NEWSLETTER

NDGS

A publication of the
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EDITOR'S NOTE--

I am including the names of the Survey geologists and engineers most directly concerned with the topics discussed in the articles in this Newsletter. These people either wrote or provided me with the information in the articles. This procedure should make it somewhat easier for our readers to contact the right person if they have additional questions or comments about the articles.

And, for the first time, as an experiment, I am including some photographs in this Newsletter.

MINING AND MINERAL RESOURCES RESEARCH INSTITUTE (Lee Gerhard) --

A mining and Mineral Resources Research Institute was recently awarded to the School of Engineering and Mines of the University of North Dakota by the office of Surface Mining, U.S. Dept. of Interior. This is one of 31 such institutes spread across the country in states where mining and mineral resources are significant. The awarding of the institute this year to the University is not only a major action for the School of Mines and Geology Department, but also for the Geological Survey. Dr. Alan Fletcher, Dean of the School of Engineering and Mines, is Institute Director.

The Institute is charged with both research and training functions. The original proposal provided for the revitalization of the Mining Engineering program and, we hope, the formal Petroleum Engineering program. Establishment of faculty positions and research programs in those areas will relieve some of the present pressures on Survey programs and create many more opportunities for our people to interact with a broader community of scientists and engineers through joint research projects, joint supervision of student research, and participation in professional development programs.

Part of the funding may be used to provide research capability; the establishment of the Department of Geology Natural Materials Analytic Laboratory with X-ray diffraction scanning electron microscope and microprobe can be complemented with full RF (fluorescence) capability so that complete chemical and particulate analyses can be routinely run.

A projected faculty increase for the programs in Mining Engineering and Petroleum Engineering, if accomplished, can add expertise to Survey research programs. Along with this aspect of the institute, it may be possible to train even more of the technical people needed in the state's energy industry, helping keep North Dakotans in North Dakota.

Research in these areas of interest may well help solve some of the technical problems caused by energy development and help separate real problems from inferred problems.

The Mining and Mineral Resources Research Institute will have funding of \$110,000 a year for five years for operations, facility, and faculty. \$160,000 will be available over three years for graduate student research assistantships and post-doctoral appointments; the faculty of the University will be able to submit proposals for research support to a major fund set aside for Mining and Mineral Institute grants. It is rumored that this year's fund will be about \$5 million.

The North Dakota Geological Survey; Mining and Mineral Resources Research Institute; Department of Geology; Department of Energy, Grand Forks Energy Technology Center; UND Engineering Experiment Station; and the School of Engineering and Mines together create one of the largest and most active centers of energy research and development activity in the country.

NEW CORE AND SAMPLE LIBRARY WILL BE NAMED FOR WILSON M. LAIRD (Erling Brostuen)

Construction of a new structure to house the Geological Survey's well core and sample collection will commence next spring. The new facility will be named for Wilson M. Laird, former State Geologist and Professor Emeritus of the University of North Dakota. It will be named the Wilson M. Laird Core and Sample Library and it will be located immediately south of Leonard Hall on the site of the old Winter Sports Building.

North Dakota law requires that all requested core and samples and all geophysical logs acquired during exploration and development of oil and gas, lignite, and subsurface minerals be furnished to the State Geologist. We have accumulated and maintained these materials since the discovery of oil in the state in 1951. As a result, the North Dakota Geological Survey posesses what is possibly the nation's most complete and accessible collection of subsurface geologic and engineering data obtained from exploratory and development drilling. Samples from North Dakota State Water Commission test holes drilled for the county groundwater studies are also stored in the Core and Sample Library.

Funding for the new facility was appropriated by the 1979 session of the State Legislature from the State Board of University and School Lands Land and Mineral Trust Fund. The trust fund provides financial support for land and mineral resources related activities.

Dr. Wilson M. Laird came to North Dakota in 1940 as Assistant Professor of Geology at the University. In 1941 he was named State Geologist and Supervisor of Oil and Gas for the North Dakota Industrial Commission. He served in these capacities and as Chairman of the Geology Department until 1969 when he accepted a position with the U.S. Department of the Interior as Director of Oil and Gas. Dr. Laird was the architect of the Geological Survey as it exists today. Due to his foresight, North Dakota had an oil and gas conservation statute in place prior to the discovery of oil in 1951 which enabled the orderly development of the oil and gas industry in the State. His insistence on the preservation of data acquired during petroleum exploration and development resulted in the collection of core and samples maintained by the Survey today.

The Core and Sample library has proven to be a valuable source of information for Survey and industry geologists, and faculty and students in the Geology Department at the University of North Dakota. Its existence and use is a factor in the acceleration of exploration activities for oil and gas and subsurface minerals in the state. The core and sample library is vital to the performance of the Survey's statutory responsibilities.

The old core and sample library is housed in a metal building on the east side of the UND campus, just east of the football stadium. It contains 9600 square feet of floor space and, with the exception of a small examination room, is unheated. No laboratory or washroom facilities are provided in the building.

For this reason, core and samples must be transported between the library and Leonard Hall for study. The facility is now filled to its capacity.

The new facility will contain 20,482 square feet of floor space to provide 18,432 square feet for core and sample storage and 2,050 square feet for laboratories and office space. The temperature in the storage area will be maintained above freezing during the winter to alleviate thermal shock to the building. The laboratories and office will be both heated and air conditioned. This will be welcome news to anyone who has had the opportunity to examine cores in the old facility during the winter months. The potential storage capacity of the new facility is 200,000 boxes of cores.

COMPUTERIZED OIL AND GAS WELL FILE (Ken Harris) --

In March, 1979, the North Dakota Geological Survey entered into a cooperative agreement with the Department of Energy (DOE-FC07-79ID120) to evaluate the hydrothermal resources of the state. Part of the requirements of our contract included the development of a computer data management system that would provide a quick, accurate reference to the information stored in our oil and gas well files. In order to implement this requirement, a location-oriented data management system, named GEOSTOR, was selected to be the library in which our well data would be stored. The GEOSTOR program was designed by Laramie Winczewski, a University of North Dakota geologist, with funds provided by the Surface Environment and Mining (SEAM) research group of the U.S. Forest Service.

This computer well file system, which incorporates well data previously compiled and computerized by Sid Anderson (NDGS), is designed to store and display oil and gas well data. The information in storage for each well includes: owner-operator, location, reference elevation, deepest formation penetrated, total depth, bottom-hole temperature, well status, initial production, producing formation, perforated interval, available cores and samples, available geophysical logs, and selected formation tops.

Our computer library has been assembled and we are in the process of proofing and correcting the information stored in it.

The North Dakota Geological Survey plans to begin publishing, in the not too distant future, listings of the computer well file data. The information published will be presented in a location-oriented format and it will include the general oil and gas well data, information on available cores and samples, and available production data. It is hoped that subsurface workers in North Dakota will find these listings helpful in identifying and locating useful information.

Over the next few years we hope to greatly expand the stratigraphic capabilities of the computer well file. We will be developing the computer graphics capabilities needed to construct detailed structural and stratigraphic maps. The ability to generate rapid, accurate subsurface maps of the Williston Basin will be a valuable tool in helping to understand the geology and resource potential of North Dakota.

NORTH DAKOTA OIL EXPLORATION AND PRODUCTION IN 1979 --

The recent successes of the past few years by oil explorationists in North Dakota have continued through 1979. As a result of these discoveries, our oil production has climbed, reaching a current all-time high of about 90,000 barrels a day in October; production figures are not yet available for November and December. We expect to produce about 32 million barrels of oil this year in North Dakota. This is up from 25 million barrels in 1978, 23 million in 1977, and a recent low of about 19½ million barrels in 1974. The previous high was 27 million barrels in 1966.

A total of 27 new pools have been discovered in 1979, through December 10. Discoveries included 12 from the Red River Formation, 8 from the Madison, 5 from the Duperow, and one each from the Stonewall and Bakken. There were a total of 643 dilling permits issued in 1979.

DISCOVERY WELL WILL BE REDRILLED --

North Dakota's first commercial producing oil well, the Clarence Iverson #1, was plugged on August 2, 1979 after the casing collapsed. The well, located in the Beaver Lodge Field in Williams County, has an interesting history.

Drilling on North Dakota's discovery well began on September 3, 1950 and the historic pint of oil was recovered on January 3, 1951. Testing of the well began in late February and on March 23, three gallons of 45 gravity oil were recovered. On April 4, 1951, Amerada Petroleum Corporation announced a flow of 18 barrels of oil an hour from a depth of 11,660 feet (Silurian). In mid December of 1951, the well was completed in the Madison flowing 670 barrels of oil a day. The well subsequently produced from the Silurian (total of 81,960 barrels of oil), Devonian (total of 324,488 barrels), and Madison (total of 180,041 barrels) for a total production of 586,489 barrels of oil.

Amerada Hess Corporation plans to redrill the well next year as the oil pool is by no means exhausted.

ENVIRONMENTAL EFFECTS OF OIL WELL DRILLING MUDS (Alan Kehew) --

A new project now in the planning stages at the NDGS involves the study of disposal of oil well drilling muds. The common method of drilling mud disposal is to retain the muds in a reserve pit constructed adjacent to the drilling rig. After drilling is completed, the pits are reclaimed by covering the mud residue with soil. The purpose of the proposed study is to determine whether or not any of the components of drilling mud migrate through the soil zone by leaching as a result of precipitation falling at the surface and percolating through the soil after the sites are reclaimed.

The study will involve the selection of several representative reclaimed mud pits and the monitoring of soil and groundwater conditions in the vicinity of each site. Soil cores will be taken for analysis and wells will be installed so that groundwater samples can be collected and analyzed regularly.

The project will be a joint effort of the NDGS and the State Health Department. The Survey will be responsible for the installation of the monitoring equipment and the interpretation of the soil and geological conditions at each site. The Health Department will participate in the collection and analysis of samples. Funding for the project, which should get underway next summer, will be obtained from the U.S. Environmental Protection Agency.

EXPLORATORY COAL DRILLING PROGRAM COMPLETED (Kelly Carlson) --

The North Dakota Geological Survey has been conducting cooperative drilling projects with the Conservation Branch of the U.S. Geological Survey each summer since 1975. The primary objective of these projects has been to obtain information about the lignite resources of western North Dakota and make it available to the public. The program was designed to obtain near-surface information, from depths of 200 to 500 feet. However, for correlation purposes, deeper holes ranging from 700 to 760 feet deep were drilled at some sites. In most areas, drill sites were selected to provide two or three sites per township.

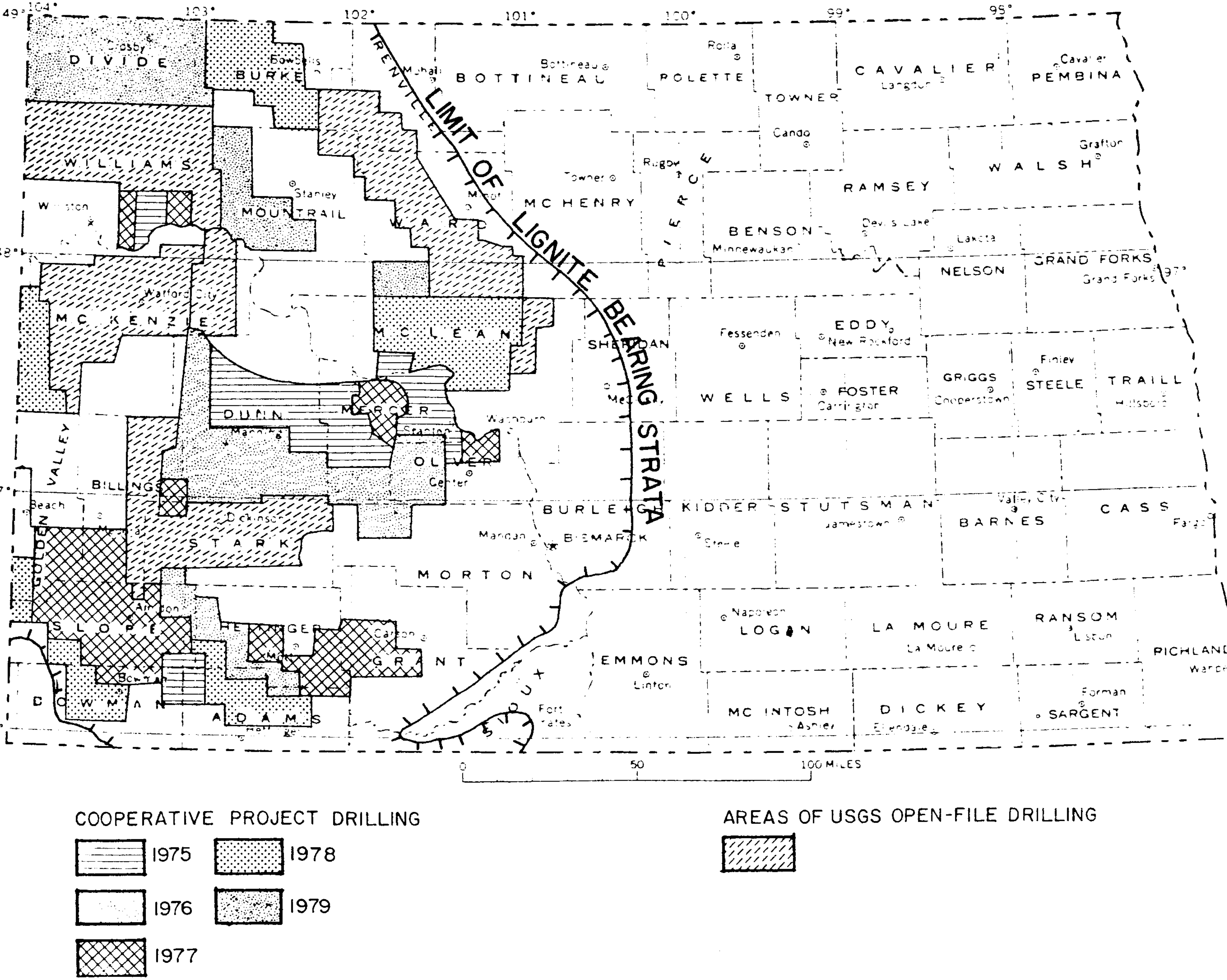
Programs of 1975 through 1978 provided about 180,000 feet of drilling at about 550 sites plus about 250 feet of lignite cores. Chemical analyses of the cores were provided by the U.S. Bureau of Mines and trace element analyses have been performed by the Coal Branch of the U.S. Geological Survey. Results of the 1975 through 1978 programs have been released jointly by the North Dakota Geological Survey and the U.S. Geological Survey as open-file reports. The reports consist mainly of basic data with maps of locations of test sites, logs, and lithologic descriptions of each testhole, and chemical analyses of cores. Logs include gamma ray, density, self-potential, and resistivity.

Previously released open-file reports are:

1975.	OF 76-869	64 sites	142 pages	$ 5.00
1976.	OF 77-857	115 sites	336 pages	20.00
1977.	OF 78-888	239 sites	541 pages	30.00
1978.	OF 79-1051	131 sites	418 pages	25.00

The 1979 drilling program was conducted at 17 sites in Ward County, 32 sites in Mountrail County, and 68 sites in Divide County. It amounted to about 44,000 feet of drilling with no cores cut. The report on the 1979 drilling is in preparation and, after review by the U.S. Geological Survey, it will be released in the late spring of 1980.

The map accompanying this article (see page 7) shows the areas covered by the cooperative drilling program of the past five field seasons as well as areas where the Conservation Branch of the U.S. Geological Survey has produced similar open file data. The data collected as a result of these programs now provides a good reconnaissance view of the lignite resources. Generally, projections can be made from the adjacent drill hole data and surface exposures around the undrilled eastern margins of the coal lands in Grant and Morton Counties. Undrilled areas of Billings, Golden Valley, and McKenzie Counties are mostly badlands or are near badlands areas along the Little Missouri River where outcrop information is readily available. The undrilled portions of Ward, Burke, and eastern Mountrail Counties are mostly areas of thick glacial drift. One large area of coal lands for which information is sparse is the Fort Berthold Indian Reservation, but problems of access must be resolved before this area may be investigated.


LIMIT OF LIGNITE BEARING STRATA
DIVIDE
BURKE
WILLIAMS
MOUNTRAIL
WARD
MC KENZIE
MC LEAN
DUNN
MERCER
OLIVER
BILLINGS
GOLDEN VALLEY
STARK
MORTON
SLOPE
HETTINGER
GRANT
BOWMAN
ADAMS
SIOUX
BOTTINEAU
RENVILLE
MC HENRY
PIERCE
ROLETTE
TOWNER
CAVALIER
PEMBINA
WALSH
RAMSEY
BENSON
NELSON
GRAND FORKS
SHERIDAN
WELLS
EDDY
FOSTER
GRIGGS
STEELE
TRAILL
BURLEIGH
KIDDER
STUTSMAN
BARNES
CASS
EMMONS
LOGAN
LA MOURE
RANSOM
RICHLAND
MC INTOSH
DICKEY
SARGENT
Crosby
Bowbells
Stanley
Watford City
Manning
Stanton
Washburn
Center
Dickinson
Beach
Amidon
Carson
Bowman
Mandan
BISMARCK
Steele
Jamestown
Valley City
Fargo
Napoleon
Linton
Fort Yates
Ashley
Ellendale
La Moure
Lisbon
Forman
Wahpeton
Mohall
Minot
Towner
Bottineau
Rolla
Cando
Rugby
Langdon
Cavalier
Grafton
Devils Lake
Lakota
Minnewaukan
Grand Forks
Fessenden
New Rockford
Carrington
Cooperstown
Finley
Hillsboro
49°
48°
47°
46°
104°
103°
102°
101°
100°
99°
98°
97°
0
50
100 MILES
COOPERATIVE PROJECT DRILLING
1975
1976
1977
1978
1979
AREAS OF USGS OPEN-FILE DRILLING

We believe that we currently have a good general knowledge of North Dakota's lignite resources. The increased oil exploration and the increasing practice of running gamma ray logs to the surface in these holes is providing additional public information regarding the lignite beds. For this reason, we do not anticipate a continuation of the cooperative program.

MECHANISMS, DISTRIBUTION, AND FREQUENCY OF GROUNDWATER RECHARGE IN UPLAND AREAS OF NORTH DAKOTA (Funded by Water Resources Research Institute) (Gerald Groenewold) --

In nearly all of North Dakota, as well as in neighboring states, groundwater is the sole water supply for extensive areas and most of the population. The groundwater resource is a dynamic reservoir, which is constantly being depleted due to use by man as well as by natural discharge. For this reason, both the quantity and quality of water available depends almost entirely on natural recharge. During periods of climatic stress, when the amount of water available to infiltrate into the ground is reduced, the recharge of the groundwater reservoir is also reduced. This reduction in recharge almost invariably results in drastic declines in water levels, and in many areas it can result in seriously degraded water quality unless water use is severely curtailed. In many areas, changes in land-use will have impacts on the groundwater recharge characteristics of the landscape. At the present time, it is difficult to nearly impossible to evaluate the direction and magnitude of the impacts of such changes in land-use or recharge because the details of the location, timing, and mechanism of groundwater recharge are so poorly understood.

This project, ongoing since mid 1978, is evaluating the details of the recharge process in the Falkirk area of western North Dakota by directly observing fluctuations in the water table through the use of observation wells and then relating these fluctuations to climatic events. The historical record of recharge is being evaluated in the area by measuring water chemistry and especially the environmental isotopes, tritium, deuterium, and oxygen-18, which together will permit determination of the time since, and the climatic conditions under which major recharge occurred. The final report on this project will be completed in early 1980.

INVESTIGATION OF THE SUBSIDENCE AND SURFACE COLLAPSE FEATURES IN RECLAIMED SURFACE COAL MINE SPOILS (Funded by U.S. Bureau of Mines) (Gerald Groenewold) --

Reconnaissance of existing graded spoils indicates that various engineering problems exist within these areas. These include differential subsidence of the surface of the spoil, slope instability, and piping failures. Post-mining land use requires that the landscape maintain a stable configuration. This is of concern not only for agricultural uses, but also for commercial and residential utilization of these areas. The proposed expansion of towns, construction of power lines, and construction of ponds, lagoons, and other facilities and structures related to power plants on areas of spoils requires a knowledge of the geotechnical characteristics of these materials.

This project began in April, 1977 and will continue through March 1981. Initial work involved instrumentation of a study site at the Indian Head Mine. A second series of sites at the Center Mine were instrumented in the summer and fall of 1979. Instrumentation consists of concrete survey markers and piezometers.

These are monitored on a monthly basis, allowing for a determination of surface movements of the spoil materials and subsurface water conditions at the sites. The locations of the markers were chosen in such a way as to maximize the monitoring at positions where significant variables occur within the spoils. These variables include: the original nature of the overburden, methods of stripping and consequent spoil morphology, the time of year during which stripping and contouring occur and the method of emplacement of the materials during contouring operations.

Data obtained so far indicate that severe instability may occur on certain post-mining landscapes in the Northern Great Plains. Large-scale collapse, as indicated by this study, occurs soon after cessation of contouring operations and only in areas where frozen materials are contoured with a dozer. Thawing of, and collapse around, concentrations of large frozen blocky materials in the base of the spoils apparently is the cause of this type of instability. This type of instability is thus largely machine and seasonally controlled. In the Northern Great Plains, spoils are generally frozen from the beginning of December through mid-April. Winter contouring with a scraper appears to result in a very stable landscape.

Piping (subsurface water erosion resulting in tunneling and collapse), on the other hand, appears to be controlled by a combination of physical and chemical conditions in the spoils. All piping observed at the study sites began as a crack on the surface of the spoils. The cracking is due to the extremely dispersive nature of the clays in the spoils. SAR (sodium adsorption ratio) values for the overburden at these sites range as high as 60 (the high SAR values result from the accumulation of sodium).

Surface cracks allow access for precipitation runoff to flow into the subsurface of the spoils. Piping is more likely to develop if an avenue for water movement is present in the subsurface of the spoils. Subsurface fracturing commonly results from differential movement between the very stable scraper-contoured areas and less compact and less stable dozer-contoured areas. Scattered piping also occurs within dozer-contoured areas and is apparently due to the less compact nature of those spoils. In all cases, the permeable zone in the base of the spoils allows for lateral and vertical discharge of the water entering through the piping features.

COOPERATIVE PROGRAM TO EVALUATE SURFACE AND GROUNDWATER PROBLEMS ASSOCIATED WITH POTENTIAL STRIPMINE SITES (Funded by Environmental Protection Agency) (Gerald Groenewold) --

This project, which is a cooperative effort with research groups in Montana and Wyoming, is presently in its fifth year. Phase I of the project, which ended in September, 1978, produced a detailed physical and chemical characterization of the study site (Falkirk area) and associated waters prior to mining. The final Phase I report is presently in the process of review. Phase II, which ends in December 1981, involves monitoring of the effects of mining during the initial mining period. These data are being used to develop and refine a predictive framework capable of explaining initial (pre-mining) conditions and providing predictions of the effects of given mining scenarios.

Two modeling efforts are presently underway. These are a groundwater response model and an equilibrium-based geochemical model. The groundwater response model is a large quasi-three-dimensional, finite-element model. Trial runs of this model will begin in the next month or two. Actual observed effects of mining in the Falkirk area will be used as tests to determine how successfully this model simulates groundwater conditions and mine-related responses of the system.

The hydrogeochemical model is progressing well and is presently undergoing trial runs utilizing various subroutines. It has succeeded in producing simulations of various simple hydrogeochemical systems and, hopefully, will soon be sufficiently refined to simulate hydrogeochemical conditions in the Falkirk area.

GEOLOGIC AND GEOCHEMICAL CONTROLS ON THE CHEMICAL EVOLUTION OF SUBSURFACE WATER IN SURFACE COAL MINE SPOILS (Funded by U.S. Bureau of Mines) (Gerald Groenewold) --

Surface mining and associated postmining reconstruction of the landscape results in the creation of new physical and geochemical environments. These changes can potentially have a marked effect on local groundwater conditions. Of major concern is the potential for chemical degradation of the groundwater.

Existing groundwater instrumentation at several proposed and active mining sites in western North Dakota has allowed for the development of a conceptual model for the chemical evolution of groundwater in undisturbed landscapes. This model focuses on several key chemical processes which are responsible for existing groundwater chemical characteristics. Critical factors are textural and mineralogical variables in the materials. These same geochemical processes are operating in disturbed (postmining) landscapes. The long-term effects upon groundwater quality are not presently known. Verification and refinement of the geochemical model in disturbed landscapes will allow for the design of postmining landscapes in which the water chemistry is predictable.

The objectives of this project are:

(1) To characterize the quality of groundwater in geologically and geochemically distinct postmining landscapes.

(2) To determine the mineralogy of the material matrix through which groundwater flows in those landscapes.

(3) To relate this mineralogy to the chemistry of the groundwater in those landscapes.

(4) To define the minerals and chemical reactions that control the chemical evolution of groundwater in postmining landscapes and thereby gain the capability to design postmining landscapes in which groundwater quality can be predicted and guaranteed.

This project began October 1, 1979 and will end September 30, 1981. Activities will include the sampling of piezometers in spoils and associated materials at the Center and Indian Head mines in western North Dakota. Total instrumentation in spoils and associated unmined materials at the two mines consists of approximately 200 piezometers. Overburden at the Center and Indian Head mines shows the complete range of mineralogical and textural variability as found at the various study sites and thus allows an excellent opportunity for comparing overburden characteristics and postmining groundwater quality. The Indian Head site is characterized by fine-textured (clay and silt) sediments of Tertiary age. The Center site is characterized by Tertiary clay, silt, and sand overlain by a veneer of Quaternary till.

Overburden samples will be obtained from highwalls and by Shelby sampling of overburden at selected locations. The overburden sampling program will be designed to maximize the characterization of all materials having significant textural and mineralogical variability. To maximize an understanding of rock-water relationships, splits of each sample will be analyzed by SEM and diffraction techniques and compared with data obtained by leaching columns utilizing the remaining portion of each sample. These procedures will result in quantitative mineralogical descriptions of the various overburden materials which, in turn, will be compared with the chemistry of the water flowing through those materials as determined by the column experiments. This will allow for the identification of key geochemical and mineralogical variables and, in turn, an evaluation of these variables relative to the characteristics of the groundwater at the study sites. This approach will allow for the evaluation and refinement of the existing geochemical model. Most importantly, it will give the capability to predict postmining groundwater quality in various settings and thereby allow for the design of disturbed landscapes such that deleterious effects upon groundwater quality can be minimized.

Existing analyses of waters from the base of the spoils at the Center and Indian Head mines show extreme variability over small areas. Total dissolved solids concentrations in spoil waters at Indian Head vary from 1,500 to 16,000 mg/L within a 16 hectare area. Analyses of water from piezometers allows only for the determination of water quality at a specific location. Of great interest in reclaimed areas is the areal distribution of these highly variable types of water. As part of this project, an attempt will be made to use earth resistivity techniques as a means to better determine the areal variability of water quality in the study sites. These techniques will also be useful in delineating areal variations in the permeability characteristics of the spoils.

RECENTLY RELEASED PUBLICATIONS --

Since our last Newsletter in June, the Survey has published the following reports:

Report of Investigation 64 -- "Geology and Geohydrology of the Knife River Basin and Adjacent areas of West-Central North Dakota." The report was written by Gerald H. Groenewold and five others. It deals with the surface and subsurface geology, regional groundwater-flow systems, chemistry, and chemical evolution of groundwater in the units overlying the Pierre Formation in west-central North Dakota. A total of 12 different lignite beds have been recognized, named, and correlated throughout the Knife River Basin.

The study concentrates on the area within the Knife River Basin. Two additional study sites outside the Knife River Basin, the Center and Falkirk sites, are also discussed. The report also includes a discussion of the groundwater-flow patterns, chemistry, and chemical evolution of water in the Fox Hills aquifer throughout southwestern North Dakota. Detailed mapping of surface and near-surface materials in the Beulah-Hazen area has allowed for the generation of a series of land-use suitability maps for that area.

The report is 402 pages long and includes 37 plates. It is available from the North Dakota Geological Survey for $10.00.

Bulletin 65, Part I -- "Geology of Adams and Bowman Counties, North Dakota" was written by C. G. Carlson. This report provides a summary of the stratigraphy and geologic history of the area with an emphasis on the near-surface units. The report contains geologic maps of the two counties, descriptions of the formations present at the surface, and cross-sections providing an interpretation of the surface to subsurface relationships. Bulletin 65, Part I contains 29 pages of text and figures and 4 plates. It is available free from the North Dakota Geological Survey.

Bulletin 67, Part III -- "Ground-water Resources of Grant and Sioux Counties, North Dakota" was written by P. G. Randich. The report describes the hydrology of groundwater in Grant and Sioux Counties. Groundwater in the two counties is obtainable from aquifers of Late Cretaceous, Tertiary, Pleistocene, and Holocene age. Aquifers of Cretaceous and Tertiary age are larger in areal extent, but those of Pleistocene age provide larger yields of better quality water to individual wells. The report is 49 pages long and includes several maps including a map showing the availability of groundwater in the two-county area. It is available free of charge from the North Dakota Geological Survey.

Bulletin 69, Part I -- "Geology of Ransom and Sargent Counties, North Dakota" was written by John P. Bluemle. The report describes the subsurface and surface geology, the geologic history, and economic geology of the area. Emphasis is on stratigraphic correlations of Pleistocene units and on surface landform formation. The report includes a colored geologic map of the two counties, 84 pages of text and figures. It is available free from the North Dakota Geological Survey.

Bulletin 69, Part II -- "Ground-water Basic Data for Ransom and Sargent Counties, North Dakota" was compiled by C. A. Armstrong. The report includes geologic and hydrologic records for 1,279 wells and test holes, water-level measurements in 182 observation wells, chemical analyses of 408 ground-water samples, and chemical analyses of ground water for trace elements from 8 wells. The data may be used in evaluating geologic and ground-water conditions in Ransom and Sargent Counties. The report is 637 pages long and is available free of charge from the North Dakota Geological Survey.

Bulletin 70, Part I --"Geology of Dickey and LaMoure Counties, North Dakota" was written by John P. Bluemle. Similar in content to Bulletin 69, Part I, (described above), this report includes colored geologic maps for each county. The report is 72 pages long. It is available free from the North Dakota Geological Survey.

"The Official Oil Production Statistics and Engineering Data for the Second Half of 1978" contains the oil and water production by individual wells as well as other pertinent information. This publication costs $4.00.

In addition to the publications just described, the Survey released an Open File Report entitled "Lignite Drilling During 1978 in Western North Dakota: Adams, Billings, Bowman, Burke, Golden Valley, Hettinger, McKenzie, McLean, and Slope Counties," contains maps showing locations, logs (gamma ray, density, self potential, and resistivity) and sample descriptions for the 131 test holes drilled in this area during 1978. It also contains analyses of 7 lignite cores.

Copies of this report (Open File Report 79-1051) may be obtained from the Grand Forks Office of the North Dakota Geological Survey for $25.00.

The newly issued version of the "General Rules and Regulations for the Conservation of Crude Oil and Natural Gas," has an improved format. In the new issue, each rule includes a cross-reference to the North Dakota Century Code indicating the General Authority under which the rule falls. In addition, the rules are identified by their North Dakota Administrative Code Number. For example, Rule 1 in the previous edition of the General Rules read: Rule 1. Scope of Rules and Regulations. In the new edition of the Rules and Regulations, this has become: 43-02-03-02. Scope of Chapter. The General Authority for this rule is shown as NDCC 38-08-04. The content and intent of the rules is generally unchanged. This new method of listing the rules is an important change as it will enable the user to easily refer to the portion of the Century Code that applies.

SOON-TO-BE RELEASED PUBLICATIONS --

Several publications that we have been working on for some time are not yet ready as this Newsletter is written, but all of them should be released within the next few months. Among them are a new stratigraphic column for North Dakota that includes type logs with formation tops indicated as well as revised (more accurate) terminology and descriptions for many of the formations.

The United States Geological Survey is printing a new geologic map of North Dakota that was drawn by Lee Clayton, formerly with the University of North Dakota geology department. This detailed map will be published at a scale of 1:500,000 (about 8 miles to the inch) and it will show surface units. The North Dakota Geological Survey will be providing an Explanatory Text to accompany the map.

We are nearly ready with a report on the geologic and hydrologic conditions affecting land use in the Bismarck-Mandan area. This report will include detailed geologic maps and a series of land-capability maps of the area.

A revised version of a report dealing with flooding along the Red River in the Grand Forks-East Grand Forks area should be released early in 1980.

Finally, we are updating our List of Publications. The revised listing should be available soon.

REPRINTS OF NEWSLETTER ARTICLES AVAILABLE --

This is the thirteenth issue of the NDGS Newsletter. In looking back over past issues of the Newsletter, I recall that certain articles seemed to arouse the readers' interest. Most of the information I have included in the Newsletters has been of a somewhat specific nature and only of temporary interest, but some of the articles may continue to interest some of you, particularly if you missed them the first time. For this reason, I have compiled a listing of articles on some of the topics that have appeared in past issues of the Newsletter. If there is sufficient demand for them, we will compile a reprint file and supply them upon request. Please contact me (John Bluemle, Newsletter Editor) if you have comments or if you are interested in any of the articles.

Title of Article (short description of content)	Newsletter page and date
Articles Dealing Mainly with Mineral Resources	
Mineral Resources in North Dakota (an overview of the state's mineral resources)	p. 1 - June 1974
North Dakota Needs More Exploratory Drilling (shows, statistically, how little exploration has really been done)	p. 7 - Dec. 1975
The Origin of Oil and Gas (a discussion for the layman)	p. 14 - Dec. 1978
Exploration Ingenuity (about new ways to find oil)	p. 10 - June 1977
Strippers (about old oil wells producing less than 10 barrels of oil daily)	p. 19 - June 1977
North Dakota's Red Wing Creek Field (discusses the theory that a meteor formed the oil-trapping structure)	p. 3 - June 1975
Interest Mounts in North Dakota Potash (deals with the occurrence of potash in North Dakota)	p. 2 - Dec. 1974
Potash in North Dakota (additional information on potash)	p. 9 - Dec. 1976
Potash Resources (additional information on potash)	p. 21 - June 1978
Groundwater in North Dakota--An Overview (deals with the occurrence of groundwater)	p. 16 - June 1979
Cement Rock in North Dakota (history of cement rock in the state and the Survey's search for a suitable source)	p. 10 - Dec. 1978
Gold in North Dakota (history of gold mining in the state)	p. 9 - Feb. 1974
Uranium in North Dakota (history of uranium mining and how uranium occurs in the state)	p. 4 - June 1976
North Dakota Scoria (how scoria forms)	p. 6 - Dec. 1976
Estimated Original Strippable Lignite Reserves and Lignite Resources in North Dakota (a tabulation of reserves by county)	p. 5 - June 1974

Articles of General Interest

NEW SURVEY STAFF --

The addition of Robert Garbe to the staff in our Bismarck office brings our force of field inspectors to eight. Bob is from Minot and his earth science degree is from Minot State College.

Cheryl Duggan is our new publications officer. She is from Buxton, North Dakota and has an Associate Arts Degree from Mayville State College in Secretarial Science.

Connie Kadrmas recently joined our Bismarck staff as a clerk-typist. She is a 1973 graduate of Killdeer High School. Prior to coming to the Survey, Connie was a secretary at the Prince Hotel in Bismarck.

We now have two full-time drafting technicians. Luke Savoy comes originally from Washington, DC. After high school he attended the National Academy of Art in Washington for 2½ years. He joined the U.S. Air Force in 1957 and remained there for 22 years until his retirement on June 1, 1979. He was stationed at Grand Forks Air Force Base for 10 years. Luke joined the NDGS on August 15 as a drafting technician.

Dave Ruddy has been with the Survey as a part-time drafting technician for the past two years. He began full-time employment on July 1. Dave is a 1978 graduate of Grand Forks Central High School and he was employed by Richmond Engineering in Grand Forks prior to coming to the Survey.

Our new Computer Programmer is Howard Umphrey. Howard has extensive experience in programming, especially computer graphics, and as a program developer for a geologic data base. Since joining the Survey, Howard has been developing a computer well-filing system and graphics system. He is also adapting our System Six (the machine we use to compose our printed publications) with computer capability to enable it to automatically produce the production statistics. This also involves computerization of the production statistics files.

Eula Mailloux is our new Clerk II in the Engineering Division. She comes originally from Grand Rapids, South Dakota, and has lived in Grand Forks for two years. Eula has completed a Junior Accounting Course at Aakers Business College.

LANDSLIDES AND THE LANDSLIDE PROBLEM IN NORTH DAKOTA (Alan Kehew) --

The potential failure of natural or altered slopes is a serious problem in many parts of North Dakota. Nationwide, various types of landslides annually result in millions of dollars of damage to roads, buildings, bridges, and other engineering works. Occasionally, landslides can lead to injury or death to people involved. Although North Dakota does not have as severe a problem as many states, slope stability must be considered in many engineering projects in the state.

Basically, slope failure and downslope movement occur when the forces increasing the stress (load) on a mass of soil or rock equal or exceed the strength of that mass of material. Unfortunately, the circumstances that lead to this condition are extremely complex and commonly difficult to predict. The basic variables involved include amount of slope, nature of the slope materials, and moisture conditions within the slope materials.

The best way of examining the problem is to divide the factors influencing stability into those which increase the stress within a slope and those which lead to a decrease in the strength, or resistance of the materials to failure. Examples of those factors which tend to increase the stress include: removal of lateral support (such as undercutting by rivers or waves, or man-made cuts and excavations); increased disturbing forces (such as natural accumulations of water or snow, or man-made accumulations of ore, rubbish dumps, or buildings); transitory stresses (such as earthquakes or heavy traffic). Other factors tend to decrease slope stability by decreasing the internal resistance of the mass of materials to down-slope movement. These include the composition of the materials (beds such as clays and shales decrease in strength if water content increases); weathering changes, which cause slow physical and chemical changes in the materials over long periods of time; and pore-water increases (higher groundwater table because of increased precipitation or human interference).

Engineering studies of slopes express relative slope stability by use of a number known as the factor of safety (F.S.). This is defined as the ratio of the forces resisting slope failure to the forces tending to produce failure, and can be applied by use of the formula,

$$\text{F.S.} = \frac{\text{Sum of forces resisting failure}}{\text{Sum of forces tending to produce failure}}$$

A factor of safety of 1.0 means that the two types of forces are exactly in balance and the slope is in a state of potential or incipient failure. The higher the factor of safety above 1.0, the greater the relative stability of the slope.

The strength of unconsolidated materials (soils) is derived from two sources: friction between individual particles and cohesion (the attractive forces between clay particles). Therefore, the behavior of the soil is strongly dependent on the amount and type of clay present. Clay-rich soils, such as those of the Red River Valley and much of eastern North Dakota, have relatively high strengths when dry, but they lose strength rapidly when water is added. Water also tends to increase the pore pressure. When the pores of a soil are saturated with water, a force proportional to the saturated depth is exerted in all directions. The net effect is a bouyant force acting upon the soil mass. Because the bouyant mass of soil can exert less downward pressure to produce frictional strength, the possibility of down-slope movement is increased (the F.S. is decreased). This is why slope failure often occurs during periods of abnormally heavy precipitation.

Once a slope fails, down-slope movement may take place at different rates of motion, and produce any of a number of different types of deposits. The overall term for any movement of material down-slope under the influence of gravity is mass wasting. Many terms have been applied to the deposits, depending on the type of movement, rate of movement, nature of the failure surface, type of material, and amount of water involved. The processes can range from rockfall off steep cliffs to creep, which is an imperceptibly slow down-slope movement of soil on gentle slopes.

Reduction of hazard to human life and property can be accomplished by identifying unstable or potentially unstable slopes and then following proper planning and engineering procedures to eliminate the problems. Corrective measures applied after slopes fail generally have a high cost and only a limited success. Careful geologic mapping is the most successful method of locating potentially unstable slopes. Air photo analysis is an excellent aid to the recognition of areas of landslide topography. Once the potentially unstable areas have been identified, planners and engineers may be able to control development so that risk of slope failure is reduced to an acceptable level. Detailed study of the potentially unstable sites with particular emphasis on the engineering properties of the materials is a necessity. Complete avoidance of the slope may be the safest alternative in some high-risk cases. If construction and development is considered feasible, many techniques for stabilization of slopes and prevention of failure may be utilized. Most of these methods can also be used as corrective measures after failure has occurred, but often at a much higher cost because of prior destruction of private property. Among the more common methods of slope stabilization are treatment of the slope geometry and drainage. Methods of treatment of slope geometry include such techniques as "loading the toe" (adding material to the base of the slope to provide lateral support) and excavating material from the upper portions of the slope to decrease the weight on the potentially unstable zone.

A North Dakota case history of a landslide was recently presented in a senior thesis at the University of North Dakota by Edward C. Murphy, a geology major at the University. Several members of the Survey were involved in test drilling during the project. Ed's study area was the Sunny Slide, a landslide about 5 miles west of Mandan along U.S. Highway 10. By use of geologic mapping and air photo interpretation, Ed concluded that the area had been the site of natural landslide activity prior to the settlement of the area by white men in the late 1800's. Construction of Burlington Northern Railway's central line and Highway 10 across the slope have caused reactivation of the ancient slides. Down-slope movement in the present cycle began in 1953, a particularly wet year, and it is continuing at a very slow rate at the present time. Since the movement began, relocation of the highway was necessary and may be necessary again if the slide area remains active.

Other areas of landslide activity in North Dakota include the badlands, with its steeply sloping topography, and deep river valleys in all parts of the state, wherever geologic materials of low strength are found. NDGS studies and mapping projects in the past have identified materials susceptible to landsliding as well as landscapes which have been influenced by landslide activity in the geologic past. As development of the state and its resources continue, such studies become increasingly important in minimizing the potential for damage to human life and property.

GLACIAL THRUSTING AS A LANDFORMING MECHANISM IN NORTH DAKOTA

Among the more interesting landforms resulting from glaciation in North Dakota are various types of hills, groups of hills, and lakes that formed due to large-scale thrusting and shoving by glacial ice. Several different types of ice-thrust deformation have been recognized and described in the glaciated part of North Dakota, but in this article, I'll deal mainly with ice-thrust landforms consisting of individual hills located adjacent to lakes or sloughs. The hills are of various sizes and consist of blocks of material that were moved short distances by the glacier. They are typically located a short distance, a tenth of a mile or less, from a depression that is commonly flooded by a lake or slough. The lake or slough is typically about the same shape and size as the hill.

I think these ice-thrust features are particularly interesting. For example, it is intriguing to realize that the lake at the town of Anamoose (Steele Lake) occupies a hole that was formed when the glacier extracted--lifted or "plucked" if you prefer--a large chunk of material, moved it as a single piece, then set it down a tenth of a mile to the southeast. (When we first realized the origin of these hill-depression combinations in the late 1960s, we named them "anamooses," but the grammatical problems arising from that name soon led us to switch, simply, to "ice-thrust hills" or "ice-thrust masses.")

I think it adds a new dimension to our understanding of the power of glaciation if we realize that the glacier was actually able to move blocks of material that were over a hundred feet thick without breaking them into small pieces. The amount of "work" done by the glacier in transporting these hills is considerable. The ice-thrust hill at Anamoose has a mass that can be conservatively estimated at 10 million tons and it is a relatively small feature. Some of the ice-thrust masses probably exceed a hundred million tons and it is important to realize that the blocks have been raised tens, even hundreds, of feet as well as being moved laterally.

Ice-thrust hills are particularly numerous and spectacular in certain parts of North Dakota. Examples of the hill-depression combinations, in addition to the one at Anamoose, include Egg Lake Hill and Egg Lake southeast of Harvey in Wells County; Butte de Morale and Goose Lake north of Harvey; the Grasshopper Hills and Medicine Lake north of Jamestown in Stutsman County; Devils Lake Mountain and the adjacent depression in southern Ramsey County; Sullys Hill and part of Devils Lake in southern Ramsey and northeastern Benson Counties; Wolf Lake and the adjacent depression in northeastern Sheridan County; and a prominent hill adjoining Meszaros Slough in western Sargent County. This listing probably represents less than 5 percent of the ice-thrust hills that we have so far identified in North Dakota. It merely provides examples from areas throughout the state; many more ice-thrust hills located adjacent to depressions occur throughout the glaciated parts of North Dakota.

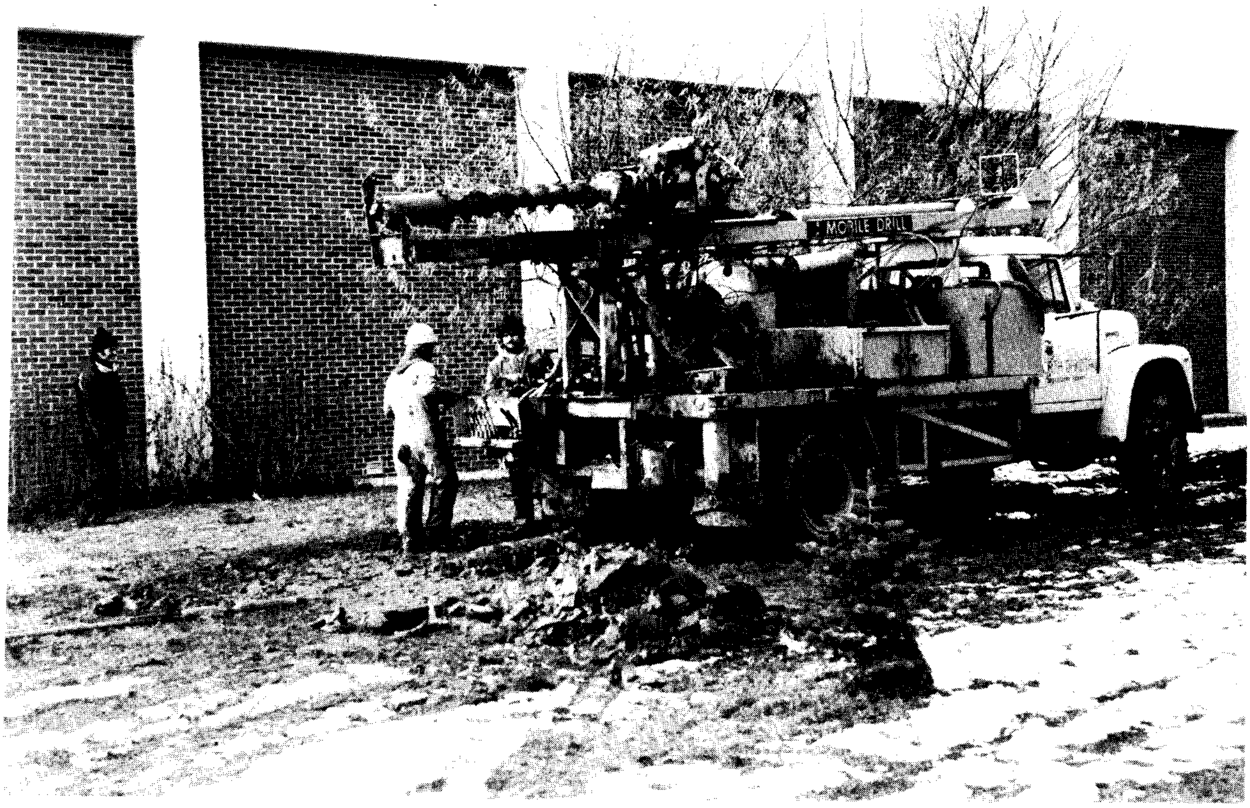
Most geologists have traditionally believed that glacial sediment and the glaciated landscape were deposited and shaped largely by the ablation (letting down or settling) of materials in the ice as the sediment-laden glacier melted. Sediment was thought to have been delivered to the margin of the glacier somewhat in the manner in which a gravel pit conveyer belt delivers material to a gravel pile; that is, virtually all the rock and sediment associated with glaciation was simply dumped at the edge of the glacier as it melted back. However, the ice-thrusting process that formed the hills I just described is apparently also a significant factor that needs to be considered before one can understand how the modern glacial landscape developed in North Dakota. Thrusting was an important mechanism by which the glacier moved material. In fact, in some places such as in central Sheridan County, thrusting of sediments by the glacier was probably the most important single way that glacial sediment was transported.

Ice thrusting apparently occurs only if certain hydrogeologic and hydrologic conditions exist in the sediments beneath the glacier. Generally, the groundwater contained in the sediments within or beneath the layer that is to be thrust by the glacier must attain a high pressure. This may happen in any of a combination of several ways. The weight of the overlying glacier coupled with the large amount of groundwater resulting from melting at the bottom of the glacier can cause high pressures to build up in buried layers of sediment beneath and ahead of the glacier's margin. As a result, sediment or rock layers above the zone of high-pressure water may be forced upward (due to the high water pressure) into the path of the moving glacier. The escaping water also helps to lubricate the surface on which the ice-thrust material slides, making it possible for the glacier to shove the material a short distance.

NEAR-SURFACE GEOTHERMAL HEAT EXPERIMENT UNDERWAY ON UND CAMPUS --

As we are now offsetting the Newsletter, I decided to include a couple of photographs, just to see how they might turn out. Of course, I know there is no reason why I shouldn't be able to use photos, but to quote Murphey's Law, "If anything can go wrong, it will." That's more or less the point I'm illustrating with my photos too. Below, you see two of our geologists, Dr. Kenneth Harris and Dr. Alan Kehew, along with our driller, Mr. Dan Walker, right behind our Grand Forks Office on the University of North Dakota campus (I refer to Alan and Ken as "Dr." to prove that even PhDs do real work sometimes and even get dirty).

This is a picture of a dejected, two-headed, stuck-in-the-mud geologist who doesn't know whether he is coming or going (Alan Kehew in stocking cap, Ken Harris in hardhat, and Dan Walker with back to camera). Here, Alan and Ken contemplate a hole full of auger pipe and a fishing tool, trying to figure out how to retrieve the pipe.



Mission accomplished! Our drill rig is a Mobile B-50, hollow-stem auger drill, capable of drilling depths of about 200 feet. A few equipment changes would allow us to rotary drill as deep as 1000 feet or diamond-core to 1400 feet. The rig has seen a great deal of use since we obtained it in 1975.

The Survey agreed to help the University of North Dakota Engineering Experiment Station in a project calling for the installation of a half dozen shallow test holes. The purpose of the test holes is to experimentally determine the amount of heat available at various near-surface depths for heat exchange. The heat would be extracted from the ground and used to supply heat pumps, which could then supply a certain amount of heat, at a low cost, to a building--a home perhaps.

However, during the process of drilling the holes in our glacial lake clay, which is extremely heavy and sticky, the auger got stuck. It's sort of like drilling a hole in vaseline. When the auger gets stuck, the operator can either try to lift the auger flights, or turn them backward to loosen them. In this case, the connecting pin came undone, the flights fell off, and experts Alan and Ken were called on to "go fishing" for the lost flights--five of them. Their mission was successful, the lost flights were recovered and the observation wells were completed.