NEWSLETTER

NDGS

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QUESTIONS FOR REAP

The Regional Environmental Assessment Program (REAP), which was established by the 1975 North Dakota Legislature to collect information on the state's resources, people, and environment (see item on page 4 of the June, 1975 Newsletter) will concern itself in part, with various types of geologic data. North Dakota Geological Survey staff are participating in the geology and water task forces of REAP. These task forces met in September to discuss uses, needs, existing data and where it was available, and data needs. The geology task force assembled a tabulation of projects underway in North Dakota, and it is now preparing recommendations of priorities for future projects. Priorities will be based on questions in the natural resources area that REAP officials expect users to direct toward the organization. Questions such as those that follow are anticipated:

1. What kinds of materials (geologic) will be encountered in construction?
2. Where are sources of construction material such as sand and gravel?
3. Where are sources of groundwater?
4. What are the best uses of land in a specific area?
5. Where is the coal and how thick is it?
6. Where would subsurface waste disposal be most practical?
7. Where would the best routes be for such things as pipeline construction to avoid areas of subsurface coal or mineral deposits?
8. How will construction affect underlying geology?
9. How will underlying geology affect construction?
10. What is the potential earthquake hazard in North Dakota?
11. Are there any areas where subsurface storage might be located?
12. Are there any geologic areas which should be preserved because of unique or rare significance?
13. What additional mineral deposits exist for potential development in North Dakota?
14. How might saline seeps be controlled?

The list of user questions is far from complete, but it probably represents a cross section of the type that might be asked of REAP.

ENGINEERING PROPERTIES OF SEDIMENT IN THE GLACIAL LAKE AGASSIZ BASIN OF NORTH DAKOTA

Mike Arndt presented a paper at the 18th Annual Meeting of Engineering Geologists, which was held in November at Lake Tahoe, Nevada. The meeting included two days of field trips and two days of technical sessions. Mike's paper dealt with the engineering properties of sediment in the Lake Agassiz basin and was a part of a report now being prepared for publication by the North Dakota Geological Survey. The abstract of his paper is reproduced below:

Glacial Lake Agassiz occupied the Red River Valley of North Dakota and Minnesota between about 13,800 and 9,000 years ago. The stratigraphic units defined in the offshore part of the Agassiz basin can also be characterized on the basis of distinct engineering properties. These properties include water content, unit weight, liquid limit, plasticity index, unconfined-compressive strength, consistency index, and standard-penetration test.

The engineering properties of the Sherack Formation include low to moderate water content (17% to 56%), wide range of liquid limit (27% to 92%), and wide range of consistency index (22% to 86%). The northern part of the Brenna Formation has high water content (62% to 88%), a high liquid limit (63% to 104%), and very low penetration resistance (4 to 7 blows per foot). Where this unit is close to the surface, failure of bridges and roads is common. Heavy slab foundations, where uneven loading may take place, are subject to the risk of failure. The southern part of the Brenna Formation and the Wylie and Argusville Formations have similar engineering properties. The range in water content (38% to 69%), liquid limit (39% to 93%), and penetration resistance (4 to 16 blows per foot) for these units are similar. The Poplar River Formation is under confined piezometric conditions; and, in places, the piezometric head is above the land surface. Excavations or foundations in it are subject to quick conditions unless steps are taken to alleviate the high pore pressures. The Falconer and Huot Formations have engineering properties similar to the Sherack, Wylie, and Argusville Formations. The glacial sediments underlying the Lake Agassiz sediment provide a suitable foundation for nearly all types of construction.

THE MINERAL INDUSTRY IN NORTH DAKOTA IN 1974

The total value of mineral production in North Dakota in 1974 was $179.6 million, an increase of 60.5% over the $111.8 million reported in 1973. Mineral fuels accounted for approximately 90.3% of the total value. The remaining 9.7% of the value was the result of production of sand and gravel, clays, stone, salt, and small amounts of other mineral commodities.

Production of crude petroleum, the state's most valuable mineral commodity, decreased from 20.2 million barrels to 19.5 million barrels, a 3.5% decrease, while its value increased 68% because of an average increase in price from $3.90 per barrel to $6.79 per barrel (in all cases, the figures for 1973 are final compilations, while the 1974 figures are still preliminary and subject to change). Marketed natural gas increased from 27.7 billion cubic feet to 29.9 billion cubic feet in 1974, a 7.9% increase, while its average value at wellhead increased to 27.3 cents per thousand cubic feet from 19.7 cents in 1973 for a total value increase of 49.6%.

Lignite, the state's second largest mineral commodity in terms of value, accounted for 11.9% of the total mineral production. Compared with 1973, production was up 23.3%, and the average value per short ton increased from $2.07 to $2.50.

The production of sand and gravel, the highest valued non-fuel mineral commodity, dropped by 20%; while its value fell only 11.4% because the unit value increased from $1.00 to $1.11 a short ton. Lime production increased 221.1%, but its average value decreased 61%. Production of clays decreased further by 11.3%, while salt production increased 34.1%.

Table 1. Mineral production in North Dakota
(1974 figures are preliminary)

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)
Coal--thousand short tons	6,906	$ 14,328	8,516	$ 21,290
Gem stones	NA	2	NA	2
Natural gas--million cu. ft.	27,703	5,457	29,912	8,166
Petroleum (crude)--thousand 42-gallon barrels	20,235	78,196	19,428	132,595
Sand and gravel--thousand short tons	6,011	6,021	4,809	5,337
Value of items that cannot be disclosed: clays, lime, natural gas liquids, salt, pumice, and stone	XX	7,129	XX	12,185
Total	XX	111,853	XX	179,575

NA=Not available

The production figures on this table are as measured by mine shipments, sales, or marketable production (including consumption by producers).

This article is based in part on information supplied by the Division of Fossil Fuels-Mineral Supply, U.S. Bureau of Mines, U.S. Department of the Interior.

DRILLING-PRODUCTION INCREASE IN 1975

Drilling activities have increased in North Dakota every year since 1972, but not to the extent of the surge this year. Even though 1975 hasn't brought another oil boom to the state, the increase in the price of oil has caused a marked upswing in drilling activities. Through the first nine months of the year, 140 wells were completed in North Dakota. Of these, 56 were producers, compared to 105 wells completed with 40 producers during the same period in 1974. This is more than double the nationwide drilling increase of 15%. The 40% success ratio for wells drilled in North Dakota is also above the national figure of 36%. The vast majority of the wells drilled, approximately 95% of them, were drilled by companies that do not have retail products outlets (independent wildcatters).

The increased drilling in North Dakota has been accompanied by a corresponding increase in oil production, and it is reflected by an increase in the number of new oil pools being discovered. Through the first nine months of 1975, nine new oil pools have been discovered, compared to eight in all of 1974. This year promises to be the best for new pool discoveries since 1965; and, hopefully, we can still top the 10 discovered that year.

Yearly oil production in the state has declined since the peak year of 1967, when 25.3 million barrels were produced to 19.5 million barrels in 1974, but 1975 will see a reversal of this downward trend. Through the first nine months of the year, 15.1 million barrels of oil were produced in North Dakota, compared to 14.7 million barrels in the same period in 1974. In August of 1974, North Dakota oil fields produced 1.8 million barrels, the highest monthly production since December, 1971.

NDGS HAS NEW AUGER DRILL

The North Dakota Geological Survey recently took delivery of a new Mobile B-50 Auger Drill. The B-50 is mounted on an International 4-wheel drive truck for maximum mobility. With this rig we now have the capability of auger drilling to depths of 200 feet, although we presently have only 75 feet of hollow-stem auger. A few equipment additions would allow us to rotary drill as deep as 1,000 feet or diamond-core to 1,400 feet. Some other features of the rig include a 17-foot, fold-down mast, complete hydraulic operation, and a feature that Mobile calls "Slidramatic." The Slidramatic feature allows for a lateral shift of the rotary table of about 18 inches, thereby greatly simplifying access to the hole. This is particularly handy for dropping a core barrel down the hole or for piezometer installation. Another feature that makes the rig a substantial improvement over our old auger is the inclusion of a pair of rear hydraulic jacks. At last, we'll be able to drill holes that at least will start off straight.

Even though the new rig is a somewhat complex piece of equipment, it is relatively easy to operate. Mike Arndt, who picked up the rig in Indianapolis in October, has used it once so far, to install some piezometers at his sanitary landfill project near Langdon. He said it worked nicely.

In addition to stratigraphic drilling and well installation, we expect to use the new drill rig for many other purposes. We will be doing some shallow drilling (less than 150 feet) in the coal areas next summer to collect coal cores for analyses, probably as an extension of the lignite evaluation grant we had last summer with the United States Geological Survey. The B-50 Auger Drill will be ideal for our proposed spoil bank study. All in all, the new rig will be an extremely valuable piece of equipment that will be used extensively in the coming years.

SURVEY ACTIVITIES

Most of the material in this item has been extracted from the Nineteenth Biennial Report of the North Dakota Geological Survey (1973-1975), due to be published shortly. This report covers the activities of the Survey during the last biennium, ended June 30, 1975. Most of the projects are still in progress.

In addition to the regular surface geologic program, the staff of the Survey has continued its subsurface studies and carried on the oil and gas regulatory program as administrative agent for the State Industrial Commission. Personnel of the Survey have continued to aid the Department of Health in evaluating proposed or existing sites for solid waste disposal facilities. We have cooperated with the reclamation officer of the Public Service Commission in review of strip-mine reclamation plans and review and revision of the reclamation laws. We have cooperative studies through the Old West Regional Commission in areas where strip mining is expected to begin. Many inquiries have been received from companies interested in lignite development and much open file information has been distributed. The county groundwater studies are continuing, with the work in various stages from beginning field work to reports written, awaiting publication funds. The following projects are in progress:

Geology of Bowman County, Adams County, Ransom County, Sargent County, LaMoure County, Dickey County, Grant County, Sioux County, Morton County, Ramsey County, Billings County, Slope County, Golden Valley County, and McHenry County.
Clay Resources of North Dakota (continuing study).
Uranium Potential of North Dakota (continuing study).
Detailed Study of Sediments in glacial Lake Agassiz.
Lithostratigraphy of Glacial Sediments in North Dakota.
Bibliography of North Dakota Geology 1959-1969.
Subsurface Geologic Studies (continuing study).
Surface Geology Map of North Dakota.
Storing and Indexing of Samples (well cuttings) and Cores (continuing project).
Exploratory Drilling Maps--Precambrian, Ordovician, Silurian, Devonian, Madison, Newcastle (current posting).
Preparation of Educational Series for western North Dakota.
Additional program aids.
Compilation of status of wells (i.e., producing, abandoned, deepest Fm. penetrated, cores, logs, and samples available).
Geologic and hydrologic studies of potential strip-mining areas (Underwood, Beulah-Zap, Dunn Center).
Preparation of educational materials for North Dakota Park Service, U.S. Forest Service.
Geologic Highway Map of North Dakota.
Preparation of generalized geology of North Dakota for Educational Series.
Revision of North Dakota Stratigraphic Column.
Study of subsurface thermal gradients.
Potash study.

Oil and gas regulatory functions continued during the 1973-75 biennium with the permitting of 348 wells, the collection and publishing of production data, and the issuing of 131 orders in 116 cases heard by the Industrial Commission. Emphasis is continuing on the enforcement of the 1969 rule dealing with salt-water pollution.

The Survey supported bills passed by the 44th Legislative Assembly which require permits for coal or subsurface mineral exploration and provide for filing information obtained from such programs with the Survey. These bills also assign responsibility to the Survey to supervise the regulatory functions of the Industrial Commission regarding proper plugging of holes drilled under such permits.

The services of the Survey are being repeatedly offered to other state agencies involved in land-use planning and other programs in which information on the physical environment is required or desirable.

The North Dakota Geological Survey is making available to service clubs and other groups a series of Program Aids in the form of movies, slide-tape presentations, and tape recordings. The Survey continues to maintain a microfilm file of mechanical well logs (i.e., electric, radioactive, etc.).

LIGNITE PRODUCTION PREDICTIONS

In the Febuary, 1974 Newsletter, we included a table entitled "Lignite Production over the Years" in which we made projections of lignite usage in North Dakota to 1990. The prediction called for 35.2 million tons of lignite to be produced in 1980, 58.4 million tons in 1985, and 97.6 million tons by 1990. (These figures compare with 1974 figures of 8.5 million tons).

Now we have a new prediction by Mr. Currie Conrad, who publishes the "Energy Era." Mr. Conrad's prediction calls for an annual production of 50.7 million tons by 1980. This is substantially greater than our estimate for 1980, and the difference is the result of Mr. Conrad's assumption that El Paso Natural Gas Co. will be producing 16 million tons of lignite for gasification and electrical generation by that time. In our view, this is not likely.

Mr. Conrad's breakdown of coal production by companies for 1980 is interesting. He expects North American Coal Company to be producing 23 million tons annually by that time. Of this, 15 million tons will go toward gasification and 8 million tons will go for electrical generation. Knife River Coal Company would be producing 5.1 million tons, Consolidation Coal 2.6 million tons, and Baukol-Noonan 4.0 million tons. The Baukol-Noonan production would be entirely at Center, as their Burke County production will be phased out by 1980.

NORTH DAKOTA NEEDS MORE EXPLORATORY DRILLING

Has North Dakota's Williston basin been thoroughly tested? Have we found most of the oil there is to find there?

The other day I was looking at the Survey's large, wall-sized map that shows the locations of all the wells that have been drilled in North Dakota in search of oil and one feature that stood out was the number of really large areas that have had little or no test drilling. For example, only a handful of exploratory wells have been drilled in Williams County off the Nesson Anticline, or, for that matter, east of the anticline in Mountrail County. Many large, untested areas are virtually surrounded by some of our best production.

Just for fun, I decided to look at several areas a little more closely and, when I did so, I was even more surprised. Adams County, for example, has had only four exploratory wells drilled, none deeper than the Cretaceous. It's hard to believe that Adams County is so poor a prospect, in view of the fact that Bowman and Slope Counties both have production, some of it as near as 15 miles from Adams County.

When I looked at some counties in which there is production, the situation was no less surprising. Divide County, in the northwest corner of the state, currently has 7 active fields. Fifty wells are located within the boundaries of those fields. Another 75 wells, dry holes, were drilled in search of oil in non-field areas. Of these 125 wells, only 16 were drilled past the Mississippian section into Devonian rocks. Only 12 wells were drilled into the Silurian, 10 into the Ordovician, and only one was drilled as deep as the Cambrian.

Seven townships in Divide County have had no exploratory drilling of any kind. In another nine townships, only one well has been drilled; in five townships, only two. Of the approximately 36 townships in Divide County, 28 of them have had five or less exploratory wells drilled. In fact, I calculated that the percentage of Divide County, exclusive of field areas, that has been adequately tested by exploratory drilling (I assume that a well effectively tests 40 acres) is only 0.377%, less than one half of one percent of the county, and even that drilling has tested only the Mississippian section. I calculated that only 0.048% of the Ordovician section in Divide County has been tested.

Burke County, also in northwest North Dakota, has 17 active oil fields distributed about as equally throughout the county as the production in any county in the state. A total of 653 wells have been drilled in Burke County, an area of 717,440 acres. That's one well for every 1,100 acres. Of those 653 wells, however, only 161 were drilled in non-field areas; many of the others were development wells or offsets. So even Burke County hasn't really been adequately covered. Only seven wells in the county (7 out of 653) have gone past the Mississippian. Five Devonian tests have been drilled, and only one Silurian and one Ordovician test. Nothing deeper. One township in Burke County has had no exploratory drilling, two townships have had only one well, and only two wells have been drilled in three townships.

So much for meaningless statistics; I won't try to prove anything with them. I realize, of course, that geological factors play a strong role in determining where wildcat wells are drilled, and I know that some areas are much more favorable for oil exploration than others. But much of our knowledge of the geology in North Dakota has been obtained only through exploratory drilling and, without that drilling, we really don't have adequate knowledge to make intelligent decisions about many areas. Large areas of North Dakota simply haven't had nearly enough drilling, and considerable oil has undoubtedly not yet been found.

EDUCATIONAL ACTIVITIES

We are in the process of revising and reprinting four of our educational series guidebooks, which have been out-of-print. They are the ones for northeast, southeast, north-central, and south-central North Dakota, and they should be ready in a few weeks. Response to the series has been better than we had anticipated, and usage of the guidebooks by both primary and secondary school teachers has been substantial. In addition to providing generalized descriptions of the geology of the areas, each guidebook includes several roadlogs, at least one for each county, that teachers can follow in field trips of their own areas.

With the guidebooks for northwest North Dakota, published this past summer, and the one for southwest North Dakota, which should be out in December, our guidebook series of the state will be complete.

As the guidebooks have become more widely distributed, teachers have been contacting me in increasing numbers requesting additional information specific to their areas. I have found that an effective way of providing this information is to take the teachers on field trips of their own areas, usually in groups of 15 to 25. The teachers have been enthusiastic about the trips as it helps them to teach earth science using the local field as a classroom.

MORE ON THE RECLAMATION OF MINED LAND

We reported in the last NDGS Newsletter (June, 1975) that large-scale mining of lignite in North Dakota raises two principal environmental concerns: the preservation of agricultural productivity and the maintainence of high-quality groundwater supplies. Our goal in North Dakota is to reclaim all mined land to a level of productivity no less than 100% of the level prior to mining.

Four Survey and University of North Dakota geologists, Stephen Moran, Gerald Groenewold, Leroy Hemish, and Curtis Anderson are involved in a project being conducted by the North Dakota Geological Survey. The study is funded by the Old West Regional Commission and has the support and active cooperation of a number of mining companies and potential coal producers. The NDGS study is directed at developing techniques to determine the geologic characteristics of overburden materials (materials on top of the coal) to help in planning reclamation procedures. It will also examine various techniques for monitoring groundwater conditions in mining areas for regulatory purposes.

Survey geologists involved in the project have studied the overburden materials in areas of proposed mining. They collected large amounts of data from three proposed mining areas, sampling at intervals of five feet or less during the drilling of the testholes and core holes that were drilled by the operator to obtain data on the coal. Information collected included lithologic descriptions of the samples, and geophysical logs that included resistivity, spontaneous potential, natural gamma-ray, and gamma-gamma density. These interpretive logs were then combined into cross sections to depict the relations of the bodies of sediment in three dimensions.

The main thrust of reclamation studies in North Dakota is on the development of a premining geochemical framework, which will consist of physically and chemically defined "reclamation units." These reclamation units will then serve as a basis for mine-plan design. They will be used to identify overburden materials as harmful or favorable for soil development and for the establishment of vegetation. Various reclamation units can then be placed at the surface of the reclaimed spoil or buried far from the surface, depending on their characteristics.

Samples collected from a portion of the testholes are analyzed to determine the abundance and type of readily soluble ions. The chemical composition of the overburden materials depends on the type of material and is a result of a number of complex interactions. In general, glacial sediment contains much less sodium, but has a higher lime carbonate content than do any of the preglacial bedrock materials. The soluble-ion content of clayey sediment in the bedrock is greater than that of sandy material.

Studies are also underway to determine how to best design the most suitable landscape in reclaimed areas. The reclaimed landscape must assure a minimum of surface subsidence, slope instability, erosion by gullying, and contamination of groundwater and surface water with ions leached from the spoil material. The interactions of all the physical, chemical, and biological systems operating in a landscape need to be considered in designing optimum landscapes in reclaimed areas.

GAS FLARING

In these days when energy resources are strained and energy costs have smashed holes in the average householder's budget, it seems inconsistent to see natural gas flares illuminating western North Dakota oil fields. Why is this seemingly wasteful burning permitted? Let's take a look at natural gas in North Dakota, and try to answer this and other questions.

Natural gas is a gaseous phase of petroleum. Under confined pressure it may be liquid, a part of associated oil in a well, much like the carbon dioxide in soft drinks or champagne. It may be a "cap" of pressurized gas overlying heavier liquid oils. Natural gas may be thought of as a low-boiling point liquid, which escapes as so much "steam" at Earth-surface temperatures and pressures. Because of its gaseous nature at the earth's surface, natural gas is extremely volatile and dangerous to work with unless special precautions are taken.

When a bottle of carbonated beverage is opened, there is usually a loud pop, followed by an overflow of bubbling liquid. If you place your hand near the breaking, fizzing bubbles, a small amount of liquid will be carried to your hand. This is the result of the carbon dioxide in the beverage coming out of solution as the pressure is suddenly decreased when the bottle is opened.

In a somewhat similar way, natural gas disassociates from oil when the petroleum reservoir is tapped by a drill. A pressure decrease occurs at the well bore, and natural gas tends to boil off, out of the oil. The quantity of gas that is dissolved in the oil is highly variable. Some liquids are nearly free of natural gas while others are essentially pure natural gas in liquid form. The majority of North Dakota oil fields have only small amounts of gas, and are said to have low "gas-oil ratios."

Natural gas is heavier than air, highly volatile, may be driven out of the well under great pressure, and may bring light liquid oils or "condensates" out of the well bore. Natural gas is extremely useful because of these characteristics, but it is also extremely hard to handle because of these same characteristics.

At least some gas usually comes up with the oil, and this gas has to be disposed of in some way. The method of disposal depends on the amount of gas available. If a large amount of gas is being produced, and production will continue for a long time, then the gas obviously has commercial value. A pipeline might be constructed, the gas processed, and distributed to consumers. If practically no gas is produced, the minute quantities that are present are simply vented and allowed to escape to the atmosphere and thereafter they are undetectable. It is the third category, intermediate amounts, that are the problem; many North Dakota oil fields fall into this third category.

Unlike many of the vast West Texas fields, gas-oil ratios in North Dakota are low, and the number of gas-producing wells is also low. Therefore, in some cases, the value of the gas being produced and gas potentially producible, either in dollars or energy units, is less than the cost of building an on-site processing plant and transportation facilities. Whether we talk about dollars or energy units, if it costs more to collect the gas than the gas is worth on the market, it can't very well be collected. In fact, in terms of energy units, it would be extremely wasteful to expend more energy (mostly petroleum-based energy, at that) than could be replaced by producing the gas. You can be assured that little economically useful gas is being wasted except for that lost while a new well is being tested and equipped for production, or that which is lost while waiting for construction of pipelines and processing plants. Some such regrettable loss is unavoidable, and it is held to a minimum.

Gas that is neither ventable nor producible is burned, or "flared," at the well site. In many North Dakota wells, there is too much gas to vent and too little to produce. It is used in the oil fields to operate oil field equipment, so not all of it is wasted. If vented, the gas-borne fluids could harm soils and vegetation downwind from the well site by coating them with films of oil. The polluted air could also be harmful to humans. Further, even if the gas is "dry," it is heavier than air, and will collect in low areas. One spark from a passing automobile, and--well, it has happened in other areas where wells have gotten out of control.

So, the gas is flared. It burns cleanly and does not harm the local environment. Some people see the flares as a waste of resources; other people see dollars going up in flames. Yet, if you see a flare, you can be sure that (1) a new well is being tested, or (2) only a small amount of gas is available, and it is not economical to produce, but it cannot be directly vented, or (3) a malfunction of equipment has occurred and this is an automatic safety flame, or (4) the oil well owners are waiting for gas processing and transportation facilities to be constructed.

Some specific instances of flaring are particularly visible and difficult to explain until energy economics are considered. The Buffalo Creek field, in Stark County, North Dakota, is a good example. A well in this field has been flaring since 1966. It so happens that this is the only producing well in the field, and the field is located 77 miles from the nearest gas processing plant (a high-pressure product distribution line is located 12 miles north, but gas must be processed before being added to such a product system). In any case, the total gas production of the Buffalo Creek well has been 273,392,000 cubic feet as of July 1, 1975. At average prices, the value of the gas is about $60,000, or about $6,600 per year on 30,377,000 cubic feet per year average production (usually these volumes are calculated in thousands of cubic feet, that is, 273,392 MCF total production, and 30,377 MCF average annual production). Wellhead prices have averaged about 22¢ per thousand cubic feet.

While that sounds like a lot of gas and a lot of money, a collection pipeline system would cost about $5.50 per foot, for 77 miles, about $2,236,080.

It doesn't take a lot of imagination to see how impractical it would be to spend more than $2¼ million to save $60,000.

The above figures assume that all the gas is flared and lost. Actually, this is not true as some of the gas is being used to run the pump and treater for the oil being produced, so that no outside energy is consumed by production requirements. All of us, including the operator of the well, would like to be able to conserve the gas being flared, but no one seems to know how to accomplish this without using more energy than could be produced from the gas. And, after all, the well has produced 321,012 barrels of oil (to July 1, 1975), valued at over $1,000,000. This amount of oil has operated the machinery on a lot of North Dakota ranches and farms for the last nine years as well as townspeople's cars and businesses.

In summary, no one wants to waste gas, or any other resource, <u>especially</u> the corporations owning the wells. Operations in North Dakota are remarkably free of waste, viewed on overall energy economics. If you have further questions, please give us a call.

SURVEY HAS NEW MEMBERS

Dr. Lee C. Gerhard recently came to the North Dakota Geological Survey as Assistant State Geologist. Dr. Gerhard's major geological studies at the Survey are in basinal environmental analysis of carbonate rocks in North Dakota and sedimentation in the Lake Sakakawea-Missouri River system.

He brings a variety of experience to the Survey, including scientific administration, petroleum exploration, teaching, and consulting. His most recent position was directing the West Indies Laboratory of Fairleigh Dickinson University in St. Croix, U.S. Virgin Islands, which specializes in studies of marine ecology and geology. Lee has done extensive work in carbonate geology, both in modern sediment studies and ancient environment analysis. He has published numerous scientific papers, including one about North Dakota lignite-bearing rocks.

Dr. Gerhard received his B.S. from Syracuse University and his M.S. and Ph.D. degrees from the University of Kansas. He was born in western New York, but realized the error of his ways early and moved west in 1958. He is active in the American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, Rocky Mountain Association of Geologists, Geological Society of America, and Colorado Scientific Society. Lee is also a Registered Geologist in the State of Maine.

Mr. Roger N. Borchert joined the North Dakota Geological Survey as a field inspector in July of 1975. He is currently located in Bismarck. As a field inspector, Roger will be concerned with enforcing our oil and gas regulations.

Roger holds a B.S. in geology from Winona State College in Minnesota. He is a former high school and junior high teacher in Hulett, Wyoming, and he has had experience as an engineer with a Minneapolis engineering and manufacturing firm. With this firm, he also had experience with the field installation of chemical etching and regeneration equipment and as a purchasing agent.

Roger hopes to eventually become an exploration geologist. He is a member of the Devils Tower Natural History Association, the Crook County Historical Society, the Wyoming State Historical Society, and the Friends of the Pleistocene.

Mr. Doren Dannewitz joined the North Dakota Geological Survey as a field inspector in July of 1975. He is currently located in Minot. Doren will be concerned with enforcing the state's oil and gas regulations.

He holds a B.S. in Earth Science from Minot State College. He has had experience in oil field work as a roustabout in Tioga, North Dakota and he has worked with Chevron Geophysical. Prior to coming to the Survey, Doren worked with the Burlington Northern Railroad.

Doren served in the U.S. Army in Vietnam for three years. He is interested in skiing, hunting and fishing.

INFORMATION ABOUT THE NDGS STAFF

I have had several letters from readers of our newsletter asking me to include an article on the NDGS staff. I hope the following list of short biographies will give an idea of the backgrounds of the individual Survey members as well as some of the activities in which they are currently involved. This article is restricted to Survey staff in Grand Forks, but I will include a similar article on our Bismarck, Minot, and Williston staff in a later Newsletter.

Sidney B. Anderson, Ph.B.

Sid has been with the Survey since 1952, and, as chief subsurface geologist, he oversees the subsurface division of the Survey. He is involved in all aspects of subsurface geology, and he has worked extensively on the geology of nearly all the mineral resources found in North Dakota. His studies include, among others, many dealing with oil and gas, potash, limestone, and salt. Sid's subsurface studies have led to numerous publications on Williston basin stratigraphy, particularly those pre-Tertiary sedimentary units that have oil potential. He is currently preparing a report on potash prospects in North Dakota.

Sid's regular duties include answering many of the numerous requests the Survey receives for information from the public, industry, and various federal and state agencies. He is in charge of the North Dakota Geological Survey Core and Sample Library and currently is working on a project to devise a computor retrieval system for the information available on all the test wells that have been drilled in North Dakota.

Degree from the University of North Dakota.

Michael Arndt, Ph.D.

Mike has been with the Survey since 1968. Mike's strong interest in engineering geology (he is a member of the Association of Engineering Geologists) has led him to become involved with such projects as landfill siting and monitoring, reports on the environmental geology of various towns, groundwater pollution, and land-use planning.

Mike is currently involved in a report on groundwater contamination potential of a landfill at Langdon, North Dakota, and in a land-use study for Minot. He is a member of the technical task force of the North Dakota Regional Environmental Assessment Program.

Degrees from Western State College of Colorado, the University of South Dakota, and the University of North Dakota.

John P. Bluemle, Ph.D.

John has been with the Survey since 1962. Basically a Quaternary geologist and geomorphologist, John spent his first 10 years with the Survey mapping the surface geology of about 15 North Dakota Counties, mainly in the glaciated portion of North Dakota as part of a continuing groundwater studies project in which the Survey is involved. These studies have led to several Survey bulletins and publications in various journals on a variety of aspects of Quaternary geology in North Dakota. As the County Groundwater Studies projects have been winding down, John has shifted his attention to such things as environmental education and public information, providing assorted technical, semi-technical, and non-technical materials to schools, engineering firms, and other organizations.

Degrees from Iowa State University, Montana State University, and the University of North Dakota.

Clarence G. Carlson, M.S.

"Kelly," our Senior Geologist, has been with the Survey since 1954. Basically a stratigrapher, Kelly spent most of his first 12 years in studies of samples, cores, and logs filed with the Survey from oil exploration activities. These subsurface studies led to publications related mostly to lower Paleozoic rocks with an emphasis on their distribution and oil potential. As part of the county groundwater studies program, he has shifted to surface mapping with most of his time spent in the counties southwest of the Missouri River. Recently, he has been helping direct coal resource studies in a cooperative program with the Conservation Branch of the U.S. Geological Survey. In addition to these projects, he has handled some editing duties and the processing of manuscripts through the printing process to their publication.

Degrees from the University of Minnesota and the University of North Dakota.

C.B. Folsom, Jr., M.S.

"Burt" is our Chief Engineer in charge of the Oil and Gas Conservation Division. He has been with the Survey since 1953. Besides duties of administration of the Oil and Gas Conservation Act and advisor to the Industrial Commission, Burt maintains current reserves estimates of all the oil fields in the state. He has also engaged in numerous engineering studies of the oil fields in North Dakota and published many articles on them. For the past 10 years, Burt has been teaching one or more courses in Petroleum Engineering each semester in addition to his regular duties.

Degrees from the Colorado School of Mines.

Gerald H. Groenewold, Ph.D.

Since joining the Survey in 1974, Jerry has been involved primarily with strip-mine reclamation studies. These studies include research into the potential effects of strip mining upon groundwater supplies, chemical characterization of overburden materials with emphasis upon predictive modeling and the designing of shallow groundwater monitoring systems in proposed mining areas. In addition, he is preparing for publication an environmental geology report for the Bismarck-Mandan area. Jerry is also involved with subsurface stratigraphic correlation of the Fort Union Group in western North Dakota, particularly the Tongue River and Sentinel Butte Formations.

Degrees from the University of Illinois and the University of North Dakota.

Clara Laughlin, M.A.

Clara is Administrative Officer and has been with the Survey since 1965. She is in charge of the Administrative Division of the Survey and supervises a clerical staff of nine people. She assists in the editing of geologic publications, which are prepared, under her direction, on a magnetic tape system. Clara is currently representing the Survey in dealing with State Central Personnel during the conversion of Survey staff to a statewide classification system.

Degrees from the University of North Dakota.

Stephen R. Moran, Ph.D.

Steve has been deeply involved with a great variety of interests since joining the Survey in 1969. In addition to his Survey position, he holds a professorship with the University of North Dakota Geology Department. He has done extensive work on Pleistocene and Paleocene stratigraphy in North Dakota and elsewhere, and he acts as supervisor for several students working on similar stratigraphic studies. Steve has recently been concerned with various strip-mine reclamation studies, particularly with potential effects on the groundwater in mined areas.

Degrees from the College of Wooster and the University of Illinois.

E. A. Noble, Ph.D.

Dr. Noble worked for the Atomic Energy Commission for more than ten years in Colorado, Utah, and Wyoming. He spent one year with the International Atomic Energy Agency as advisor to the government of Argentina in nuclear raw materials. Prior to joining the Atomic Energy Commission in 1954, he taught at Tufts University and was employed as geologist with the Ground Water Branch of the U.S. Geological Survey. His educational background includes degrees from Tufts University, the University of New Mexico, and the University of Wyoming.

He currently is employed in the dual position of State Geologist (Director of the North Dakota Geological Survey) and Chairman of the Department of Geology at the University of North Dakota in Grand Forks.

F. E. Wilborn, Jr., B.S.

Jack has been with the North Dakota Geological Survey since 1957 in various capacities: field inspector, statistician, and, more recently, Assistant to the Chief Engineer. In the past he was able to participate in various geological and engineering studies of oil fields in North Dakota, but recently all of his time has been devoted to the operation of the Oil and Gas Conservation Division.

Degree from Texas Christian University with additional studies at the University of North Dakota.

DRILLING PERMITS ISSUED BY THE NORTH DAKOTA GEOLOGICAL SURVEY

From the last printing of the newsletter to December 1, 1975, there have been 188 permits issued by the Oil and Gas Section of the Survey. Permits issued each month are listed in the Monthly Oil Production Report. Anyone desiring this information should subscribe to that publication.