NEWSLETTER NDGS

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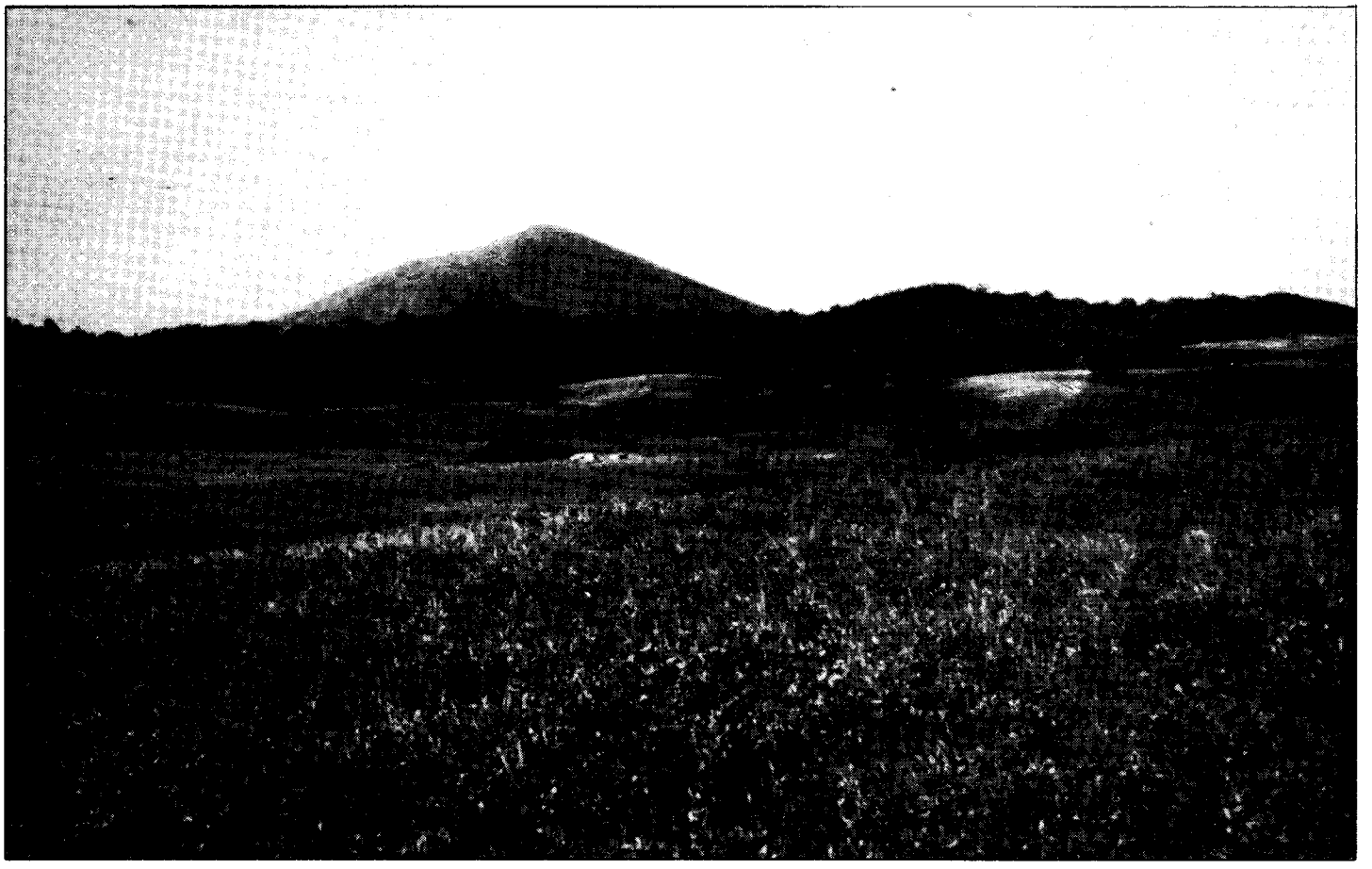

Devils Heart Butte, located about a mile and a half northwest of Tokio in Benson County, North Dakota. This 175-foot-high hill occurs in close association with intensely ice-thrust topography south of Devils Lake. It is composed of sand and gravel and may have formed as a "veblin", a hydrodynamic blowout feature, when high-pressure groundwater flowed to the surface during glacial thrusting. Photo by John Bluemle.

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Your comments - and contributed articles, photographs, meeting announcements, and news items - are welcome. Correspondence, subscription requests, and address changes should be addressed to Editor, *NDGS Newsletter*, North Dakota Geological Survey, 600 E. Boulevard Ave., Bismarck, ND 58505-0840; (tel. 701 224-4109).

NEWSLETTER

NDGS

FROM THE STATE GEOLOGIST

by John P. Bluemle

Geologic Mapping in North Dakota

Since it was founded in 1895, one of the most important functions of the North Dakota Geological Survey has been to map the geology of the State. Occasionally, I am asked when we will finish our mapping. The answer is that the process is ongoing and is never really complete. If all that was needed was a very generalized map, the work might have been completed by 1900. But, as the State's population has grown, as the need for information about geology and mineral resources has increased, and as impacts to the environment have become more severe, the need for ever more accurate and current maps has constantly expanded.

In its most basic form, geologic mapping involves gathering information about the distribution of rocks and minerals, and distinctive groups of rocks and minerals called formations, and plotting this information on maps. We gather information from our field surveys and other sources of geologic information, such as geophysical and remote-sensing data (air photos, satellite images, etc.) and drilling and mining records. All segments of society, including state and local government, private industry, academia, and the public benefit either directly or indirectly from the use of detailed, current geologic maps.

With modern geographic information systems (GIS) computer equipment, the North Dakota Geological Survey has the capability to analyze vast amounts of spatial (map-related) data. Computer-generated maps will be used by nearly all resource managers and policy makers in the future. Much as Galileo's telescope allowed people to look at tiny specks in the sky in a new way, so too will GIS let managers look at vast amounts of geologic data in ways and in detail not possible before. Storage of our geologic maps in digital form (on the computer) will also allow us to more easily update maps as more information becomes available.

Why am I so concerned about geologic mapping? Simply because it is critical that we have this kind of information if we hope to successfully address the pressing environmental, mineral-resource, geologic-hazard, and urban-planning issues facing us today. Knowledge of the geology of our mineral and water resources depends on geologic mapping for their discovery, evaluation, and development. The availability of detailed geologic maps is equally important in insuring our ability to deal with the many environmental and planning problems we face.

Knowledge of geology is basic to many important issues in our society, but a geologic map is not a commodity that can be ordered up in a short period of time. Geologic maps are built on a long history of previous geologic investigations in the vicinity, as well as regionally. As concepts and information change, so is geologic mapping an on-going, ever-changing process. Mapping must be continued at a certain level, so that the database is available when specific decisions are needed or more detailed or site-specific geologic or derivative maps are required.

Early in the Survey's history, various aspects of the State's geology were studied and mapped--lignite, clay deposits, and others--but it wasn't until 1959 that a real effort began to map the entire State. Over the next 30 years, the NDGS, working in close cooperation with the State Water Commission and U.S. Geological Survey, produced geologic maps of each of North Dakota's 53 counties. These maps were published at a scale of 1:125,000 (one inch on the map equals 125,000 inches or two miles on the ground). North Dakota is, I believe, one of only several western states that has been mapped in its entirety, even at this reconnaissance scale.

About six years ago we began compiling the geology of the North Dakota into a series of atlas maps. We are publishing these maps at a scale of 1:250,000 (one inch equals 4 miles on the ground). Each of our atlas maps covers an area measuring 1 degree of latitude by 1 degree of longitude--in North Dakota that amounts to approximately 3,200 square miles. This approach allows us to show a variety of geologic factors in separate map coverages for each one-degree area. In true atlas fashion, each one-degree area will be covered by derivative maps showing such things as near-surface stratigraphy, thickness of glacial deposits, bedrock geology, availability of mineral resources, suitability for construction, engineering constraints, and, as appropriate, other special maps. So far, we have published three of these maps and a fourth is underway.

We are now beginning to map some areas of the State at a scale of 1:24,000 (one inch equals 2,000 feet on the ground). This more detailed scale is needed for addressing some of the current and anticipated geologic problems, especially environmental, that the Survey must handle. Our first effort at geologic mapping at this more detailed scale will be in the Jamestown area. We expect to limit our efforts, initially at least, mainly to urban areas around the state. Two states and Puerto Rico have already been entirely mapped at a scale of 1:24,000. Kentucky (1960-1978), Massachusetts (1938-1982), and Puerto Rico (1952-1988) were each mapped at this detailed scale as part of cooperative projects with the U.S. Geological Survey. The Kentucky project took 18 years to complete and cost $22 million. The Kentucky Geological Survey estimates that the cost of mapping has been repaid to the state at least 50 times over. According to Don Haney, State Geologist of Kentucky, the maps are indispensable tools in the search for much-needed fossil fuels and other mineral resources. The detailed maps are also indispensable for solving environmental and planning problems.

Congress recently passed a bill entitled "H.R. 2763 - The Geologic Mapping Act of 1992"; President Bush signed the bill on May 18. The bill appropriates up to $79 million to the State Geological Surveys for geologic mapping. This is certainly good news for North Dakota because, if the money appropriated by the bill is distributed reasonably evenly among the various states, the North Dakota Geological Survey should be able to make a substantial effort at a detailed geologic mapping program.

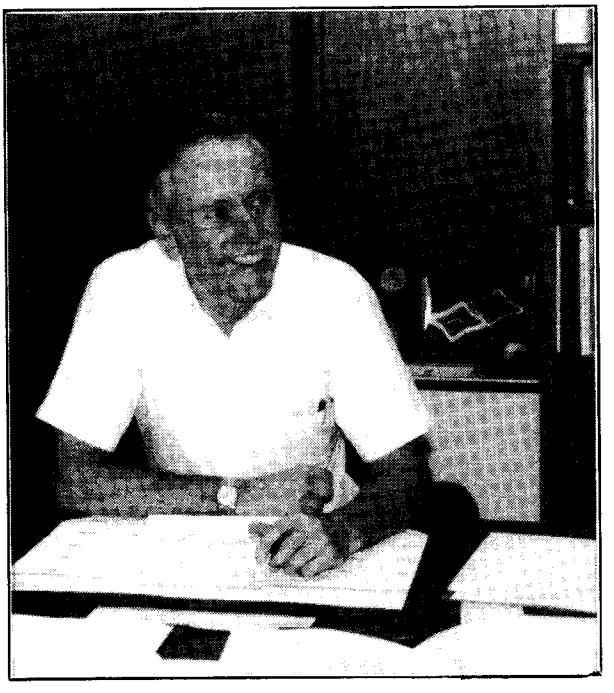
Survey Hires New Assistant State Geologist

Dr. William A. McClellan began work as the new Assistant State Geologist for the North Dakota Geological Survey on April 16. Bill has 23 years of professional experience, ranging from the Great Basin of Nevada to northern Alberta, and including 13 years working in petroleum exploration of the Williston Basin. He moved to Bismarck from Houston, Texas, where he was employed by Columbia Gas Development Corporation for the past 4 years. While with Columbia Gas, Bill worked with the regional stratigraphic and structural geology of the Williston Basin, most recently on the Mission Canyon and Red River Formations. He also developed and directed Columbia's exploration in the Bakken horizontal play in Billings County.

Prior to going to Columbia, Bill had been employed by Transco Exploration Company, MGF Oil Corporation, Odessa Natural Corporation, and Amerada Hess Corporation, all located in Denver. Bill's experience with Transco also involved exploration and drilling in the Williston Basin in North Dakota and Montana. Bill also worked for Atlantic Richfield in Calgary as an exploration geologist for 4 years as well.

In addition to his industry experience, Bill taught in the geology department at the University of Nevada, Las Vegas for 7 years, from 1969 to 1976. He served as department chairman for two years during that time, and he taught and did research in stratigraphy, paleontology, and regional geology. Bill has degrees from the University of Washington (Ph.D.), the University of Cincinnati (M.S.), and the University of Arizona (B.S.).

As Assistant State Geologist, Bill will have a variety of duties. His extensive background and knowledge of Williston Basin geology will enable him to direct most of the activities of our subsurface section. One of his initial research projects will be to map the shoreline trend of the Sherwood zone of the Mission Canyon Fm. (Mississippian) in McLean and Dunn Counties. The study is a regional extension of the play that includes the recently discovered Lucky Mound Field.



NDGS Newsletter

by Bob Biek

A Tribute to Its Founder

In 1974, when I was in the 7th grade, John Bluemle founded the *NDGS Newsletter*. John recognized the need to reach out to those who are interested in or rely on earth science information in North Dakota. As its editor for the past 18 years, he guided 37 issues to press. His dedication to furthering earth science literacy among North Dakota's citizens is unparalleled.

John began with a 9-page mimeographed newsletter. Under his patient guidance, it has grown to over 50 pages and 2,500 copies. There are currently 1,951 subscriptions, which includes 53 subscriptions mailed to Canadian addresses and 61 more to other foreign countries.

The *NDGS Newsletter* has changed little over the years. It gained a colored cover in 1977, black and white photographs in 1979, a cover photograph in 1983. Photo-offset printing replaced mimeograph in the July, 1979 issue, and the welcome addition of computer word processing appeared in 1984. It has, over the years, remained an inexpensive, non-technical publication.

New Editor

This past winter, John Bluemle handed the editorial reins to Bob Biek. With zeal characteristic of a fresh editor, I have made several changes to the *NDGS Newsletter*. Most are cosmetic in nature, as one often does when moving into a new house. One of the more significant, yet simple, changes is that regular features ("departments") will be listed separately in the table of contents. Several new regular features will be added. The objective of these and other changes is to make the *NDGS Newsletter* easier to read and easier to use.

While the *NDGS Newsletter* may have a new look - a new cover, a less cumbersome, easier to read typeface, and regular features - it will remain true to its original purpose. The *NDGS Newsletter* will continue to present a variety of technical and general interest articles and information on the geology and mineral industry of North Dakota.

NEWS IN BRIEF

compiled by Bob Biek

Landfill Investigations

by Phil Greer

The North Dakota Geological Survey, in cooperation with the State Water Commission (SWC), will be evaluating the state's currently active municipal landfills during the next three years. Seventeen landfills have been selected for study in 1992. The study includes soil borings and monitor wells to determine the character of subsurface materials and groundwater. An average of six water samples will be taken at each site.

This project originated with North Dakota House Bill 1060, the comprehensive solid waste management bill passed by the legislature in 1991. One of the provisions of this bill directs the state engineer and the state geologist to complete site suitability reviews of all municipal landfills by July 1, 1995.

Also in 1991, the United States Environmental Protection Agency published regulations for municipal landfills. The EPA regulations, known as Subtitle D, impose strict standards for the location, design, operation, and closure of landfills. These regulations are intended primarily to protect groundwater from contaminants found in household and industrial waste at municipal landfills.

Jeff Olson of the SWC and Phillip Greer of the NDGS will write reports on the geology, hydrogeology, and hydrology of each landfill. These reports will be provided to the landfill operators and to the State Department of Health and Consolidated Laboratories to aid in complying with the new regulations.

COCORP Returns to North Dakota by Tom Heck

COCORP, the Consortium for Continental Reflection Profiling, in cooperation with the United States Geological Survey, is in the process of returning to North Dakota for additional data acquisition across the Trans-Hudson Orogen. When COCORP first came to North Dakota in the summer of 1990, they planned on the simultaneous acquisition of seismic data from 2 different energy sources (vibrator trucks and dynamite). At that time, they were unable to acquire the dynamite portion of the data, and so used only vibrator trucks as their energy source. This year they received the necessary funding to return and acquire the dynamite portion of the line.

The 1990 "shooting", or data acquisition, was some of the most continuous coverage COCORP had ever recorded and the data quality was excellent. This summer they will attempt to reshoot many of the same surface locations recorded in 1990, as well as record new data using dynamite as the energy source. This new data will be obtained along a north-south line near the Nesson Anticline, from the Canadian border to the Missouri River. The reason this new data is being recorded is to "tie" or match up the data recorded in the U.S. with similar seismic data being recorded in Canada.

Representatives from COCORP and the USGS visited us here in Bismarck and reviewed their program before leaving to scout the proposed seismic lines. Permitting of the seismic lines has already begun with the goal of beginning data acquisition in late summer. This new data will help in the interpretation of how the Williston Basin formed and the subsurface extent and structure of the Trans-Hudson Orogen.

Dr. Cooper Land Donates Library and Samples to NDGS by John Bluemle

Dr. Cooper Land recently made an important contribution of core and samples to the North Dakota Geological Survey, as well as his personal library of geologic volumes. The library is a substantial one, and contains many valuable materials. It includes volumes that we needed to help make our library more complete, particularly in view of the fact that when we moved to Bismarck from Grand Forks three years ago, we had to leave our library at the University of North Dakota.

Among the materials donated by Dr. Land are a nearly complete set of *AAPG Bulletin* dating back to the 1920s, and volumes of *Geological Society of America Bulletin, Journal of Paleontology, Journal of Sedimentary Petrology, Mountain Geologist*, and *Sedimentary Geology*. The library includes about 160 USGS publications, including a variety of professional papers and bulletins. It also includes well over 200 books.

The library also includes an extensive collection of publications dealing with uranium, especially in the states of North and South Dakota, Colorado, Wyoming, and Texas. These should be especially valuable to NDGS geologists studying North Dakota's uranium resources.

I want to acknowledge and thank Dr. Land for his generous contribution.

Workshop on Industrial Minerals

"Industrial Minerals Today and Tommorrow: The Raw Materials to Build the Upper Midwest" is the title of a workshop to be held in Minneapolis, Minnesota, September 10-12, 1992. The workshop is sponsored by the U.S. Geological Survey in cooperation with the U.S. Bureau of Mines and the Minnesota Geological Survey. State geological surveys of Illinois, Indiana, Michigan, North Dakota, Ohio, South Dakota, and Wisconsin have helped to define the agenda for this workshop.

The workshop will bring together a wide variety of professionals to discuss: industrial mineral demands and availability; environmental issues and solutions; land use conflicts and resolutions; research needs; and zoning case studies. Planners, politicians, industry representatives, environmentalists, educators, and scientists will participate in this workshop. A fieldtrip on September 12, conducted by the Minnesota Geological Survey, will include stops at Minnesota River Valley dimension stone quarries and a clay pit.

For more information about this workshop, please contact Bob Biek at the NDGS.

Topographic Map and Compass Programs Offerred

Mark Luther, NDGS Geologist, has developed two educational programs that he is willing to present to ND Fishing and Wildlife Clubs. One program will teach interested persons how to read topographic maps; the program lasts for 35 to 45 minutes and will include map reading tips and the presentation of a variety of map types available from the NDGS. A second program (that can be given following the map program) demonstrates compass use; it lasts 45 minutes. The compass program will teach the public how to use a map and compass for locating positions and planning travel routes. A television and a VCR is required for the compass program.

Mark plans to offer these programs statewide, twice per month on a first-come, first-served basis. Day or evening presentations will be accomodated. If your group is interested in hosting a map-use and/or compass-use presentation, please submit a written request, with preferred date(s) and location to: Mark Luther, NDGS, 600 E. Boulevard Ave., Bismarck, ND 58505-0840.

ND Water Quality Symposium Proceedings Available

Proceedings from the Third Biennial North Dakota Water Quality Symposium, held last March in Bismarck, are now available. The proceedings will be mailed to those who registered for the symposium. Persons not so registered can obtain the proceedings for $10 from: Bruce Seelig, Symposium Coordinator, Extension Agricultural Engineering, P.O. Box 5626, North Dakota State University, Fargo, ND 58105; (tel. 701-237-8690). Checks should be made payable to North Dakota State University.

The syposium focused on: factors affecting groundwater and surface water quality; interbasin biota transfer; water quality monitoring, testing, and inventory; water resource protection; and public health issues and water quality education. Approximately 270 people registered for the two day symposium. The symposium was sponsored by the NDSU Extension Service and Experiment Station, in cooperation with 24 other agencies and organizations.

Job-Opportunity Newsletter

Earth Science Opportunities is a new monthly newsletter of current employment opportunities as well as internship, fellowship, and grant announcements. The newsletter provides coverage throughout North America and was first issued in September, 1991. The venture is an attempt to provide a consolidated forum for job listings in all areas related to the earth sciences. Announcements are printed free of charge and may be sent by mail, e-mail, or modem and may include graphics, if these are submitted as Macintosh PICT files.

Earth Science Opportunities is available by subscription at $24.95 for six months, $44.95 for one year, or $84.95 for two years. International rates are available on request. Subscriptions should be sent and checks made payable to Editor, Earth Science Opportunities, 2089 Rt. 9, Cape May Court House, NJ 08210 (tel. 609-624-0608).

Regulations Available

The NDGS administers regulatory programs for subsurface minerals, coal exploration, Class III injection wells, geothermal resources, and paleontological resources.

Subsurface Minerals	-	NDCC ch. 38-12
		NDAC ch. 43-02-02
Coal Exploration	-	NDCC ch. 38-12.1
		NDAC ch. 43-02-01
Class III Injection Wells	-	NDCC ch. 38-12
		NDAC ch. 43-02-02.1
Geothermal	-	NDCC ch. 38-19
		NDAC ch. 43-02-07
Paleontological	-	NDCC ch. 54-17.3
		NDAC ch. 43-04-01

Persons seeking information about these programs and regulatory requirements are encouraged to contact the NDGS. Copies of these statutes, and attendent regulations and forms, are available free from the NDGS.

Geothermal Regulatory Program

Geothermal (groundwater) heat pumps use normal temperature earth or groundwater for heating during the winter, cooling during the summer, and supplying hot water for domestic use year-round. Because electricity is used only to transfer heat, not to produce it, the groundwater heat pump delivers 3 to 4 times more energy than it consumes.

Not suprisingly, such geothermal heating and cooling systems are becoming increasingly popular with homeowners and both large and small organizations and businesses. Geothermal heating and cooling systems were the focus of two previous *NDGS Newsletter* articles. The June, 1982 article discussed the cost effectiveness of geothermal heating and cooling systems. The December, 1990 discussed closed-loop systems. Here, I want to remind potential owners of such systems - and the consultants and contractors that design and install them - about North Dakota's Geothermal Regulatory Program.

In 1984, the North Dakota Legislature declared it to be in the public interest to regulate geothermal heating and cooling systems. These regulations are contained in Chapters 38-19 and 43-02-07 of the North Dakota Century and Administrative Codes, respectively. They require that a permit be obtained prior to the installation of geothermal heating and/or cooling systems; a permit is not needed for private residential systems.

The NDGS is responsible for the State's Geothermal Regulatory Program, and, in fact, we are mandated to encourage the proper and safe use of geothermal resources. Our permit review process helps to ensure that geothermal systems are properly designed and constructed. Our principal concerns are to avoid groundwater contamination and to protect correlative rights of adjacent landowners.

Persons seeking additional information on geothermal regulations, or geothermal heating and cooling systems in general, are encouraged to call Bob Biek at the NDGS.

Nonfuel Mineral Industry Statistics

The U.S Bureau of Mines recently released 1991 estimates of nonfuel mineral production for North Dakota. The value of North Dakota's nonfuel mineral production was nearly $18 million in 1991, a decrease of 33% from that of 1990. Construction sand and gravel accounted for nearly 78% of the value of North Dakota's nonfuel mineral output. Elemental sulfur was recovered from natural gas processing, but is not included in the bureau's estimates.

Nonfuel mineral production in North Dakota 1/

Mineral	1989		1990		1991e/	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays ---------- metric tons --	47,903	W	50,485	W	40,823	W
Gem stones ----------	NA	$10	NA	$10	NA	10
Lime ---------- thousand short tons --	107	5,439	82	4,623	68	3,813
Sand and gravel (construction) --- do.--	e/3,600	e/8,100	7,644	17,219	e/6,000	e/13,800
Stone (crushed) ---------- short tons --	--	--	e/1,000	e/4,600	--	--
Combined value of other industrial minerals and values indicated by symbol W ----------	XX	111	XX	116	XX	106
Total----------	XX	13,660	XX	26,568	XX	17,729

e/Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
1/Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Veblins, Hydrodynamic Blowouts, and Other Unusual Geologic Features in North Dakota

by John Bluemle

When groundwater, under pressure in a buried aquifer, exits forcibly to the land surface through a small opening in the ground, it can form some rather unusual landforms. Upward flows of groundwater under high pressure ("hydrodynamic or hydrologic blowouts") apparently were responsible for causing some of these features in North Dakota at the time the area was glaciated. In this article, I'll discuss this process and the kinds of landforms that resulted from it. These features are not well understood and it's likely that some geologists will disagree with some of my ideas.

Groundwater flowing upward from an over-pressured, confined aquifer may flow at the ground surface; confined aquifers are sometimes referred to as "artesian" (artesian wells are wells in which water rises in the well-bore, sometimes flowing at the surface). If the area above such an aquifer is flooded by a lake, the groundwater may flow into the lake. As I noted, extremely heavy flows of groundwater upward to the surface under high pressure are usually referred to as "hydrodynamic blowouts;" smaller flows are generally termed spring seeps or, simply, "springs." At the time North Dakota was glaciated, water sometimes flowed up to the base of the ice and, in some places, through a crack or other opening in the ice, to the surface of the glacier.

Initially, when a hydrodynamic blowout first happens, the upward flow of water may be sufficient to transport large particles upward--even gravel and rock--and rapidly build up a cone of material at the ground surface. However, as the upward flow volume becomes less concentrated (as the vent becomes broader and more diffuse), and as the flow decreases as groundwater pressure is relieved, both the amount and size of particles of clastic material being transported upward tend to decrease; water simply seeps to the surface.

Modern hydrodynamic blowouts can occur in a variety of situations. In North Dakota, the best-known of these is when a drill hole penetrates a confined ("artesian"), high-pressure aquifer. Despite efforts to contain the resulting flows, such drill holes sometimes blow, or flow, out of control (similar blowouts can happen when oil or gas wells are drilled and zones of high-pressure fluids are encountered). The flows may continue for several months, resulting in considerable amounts of water and washed material being carried upward to the surface of the ground. Geologists with the North Dakota Geological Survey experienced such a flowing well first hand several years ago near Neche in Pembina County while exploring for cement rock. We inadvertently drilled into a relatively shallow, but highly pressured aquifer that blew out so that we could not control the flow of water. The salty water and fine sand that flowed to the surface for several days were difficult for us to manage.

The fact that salty artesian "Dakota" aquifer water is escaping to the surface in eastern North Dakota has been known since the late 1800s. Descriptions of uncontrolled water flows that commonly resulted when wells were drilled into the aquifer are documented from that time. The earliest reported that I know of, in 1886, was drilled to a depth of 1,087 feet near Ellendale. It flowed between 600 and 700 gallons of salty water per minute and had a pressure reported between 115 and 175 pounds per square inch. Another, much shallower well drilled near Grafton in the late 1800s, blew out of control. This well is less precisely documented, but it was reported at the time that, in an attempt to plug the well, a railroad rail was dropped down the well bore. However, after a short time, the rail blew out of the hole. So many wells were drilled into the Dakota aquifer in the late 1800s and early 1900s that the pressure has by now been largely dissipated. Although a well drilled into the aquifer in some places may still flow to the surface, in other places the upward flow of water won't reach the surface.

The above examples were caused when man-made drill holes penetrated artesian aquifers, but hydrodynamic blowouts also occur in nature. Over the

last ten years, NDGS geologists have recognized a variety of geologic features in eastern North Dakota that probably formed as a result of blowout processes during glaciation, and especially at about the time the area was being deglaciated.

Probably the best-documented natural hydrodynamic blowout feature in the northern prairie area is Howe Lake, located in southeastern Saskatchewan. This feature was described in 1982 by Saskatchewan Research Council geologists E. A. Christiansen and W. A. Meneley, and University of Saskatchewan geologist D. J. Gendzwill (I've included a reference to their report at the end of this article). Howe Lake is an almost perfectly circular lake, 295 metres across and 26 metres deep, much deeper than most prairie lakes. Without describing the feature in detail here, it can be characterized as a flooded, cone-shaped depression with a funnel-shaped core of sand and gravel that extends downward to a considerable depth (deeper than the 138 metres they drilled). The authors of the Howe Lake article believe that the basin containing the lake was formed when groundwater flowed upward to the surface from the underlying, confined Mannville aquifer (the Mannville in Saskatchewan is approximately equivalent to the Lower Cretaceous Inyan Kara, known also as the "Dakota aquifer" in North Dakota). The Mannville aquifer was, at the time the blowout took place (probably about 12,000 years ago), highly overpressured, a result of large quantities of water building up in it when it was overlain by a glacier. I have included two illustrations taken from the Howe Lake article to illustrate these relationships (Figs. 1 and 2).

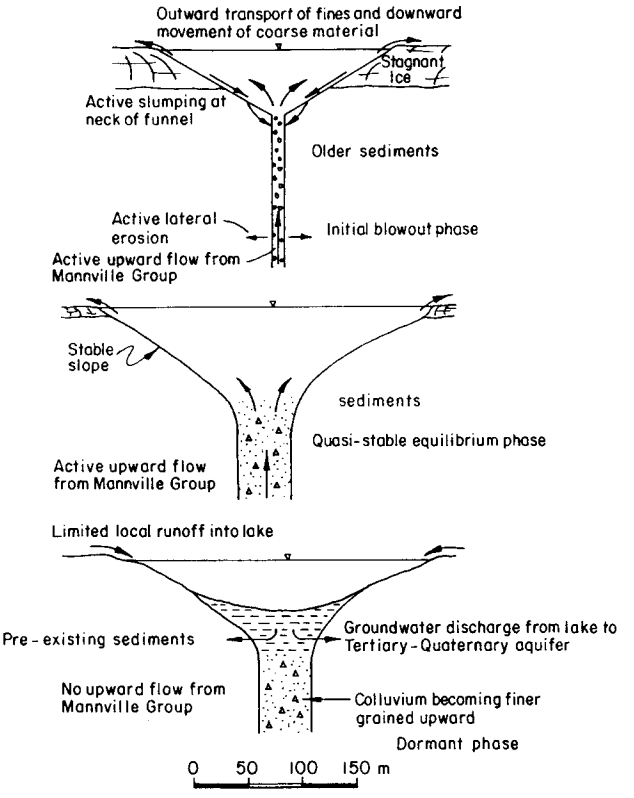


Figure 2. Generalized, hypothetical cross-section showing how the Howe Lake hydrodynamic blowout structure developed. During the initial blowout phase (top diagram), water flowing upward from the Mannville Group under high pressure transported sand and gravel. During later stages of development, the conduit became larger so that the upward-flowing water moved under less pressure and was less able to transport material. Modified from Christiansen, Gendzwill, and Meneley (1982).

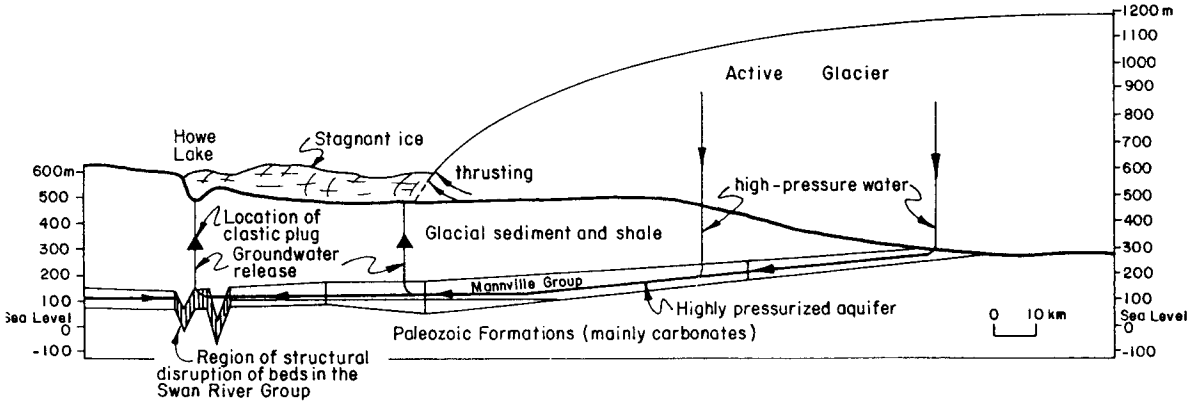


Figure 1. Generalized, hypothetical cross-section showing local groundwater flow lines beneath and in front of a glacier. This illustration represents hydrologic conditions at the time the Howe Lake structure formed. Modified from Christiansen, Gendzwill, and Meneley (1982).

In North Dakota, a variety of features that have been attributed to natural hydrodynamic blowout processes have been recognized over the years. Most of these are found in eastern North Dakota, where the Cretaceous Inyan Kara and, in some places, older Paleozoic aquifers lie directly beneath glacial sediment. Many of the features occur within the area that was flooded by glacial Lake Agassiz. At Sheldon, North Dakota in Ransom County, a small pool of clear, salty water appears to be a near-perfect analogy to the Howe Lake feature in Saskatchewan (though the Sheldon feature is smaller than Howe Lake).

Forty-six years ago, State Geologist Wilson Laird recognized that lake depressions such as Kelly Slough in eastern Grand Forks County were formed when artesian spring water flowed upward to the surface and caused sapping of the near-surface materials and the development of a spring pit (Fig. 3) (Laird, 1944). Since that time, features such as Salt Lake and Lake Ardoch in Walsh County have been recognized as having similar origins.

In the 1960s, Joe Downey, geologist with the United States Geological Survey, reported that thick deposits of glacial sand and gravel that underlie depressions like Kelly Slough appear to be hydraulically connected by sandy "stems" with the underlying preglacial bedrock. Downey referred to these stems as "clastic plugs" (Downey, 1969). He speculated that, during deglaciation of the area, meltwater resulting from pressure melting at the base of the ice sheet was forced downward into the Dakota aquifer. Upon deglaciation, as the pressure was removed, large quantities of water moved upward out of the aquifer. This upward movement of water through the overlying materials may have been rapid at first. It resulted in erosion of the glacial Lake Agassiz sediments, forming the depressions in which the two lakes exist today. Salty water continues to seep to the surface at Kelly Slough today, although at a very reduced rate.

In addition to Kelly Slough, Salt Lake, and Lake Ardoch, a number of smaller spring pits can be found on

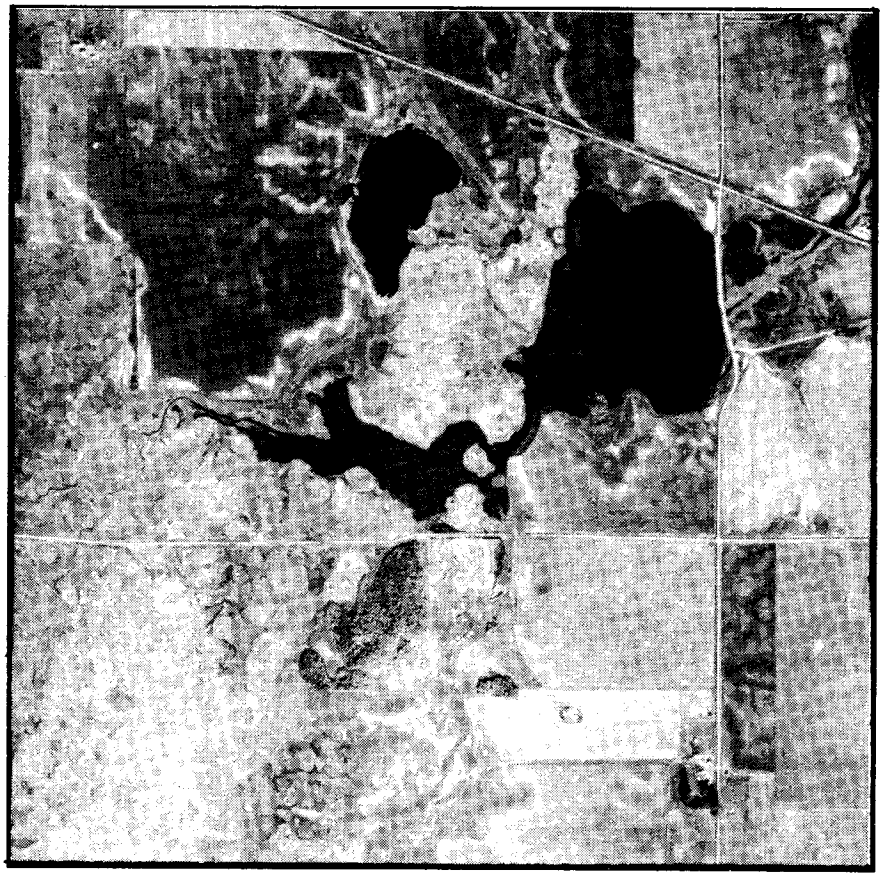


Figure 3. Vertical air photo of Kelly Slough in Grand Forks County, about six miles west of Grand Forks. Kelly Slough is a spring pit where salty groundwater is seeping to the surface. Water that reaches the surface either evaporates, resulting in the deposition of a salty crust--the white fringe along the north edge of the lake is salt left as a residue after evaporation--or it flows to the northeast, making its way to the Red River. Individual springs, places where the water is upwelling, show up as light colored circles with darker dots in the center. Kelly Slough, and other similar spring pits, originated at the end of the Ice Age when highly pressurized water in the underlying preglacial formations blew out, carrying sand to the surface. Area shown is about 1.7 miles wide; north is at top of photo.

the glacial Lake Agassiz plain, overlying the subcrop of the Cretaceous Inyan Kara aquifer and other (mainly Paleozoic) aquifers. It is likely that considerable amounts of sand were transported upward during the initial flows, when the water first burst through the ground, which at the time was flooded by glacial Lake Agassiz. In such places, where the water issued into the bottom of a lake, the sand then spread out over the lake floor and is difficult to recognize today.

In places where the groundwater vented at the land surface, some unusual landforms resulted. Near the North Dakota-South Dakota state line in Sargent and Richland Counties, a number of cone-shaped hills of sand--possible hydrodynamic blowout features--are found (these hills do not appear to be the result of other geologic processes, such as those that formed kames, etc.). Ken Harris, formerly with the NDGS but now with the Minnesota Geological Survey, first noted about 50 of these hills in 1984 and referred to them, informally, as "veblins" (after the town of Veblin, South Dakota) (Fig. 4). In a report published in 1987, he referred to the hills as "hydrologic blowout features" (Harris, 1987). Veblins generally range from 40 to 70 feet high. They are as wide as a half mile at their base, although most of them are only about 0.1 to 0.2 miles across. If additional study shows that the sand-volcano-like features were caused by the hydrodynamic blowout process, they will, as far as we know, be the first of their kind recognized.

Still another way in which the hydrodynamic blowout process operates is related to glacial thrusting. In a paper published in *Boreas* in 1984, we reported that large-scale thrusting of materials by a glacier depends largely on elevated pore-water pressures in the materials beneath the area of thrusting (Bluemle and Clayton, 1984). When glacial thrusting occurs, the high water pressure is relieved (as the pressure is relieved when a cork is popped from a bottle of champagne) and large volumes of groundwater flow rapidly to the land surface until pressure is relieved. The water flowing to the surface near the glacier terminus and away from the glacier commonly builds a small esker near the ice-thrust block.

Recently, I have hypothesized that very large veblins may also have formed during the thrusting process. The largest of these thus far noted is the Devils Heart Butte, a few miles south of Devils Lake (See cover photo). Devils Heart Butte may have formed in association with the ice thrusting episode that formed Sully's Hill and Devils Lake. Similar large veblins may be present in Pierce County, in association with the ice-thrust Antelope Hills north of Harvey.

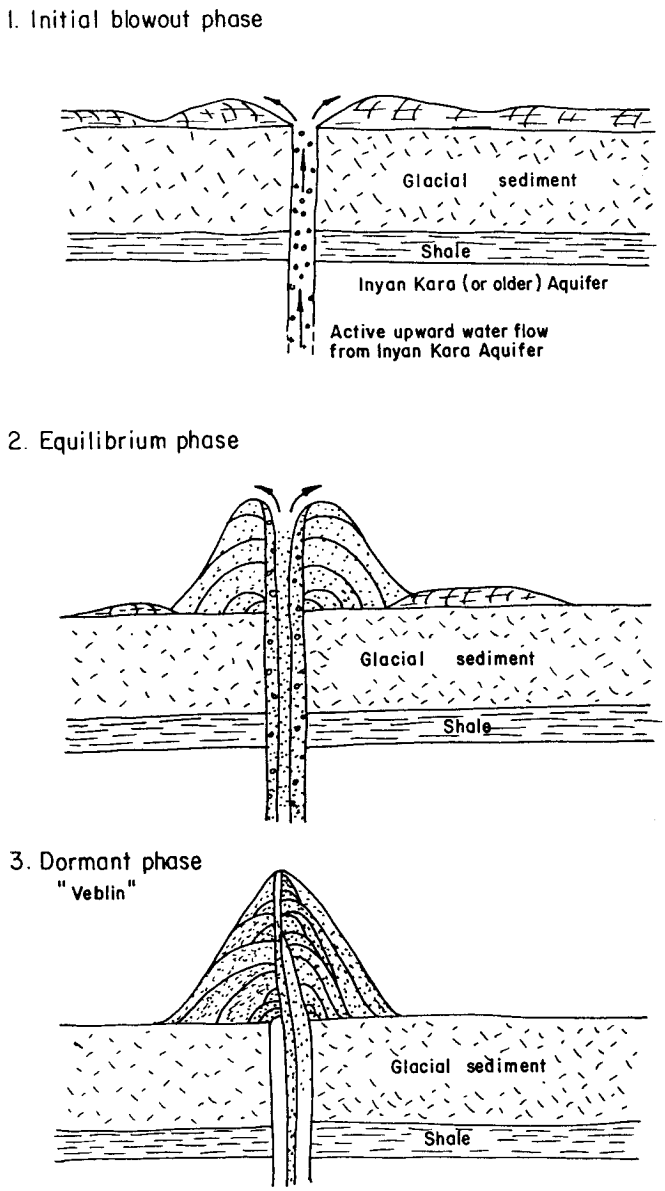


Figure 4. Generalized, cross-sections showing how veblins may have formed in southeastern North Dakota. Upward-flowing groundwater transported sand and gravel upward, depositing it above the surface vent, resulting in a "sand volcano."

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Downey, Joe S., 1969: *In* Geology of northeastern North Dakota, Pederson, D. T. and Reid, J. R., (editors). ND Miscellaneous Series 39, 30 p.

Harris, K. L., 1987: Surface geology of the Sheyenne River Map Area. North Dakota Geological Survey Atlas Series Map 15.

Laird, Wilson M., 1944: The geology and ground water resources of the Emerado quadrangle. North Dakota Geological Survey Bulletin 17, 35 p.

Paleontology in North Dakota:

by John Hoganson

A Symposium Featured at the North Dakota Academy of Science Annual Meeting

A symposium on "Paleontology in North Dakota: Fossils as a Resource in Research, Education, and Economics" was held on April 30 at the North Dakota Academy of Science 1992 annual meeting at the Center for Aerospace Studies, University of North Dakota, Grand Forks. The symposium was organized and the manuscripts edited by Joe Hartman, Energy and Environmental Research Center--UND, and Allen Kihm, Minot State University.

In North Dakota, as in the rest of the country, there is a phenomenal interest and enthusiasm about fossils. This is reflected by stories of finds in the news, foods produced in the shape of prehistoric animals, television series featuring animated dinosaurs, etc. There also appears to be more interest in teaching about fossils in primary and secondary schools and visits to museums to see fossils is increasing (about 150,000 people saw the North Dakota Fossils exhibit at the Heritage Center during the first year of its existence). This phenomenon is largely do to a renewed interest in dinosaurs. Stephen J. Gould, the most famous paleontologist of our time, has called this the "Great Dinosaur Ripoff". But interest in dinosaurs has drawn attention to other fossils as well and the need to view fossils as a resource; a resource in research, education and economics that must be professionally and carefully managed.

Joe and Allen did an excellent job of organizing the symposium and editing the symposium manuscripts. The first part of the symposium dealt with fossils as a resource. The second part of the symposium was concerned with the management and utilization of fossils as a resource. I have included the symposium agenda published in the Proceedings of the North Dakota Academy of Science, 84th annual meeting, volume 46, April, 1992.

The symposium accomplished its goal of presenting a variety of views regarding utilization and management of fossil resources. But all the participants agreed that resource managers, academicians, hobbyists, and other concerned citizens must all work together to insure proper management and utilization of our fossil resources.

A Symposium on the
PALEONTOLOGY IN NORTH DAKOTA: FOSSILS AS A RESOURCE IN RESEARCH, EDUCATION, AND ECONOMICS

North Dakota Academy of Science 1992 Annual Meeting
University of North Dakota

Symposium Coordinators and Editors
Joseph H. Hartman and Allen J. Kihm

Symposium Agenda
April 30, 1992

Introduction (8:30-8:45 a.m.)

1) *Fossils as a Resource in Research, Education, and Economics in North Dakota*:
Joseph H. Hartman, Energy and Environmental Research Center, University of North Dakota, Box 8213, University Station, Grand Forks, ND 58202 (701) 777-2551

Fossils as a Resource

2) *Fossil Vertebrates as a Resource in Research, Education, and Economics in North Dakota*:
Allen J. Kihm (8:45-9:00 a.m.), Department of Earth Sciences, Minot State University, Minot, ND 58701 (701) 857-3864
3) *Fossil Invertebrates as a Resource in Research, Education, and Economics in North Dakota*:
Joseph H. Hartman (9:00-9:15 a.m.), Energy and Environmental Research Center, Box 8213, University Station, Grand Forks, ND 58202 (701) 777-2551
4) *Microfossils and Fossil Plants as Resources in Research, Education, and Economics in North Dakota*:
Timothy J. Kroeger (9:15-9:30 a.m.), Department of Geology and Geological Engineering, University of North Dakota, Grand Forks, ND 58202 (701) 777-2821
5) *Quaternary Fossils as a Resource in Research, Education, and Economics in North Dakota*:
Allan C. Ashworth (9:30-9:45 a.m.), Department of Geosciences, North Dakota State University, Fargo, ND 58105 (701) 237-7919

Coffee/Discussion Break (9:45-10:00 a.m.)

Management and Utilization of Fossils as a Resource

6) *The North Dakota Geological Survey Fossil Resource Management Program for the State of North Dakota*:
John W. Hoganson (10:00-10:15 a.m.), North Dakota Geological Survey, 600 East Boulevard Avenue, Bismarck, ND 58505 (701) 224-4109
7) *The Role of the Federal Government in the Management of Fossil Resources*:
Dale Hanson (10:15-10:30 a.m.), Bureau of Land Management, P.O. Box 940, Miles City, MT 69337 (406) 232-4331
8) *The Perspective of the Hobbyist in the Utilization of the Fossil Resources of North Dakota*:
Earle H. Campbell (10:30-10:45 a.m.), P.O. Box 1921, Bismarck, ND 58502 (701) 255-3658
9) *Access and Utilization of the Fossil Resources of North Dakota in Primary Education*:
Mike Barnhart (10:45-11:00 a.m.), Center High School, Center, ND 58530 (2704 10th Avenue NW, Mandan, ND 58554) (701) 663-4980

Summary and Discussion (11:00-11:30 a.m.)

10) *Summary and Diagnosis of Paleontology in North Dakota*:
Allen J. Kihm (11:00-11:10 a.m.), Department of Earth Sciences, Minot State University, Minot, ND 58701 (701) 857-3864

The symposium coordinators wish to acknowledge and specifically thank the Energy and Environmental Research Center for providing support for clerical and sundry expenses for this Academy meeting.

ESIC NEWS

by Mark Luther

For several years the NDGS has been an affiliate office of the Earth Science Information Center (ESIC) network. Coordinated by the U.S. Geological Survey (USGS), this nationwide ESIC network provides information about geologic, hydrologic, topographic, and landuse maps, books, and reports; aerial, satellite, and radar images and related products; earth science and map data in digital form and related applications software; and geodetic data. As an ESIC office, the NDGS can assist the public in locating those earth science materials dealing with North Dakota, as well as other states.

New Map Products

In addition to providing information about the availability of various earth science materials, the NDGS' ESIC office operates a distribution center for federally produced cartographic products. Descriptions of four recently produced or current-interest maps that are available follows.

* I-2206. Landforms of the conterminous United States; a digital shaded-relief portrayal, by G.P. Thelin and R.J. Pike. 1991. Scale 1:3,500,000 (1 inch = about 55 miles). Sheet 55 by 35.5 inches. Accompanied by a 16-page explanatory text. Price = $6.00 plus shipping.

  The map (Fig. 1), which was compiled by computer manipulation of 12 million terrain heights from a digital elevation model, is the largest single-sheet graphic of the Nation's topography since the oblique panorama drawn by Raisz 50 years ago. A large number of faults, folds, lineations, erosional, glacial, and other geologic features are illustrated on this map.

  Editor's Note: USGS supplies of this map are exhausted; a second printing will be issued. The NDGS has a limited number of the maps still available.

* National Atlas Map - Indian Tribes, Cultures and Languages; a double-sided map of the United States illustrating the historic distribution of American Indians, by William C. Sturtevant (Smithsonian Institution). 1967 (reprinted 1991). Scale 1:7,500,000. Sheet 19 by 28 inches. Price = $4.00 plus shipping.

* National Atlas Map - Presidential Elections, 1789-1984; a double sided sheet, illustrating the results of the 1789-1968 elections broken down by state, and of the 1972-1984 elections broken down by county, plus United States totals. 1987. This is a very interesting map, illustrating the rise and fall of the various political parties active since this country's inception. Sheet size 19 by 28 inches. Price = $4.00 plus shipping.

* National Atlas Map - Presidential Election of 1988; a map of the United States illustrating the results of the 1988 election by county, plus United States totals for the popular and electoral vote. 1989. Scale 1:7,500,000. Sheet size 19 by 28 inches. Price = $4.00 plus shipping.

To place map orders or receive additional information, contact our publications clerk or the ESIC Coordinator. Shipping costs on federally produced maps purchased from the NDGS are:

1 to 5 maps	$2.75
6 to 30 maps	$4.00
31 or more maps	$6.00

Geographic Names Information System

One of the very useful new tools that the NDGS' ESIC office has recently acquired is a CD-ROM drive. Mounted in an IBM PS/2, Model 95 computer, the Compact Disk - Read-Only Memory (CD-ROM) drive enables us to use CD's produced by the USGS containing

very large earth science related databases (as much as 600 million bytes of information per disk). One of these databases, the GNIS database, has proven to be extremely useful and in demand by the public.

The Geographic Names Information System (GNIS) database is the National repository for attribute data covering all known places, features, and areas in the United States identified by a proper name. The complete, nationwide listing of GNIS records (more than 1.2 million) are contained on a single CD-ROM disk.

Examples of the types of data that can be retrieved for a specific name match are shown in the following figures. Figure 2 shows a listing of fields for which information can be entered to define a search argument. In this example, the only field containing data is the "Feature Name" field, with an entry of "Bismarck". This short argument directs the computer to search the GNIS database for all occurrences of the name "Bismarck". The number "30" in the lower right corner of the figure indicates that there were 30 different occurrences of the name Bismarck in the database.

Figure 3 shows a listing of the first 15 occurrences (of 30 total) of the name Bismarck in the GNIS database. As you can see, there are a variety of features, in several states, that are called or include the name Bismarck. In addition to the feature name, information is included about the type of feature, the county that it is in, the 7.5 minute topographic map it is on, the latitude-longitude coordinates, and on some, the elevation (in feet above mean sea level). Included in this listing are radio towers for TV or radio stations transmitting from Bismarck. The twelfth feature name in the listing is Bismarck (ppl = populated place), North Dakota.

Additional information that can be called up for Bismarck, North Dakota (Fig. 4), includes the Federal Information Processing Standards (FIPS) code, the last date that the U.S. Board on Geographic Names (BGN) did special research on Bismarck, and variant names that Bismarck has had in the past. The two variant names for Bismarck, "Edwinton" and "The Crossing" include a bibliographic reference code (ND-T3) that can be used to find the source of the information. Calling up the reference code (Fig. 5) gives information about the source of Bismarck's variant names.

The GNIS database has a wide variety of uses including: determining locations of preexisting structures or other features, tracking down family origins, and cataloging different types of features. The geographic names search service available through the NDGS' ESIC office is a valuable, time saving benefit provided to the North Dakota public. We encourage you to use this service.

(The NDGS' ESIC Coordinator is Mark R. Luther.)

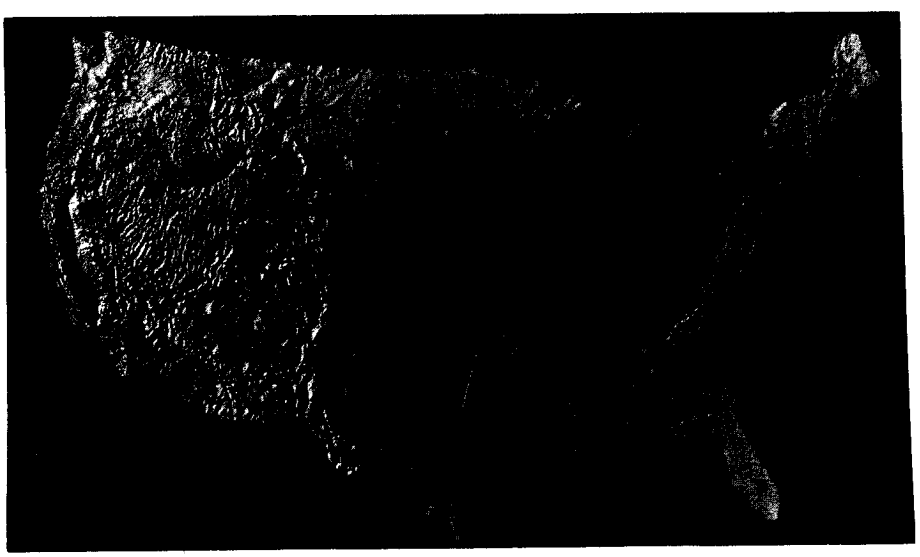

Figure 1. Landforms of the conterminous United States - A digital shaded-relief portrayal.

Search

U.S. Geological Survey
National Geographic Names Data Base

```
                State:
         Feature Name: Bismarck                                  30
       Type of Feature:
          County Name:
             Map Name:
         Variant Name:
Geographic Coordinates:
     Source of Feature:
            Elevation:
     Biblio. Ref. Code:

Connection:                                          Total:      30
```

Figure 2

List: 12 of 30

U.S. Geological Survey
National Geographic Names Data Base

Feature Name	ST	Type	County	Topographic Map	Coordinates	Elev
Bismarck Creek	AK	stream	Yukon-Koyu		622037N1570342W	
Bismarck Lake	AZ	reservoir	Coconino	Humphreys Peak	352151N1114315W	
Bismarck Mesa	AZ	summit	Yavapai	Bismarck Mesa	342840N1124723W	4725
Bismarck	AR	ppl	Hot Spring	Bismarck	341858N0931014W	
Bismarck Chapel	AR	church	Hot Spring	Bismarck	341952N0931034W	
Bismarck	AR	locale	Hot Spring	Bismarck	342109N0930926W	1282
Bismarck	AR	civil	Hot Spring		352528N0911254W	
Bismarck	CA	ppl	San	Yermo	345757N1165131W	
Bismarck	IL	ppl	Vermilion	Bismarck (IN)	401550N0873629W	
Bismarck		airport	Saint	Flat River	374515N0903700W	1038
Bismarck	MO	ppl	St	Flat River,	374609N0903729W	
Bismarck	ND	ppl	Burleigh	Bismarck,	464830N1004700W	1700
Bismarck Junior	ND	school	Burleigh	Bismarck	464917N1004900W	
KCND-FM	ND	tower	Morton	The Hogback	463517N1004807W	2200
KYYY-FM	ND	tower	Morton	The Hogback	463619N1004830W	2250

Figure 3

Display All Fields: 12 of 30

National Geographic Names Data Base

```
                State:  ND, North Dakota
         Feature Name:  Bismarck
         Feature Type:  ppl
Geographic Coordinates:  464830N1004700W 464846N1004453W
            Elevation:  1700
         Variant Name:  Edwinton (ND-T3/p.48), The Crossing (ND-T3/p.48)
    Source Coordinates:
   Map Reference Code:  46100-G7 46100-G6
          County Name:  Burleigh
  Topographic Map Name:  Bismarck, Menoken SW
     Biblio. Ref. Code:
State/County FIPS Code:  38015
               Status:  BGN 1969
        Decision List:
```

Figure 4

Display Bibliography: 1 of 1

Reference Data Base

ND-T3 - William, Mary Ann (Barnes). Origins of North Dakota Place Names. Washburn, N.D.: Bismarck Tribune, 1966.

Figure 5

Arthur Gray Leonard
State Geologist 1903-1932

Wilson M. Laird
State Geologist 1941-1969

Wilson M. Laird To Receive The Arthur Gray Leonard Award

by Ed Murphy

Dr. Wilson M. Laird will receive the Arthur Gray Leonard Medal on October 23, 1992, during Homecoming festivites at the University of North Dakota. The award is being presented in conjunction with an All Alumni Reunion of the Department of Geology and Geological Engineering. The Reunion is being held to honor the fiftieth anniversary of Dr. Wilson M. Laird's appointment as Department Chairman and State Geologist (Dr. Laird was actually named State Geologist in 1941 and Department Chairmen in 1942). Dr. Laird was only 26 years old when he assumed the duties of State Geologist. Dr. Laird was the State Geologist and Department Chairman from 1942 to 1969. Dr. Laird will be the first recipient of the Arthur Gray Leonard Medal, an award which was recently created by the Department to acknowledge the important contributions made to the geoscience field by numerous alumni, faculty, and friends of the Department of Geology and Geological Engineering. The award is named in honor of Dr. Leonard who served as State Geologist and Department Chairman from 1903 until his death in 1932.

Dr. Laird is nationally known and respected for his work in geology. He is credited with the foresight that oil would one day be discovered in the Williston Basin of North Dakota. To insure that North Dakota avoided the problems that had beset some oil producing states, Dr. Laird pushed through the state legislature oil-and-gas conservation laws 10 years prior to the discovery of oil in North Dakota.

Dr. Laird has worked on a number of diverse geologic projects in the Williston Basin of North

Dakota involving rocks varying in age from Paleozoic through the Cenozoic. The following are just a few of his many publications which indicate the diverse nature of his work: *Manganese Deposits of the Turtle Mountains, Geology of Turtle River State Park, Geology of the Pembina Hills, Geology and Ground Water Resources of the Emerado Quadrangle, Stratigraphy Structure of the Williston Basin, The Subsurface Stratigraphy of the Nesson Anticline, Geology of the North Unit of the Theodore Roosevelt Memorial Park, Study of the Spoil Banks Associated with Strip Mines, Eocene in North Dakota*, and the *Geology of Southern Morton County*. In addition, Dr. Laird has been involved in geological studies in Ohio, Pennsylvania, Minnesota, Montana, Alaska, Canada, Germany, and Turkey while he was working for the U.S. Geological Survey, the Pennsylvania Geological Survey, and several oil companies.

During Dr. Laird's tenure, the North Dakota Geological Survey grew from a staff of one (himself) to 15 employees; this increase was largely a result of the discovery of oil in the basin. A larger staff was needed to enforce the oil and gas rules and regulations and to provide information and answers to the increasing number of questions concerning the geology of the state. Several new programs were begun, including the innovative County Geology and Groundwater Resource Bulletins (a cooperative program with the U.S. Geological Survey and the State Water Commission). Subsurface studies of the Paleozoic and Mesozoic rocks and economic studies of the mineral resources of the state were also undertaken during this time.

In 1969, Dr. Laird moved to Washington, D.C. to become the Director of the Office of Oil and Gas in the Interior Department. He subsequently served as Director of the Committee on Exploration of the American Petroleum Institute. Dr. Laird retired from this position in 1979 and has remained active as a consulting geologist from his home in Kerrville, Texas and his summer home near Bemidji, Minnesota. In 1989, Reba K. Latimer, Dr. Laird's wife and companion of 50 years, passed away. Dr. Laird married Margaret L. Ray on November 30, 1990.

Dr. Laird has received many honors during his long and distinguished career. These include the President's Award (1948) and Public Service Award (1981) from the American Association of Petroleum Geologists, President of the Association of American State Geologists (1950), Honorary Member Association of American State Geologists, Honorary Doctorate of Science from Muskingum College (1964), and Honorary Doctorate of Science from the University of North Dakota (1984). In 1980, the State of North Dakota recognized his deligent efforts in collecting the information obtained from oil and gas wells by naming the new core repository the Wilson M. Laird Core and Sample Library. This building is located on the campus of the University of North Dakota.

Dr. Laird has retained his interest in North Dakota and in the geology of this area. In 1986, Dr. Laird attended a geologic fieldtrip of western North Dakota and amazed fieldtrip participants with his knowledge of the geology of the state and entertained everyone with his numerous stories. Two of Dr. Laird's papers that I have used in my own work, the Geology of Southern Morton County and The Eocene in North Dakota, have stood the test of time very well. The information that he and R. H. Mitchell gathered in Morton County and their geologic interpretations of the area have been very useful to us in our study of the Cretaceous/Tertiary boundary in south-central North Dakota.

Those wishing to attend the banquet honoring Dr. Laird should contact the Department of Geology and Geological Engineering at the University of North Dakota, Leonard Hall, University Station, Grand Forks, North Dakota 58202, (tel. 701-777-2248).

Oil & Gas Exploration and Development Activity in 1991

by Tom Heck

This article is a brief update on North Dakota oil and gas activity during 1991. This update precedes the biennial update (to be published later this year as a Miscellaneous Series) when complete well information and completion statistics are available. At this time, not all the wells completed in 1991 have been released from "tight hole" status and so not all the year's discoveries are covered in this update. However, year-end completion statistics are now available. The 195 wells completed during 1991 represents only 78% of 1990's total of 251 - a significant drop over the year.

Exploration activity was lower than in 1990. 39 wildcat wells were completed according to Oil & Gas Division annual statistics, a decrease of 20 from 1990. Of these 39, 7 were completed as producing wells and 32 were dry, an 18% success rate. Most of the wildcat drilling occurred in north-central North Dakota and was targeted for Madison reservoirs. Many of these wildcats were drilled along the "Sherwood shoreline" play. Scattered wildcats targeted Red River to Madison reservoirs elsewhere in the state. Table 1 is a partial list of the new fields and pools discovered during 1991. At least three additional new pools or fields were found, but none were named and all three are presently abandoned or soon will be due to poor performance. Four wildcats were completed during 1991 in the Bakken Shale. Two were dry. The other two new field/pool discoveries were completed as marginal producers, but are now plugged and abandoned.

Development activity also dropped from 1990 levels. Of the 156 development and extension wells drilled in 1991, 118 were completed as producing wells - a 76% success rate, virtually the same success rate as in 1990. However, 36 fewer wells were completed in 1991 than in 1990. The Madison was the most popular target with the Bakken Shale second. 84 development wells were drilled to the Madison in 1991; 56, or 67%, were completed as producers. Lucky Mound Field was the site of many of these wells, where 18 of 23 development wells were successfully completed. Lucky Mound Field was discovered in McLean County during 1990 and is only the second, and now largest, oil field in that county. Most of the other 61 Madison wells were drilled in Bottineau, Renville, and Burke Counties.

42 development wells were completed in the Bakken Shale with 40 of them producing. Two of the 40 were plugged during 1991 leaving 38 of 42 producing, a 90% success rate. Charles Koch, in last year's update, reported a total of 76 Bakken completions. The 46 Bakken wells completed in 1991 is 60% of 1990's total. This percentage is 18% below the 78% decrease in total completions for the year and is indicative of a trend away from the Bakken to other formations.

Completions, in formations other than the Madison and Bakken, were made in the Silurian (7 of 7), Stonewall (6 of 7), Red River (6 of 9), Tyler (4 of 5), and all others (3 of 3). Fields where most of these wells were drilled are: for the Silurian, Simon Butte with 2 of 2; for the Stonewall, Stoneview with 4 of 5; and for the Tyler Fryburg Field with 4 of 4 wells. Tyrone Field, an abandoned one-well Red River field in Williams County, was redrilled in 1991 and successfully completed, flowing 396 BO + 84 BW + 132 MCFPD. The highest initial potential (IP) reported for the year was from the Slawson Exploration Co. #1-14 I. C. Wolf well in section 14 T142N R102W, Ash Coulee Field, flowing 1,204 BO + 873 MCFPD.

Average IP's of all completed producing wells by zone are: 323 BO + 52 MCF (Tyler/Heath); 101 BO + 68 MCF (Madison); 289 BO + 225 MCF (Bakken); 332 BO + 356 MCF (Stonewall); 384 BO + 284 MCF (Silurian); and 210 BO + 505 MCF (Red River).

TABLE 1. 1991 NEW FIELD/POOL DISCOVERIES

Conoco, Inc. Bully Federal-"A" #4
#9608 Case# 5196 Order#6052 Comp. 1/16/91
Bully-Bakken IP 101BO 111MCF
Sec. 2113, T148N, R100W, McKenzie County

Slawson Exploration Co.-Gull State #1-16
#6587 Case# 5254 Order#6110 Comp. 2/3/91
Cedar Coulee-Bakken IP 130BO 114MCF
Sec. 16, T147N, R96W, Dunn County,

GLG Energy-LaVerne Haugen #32-19
#9608 Case# 5255 Order#6085 Comp. 4/26/91
Big Dipper-Duperow IP 25BO 0BW 0MCF
Sec. 19, T163N, R101W, Divide County

Broschat Engineering & Management-Bendixson #1-17
#7834 Case# 5286 Order#6120 Comp. 6/6/91
Good Luck-Silurian IP 244BO 2BW 30MCF
Sec. 17, T157N, R101W, Williams County

New Horizon Exploration, Inc.-#1-7 Garvin
#13019 Case# 5320 Order#6155 Comp. 6/21/91
Windmill-Madison IP 83 BO 4BW 165MCF
Sec. 7, T163N, R85W, Renville County

BHP Petroleum (Americas) Inc.-Long Creek #3
#8265 Case# 5345 Order#6214 Comp. 7/14/91
Long Creek-Bakken IP 34BO 3BW 34 MCF
Sec. 36, T154N, R99W, Williams County

Barbara Fasken-Fisher #1-5
#13247 Case# 5378 Order#6280 Comp. 11/8/91
Upper Des Lacs-Madison IP 54BO 0BW 8MCF
Sec. 5, T163N, R89W, Burke County

Long Petroleum, Inc.-McCarroll #16-1
#13237 Case# 5427 Order #6278 Comp. 11/22/91
Grover-Madison IP 25BO 120BW 4MCF
Sec. 16, T162N, R86W, Burke County

The NDGS Pursues GIS Technology

by Mark Luther

With the recent acquisition of several powerful UNIX workstations and associated software, the NDGS is taking a lead role in GIS development in North Dakota. In mapping and resource management circles it is quickly becoming recognized that GIS technology is about the only way that the increasing demands for spatial (map related) data, accurate and up-to-date maps, and map analyses and production can be met. But what is GIS?

The term GIS simply stands for Geographic Information System. To better understand what this phrase means, it helps to look at each word individually.

Geographic refers to the location of a mappable feature such as an oil well, building, river, or landfill. Information refers to the attribute information about each of those mappable features. This information is stored in a database with each record tied to a feature shown on its associated map. For example, this might include information about the number of barrels pumped from a particular well, or whether a building is a schoolhouse or pesticide warehouse. System refers to the computer hardware and software needed to draw the maps, build the database, and tie the two together. In short, a Geographic Information System (GIS) is an integrated computer-based system designed to capture, store, edit, analyze and display geographically referenced information, i.e., data identified according to their locations. Practitioners also regard the total GIS as including operating personnel and the data that go into the system.

With that brief explanation of what a GIS is, one might ask how the NDGS plans to use this emerging technology, and how it will benefit the state. GIS use by the NDGS can be broken down into two rather broad categories: automated map production and maintenance, and spatial data analysis.

Automated Map Production and Maintenance

Throughout the Survey's history one of the most common formats for presenting the results of investigations has been in map form. Maps display large amounts of data in a way that is more easily and quickly understood than the same data presented in table or text form. For this reason the Survey will continue to present many of its results in map form. By using a computer to generate those maps rather than using manual techniques, such as hand drafting and scribing, the Survey will be able to quickly produce maps and save them in digital (computer readable) form. There are several benefits to being able to save maps in digital form: first, it is a simple matter to change the size or scale of a digital map, or even to enlarge and work on just a portion of a map; second, it is much easier and quicker to incorporate new data into a map saved in digital form versus having to redraft the map as is required now; and third, maps saved in digital form are available to be used for map analysis purposes by a GIS.

Spatial Data Analysis

The second category of GIS use that the Survey intends to pursue is spatial data analysis. Spatial data analysis is where a GIS really shines. It allows users, in our case geologists, to quickly and accurately pull together vast amounts of data needed to provide answers to the many natural resource problems faced by the State's decision makers. An example of this type of problem - in this case landfill siting - is shown in Figure 1. If the data needed for analyzing this problem (land data column) exists in digital form, it can quickly and accurately be brought together in a GIS to produce the derivative maps (and associated database) needed to address the problem or question.

This sequence of pulling data together, comparing it, and producing the derivative products needed to satisfy the needs of the State is something that has always been done by the Survey. However, up to the present, providing solutions to complex resource questions has required searching for the data needed, compiling it in map form, manually drafting the needed maps at a consistent scale, then overlaying and manually comparing the maps to find the desired links. It is and has been a tedious task with the ever present possibility of human

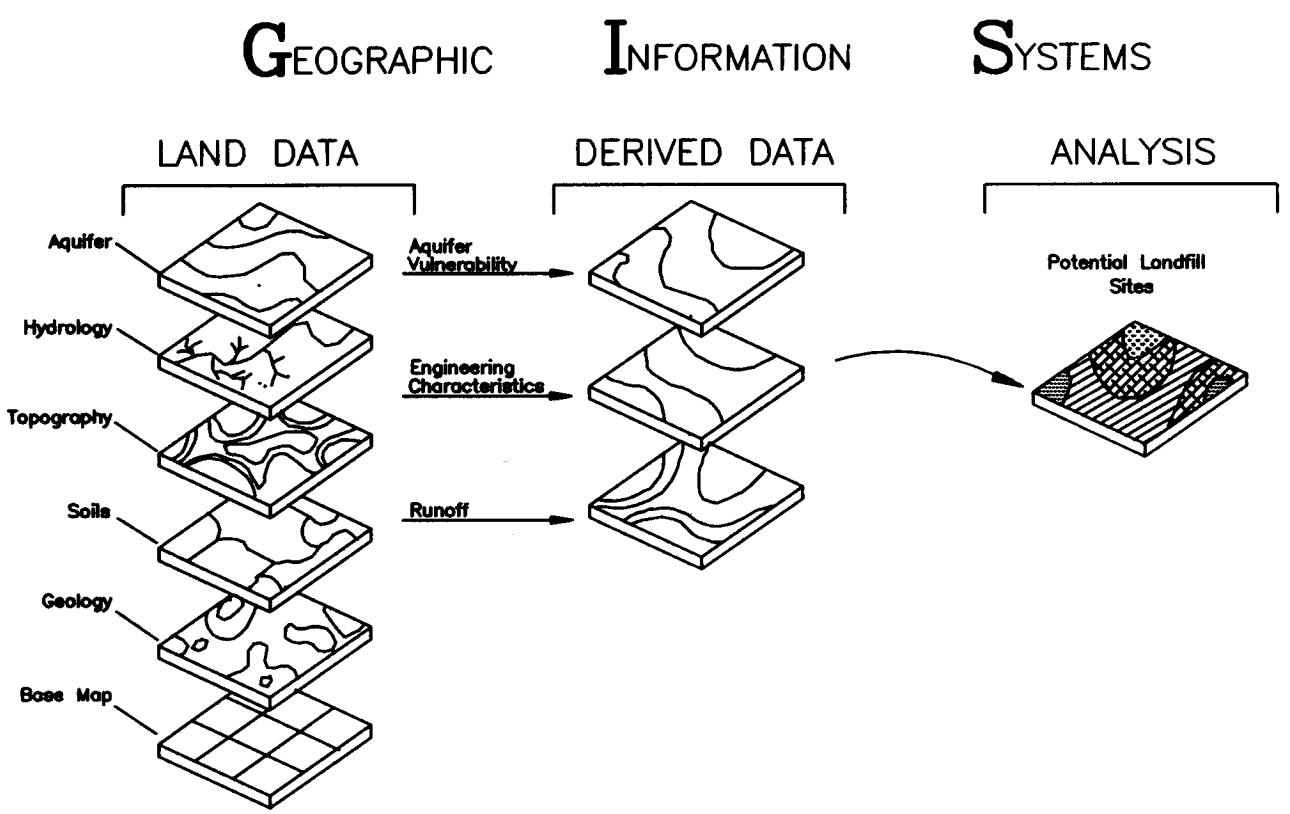

Figure 1. A hypothetical problem characteristic of the type that a GIS will be used to analyze and solve. This figure was produced on one of the Survey's UNIX workstations by Rich Baker (NDGS Draftsman).

error or bias affecting the results.

GIS' Potential

Using a GIS and digital data will greatly increase the speed and accuracy with which spatial data problems can be solved in the future, and it will allow and encourage the use of much larger datasets - leading to more accurate results - produced by a greater number of agencies/organizations.

In fact, one of the greatest benefits of automated mapping and GIS is that agencies will now have a greater ability to share maps (digital spatial data). This will be an important and money saving benefit for the state.

Since each agency now spends money on developing and displaying certain map features, often at varying scales, the ability to display another agency's map will eliminate much duplication of effort.

The ability of a GIS to analyze more and larger datasets than can be done manually will allow the Survey to address problems and opportunities that could not even be considered in the past. Much as the telescope allowed early astronomers to recognize that some order exists in the vast number of stars, so too will a GIS allow modern-day investigators to make sense, and greater use, of the vast amounts of information becoming available. The use of a GIS in North Dakota will result in greater (more well defined) protection of the environment, and improvements in the discovery and management of our economically important natural resources.

Fortunately for North Dakota, there have been recent tremendous advances in computer hardware and software technology, coupled with dramatic price decreases. These changes have made it possible for state agencies, with the assistance of federal agencies such as EPA, to begin acquisition of the hardware and software necessary to initiate a GIS. Still, it is a new and relatively expensive technology.

In order to spread out the cost of GIS implementation, and to avoid duplication of effort, the Survey, along with the North Dakota State Department of Health and Consolidated Laboratories and the North Dakota Department of Agriculture, have signed agreements to work together to build a fully functional GIS. The GIS housed at the Survey is the result of that money saving agreement and an example of agencies working together to control costs while providing the highest level of service possible.

*** If you are interested in learning more about GIS, the U.S. Geological Survey produces a brochure (#66) titled "Geographic Information Systems", that provides a good overview of the capabilities of a GIS. In addition, the 2nd Annual GIS Symposium will be held in Bismarck, at the Capitol, on November 17-18, 1992. This symposium, put on by the State GIS Technical Committee, attracted more than 200 attendees and a large number of GIS computer and software vendors last year. For more information about the symposium or GIS in general, contact: Mark Luther or Thomas Heck at (701) 224-4109.**

BRIEFLY REVIEWED

by Bob Biek

Geothermal Energy: *Clean, Sustainable Energy for the Benefit of Mankind and the Environment*, March, 1992. Published by the University of Utah Research Institute, Earth Science Laboratory, 391 Chipeta Way, Suite C, Salt Lake City, Utah, 84108-1295 (Tel. 801-524-3422).

This colorful, eight-page brochure provides an excellent summary of geothermal energy. It is written in clear, simple language, yet contains enough technical detail to be truly instructive. Both naturally-occurring hot water and steam systems, and normal-temperature earth or groundwater systems are covered. Additional sources of geothermal information are given. The brochure is available from UURI for $0.55 per copy.

Earth, published bi-monthly by the Kalmbach Publishing Co., 21027 Crossroads Circle, Waukesha, Wisconsin, 53187 (tel. 800-533-6644).

The first issue of *Earth* appeared in January, 1991. The magazine fills a void too long present in the earth science publishing community - it is a magazine dedicated to explaining earth science in a clear, engaging manner to the general reader. In my mind, it is to the earth sciences what *Smithsonian* is to geography, culture, and history. Subscriptions to *Earth* are available from Kalmbach Publishing for $19.95 per year ($24.95 for all foreign orders).

After the Ice Age: *The Return of Life to Glaciated North America*, by E. C. Pielou, The University of Chicago Press (1991), 366 pages, hardcover, $24.95.

After the Ice Age is the fascinating story of how a harsh terrain that resembled present-day Antarctica has been transformed gradually into the forests, grasslands, and wetlands we know today. E. C. Pielou weaves together a wealth of climatic, geologic, biologic, and anthropologic information that scientists use to reconstruct the events of the last 20,000 years. The science is well explained. This highly readable, well documented book reminds us of the dramatic climatic changes the earth has experienced in the recent past.

Wilson M. Laird Core & Sample Library

by Julie LeFever

NORTH DAKOTA GEOLOGICAL SURVEY
Wilson M. Laird Core & Sample Library
P.O. Box 8156
University Station
Grand Forks, North Dakota 58202
Monday-Friday - 8:00 a.m. to 5:00 p.m.

The Wilson M. Laird Core & Sample Library was built in 1980 and consists of an 18,500 sq. ft. warehouse and a 2,000 sq. ft. office and laboratory area. The library uses the state oil and gas database that allows ready access to sample and well information. It also allows the user to request a listing of available cores and samples that can be sorted by legal location or geologic formation for a minimal charge. Also available for users are a set of wellfile and well logs on microfiche or microfilm; the facility has a film and fiche reader-printer. Petroleum Information scout cards are also available for use.

The examining area has movable tables, a photographic set-up (user supplies the film), a drill press for taking core plugs, and a small trim saw. Microscopes and a UV box are also available. The facility also has a slab saw capable of cutting 3 ft. lengths and another slightly larger trim saw.

Currently, the facility houses approximately 140,000 boxes of core (approximately 80 miles), and 40,000 boxes of samples. The cores probably represent about 80% of the cores cut in the North Dakota portion of the Williston basin. A few of these cores were cut prior to the initial discovery of oil in the state. The collection is probably 95% complete for samples. In addition to oil and gas samples, the facility also houses an extensive collection of water well samples and cores.

The library is used by industry, academic, and government personnel. No fee is charged for the use of the facility. Users are encouraged to call ahead to insure requested cores or samples are available and that there is adequate work space available. Many of the cores are not slabbed; with advance notice, core can be slabbed before the user arrives.

Sampling is allowed with supervision. The amount of sampling is dependent upon the core. Where limited core is available, sampling is restricted or perhaps not available. The library attempts to preserve at least one continuous face. Samples for thin sections must be cut from the back of the core away from the slabbed face. In an effort to avoid duplication and preserve the remaining core, all special analyses performed on the samples or thin sections from the samples must be returned to the library.

Capitol Stones

A Geologist's Perspective on the North Dakota State Capitol Building

by Bob Biek

The State Capitol Building is the center of government in North Dakota. Decisions made there affect the lives of all North Dakotans. Its walls are imbued with history. Yet more than that, those very walls - and floors and stairs - are sheathed in stone. It is the stone that my biased eyes see, and it is the stone that I want to tell you about.

Governor George Schafer's Silo

There is a fascinating history of events and decisions that led to the construction of the North Dakota State Capitol Building. From the fire that destroyed the old capitol building in 1930, to innovative design, to the controversial Capitol Commission charged with overseeing the design and construction of a new capitol (and later with fraudulent expense reports!). During its construction, skeptics christened the building "George Schafer's silo" (and later Langer's silo, after our former Governors). Several good books and papers have been written about this colorful history, including: *The North Dakota State Capitol: Architecture and History*, edited by Larry Remele; *North Dakota's State Capitol*, by Kenneth W. Simons; and *Temples of Democracy: State Capitols of the USA*, by Henry-Russell Hitchcock and William Seale. For the more adventuresome, there is also the Capitol Building vertical file - filled with articles, newspaper clippings, and other documents - at the State Historical Library.

Still, the question "Why a skyscraper?" lingers on. It hinges on two critical factors: the constraint of a frugal, Depression-era budget, and the desire to attain the economy and efficiency of modern office buildings. Though its ornamentation may be simple and spare, dimension stone is an important aspect of this monumental public structure (Fig. 1).

Construction, Controversy, and the Cornerstone

Perhaps the subtitle for this section should read more explicitly: "Construction, cornerstone, controversy, and a new cornerstone." The cornerstone at Memorial Hall plaza (at the southwest corner of the administrative tower) is not the original. The original cornerstone was laid on October 8, 1932 at a grand ceremony in which former Vice President Charles Curtis, a Kansas native, was the main speaker. Three former North Dakota governors and 10,000 people attended that ceremony.

In early 1933, a series of scandals concerning fraudulent travel vouchers and the use of out-of-state materials and labor led to the replacement of the three

Figure 1. The North Dakota State Capitol Building. The administrative tower is flanked on the left by the legislative chambers and on the right by the judicial wing (completed in 1981). Memorial Hall links the administrative and legislative branches of government.

original Capitol Commissioners. Two months later, unskilled laborers went on strike, demanding a pay raise from 30 cents to 50 cents per hour. The strike led to a riot and for over a week, martial law and National Guard troops ruled the capitol grounds.

Sometime during the tumultuous first half of 1933, the original cornerstone was damaged by vandals. A second cornerstone was laid on September 5, 1933, with Governor Langer and the new members of the Capitol Commission officiating. September 5th marked the 50th anniversary of the cornerstone dedication of the old brick capitol building. The ceremony was brief, especially compared to that of 1883, when former President Ulysses S. Grant, Sitting Bull, and a remarkable host of other US and European dignitaries (on their way west to celebrate the completion of the Northern Pacific Railroad) were present.

Exterior Stone

Five different types of dimension stone are used on the exterior of the State Capitol Building and for the park benches and walkways that surround it. The building itself is sheathed in a light brown stone called Indiana Limestone. Indiana Limestone is a term used in the dimension stone industry; geologists refer to it by its formation name, Salem Limestone.

Fossil assemblages and sedimentary structures tell us that the Indiana Limestone was deposited in a warm, clear, shallow sea during Mississippian time (about 350 million years ago). Wave action and tidal currents broke and sorted the remains of calcareous shelled organisms. These remains were deposited as uniform-sized calcareous sand, which, over time, turned into limestone. A geologist might describe this rock as a light-bluish gray, massive, even-grained, porous, cross-bedded, fine grained calcarenite. Calcite is the most common mineral. Finely dispersed limonite gives a buff color to weathered surfaces of the limestone.

Indiana Limestone has been quarried since 1827 in south-central Indiana. It is called a "freestone" because it shows little preferential direction of splitting. This quality, and the fact that it is relatively soft, means that it is easily workable. It remains one of the most popular building stones in the country today.

The Indiana Limestone is composed almost entirely of small fossils and fossil fragments. *Endothyra baileyi*, a foraminifera, is the most common fossil. Small fragmented crinoid stems, bryozoans, ostracods, tiny gastropods, pelecypods, brachipods, and other foraminifera are also common. With a hand lens, one can see many spheres, small shell fragments coated with thin concentric layers of calcite. Perhaps the most easily recognizable fossils are fragments of fenestelloid bryozoans, which form very delicate fan-like colonies. They look remarkably like Rice Chex cereal. In some panels, cross-bedding is apparent (not to be confused with saw marks that are invariably parallel to the edge of the panel), and burrows, trails, load casts, and ripple marks are not uncommon. There is much for the patient eye to see!

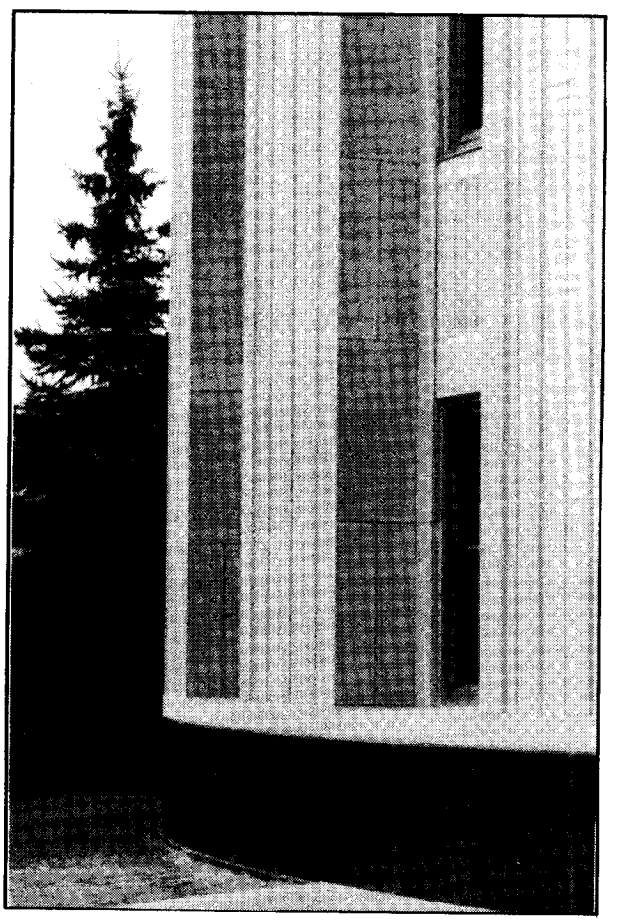

Figure 2. Base of legislative wing, showing black Wisconsin granite and light colored Indiana limestone.

A stone known as Wisconsin black granite skirts the base of the State Capitol Building (Fig. 2). Wisconsin black granite (known to geologists as the Mellon Gabbro) is a 1 to 1.1 billion-year-old igneous rock from the south shore of Lake Superior. Quarries in Iron County, Wisconsin, have recently produced crushed ornamental stone, though dimension stone has not been quarried for many years. (A similar black stone used for the base of the newer judicial wing may have come from Cold Springs, Minnesota, just southwest of St. Cloud.)

Wisconsin black granite has sulfide inclusions which can lead to rust spots on weathered surfaces of the rock. I did not observe any rust spots on highly polished Wisconsin black granite at the capitol, but I did see the sulfides. There is a small amount of pyrite (fool's gold), seen as fine, thinly dispersed, golden specks. More common, however, is nickel-sulfide (silver to bronze in color) that occurs in clusters an inch or more in diameter. The sulfides fill interstices between elongated feldspar crystals - their polished surfaces look remarkably similar, making identification difficult. The sulfides can best be distinguished by the fact that they fill spaces between elongated feldspar crystals.

The cornerstone, located at the southwest corner of the Administrative tower, comes from an exceptionally large granitic boulder from Morton County (Fig. 3). The boulder was carried from Canada to North Dakota by glaciers. Several fractures, healed by a green-colored mineral, cut diagonally across the cornerstone. In the wall behind the cornerstone is a copper box with historical documents (Fig. 4).

The wide steps to Memorial Hall, flanked by pylons made from Indiana Limestone, are made from a very coarse grained granite (Fig. 5). On a sunny day, the steps sparkle even though they are not polished. The sparkle comes from the large, flat cleavage surfaces of pink (potassium) feldspar crystals. The smaller black crystals are hornblende and biotite, while the groundmass (or space between the larger crystals) consists mostly of quartz and calcium feldspar. Like the stone at the entrance to the judicial wing, a few large black inclusions can be seen. Saw marks, parallel to the edge of the stone, are also visible.

At the east (main) entrance to the judicial wing there appear to be three different types of granitic dimen-

Figure 3. Morton County granitic boulder, a glacial erratic, from which the cornerstone was cut. Standing on top, from left to right are: William Dobson, capitol groundsman; Joseph Bell DeRemer, Grand Forks architect; Hyneck Rybnicek, Mandan stoneworker; and Ernst Warner, Secretary of the Capitol Commission. Photo courtesy of ND State Historical Society.

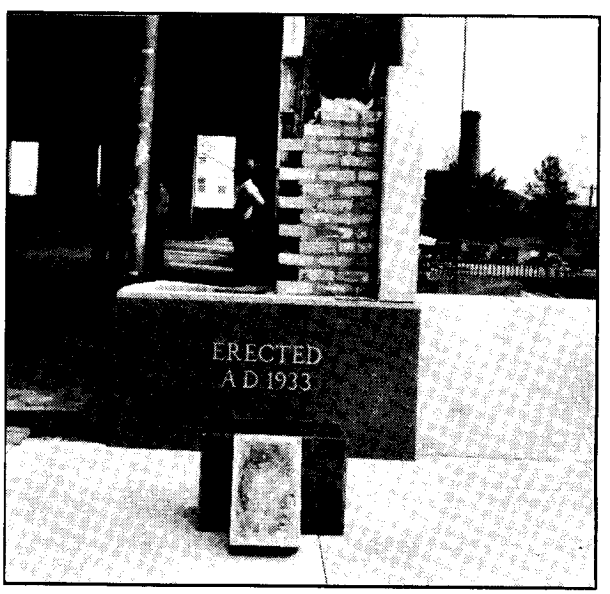

Figure 4. Cornerstone and copper box that contains historical documents. Photo courtesy of ND State Historical Society.

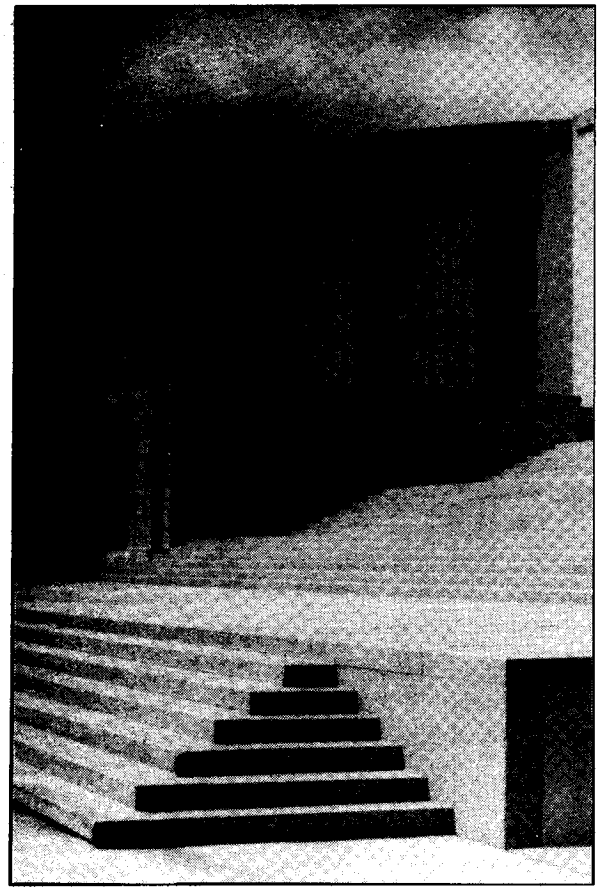

Figure 5. Granite steps leading to Memorial Hall. Note contrast of "salt'n'pepper" granite and uniform brown limestone.

sion stone. The differences arise from the way in which the surface is prepared: as highly polished slabs of the entryway itself, unpolished slabs of the retaining wall, and paving stones. To my eye, and without the benefit of detailed petrographic studies, much of this stone appears to be granite. (I am not certain, but this stone probably came from Minnesota. It is fine to medium grained and identification is difficult without microscopic studies. Some of this granitic stone may approach a more intermediate igneous composition.) In the polished slabs, pink-colored feldspar crystals (including one I saw about 1 1/2" long) can be seen. Pyrite is common in this stone; it is most easily seen as small specks in the polished slabs at the entrance. Darker, sometimes rounded, inclusions are also common. These inclusions are fragments of rock that were mixed in with the host rock while it was still molten, far below the surface of the earth.

The stone park benches located around the southeast corner of the Capitol Building are yet another type of granitic dimension stone. (Again, I am uncertain, but this stone probably came from Minnesota.)

Interior Stone

Panels of Yellowstone travertine grace ground floor walls of the State Capitol Building and Memorial Hall (Figs. 6 and 7). Travertine consists almost entirely of calcium carbonate; impurities give it an overall light brown color. The travertine is beautifully banded, with both parallel and pillow-like layers. It was originally quite porous, but many of the pores have been filled with an opaque beige- or cream-colored artificial filler. (A similar cream-colored travertine is also used in the hallway connecting Memorial Hall and the Supreme Court.)

From a geological perspective, the Yellowstone travertine is relatively young. It is Quaternary (perhaps Tertiary too) in age. It comes from quarries near Gardiner, Montana, just north of Yellowstone National Park. The quarries are now operated by the Livingston Marble and Granite Company. The North Dakota State Capitol is the first large building where this stone was used extensively.

The floors of the Theodore Roosevelt Roughrider Hall of Fame and Memorial Hall, and the stairs leading to Memorial Hall, are Tennessee Marble. Tennessee Marble is also used on the walls in the men's room off the Hall of Fame, and, all things being equal, I would assume it is used in the women's room as well. The Tennessee Marble is a Middle Ordovician limestone known to geologists as the Holston Marble. The Holston Marble derives its name from the Holston River, near Knoxville, where it has been quarried since 1852.

The Tennessee Marble is not a true marble; rather, it is a fine to coarse grained limestone. It takes a good polish and has little figure or pattern to it. Such uniformity was demanded by capitol architects. They wanted a stone with no "crowsfeet", the jagged, dark-colored solution seams geologists call stylolites. A few such seams are visible, however, especially on the steps to Memorial Hall.

Belgium black marble is used for the walls of the main stairwell to Memorial Hall and as an accent or trim in the hall itself (See Fig. 7). Belgium black marble comes from the Namur region of central Belgium where it has been quarried since Roman times. It is a massive limestone, nearly featureless except for fingerprints on its mirror-like surface.

Reflections

Robert Bruegmann, in his excellent review of the architectural history and symbolism of the North Dakota capitol building, suggested that we may be too close in time to the State Capitol Building to consider it historically important. Yet, in a very real sense, a billion years of history cloak the building. The history of a fantastically old Great Lakes mountain range, a Caribbean-like sea with white sand beaches, the hotsprings of Yellowstone. History ... written in stone.

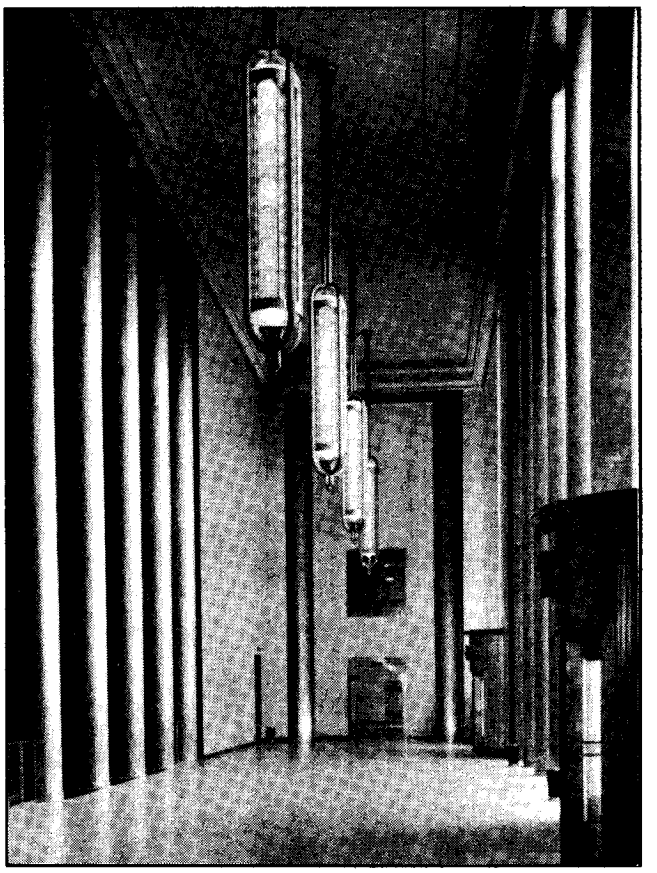

Figure 6. Memorial Hall. Photo courtesy of ND State Historical Society.

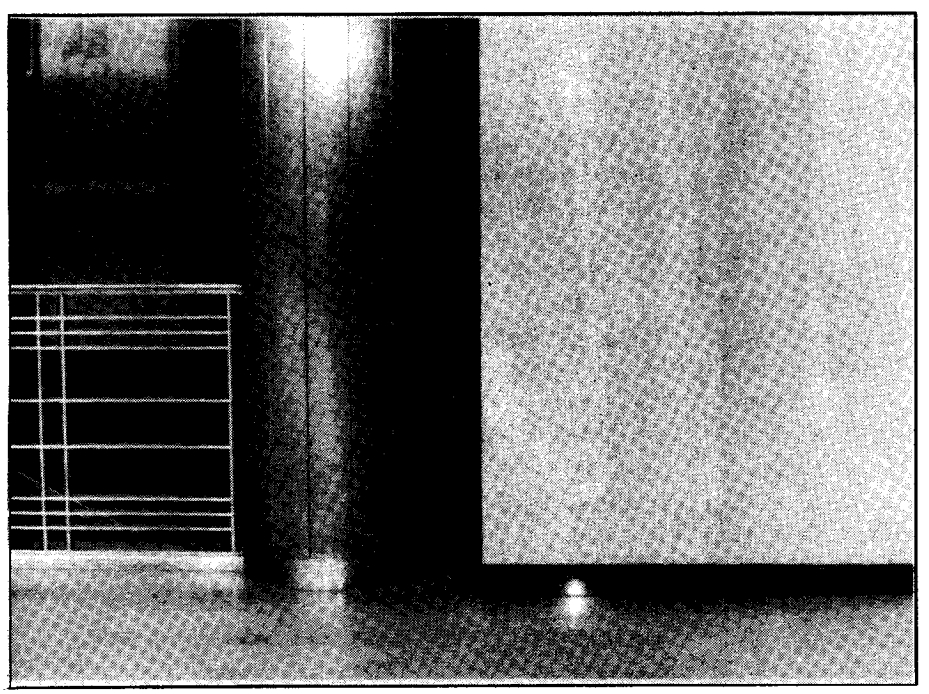

Figure 7. Detail of Memorial Hall showing travertine wall, floor of Tennessee Marble, and trim and stairway wall of Belgium black marble. Note reflection of U.S. flag in marble wall.

CURRENT SURVEY ACTIVITIES

compiled by Bob Biek

Bob Biek joined the NDGS in January as an environmental and mapping geologist. As that title suggests, I have become involved in a variety of projects, including: geothermal regulatory program; review of landfill permits; and *NDGS Newsletter*. I represent the Survey on the State Department of Agriculture's Pesticide Advisory Committee, and I am working to ensure that NDGS facilities meet the requirements under the newly passed Americans With Disabilities Act.

I have also begun detailed geologic mapping of the Jamestown and Bloom 7.5' quadrangles. The resulting maps and report are intended to serve two different audiences: the geologic community, and laypersons (planners, engineers, and the public).

In January, I participated in a planning session for an industrial minerals workshop (see article page 4). I will represent the NDGS at that workshop and I plan to present a poster on North Dakota's industrial minerals. In March, I attended the third biennial North Dakota Water Quality Symposium (see article page 5).

John Bluemle, as State Geologist, has been busy with administrative duties. That load will be somewhat lessened now that he has hired Dr. William A. McClellan as Assistant State Geologist (see article on page 2). John has also given several presentations. In January, he spoke to the North Dakota Geological Society on glacial thrusting and also to a group at the Bismarck Public Library. In March, he travelled to Sweden, where he lectured at the Universities of Stockholm, Gothenburg, and Lund, and also at the Sweden Geological Survey in Uppsalla. He gave a total of 11 lectures in Sweden, most of them on glacial tectonic features in North Dakota and landforms common to both Sweden and North Dakota. John and his wife Mary were guests at the numerous Swedish institutes and universities where he spoke.

John also attended the USGS-sponsored annual McKelvey Forum, held last February in Houston. In June, he expects to attend the Association of American State Geologists meeting in Alabama, and the American Association of Petroleum Geologists meeting in Alberta.

Randy Burke spent a majority of his time on a study of cores taken from the reservoir in Lucky Mound field. The reservoir is in the Sherwood subinterval of the Madison Mission Canyon Formation. He also worked on a variety of derivative maps of Lucky Mound field.

Randy has continued to work on a geophysical study of Winnipegosis reefs and on Devonian cross-sections that show formational correlations into South Dakota. He also set up a display of cores at the NDGS office in Bismarck showing examples of Williston Basin lithologies representative of most of the subsurface stratigraphic column.

Phil Greer began working for the NDGS in November, 1991. Together with Jeff Olson (recently hired by the State Water Commission), he will examine a total of about 45 North Dakota landfills over the next three years. Phil and Jeff completed a work plan for evaluating these landfills, and this past April began field investigations. Seventeen landfills are on the agenda for this field season (see article page 3).

Tom Heck has spent much of his time "talking and listening" since the last newsletter issue. In January, Tom presented an invited talk at the Bureau of Land Management's reservoir workshop in Reno, Nevada. The topic was on drainage and spacing in the Bakken Formation in western North Dakota. In April, he presented a guest lecture entitled "Petroleum Geology of the Gulf of Mexico" to the Petroleum Geology and Well Logging classes at NDSU. In May, he gave a talk on horizontal drilling in Saskatchewan to the Society of Petroleum Engineers in Williston; this was the third time Tom has given that talk.

In January, Mark Luther and Tom attended a course on ARC/INFO at the U.S. Geological Survey in Denver in preparation for the Survey's move into the world of Geographic Information Systems (GIS). He also attended UNIX training courses.

Much of Tom's remaining time was taken up by his work on the Committee on Natural Gas Reserves

(CONGR). This committee is part of the American Gas Association and prepares an annual estimate of natural gas reserves for the entire U.S. This is the second year that Tom has estimated gas reserves for North Dakota. In April, he presented this information at the annual Rocky Mountain area work meeting in Albuquerque.

John Hoganson recently completed work on the restoration of the Highgate Mastodon; he was assisted by Dr. George Lammers, vertebrate paleontologist from the Manitoba Museum of Man and Nature. With Allan Ashworth, he published an article in *Quaternary Research* dealing with beetles as indicators of Quaternary climate changes. With Alan Cvancara, he has an article on vertebrate fossils from the Cannonball Fm. accepted for publication in the *Journal of Vertebrate Paleontology*. John also evaluates Oil and Gas Lease Sale land for potential impact to paleontological resources.

At latest count, John gave 13 public service presentations - about North Dakota fossils and restoration of the Highgate Mastodon - to a variety of North Dakota service groups and organizations, ranging from the Bismarck Breakfast Club to the Southwestern Teachers Conference in Dickinson. John also gave presentations on the NDGS Fossil Resource Management Program to the South Dakota Task Force Meeting on Fossil Resource Management, and a technical presentation on this same subject at the North Dakota Academy of Science 84th annual meeting.

Julie LeFever completed a manuscript for the Rocky Mountain Association of Geologists' *Geologic Studies Relevant to Horizontal Drilling, Western North America* (now in press). Her paper is entitled, "Horizontal Drilling in the Williston Basin in the U.S. and Canada." She also co-authored a paper with principal author Leigh Price of the USGS entitled, "Does Bakken Horizontal Drilling Imply Huge Oil Resource Base in Fractured Shale?". In January, she presented a paper on the middle member of the Bakken Formation at a meeting of the Montana Geological Society.

Julie is continuing a joint project with the USGS on the Bakken Formation and oil from the Bakken. The objectives of this project are numerous and include: correlating source rocks to oil samples in an attempt to define the extent of lateral and vertical migration of oil; studying the influence of drilling and well completion on the reservoirs; and characterizing the organic and inorganic chemistry of the formation. She continues her own study of the Bakken Formation, mapping lithofacies of the Bakken and the lower portion of the overlying Lodgepole Formation ("false Bakken").

Julie is director of the core and sample library in Grand Forks. In addition to her research, she handles the daily management of the core and sample library. On average, she gives one tour of the library per month. She expects to undertake a full-scale inventory of cores and samples at the library this summer. In April, she gave a talk on the history of oil production in North Dakota (and career opportunities in petroleum geology) for a 4H career day conference in Bismarck.

Mark Luther has devoted most of his time to putting our Geographic Information System (GIS) together - acquiring equipment, software, and training. We now have 3 UNIX workstations and a 486 PC on a network running AutoCAD, ARC/Info, and Atlas GIS. The acquisition of the NDGS's GIS has been a joint effort between the NDGS, State Department of Health and Consolidated Laboratories, and the State Department of Agriculture. Mark has also been looking into Global Positioning Satellite (GPS) receivers that will be used with our GIS for mapping purposes; we will receive our first unit as this newsletter goes to press. Mark is once again coordinating the North Dakota GIS Symposium, and is chairman of a GIS committee attempting to formulate data standards for the state.

Mark is also coordinating our ESIC program and he oversees our map sales program. He has given several talks, including those on: map types and compass use; sources of stone used for tools by American Indians and their differentation using UV florescence; and groundwater. Mark continues to be active in environmental issues. He was chairman of the "Water Quality Monitoring, Testing, and Inventory" session at the ND Water Quality Symposium (see article page 5). He is also a member of the ND Nonpoint Pollution Taskforce, and the ND Water Protection Strategy for Pesticides working committee.

Ed Murphy spent a considerable amount of time reviewing landfill permits. In addition, he and Steve Pusc (ND State Water Commission) have nearly completed a report on groundwater impacts of the Devils Lake

wastewater impoundments. Ed is also finalizing a report on the environmental impact of six North Dakota landfills. With John Hoganson (NDGS) and Nels Forsman (Professor of Geology, UND), he has begun to write the final report on Oligocene and Miocene deposits of North Dakota. This last project - a four-year cooperative geologic mapping (COGEOMAP) project sponsored by the U.S. Geological Survey - will be completed once analyses of volcanic ash samples are received.

This past winter, Ed submitted a grant proposal to the U.S. Bureau of Land Management to study the movement of organic compounds from buried oil and gas drilling muds on federal lands. The project is proposed to last two years and the total amount requested is $130,000. The contract has been received and is currently undergoing minor revisions prior to signing. Phil Gerla (Professor of Geology, UND) and John Fokendahl (a graduate student working under Phil) are planning to take part in this project.

In January, Ed attended a meeting in Denver sponsored by the U.S. Environmental Protection Agency. The purpose of that meeting was to provide the EPA with comments on their proposed State Comprehensive Groundwater Plan. Representatives from other EPA Region 8 states were also present, and Ed noted the high level of interagency cooperation on groundwater issues in North Dakota compared to other states.

NEW NDGS PUBLICATIONS

by Phil Greer

The Face of North Dakota, Revised Edition, By John P. Bluemle, NDGS Educational Series 21, (1991), 177 pages, 1 plate, $5.00.

This is a revised and expanded edition of the original book, which was first published in 1977. The following information was included in a press release of February, 1992.

North Dakotans interested in learning more about their state will be interested in a new book titled "The Face of North Dakota, Revised Edition." This book, which was written by John P. Bluemle, North Dakota's state geologist, is a generalized discussion of North Dakota's geology, meant to heighten people's awareness of North Dakota's natural environment and surroundings and help them better understand the changes in rocks and landforms that can be seen across the state.

The first chapter of the book describes the features that can be seen in North Dakota; the landforms and the processes that shaped the landforms. The book includes a chapter on economically valuable resources such as oil, coal, and water and various things of geologic interest, such as fossils and soils. Another chapter deals with the geologic history of North Dakota, emphasizing relatively "recent" geologic events, especially the glacial processes that were important in shaping the modern landscape.

An extensive compilation of publications that contain additional information about the geology of North Dakota is included. A copy of the "Geologic Highway Map of North Dakota" is enclosed in a pocket at the back of the book.

Bluemle says he intended the book to serve as supplementary reading for students in high school and college geology courses, but it should also be interesting to North Dakotans who simply want to know more about our state's geology. He uses a minimum of technical terms in the 175 page book, which is heavily illustrated with photographs and drawings.

North Dakota Geological Survey, List of Publications, (January, 1992), 91 pages, free on request.

This comprehensive list of NDGS publications, and oil and gas material available from the NDGS, updates the previous list published in December, 1989. It follows the same design as previous editions, though now it is pocket-sized.

EARTH SCIENCE EDUCATION

by Bob Biek

Earth Science Resources for Teachers 1992. This list includes 53 nonprofit sources of pre-college earth science reference and instructional materials. It is available free of charge from the National Center for Earth Science Education, American Geological Institute, 4220 King Street, Alexandria, VA 22302-1507, (tel. 703-379-2480).

NDGS Presentations

The following is a list of talks, some with laboratory exercises, offered by staff at the North Dakota Geological Survey. Several of the presentations are technical, intended as occasional guest presentations for North Dakota college and university students. Non-technical presentations suitable for general audiences are indicated with an asterisk. If you wish to schedule a talk or laboratory exercise, please contact John Bluemle or Bill McClellan at (701) 224-4109. Please allow sufficient advance notice for scheduling purposes.

NORTH DAKOTA GEOLOGY

* *Geology of North Dakota* - (John Bluemle)
* *Geology of the Killdeer Mountains* - (Ed Murphy)
* *Geology of selected areas of North Dakota* - (staff)

GEOMORPHOLOGY

* *North Dakota Landforms* - (John Bluemle)
* *The Red River Valley: Geology, origin, and flooding* - (Ed Murphy)

Glacial tectonics and North Dakota landforms - (John Bluemle)

MINERAL RESOURCES

* *Mineral resources of North Dakota* - (John Bluemle)
* *Non-fuel mineral resources of North Dakota* - (Bob Biek)
* *Building stones of the North Dakota State Capitol Building* - (Bob Biek)

PETROLEUM GEOLOGY

* *Oil and gas drilling and production* - (Bill McClellan)
* *Oil and gas economics in North Dakota* - (Tom Heck)

Petroleum geology - (Tom Heck, Julie LeFever, Bill McClellan)

Carbonate reservoir rocks and hydrocarbons - (Randy Burke, Tom Heck)

Drill stem tests - (Tom Heck)

Formation evaluation (wireline logs), with lab exercises - (Tom Heck)

Subsurface exploration for hydrocarbons, with lab exercises - (Randy Burke, Julie LeFever, Bill McClellan)

Quantative core analysis, with lab exercises - (Randy Burke, Julie LeFever)

CARBONATE GEOLOGY

Modern carbonate depositional environments - (Randy Burke)

Reefs through geologic time - (Randy Burke)

Carbonate geology - (Randy Burke)

Qualitative core analysis - (Randy Burke, Julie LeFever)

Porosity development in carbonate rocks - (Randy Burke)

PALEONTOLOGY

* *North Dakota Fossils* - (John Hoganson)
* *Conservation of paleontological resources* - (John Hoganson)
* *NDGS Fossil Resource Management Program* - (John Hoganson)
* *The rise and fall of the dinosaurs* - (John Hoganson)
* *Restoration of the Highgate Mastodon skeleton* - (John Hoganson)

Fossil beetles as indicators of Quaternary climate and environment - (John Hoganson)

Stratigraphy and vertebrate fossil record of the White River Group (Oligocene), North Dakota - (John Hoganson)

Vertebrate paleontology and paleoecology of the Cannonball Fm. (Paleocene) in North and South Dakota - (John Hoganson)

STRATIGRAPHY

North Dakota stratigraphy - (staff)
Upper Cretaceous and Tertiary sediments of western North Dakota - (John Hoganson, Ed Murphy)
Devonian stratigraphy of North Dakota - (Randy Burke)
Stratigraphic response to sea level fluctuations - (Randy Burke)

STRUCTURAL GEOLOGY

Structural geology - (Julie LeFever)
Tectonics - (Julie LeFever, Bill McClellan)
Origin of the Williston Basin - (Julie LeFever)

QUATERNARY GEOLOGY

Quaternary fossils as climatic and environmental indicators - (John Hoganson)
Holocene sea level record in carbonate deposits - (Randy Burke)

GROUNDWATER

Effects of drilling fluid on shallow groundwater - (Ed Murphy)
Effects of oil and gas exploration and production on shallow groundwater in North Dakota - (Ed Murphy)

OTHER TOPICS

Map interpretation with lab exercises - (Bob Biek, Mark Luther)
Field geology techniques - (Bob Biek, Julie LeFever, Mark Luther)
* *Maps and other resources available from the NDGS* - (Mark Luther)
* *Geothermal heating and cooling systems and geothermal regulations* - (Bob Biek)

NDGS publications and USGS topographic maps are available at our sales office (1022 E. Divide Ave, Bismarck), by telephone (701-224-4109), by FAX (701-224-3682), or by mail (see address below). Cash, money order, or check, payable to the North Dakota Geological Survey, will be accepted. Minimum charge per order is $1.00. Reasonable requests for items for which no price is quoted are sent free of charge. Customers will be invoiced for materials plus shipping costs, if applicable. A free copy of NDGS List of Publications will be sent upon request.

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