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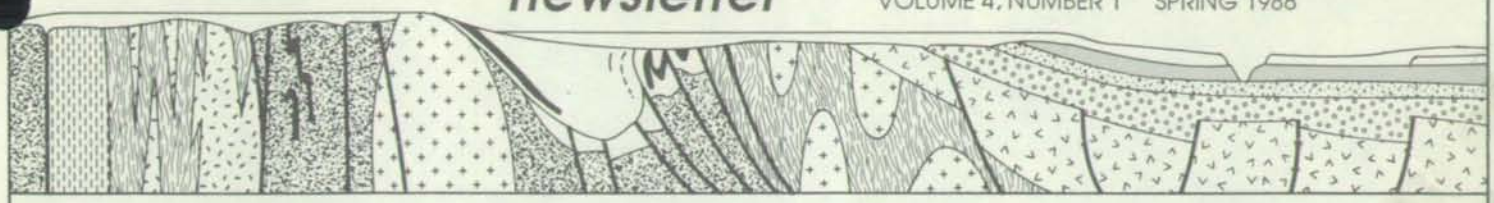

MINNESOTA GEOLOGICAL SURVEY, UNIVERSITY OF MINNESOTA
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SEISMIC REFLECTION ACROSS THE RIFT

Recent exploration for oil in the 1,100-million-year-old Midcontinent rift system has led to increased interest in using seismic reflection profiling for the scientific study of the geologic structures deep within the rift. Seismic reflection data are obtained by creating seismic waves—by explosions or large mechanical vibrators on land, or by airguns in water—and recording the returning waves as they bounce off structures in the subsurface. Earlier scientific studies in Kansas and Michigan had shown the rift to be an excellent subject for seismic reflection studies, and petroleum companies moved quickly to acquire several thousand line-miles of seismic reflection profiles as part of their exploration efforts in the rift.

The Great Lakes International Multidisciplinary Program on Crustal Evolution (GLIMPCE) was formed in late 1985 as a consortium of United States and Canadian scientists who wanted to acquire seismic reflection data for scientific study and, unlike most of the exploration companies, release it to the public. In late 1986, and largely through the cooperative efforts of the U.S. Geological Survey and the Geological Survey of Canada, six profiles across the rift in Lake Superior and Lake Michigan were acquired by GLIMPCE.

Although the results of the GLIMPCE profiles are still under study, significant advances have already been made in the understanding on the deep structure of the rift[1]. Volcanic and sedimentary rocks over 30 kilometers (about 18.5 miles) thick lie along the rift axis under Lake Superior, and prominent reflections of the Moho—a seismologically defined transition between the earth's crust and the mantle—indicate that the pre-rift crust is considerably thinned beneath the rift axis. A graben structure is evident on some of the Lake Superior GLIMPCE lines; related faults might penetrate the entire crustal section.

Midcontinent rift (gray tint), Lake Superior region. GLIMPCE profiles, dotted lines; Petty Ray profiles, dashed lines.

In conjunction with the GLIMPCE work, the Minnesota Geological Survey is investigating four proprietary seismic reflection profiles crossing the rift southwest of Lake Superior. Petty Ray Geophysical has allowed limited use of the profiles for scientific study; the work is being done in cooperation with Purdue University and the Iowa Geological Survey, with partial support from the Legislative Commission on Minnesota

Seismic continued on back page.

CROSS CUT

If you are a regular reader of our Newsletter, you've probably noticed that our masthead has a new look. We wanted a design that would symbolize Minnesota's geology at a glance, and thanks to Survey geologist Mark Jirsa, we got it! Mark's design is a very simplified geologic cross section of the state from the north-central (left) to southeastern (right) borders. On the left are various Archean rock units about 2.7 billion years old. The large, +-patterned ovoid in the left-central part of the section represents the Archean Giants Range Granite. To its right are unpatterned Early Proterozoic metamorphosed sedimentary rocks about 2.2-1.9 b.y. old. The bowl-shaped Animikie basin consists of slate, graywacke and iron-formation, the latter shown in black. The gently dipping iron-formation on the basin's left side is the Biwabik Iron Formation of the Mesabi range; the folded black unit on the right is the Trommald Iron Formation of the Cuyuna range. The southern margin of the Early Proterozoic rocks is marked by faulting within structural zones of the Penokean orogen. Right of those faults are gneissic (wavy lines) and granitic (+) rocks of both Archean and Early Proterozoic age. The Archean gneisses from this district are some of the oldest rocks known in North America, about 3.6 b.y. old. They are on-lapped by Middle Proterozoic volcanic (v) and sedimentary (dots) rock units of the Keweenawan Supergroup 1.2-1.1 b.y. old (the Midcontinent rift). The nearly flat-lying formations atop the right side of the section are Paleozoic sandstone, shale, and dolomite about 515-365 million years old. The small, unpatterned layer at the extreme right represents Cretaceous rocks about 100-75 million years old, which are sporadically exposed in southern and central Minnesota. A thin veneer of Quaternary (glacial) materials deposited in the last two million years covers almost the entire state.

THE INFORMATION EXPLOSION, KNOWLEDGE, AND ABSTRACTS

In April of this year, *Geotimes*[1] reported that the earth sciences are facing an information explosion, illustrated by the dramatic increase since 1960 in the number of citations added to the American Geological Institute's bibliographic database, GeoRef. Minnesota is faced with a similar but smaller-scaled information explosion of its own. From 1778—the year of the first published work on the geology of what is now Minnesota—through 1985, over 5000 documents describing our state's geology have been printed. Of these, 2574 (51%) were released after 1959. Minnesota may never have had a large geologic community, but that community has always been active.

Making sure that the ever-proliferating literature of geology remains accessible is a concern of all geologists. The cost of acquiring and maintaining information has reached crisis levels in academic libraries across the United States. This crisis has hit home here at the University of Minnesota, where the library is possibly facing serious cuts in the serial subscription list for the geology collection.

The authors of the *Geotimes* article suggest reasons for this flood of information. The number of earth scientists has more than doubled since 1960. Indeed, the geologic staff of the Minnesota Geological Survey itself grew from one full-time geologist in 1961 to 20 in 1985. All these geologists have created a demand for more ways to exchange information. At the same time, a desire for professional advancement has created a need to publish with greater frequency. Both needs have been answered by more and larger professional meetings. Although much of the information is exchanged verbally at these meetings, the proceedings are usually summarized in published abstract volumes. More geologists, attending more meetings, mean more abstracts, many of which contain reworked material.

The problem of finding and maintaining information on the geology of Minnesota has interested me for many years and particularly since I started to help compile the bibliography of Minnesota geology, which we now publish at five-year intervals. In 1985, we recognized that the bibliography was growing at a very rapid rate, and that a large part of this growth was due to the proliferation of abstracts.

To better understand the role of the abstract in Minnesota's own information explosion, I asked my colleague David Morrison to examine in detail the types of publications in the published volumes of the *Bibliography of Minnesota Geology*. He found that of the total 5000 citations for the years 1778-1985, some 77% are substantive publications (books, reports, papers, theses, maps, and miscellaneous other publications) and 23%, abstracts. During the early years of the Survey, from 1872 to 1910, 25 substantive publications were produced on the average every year compared to 13 abstracts (a ratio of about two to one). From 1910 to 1959, the yearly average was 16 substantive publications for every four abstracts (a ratio of four to one).

That balance shifted after 1959. For the first time, abstracts were being produced at a rate surpassing that of substantive publications: For each year from 1960 through 1985, 33 substantive publications were produced on the average for 40 abstracts (a ratio of roughly one to one).

"More geologists . . . more meetings . . . more abstracts."

So while geologists are producing more substantial works on the geology of Minnesota than ever before, they are also producing even more abstracts, which are increasing at a rate that is 24% faster than other publications. Thus, much of the information explosion in Minnesota after 1959 is really a trend toward more abstracts. This increase—this abstract inflation—worries me because of the limited value abstracts offer the serious researcher. Everyone who has searched the geologic literature using standard bibliographic sources like the American Geological Institute's *Bibliography and Index of Geology* has had the frustrating and time-wasting experience of finding abstract after abstract and little else. Because of their small size, abstracts were never intended to be end products, but rather to give the gist of an idea or announce a forthcoming publication of significance. They are not particularly valuable in transmitting knowledge. We should ask ourselves whether the abstracts currently produced in conjunction with meetings are worth the effort. If we decide they *are* of some immediate value—as a kind of current awareness bulletin board, what value will they have a year from now, or two years, or ten? How much of our meager resources should we delegate to maintaining comprehensive bibliographic and indexing systems that include all abstracts?

I don't have the answers to these questions, but I would be interested in hearing what you think.

G.B. Morey

[1]Stouffer, P.W., and Spohn, R.A., 1988, Information explosion challenges geologists: Geotimes, v. 33, no. 4, p. 11-12.

MINNESOTA GEOLOGICAL SURVEY NEWSLETTER

The Minnesota Geological Survey is a research and service arm of the School of Earth Sciences at the University of Minnesota. It investigates the geology of Minnesota and provides basic public information on the geology of the state. The Survey Newsletter is published twice a year in the summer and winter to inform readers of the Survey's activities and of other geologic research in the state.

Editors: Lynn Swanson, N.H. Balaban
Graphics: Richard Darling

PROJECT UPDATES

CARBONATE ROCKS OF SOUTHEASTERN MINNESOTA

In an unusual approach to industrial minerals research, and as part of the Mineral Diversification program of the Minnesota Legislature, the Survey and the Natural Resources Research Institute (NRRI) are studying carbonate rocks for possible (and as yet undefined) industrial mineral uses. This is contrary to the industry's usual procedure of looking for a specific mineral for a specific industrial application.

John Mossler is gathering existing chemical analyses from publications, theses, and unpublished reports and field checking the sample collection sites. For areas with few existing data, new samples will be collected and analyzed later this summer. Additional samples will also be collected in some of the previously sampled areas, because the older analyses often lack reports of important chemical constituents.

In another cooperative project with NRRI—this one involving trace element geochemistry of insoluble residues in carbonates—John Mossler and G.B. Morey are collecting well cuttings and core samples from Cambrian, Ordovician, and Devonian rocks in an east-west transect of southeastern Minnesota. After Steven Hauck of NRRI concentrates the insoluble residues from the selected rocks, the Survey will do the trace element analyses.

Earlier studies in Missouri demonstrated the usefulness of this method for detecting mineralization of the Mississippi valley-type in carbonate rocks.

WEATHERED SURFACES AND KAOLIN CLAY

Dale Setterholm and G.B. Morey have designed a drilling program to identify and characterize kaolin clay resources. Kaolin clay is a white clay used in the manufacture of products like coated paper and pharmaceuticals. The focus of the drilling will be the kaolin-rich saprolith that developed on top of the granitoid bedrock terranes of western and central Minnesota prior to Late Cretaceous time (100 million years ago). Core samples of this chemically weathered, decomposed rock will be taken from about ten holes in the Minnesota River Valley and Stearns and Morrison Counties. The best examples in the state of thick saprolith under shallow glacial cover are found in these areas.

The project is funded by the Legislative Commission on Minnesota Resources and involves the Survey, the Natural Resources Research Institute, the Mineral Resources Research Center, and the Department of Natural Resources. But this isn't the first time that the state has turned its attention to investigating the white clay. Scattered research activity can be traced as far back as the 1870s, peaking most recently in the mid-1940s and 1960s. In these older efforts, it was the kaolin outcrops that determined the locations of drilling. While the examination of outcrops is always important, also addressed today are the subsurface occurrences of kaolin and the relationship between the parent rock type (the kind of rock on which chemical weathering occurred) and the quality and quantity of the kaolin (the residual product of the weathering). This year's drilling will penetrate a variety of weathered crystalline rocks.

GRAPHITE IN THE SOUTHERN ANIMIKIE BASIN

Very promising results are coming from a Survey preliminary study of the graphite resources of the southern part of the Animikie basin in east-central Minnesota. Electromagnetic surveys and drilling (much of it undertaken by exploration companies looking for other minerals, like uranium, copper and iron) have long indicated that these rocks contain numerous graphitic units. Geochemical analyses made by Peter McSwiggen of MGS show that the carbon content of some units runs as high as 44%. This is much higher than previously reported for Minnesota rocks and suggests that more systematic and exhaustive sampling of these graphitic units will delineate high-grade occurrences.

The graphite in the Animikie basin may represent a significant source of carbon, which could be needed locally if a recently developed, carbon-based process for self-reducing taconite pellets is introduced in the state.

G.B. Morey is directing the study.

GLACIAL MAPPING AND MINERAL EXPLORATION

Howard Hobbs is compiling a map of the glacial sediments in three adjacent 15-minute quadrangles of central Lake County, northeastern Minnesota. The information is from masters' theses completed over the last ten years by J.R. Stark (northern half, Greenwood Lake quadrangle), A.L. Friedman (Isabella quadrangle), and J.M. Fenelon (Cramer quadrangle).

The area spans the interlobate junction of the Superior and Rainy lobes of the Wisconsinan ice sheet (the last glacial advance in what is now Minnesota), but dynamically there were *three* lobes: The Rainy lobe advancing from the north and northwest, the Superior lobe advancing from the southeast out of the Superior basin, and an intervening "Rainy-Superior" lobe advancing from the northeast. The exact source and path of this third lobe prior to its maximum advance is still unclear. At its outermost and first recessional positions, it deposited brown till rich in North Shore volcanics similar to the till of the Superior lobe, but when it readvanced, it partly covered its recessional deposits with gray till rich in Duluth Complex rocks, similar to the till of the Rainy lobe.

The map when finished will be used by the Department of Natural Resources Minerals Division (which is also funding the project) to guide their drift prospecting program in the area. Drift prospecting is a exploration technique used in areas with extensive glacial cover. The sediments deposited by glaciers are composed of the eroded remnants of the bedrock over which the ice moved. By examining the rocks in this glacial debris and comparing them with known outcrops, the bedrock source of possibly valuable minerals can be traced.

IF NOT THE GIANT BEAVER, WHAT?

The Pitfalls of Selecting a State Fossil

Last March a group of third-graders went to the State Capitol to present their case for the selection of ***Casteroides ohioensis,*** the giant beaver, as Minnesota's state fossil. The children got a hearing at the legislature, but their enthusiasm and perseverance were not enough to get a bill passed. By the end of the legislative session, a state muffin was selected (blueberry) but no fossil. What went wrong?

Robert E. Sloan, professor of geology and paleontology at the University of Minnesota and longtime student of Minnesota paleontology, suggests some guidelines for selecting a state fossil that he hopes will help the children in their next foray into the legislative process.

A state fossil should be common enough so that collectors can find it easily. It should not carry the name of another state or already be another state's fossil. And the state fossil should be typical of the state for which it is selected and not one found nationwide. The giant beaver fails on all three counts: it is very rare—only one complete and three partial specimens have been found in Minnesota; it is named for the state of Ohio; and last, it is found across the country.

What *would* make a good state fossil? Sloan thinks there are many that qualify, ranging from critters that roamed the oceans that once covered Minnesota to giant mammals that lived along the frigid margins of glaciers. The oldest by far is the fossil algae (stromatolite) ***Gruneria biwabika.*** It is almost two *billion* years old. The algae grew in thick mats close to the ocean shore.

Minnesota waters teemed with life during the late Cambrian and Ordovician periods (520-450 million years ago). The fossilized remains of marine invertebrates are found in the rocks on the sides of the Mississippi and St. Croix River valleys from the Twin Cities to the Iowa border. They include ***Dikelocephalus minnesotensis,*** a large trilobite (up to two feet long); ***Isotelus gigas*** and ***Eomonorachus intermedius,*** two other common trilobites; ***Rostricellula minnesotensis,*** a fancy and beautiful brachiopod; and ***Endoceras proteiforme,*** a giant cephalopod with a conical shell up to ten feet long and a foot in diameter at the open end.

Dikelocephalus minnesotensis

Then there are the large Ice Age mammals: ***Mammut americanum,*** the American mastodon, a large elephant that foraged in spruce forests all across Minnesota; the extinct western bison, ***Bison occidentalis,*** which was ten percent larger than the modern *Bison bison*; and the woodlands musk ox, ***Symbos cavifrons,*** an extinct, long-legged relative of the modern musk ox.

Rostricellula minnesotensis

Sloan himself admits to a preference for ***Dikelocephalus minnesotensis*** and ***Rostricellula minnesotensis.*** We'll have to wait until next winter to find out what the school children—and the legislature—decide.

GROUND WATER IN THE MESABI RANGE

Asked to name a resource of the Mesabi range, you will probably answer iron ore. But the range has another and vital below-surface resource, and that is ground water. Some of the best ground water in the state is found under the Mesabi range. It is free of the contaminants plaguing agricultural lands. It is abundant. Managing this valuable resource, and preserving its quality, is a concern of local government and the business community. Their interest prompted the Iron Range Resources and Rehabilitation Board to sponsor a study, now underway by the Survey, of the hydrogeology of the Mesabi range.

To understand ground water, you must first understand the rocks and sediments in which the water is held and moves. The project began with the gathering of basic data on the subsurface geology (both glacial drift and bedrock below it) in the study area from Hibbing to Virginia. Most of the data compiled came from earlier U.S. Geological Survey work and water-well records. Over 3,100 well holes were located and the information entered into INDEX, the state-wide summary file of water-well data. At 68 localities with little information, seismic readings were taken by the Department of Natural Resources, Technical Analysis Unit, to determine depth to bedrock.

Once the water-well and seismic information was entered in the INDEX data base and plotted on a base map, two additional maps were constructed that interpret the bedrock topography and drift thickness in the test area. The bedrock topographic map portrays the bedrock surface as if the glacial deposits covering it were removed. Without the glacial cover, deep valleys cut by glacial meltwater over 15,000 years ago become visible. The drift thickness map portrays the varying thicknesses of the glacial debris that covers the bedrock surface.

The maps can be used to locate areas with the most abundant ground water. In the range, these areas are concentrated in bedrock valleys. South of the range are many deeply cut valleys filled with as much as 300 feet of sand and gravel. These thick glacial deposits are an excellent source of water; the loose, gravelly fill is coarse and water easily enters and accumulates in it. Shallower valleys cut into the range's high ridge of iron-formation. The bedrock at the base of these valleys is fractured; water accumulates within these broken zones, providing an additional source of ground water for the range.

The Mesabi range hydrogeologic study demonstrates how the INDEX summary file of water-well information can help local governments manage water resources in their districts.

Survey geologists Bruce Bloomgren and Gary Meyer directed the mapping. The maps themselves are available for purchase. See the back page for further information.

STAFF NEWS

● ***Rich Lively*** was a guest on KTCA-TV's public affairs program "Almanac," Friday, May 6, where he discussed radon and its effects with hosts Eric Eskola and Jan Smaby.

● ***G.B. Morey*** has taken part in several Minnesota Minerals Forums since last fall. The forums are sponsored by the Blandin Foundation and bring together representatives from various state organizations to discuss ways of developing Minnesota's mineral economy.

● The Survey welcomed a new geologist to its staff in mid-March. ***Fred Campbell*** brings to the Survey experience gained through working at the Minnesota Department of Transportation, Meridian Minerals Company and E.K. Lehmann and Associates, Inc. He received his B.A. from Macalester College and his M.S. in geology from the University of Minnesota, Duluth, in 1982. Fred and his wife Susan, who is a medical assistant, have two children.

● ***Dave Southwick*** taught the Introduction to Geology course in the Department of Geology and Geophysics winter quarter.

● ***Sarah Mills Ervin*** and ***Bob Ferderer*** both finished their work for graduate degrees this spring and have left the Survey for what we hope will be green pastures. Sarah received her master's from the University of Minnesota, Duluth. The title of her thesis is "The Relationships between the Cloud Zone and Basal Zone Cu-Ni Sulfides, and the Significance of Mafic Pegmatites, Minnamax Property, Duluth Complex, Minnesota." She is now taking a well-earned break with her husband; they are traveling near and far—New Zealand to France and points between.

Bob Ferderer successfully defended his Ph.D. dissertation, the title of which is "Application of Werner Deconvolution to the Penokean Orogen, East-Central Minnesota." Bob has worked for Val Chandler as a graduate research assistant since late 1982.

● ***G.B. Morey*** spoke to the Mesabi Range Geological Society April 13 on the activities of the Survey.

FUNDING REPORT

A State Special appropriation from the Minnesota Legislature provides operating funds (salaries, benefits, supplies, travel, etc.) for the Survey. These appropriations are made by the Legislature on a biennial (24-month) schedule. State appropriations for the first year of the biennium beginning July 1, 1987, were $951,900, plus $649,000 from the Legislative Commission on Minnesota Resources for special projects like the state-wide aeromagnetic survey and its accompanying scientific test drilling. For fiscal year 1988 the total funds from all sources were about $1.9 million. The contracts and grants listed below were active in the fiscal year ending June 30, 1988, and many will carry over into the next fiscal year and longer.

FEDERAL CONTRACTS AND GRANTS

COGEOMAP (Cooperative Geologic Mapping) Program in the Duluth Complex, Northeastern Minnesota—U.S. Geological Survey.

Aquifer Thermal Energy Storage—Battelle Pacific Northwest Laboratories.

A Structural-Metamorphic Transect of the Vermilion Granitic Complex, Northeastern Minnesota—National Science Foundation (in cooperation with the University of Minnesota, Department of Geology and Geophysics).

Manganese Potential of the Zuni Strandline, Iowa, Nebraska, South Dakota, Minnesota—U.S. Geological Survey.

STATE AND OTHER CONTRACTS, GRANTS, AND APPROPRIATIONS

Surficial and Subsurface Geologic Mapping of the New Brighton 7.5-Minute Quadrangle, Minnesota—Minnesota Pollution Control Agency.

Pleistocene Geologic Mapping in the Greenwood Lake, Isabella, and Cramer 15-Minute Quadrangles, Lake County, Minnesota—Minnesota Department of Natural Resources.

Public Sample Analysis Program—Minnesota Department of Natural Resources.

Industrial Minerals: Clay Resources—Legislative Commission on Minnesota Resources and Natural Resources Research Institute.

Hydrogeologic Study of the Mesabi Iron Range—Iron Range Resources and Rehabilitation Board.

Olmsted County Geologic Atlas, Phase III—Olmsted County, Minnesota.

Hennepin County Geologic Atlas—Hennepin County, Minnesota.

Washington County Geologic Atlas—Washington County, Minnesota.

Dakota County Geologic Atlas—Dakota County, Minnesota.

Aeromagnetic Mapping—Legislative Commission on Minnesota Resources.

MINERAL DIVERSIFICATION PROJECTS

Geologic Drilling and Mapping—Minnesota Department of Natural Resources.

Stratigraphy, Structure, and Paragenesis of Manganiferous Ores and Iron-Formation in the Roosevelt Lake Area of the Emily District, Cuyuna Range, Minnesota—Minnesota Department of Natural Resources and Mineral Resources Research Center.

Carbonate Rocks: Resource Evaluation—Minnesota Department of Natural Resources and Natural Resources Research Institute.

John Prairie, Jr.

Left, Roman Kanivetsky, Survey hydrogeologist; *center,* Paul Weiblen, director of the University's Space Science Center and Survey staff member; *right,* Alexander S. Ivanchenkov, Soviet cosmonaut. Roman served as interpreter for Ivanchenkov during the latter's visit to the Twin Cities April 24-30. Ivanchenkov was one of several foreign delegates participating in Student Space Week '88. The week's activities provided an unusual opportunity for discussion of possible international space ventures. Roman is a native of Leningrad and came to the U.S. with his family in 1976.

Seismic continued from front page.

Resources. In this project, seismic interpretations are correlated with gravity and magnetic modeling. Results indicate that over 15 kilometers (about 9.3 miles) of sedimentary and volcanic rocks underlie parts of the rift southwest of Lake Superior, and segments of the rift are noticeably asymmetric in cross section, which is consistent with a half-graben accommodation zone model for rift development. Seismic data from northwestern Wisconsin and east-central Minnesota imply the presence in the rift of at least two major volcanic packages separated by angular unconformities.

The seismic reflection studies of the rift by the scientific community and by exploration companies have already enlarged our understanding of this ancient rift and will continue to do so in the future.

Val Chandler

[1]Behrendt, J.C., and others, 1988, Crustal structure of the Midcontinent rift system: Results from GLIMPCE deep seismic reflection profiles: Geology, v. 16, no. 1, p. 81-85.

WOULD YOU REPEAT THAT LAST BIT, PLEASE?

(Don't belittle the proofreader's art. For want of a single letter, sense becomes nonsense, or at least something very peculiar, as the following amply illustrate.)

The Planetarium at the Minneapolis Public Library recently opened a show on the "Death of the Dinosaurs." Public notice for it appeared in community newspapers around the Twin Cities, including one from White Bear Lake spotted by Dale Setterholm that named "steroid impacts on earth" as one of the popular theories to explain the dinosaurs' demise.

John Splettstoesser has treasured for 20 years a clipping he took from the *Washington Post* of a man's photograph with this caption:

John McElhinney
. . . heads unclear research.

RECENT SURVEY PUBLICATIONS

GEOLOGIC MAP OF THE SHERRY LAKE QUADRANGLE, ITASCA COUNTY, MINNESOTA, by M.A. Jirsa. Scale 1:24,000, 1 sheet. (Miscellaneous Map Series M-64). $5.00.

Bicolored bedrock geologic map. Included on the sheet is a discussion of the stratigraphy, metamorphism, and structure of the Archean and Early Proterozoic rocks in this quadrangle.

MINNESOTA GEOLOGICAL SURVEY NEWSLETTER: v. 3, no. 2, Fall 1987; v. 4, no. 1, Spring 1988 (this issue). Free over the map sales counter; $1.00 if requested by mail.

DATA BASE, BEDROCK TOPOGRAPHIC, AND DRIFT THICKNESS MAPS OF THE MESABI RANGE, HIBBING TO VIRGINIA AREA, MINNESOTA, by B.A. Bloomgren, T.G. Guyer, D.R. Kunze, R.E. Rutanen, and A.R. Streitz. Scale 1:62,500, ozalid copy, 3 sheets. (Open-File Report 88-1). $5.00 per sheet. This mapping was sponsored by the Iron Range Resources and Rehabilitation Board. Related article on p. 4.

GEOLOGIC MAP (SCALE 1:250,000) OF THE PENOKEAN OROGEN, CENTRAL AND EASTERN MINNESOTA, AND ACCOMPANYING TEXT, by D.L. Southwick, G.B. Morey, and P.L. McSwiggen. 25 p., 1 folded, full-colored map. (Report of Investigations 37).

The geology of the Animikie basin and contiguous rocks of Early Proterozoic age in central and eastern Minnesota (collectively constituting the western end of the Penokean orogen) is reinterpreted in terms of plate-tectonic theory on the basis of new geophysical and geological data.

DECADE OF NORTH AMERICAN GEOLOGY (DNAG)—FIELD GUIDES TO SELECTED MINNESOTA LOCALITIES. 20 p. (Reprint Series 63). $1.00.

A compilation of four articles by Survey geologists taken from Biggs, D.L., editor, 1987, North-Central Section of the Geological Society of America: G.S.A. Field Guide, v. 3. Included are guides to the Seagull Lake-Gunflint Lake area; an Archean greenstone belt, western Vermilion district; Jay Cooke State Park and Grandview areas; and Pipestone National Monument: Sioux Quartzite.

Mail orders must be accompanied by check or money order made out to the University of Minnesota. There is a $1.00 postage and handling fee, and Minnesota residents must add 6% sales tax. Please direct inquires and orders to Maps and Publications Sales, (612) 627-4782.

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