic and hydrologic aspects are frequently involved because lakes receive much of their water and nutrients from the hillslopes of the drainage basin. Also, wherever possible, a long time dimension is considered in the analysis of equilibrium conditions in lakes — and time involves an appreciation for past environmental changes that can be worked out best by the standard geologic methods of stratigraphy and historical geomorphology.

Thus a paleolimnological angle is inserted into many investigations that start out with only a study of this year's or last year's lakes. This approach is most informative when one wishes to determine the degree of cultural eutrophication (i.e., pollution) of a lake within the past four decades. Twenty years ago few lakes had the kind of base-line limnological study that is ordinarily necessary to evaluate the trophic status of a lake, so that it is difficult to determine how extensive modern changes have been and how much effect cultural disturbance has had. But some of the marks of pollution, such as the species composition of the diatom population, leave behind fossils in great abundance, so a stratigraphic analysis of diatoms in the

uppermost part of the sediment section can reveal changes in water quality that could otherwise be postulated only on the basis of the fish stories of old settlers.

An independent stratigraphic indicator that marks the time of general landscape disturbance is the increase in ragweed pollen in sediments. Changes in the elemental or isotopic chemistry of recent sediments might provide additional markers for cultural disturbance, but ions do not stay put like microfossils, so stratigraphic geochemistry is more elusive.

This brand of stratigraphic micropaleontology (and stratigraphic geochemistry, if it works well) is basically historical geology applied to the modern scene. Once a diatom loses its protoplasm — usually in a year or so — it's just as good a fossil as if it had been buried for millions of years. For historical problems of the last few decades, or even for the last few millennia, there is usually little doubt about the general geologic and hydrologic setting of the lake in which the diatoms and other organisms lived, so that paleoecologic interpretation can be circumscribed by modest controls. Several Minnesota lakes will be studied in this manner in the next few years — with the aid of funds from the Atomic Energy Commission and other sources, including the Minnesota Resources Commission.

Other Publications on Minnesota Geology

Matsch, C.L., and Wright, H.E., Jr., 1967, The southern outlet of Lake Agassiz, p. 121-140 in W.J. Mayer-Oakes, ed., *Life, land, and water. Proceedings of a 1966 Conference on Environmental Studies of the glacial Lake Agassiz Region: Winnipeg*, Univ. Manitoba Press, 414 p.

U.S. Geological Survey

Water Resources Division

Water resources investigations in Minnesota were continued by the U.S. Geological Survey during 1969 fiscal year in cooperation with the following state or local agencies: Department of Conservation, Division of Waters, Soils and Minerals; Department of Highways; Department of Iron Range Resources and Rehabilitation; and Metropolitan Council of the Twin Cities area. Some of the funds in the cooperative program with the Department of Conservation were contributed to the state by several municipalities, soil conservation and watershed districts, and even mining companies. Funds totaling \$205,360 from cooperating state agencies were matched by USGS funds. Other programs were financed entirely by the U.S. Geological Survey, St. Paul District Corps of Engineers, Federal

Water Pollution Control Administration, Bureau of Sport Fisheries and Wildlife, Department of State, and power companies under FPC requirements.

Water data collection programs included state-wide networks of stations at which ground water levels, stream flow, water quality, and sediment loads were measured. Water levels and artesian pressures were measured continuously at 43 observation wells and periodically at 132 wells during the year. Many of the wells are included in the state-wide observation well network, some are in project areas and will be operated only for the duration of the project. The chemical quality of the ground water was determined for samples from many of the wells.

The stream-flow gaging station network during 1969

fiscal year consisted of 123 daily gaging stations, 34 gages where measurements were made periodically, and 36 sites where measurements were made only during high flow. In addition, a network of 138 stations in small drainage basins throughout the state was maintained to determine the annual peak discharge of these streams. A report on small-stream flood investigations in Minnesota, 1958-69 was released to the open file. During the floods of April-May 1969, special measurements were requested by other agencies and many other sites. Measurements of these flood discharges were made at a total of about 400 sites in Minnesota. An open-file report of this major flood event is nearing completion.

Lake and reservoir stage records were collected at 33 sites and precipitation records were obtained at 69 sites.

Chemical quality analyses were made monthly or periodically at 58 surface water stations, and one continuous specific conductance recorder was in operation. The sediment discharge of streams was measured daily at two stations and periodically at 15 stations during the year. Water temperature data of streams were obtained daily at four stations and periodically at 122 stations. The records of stream flow and water quality for the 1967 water year were published in the annual report series "Water Resources Data for Minnesota."

The appraisal of water resources of the 39 major watersheds in Minnesota was continued. During 1969 fiscal year, Hydrologic Investigations Atlas HA-296, Otter Tail River; HA-307, Buffalo River; HA-272, Mustinka and Bois de Sioux Rivers; HA-286, Chippewa River; and HA-278, Mississippi Headwaters watersheds were published. Six had been published previously. Atlases HA-339, Wild Rice River; HA-346, Red Lake River; HA-320, Yellow Medicine River; HA-345, Redwood River; and the atlas for the Crow Wing River watershed were released to the open file and are in press. Field work or office compilation were in process for the Cottonwood, Lower Minnesota River, Mississippi-Sauk, Rum, Snake, and Lower St. Croix watersheds.

These atlases describe the general availability, variability, and water quality of the surface and ground waters in the watersheds. They include an analysis of the stream flow records for flood frequencies, flow duration, and low flow and storage requirements. The potential for ground water supplies, the extent and thickness of the glacial drift, and the general configuration of the underlying bedrock are given. The water table and regional movement of ground water are shown.

The U.S. Geological Survey continued to measure the inflow and outflow of Shagawa Lake near Ely and of the St. Claire-Muskrat-Sallie chain of lakes near Detroit Lakes and to determine the ground water contributions or loss to Lake Sallie. These data will be used to determine the water budgets of the lakes as part of the lake eutrophication studies of the Federal Water Pollution Control Administration.

As part of the national program for managing flood losses, the flood-prone areas were delineated on 33 topographic quadrangle maps and released to the open file. For Minnesota, 55 of these maps which show the area subject to flooding are now available.

Intensive studies to determine the availability of ground water for irrigation in the Wadena area and the Brooten-Belgrade area were completed and the reports are in press for publication as USGS Water-Supply Papers. The extent, thickness, and water-yielding characteristics of the water table aquifers, and the effect that several plans for development would have on the aquifers and surface waters in the areas are described. A report for a similar study for the Perham area is near completion. Augering and installation of observation wells, and collection of hydrologic and geologic data were begun for the Little Falls area.

Hydrologic Investigations Atlas HA-299, Reconnaissance of the Red Lake River, Minnesota was published. This atlas evaluates the flow characteristics, water quality, geology, and hydrologic environment as they pertain to the recreational aspects of the river.

A regional study of the geology and water-bearing characteristics of glacial deposits in northeastern Minnesota was continued. During the year, field work was completed, samples of the materials were analyzed for grain size, hydrologic properties, and chemical content, and preparation of the final report was begun.

A study of the hydrology of the Twin Cities metropolitan area was begun in January 1969. The study, based primarily upon existing data, will provide; (1) a first approximation of the surface and ground water resources of the Twin Cities artesian basin, and (2) a basis for immediate water management decisions. Areas requiring further investigation to provide an adequate understanding of the hydrologic system for planning, development, and management of the water resources will be identified.

DIVISION OF WATERS, SOILS AND MINERALS

(Minnesota Department of Conservation)

Underground Gas Storage

History was made in Minnesota on August 16, 1968, when the Department of Conservation issued to the Minneapolis Gas Company the first permit for storing gas underground in the Waseca-Waterville area. This permit

authorized the injection of natural gas into the Mt. Simon Member of the Dresbach Formation for the purpose of testing the feasibility of using the Eau Claire Member as a cap rock.

The first trial injection of gas began on September 26, 1968, and a test gas bubble started forming at about 4:05 P.M. under 309 pounds per square inch pressure. Continuous injection of approximately one million cubic feet of gas per day started on September 29, 1968. As of June 18, 1969, 122 million cubic feet of gas had been injected into the underground structure. The provisions of the permit require periodic shutdowns to observe fluid levels and gas pressures in the wells. Minnegasco is also required to submit monthly progress reports and records from the observation and injection wells. In addition, the Division makes frequent field checks of the project and has conducted water quality tests of farm wells in the area to establish the natural level of methane gas occurring in the ground water.

Proposed Metropolitan Airport at Ham Lake

During the past year, the Metropolitan Airports Commission proposed the construction of a major airport facility in Ham Lake Township, Anoka County. Due to the controversial nature of the Ham Lake site, Governor Harold LeVander requested that the State Planning Agency collect the factual data from concerned state agencies for submission to the Metropolitan Council to assist them in their determination of feasibility of the site.

In response to this request, the Division of Waters, Soils and Minerals conducted a reconnaissance study of the water resources in the vicinity of the proposed airport site. The study involved photogeologic mapping, extensive auger boring, and field surveys in an area encompassing 50 square miles of the Anoka Sand Plain. Conclusions from this study were incorporated in the Department of Conservation report "Water Resources and Wildlife Study of the Proposed Ham Lake Airport Site, Anoka County."

Metropolitan Area Ground Water Study

Currently the division is involved in a reconnaissance study of ground water resources in the Twin Cities Basin. The objectives of this study are to make a general evaluation of all ground water resources above the base of the Hinckley Sandstone in an area involving approximately 18 counties and to publish as soon as possible a lay reader report that will assign gross values to ground water resources. It is planned that this work will be coordinated with and complemented by a concurrent study of the same area by the U.S. Geological Survey, which will result in a more comprehensive and technical report at a later date.

Mapping

The division continued to assist the State Geological Map Atlas Project of the Minnesota Geological Survey by contributing photogeologic reconnaissance maps of selected areas in the Hibbing, Roseau, and Two Harbors Sheet.

Collection of Basic Data

The collection of basic data continued under a cooperative agreement between the Division and the U.S. Geological Survey. The program includes cooperation in maintaining 71 stream-gaging stations and several recording lake-stage stations. The division is cooperating with the U.S. Geological Survey in a program of evaluating the basic

hydrologic data network in the state, including an analysis of ground water, surface water, and water quality measuring and collection systems. Numerous samples were taken from both ground water and surface water sources for chemical analysis and sediment studies. The division is expanding the state-wide lake-level gaging program.

Mineral Leasing

On August 15, 1968, the first sale of State copper-nickel mining leases in greenstone areas was held by the Department. As a result of this sale, 129 leases were issued covering 58,235 acres in Koochiching and Lake of the Woods counties. A second sale in the greenstone areas was held on December 11, 1968, and resulted in 238 leases being issued covering 88,081 acres in St. Louis, Itasca, and Koochiching counties. As exploration in these areas progresses and the state geologic mapping program advances, it is expected that interest in the greenstone belts will expand into other areas. A previous sale of State copper-nickel leases in December, 1966 resulted in 267 leases being issued covering 87,633 acres in Cook, Lake, and St. Louis counties. Exploration in those areas has been continuous since that time.

Long Range Objectives

The future long range objectives of the Division of Waters, Soils and Minerals, as summarized in the Department of Conservation Biennial Report, follows:

1. Promote exploration and extraction of State-owned mineral lease sales and lease negotiations.
2. Provide equitable rental and royalty income from State-owned mineral lands for the school and university trust funds and local taxing districts.
3. Expand data-processing program for exploration-mineral testing data used in evaluation of State-owned mineral properties.
4. Update mineral lease laws.
5. Expand flexibility of Division's applied mineral research and testing facilities.
6. Adopt royalty accounting to a data processing system.
7. Develop mineland reclamation program.
8. Develop flood plain management program.
9. Develop shoreline protection program.
10. Improve water management policies.
11. Provide inventories and informational reports on surface and underground water resources of the state.
12. Provide periodic public information reports on surface and underground water levels and water usage in the state.
13. Provide comprehensive administrative services concerning water resources activities throughout the state.
14. Provide a coordinated water resources management plan for Minnesota.
15. Provide long range plans for hydrologic studies and investigations in the state.

