NEWSLETTER

NDGS

A publication of the
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JUNE, 1980

EDITOR'S NOTE--

In this issue of the Newsletter I am including short profiles of two senior members of our staff, Sid Anderson and Kelly Carlson. Several people have suggested that I do so, as I have made a practice of saying something about new arrivals at the Survey. I have also included several "essay" articles that I hope will be of interest to some of our readers.

PUBLIC EDUCATION AND RESOURCE DEVELOPMENT (Lee Gerhard) --

Recently one of our scientific staff was seriously misquoted yet another time in published materials. The dull monotony with which special interest groups distort valid data and information raises questions for us about our responsibility to disseminate accurate information to the public. How can our scientists and engineers insure that the data and information they provide is fairly presented when it is quoted?

Even elected officials sometimes refuse to use the facts available to them and, when faced with reality, they lash out at the technical people who have corrected them. It becomes ever more difficult to recruit and retain the outstanding technical staff this agency and others in state government must have to provide factual information.

Over the last few years, the North Dakota Geological Survey has endeavored to provide both technical and nontechnical publications. Our educational maps and pamphlets have had good distribution. We hope they have had a positive impact on the knowledge of North Dakota citizens about the geology of North Dakota.

The only defense against blatant misrepresentation of information and data is a well-informed public who can critically evaluate special interest "news." To that end, the Survey is committed to an increasing amount of information dissemination to North Dakotans. For instance, we will soon publish an oil and gas development brochure, we have recently published a new stratigraphic chart, and public information documents of all kinds have been given publication priority in our system.

All of this raises a question: if you, our readers, had the choice to make, to what public information topics or materials would you assign the highest priorities? What do you need to know about energy and mineral resource development that will help you to discriminate between honest assessment of impacts and special interest group propaganda? Please write and tell us--it would be helpful to all of us.

DRILLING ACTIVITY IN NORTH DAKOTA (Wes Norton) --

Almost all drilling, production, and discovery records were surpassed in North Dakota during 1979, and no slowdown is in sight. Red River Formation discoveries accounted for 17 of the forty discoveries during 1979 (see the table at the end of this article). The Whitetail - Yourk #1 well in Billings County was one of the more significant, having an initial potential of 8.4 million cubic feet of gas per day with 70 barrels of liquids. One additional well has been completed; both wells are presently shut in waiting on facilities to handle the gas. The production potential of the two wells and the potential productive area are considerably larger than most Red River reservoirs in the Williston Basin. Other significant Red River discoveries were Charlson, Scairt Woman, Big Stick, Beaver Creek, Corral Creek, and several in Williams County.

High-potential Duperow finds made by Getty Oil in T-R Field, W. H. Hunt in Treetop Field, and Tenneco Oil in Big Stick Field resulted in a higher percentage of wells drilled below the Madison on the so-called "Billings Nose." The initial potential of many of these wells is in excess of 500 bbls. per day.

The Stonewall Formation discovery by Lamar Hunt in the Springbrook Field added an additional new production for the state. At present, Stonewall production has also been established in the Missouri Ridge Field by Tenneco, adding another potential target in the deep part of the Basin.

Most of the other important discoveries were Madison wells on the "Billings Nose" and in southwestern McKenzie County. Many of these wildcats and the resulting development wells also have high potentials with a few capable of production up to 2000 bbls. of oil per day.

Development drilling for the year 1979 was again heavily concentrated on the "Billings Nose" and the MonDak trend. MonDak has nearly 100 wells capable of production on the North Dakota side with many wells yet to be drilled. The "Billings Nose" (T-R, Big Stick, Treetop, Whiskey Joe, Four Eyes, and Elkhorn Ranch) now has about 75 wells capable of production with many more in the process of completion. The monthly production of these wells has surpassed that of Little Knife. Little Knife slowed, with 106 wells now capable of production. The Little Knife-Madison reservoir was selected as a pilot CO_2 recovery project, partially funded by the Department of Energy.

January 1979 production averaged 71,600 barrels of oil per day. This increased to a December average of 95,600 barrels of oil per day. The 1979 total was about 31 million barrels, for a 25% increase over 1978. This was also approximately 4 million barrels greater than 1966, the previous record year. North Dakota now has about 256 producing oil fields.

Gas line connections to existing or new gas processing facilities decreased the amount of associated gas being flared at year end. With additional plants and lines, most of the previous flaring problems will be at a minimum; and gas production, along with the extracted fluids, will also be at record levels.

The success ratio for wildcats was one in three, and more than 80% of the development wells were productive.

The year 1980 will probably far surpass 1979 in every category. The rig count at present is near 90, compared to approximately 50 a year ago. During the first six months of 1980, 367 drilling permits were issued, compared to 238 permits during the first six months of 1979, when a total of 644 drilling permits were issued. About twice as many wells have been spudded this year as in the same period last year. Drilling footage for 1979 was about 4 million feet, over a million feet more than in 1978; we won't make a guess on the 1980 figure.

Success ratios, well potentials, and the greater number of rigs available make North Dakota an extremely attractive region for the future.

NORTH DAKOTA OIL AND GAS DISCOVERIES IN 1979

COUNTY	OPERATOR, WELL, LOCATION	FIELD	PROD. DEPTH	Initial Potential OIL b/d	Initial Potential GAS Mcfd	PRODUCING FORMATION
Billings	W. H. Hunt Trust Estate, Kordon #1 SW NW 32-143N-100W	Four Eyes	9,606- 9,609	196	205.8	Madison
	Amoco Production Company, Yourk #1 SE SE 9-143N-99W	Whitetail	13,650-13,692	696	8,440	Red River
	Tenneco Oil Company, Egly #1-20 NW NW 20-142N-100W	Big Stick	12,516-12,723	..	2,218	Red River
	Tenneco Oil Company, Egly #1-20 NW NW 20-142N-100W	Big Stick	10,995-11,044	1,242	1,242	Duperow
	Tenneco Oil Company, Stuart USA #2-7 NE NW 7-142N-100W	Big Stick	9,720- 9,727	1,470	1,264	Madison
	Koch Exploration Co., Simnioniw #2 NW SE 32-143N-100W	Four Eyes	13,034-13,056	..	4,252	Red River
	Getty Oil Company, Mystery Creek #1-1 NE NE 1-141N-101W	T. R.	10,910-10,928	1,067	1,000	Duperow
	Al-Aquitaine Exploration, Ltd. 22-141-100 US #1-22 C NE NE 22-141N-100W	Whiskey Joe	9,511- 9,518	165	165	Madison
	Jerry Chambers, T.R. Federal #1-12 SW SW 12-141N-101W	T. R.	12,504-12,520	162	1,432	Red River
	W. H. Hunt Trust Estate, Osadchuk #1 SW NW 23-142N-100W	Treetop	9,638- 9,580	433	364	Madison
	W. H. Hunt Trust Estate, Osadchuk #1 SW NW 23-142N-100W	Treetop	11,278-11,298	1,144	1,060.4	Duperow
Bottineau	Texas American Oil Corp. Ruth Vedquam #1 C NW SE 35-162N-79W	Kane	3,261- 3,279	150	..	Madison

NORTH DAKOTA OIL AND GAS DISCOVERIES IN 1979

COUNTY	OPERATOR, WELL, LOCATION	FIELD	PROD. DEPTH	Initial Potential OIL b/d	Initial Potential GAS Mcfd	PRODUCING FORMATION
Divide	Mosbacher-Pruet Oil Company Harold W. Haugen #25-1 SE SW 25-161N-103W	Daneville	7,124- 7,141	38	19	Madison
	Shell Oil Company, Svangstu #24-18 C SE SW 18-163N-95W	Unnamed	6,322- 6,354	35	16	Madison
	Gulf Oil & Mosbacher-Pruet, Geo. C. Anderson #1 SW SE 25-161N-103W	Daneville	11,185-11,194	792	479	Red River
Golden Valley	Diamond Shamrock Corporation Williamson Federal #24-25 SE SW 25-143N-103W	Beaver Creek	12,443-12,620	610	892.4	Red River
	Shell Oil Company, Kremers #21-22R, NE NW 22-137N-106W	Williams Creek	10,479-10,580	130	44.9	Red River
Dunn	Mesa Petroleum Company Brandvik #1-13 SW NW 13-147N-96W	Corral Creek	14,221-14,343	720	8,000	Red River
	General American Oil Co. of Texas Signalness Unit #1 SW SE 10-148N-96W	Lost Bridge	14,038-14,140	141	467	Red River
McKenzie	Texaco, Inc., Red River Unit 1 #1 NW SW 34-154N-95W	Charlson	12,996-13-016 13,040-13,074	206	5,921	Red River
	Shell Oil Company, USA #43-11 NE SE 11-150N-104W	Cartwright	12,931-12,955	355	461.5	Red River
	Ladd Petroleum Corporation, Duncan-Federal #30-24, SE SW 30-145N-99W	Scairt Woman	9,690- 9,728 9,660- 9,670	630	677	Madison
	Ladd Petroleum Corporation, Duncan-Federal #30-24, SE SW 30-145N-99W	Scairt Woman	13,308-13,318 13,442-13,450 13,460-13,472	..	3,459	Red River

NORTH DAKOTA OIL AND GAS DISCOVERIES IN 1979

COUNTY	OPERATOR, WELL, LOCATION	FIELD	PROD. DEPTH	Initial Potential OIL b/d	Initial Potential GAS Mcfd	PRODUCING FORMATION
McKenzie	SunBehm Gas, Inc., Norman Rod #1 SW NE 5-149N-102W	Charbonneau	11,332-11,501	270	350	Duperow
	The Superior Oil Company, Donald Link et al #1, SW NW 35-152N-102W	Unnamed	13,521-13,569	33	..	Red River
	Alpar Resources, Inc., Norstog #1-3 C SE SE 3-149N-99W	Cherry Creek	11,664-11,690	565	678	Duperow
	Gas Producing Enterprises, Inc., 5-146-103 BN #1, NW SE 5-146N-103W	Poker Jim	11,142-11,146	163	109.8	Duperow
	Pennzoil Company, Depco #15-44 BN SE SE 15-146N-101W	Flat Top Butte	9,406- 9,478	198	99	Madison
	Tiger Oil Co. & Texaco, Inc. P. S. Thorlackson #21-26 C NE NW 26-153N-95W	Charlson	10,326-10,372	70	158	Bakken
	Crystal Exploration, Schmidt #1 SW SW 15-142N-98W	Saddle Butte	9,756- 9,766	57	1,140	Madison
Renville	Inexco Oil Company, Randolph #1-21 C NE NE 21-159N-84W	Lockwood	5,052- 5,068	38	..	Madison
Williams	Mosbacher-Pruet Oil Co. Hefflefinger #3-1 NW NW 3-154N-100W	Williston	13,865-13,884	214	313	Red River
	Hardy Salt Company, Hardy #4 SW SW 17-158N-100W	Catwalk	9,578- 9,610 9,406- 9,444	78	75.6	Madison
	Tenneco Oil Corporation, Jensen #1-5 NE SE 5-155N-101W	Missouri Ridge	13,136-13,144	635	901.7	Stonewall
	Lamar Hunt, Rolfstad #1 C NE SW 29-155N-100W	Springbrook	13,150-13,160	628	1,325.7	Stonewall

NORTH DAKOTA OIL AND GAS DISCOVERIES IN 1979

COUNTY	OPERATOR, WELL, LOCATION	FIELD	PROD. DEPTH	Initial Potential OIL b/d	Initial Potential GAS Mcfd	PRODUCING FORMATION
Williams	Getty Oil Company, Price #12-28 C NW SW 28-159N-103W	Grenora	11,724-11,727 11,732-11,737	54	..	Red River
	Patrick Petroleum Co., Fedje #1 C NE NW 14-156N-102W	Bone Trail	12,953-13,073	309	295	Red River
	Argonaut Energy Corp., Barkie #1 SW SW 23-156N-103W	Bull Butte	10,065-10,115	5.84	..	Lodgepole
	W. H. Hunt Trust Estate, Tangen #1 SW NE 10-158N-101W	Little Muddy	12,320-12,316	49	97	Red River
	Hunt Energy Corp., Halvorson-FLB #1 C SE SW 10-159N-97W	Corinth	8,755- 8,760	11.69	4.6	Madison

North Dakota---5-Year Production Summary

Year	CRUDE OIL (bbl) Avg. Daily	Total Annual	Value at Wellhead*	NATURAL GAS (MMcf) Total Annual	Value at Wellhead*
1975	56,031	20,451,510	$173,837,835	28,900	$5,779,900
1976	59,354	21,723,446	$162,925,845	27,600	$5,519,900
1977	63,716	23,256,355	$174,422,662	29,192	$5,838,254
1978	67,988	24,815,577	$215,127,226	33,400	$6,399,840
1979	84,696	30,914,057		*40,000	

*Estimated

North Dakota---5-Year Drilling Summary

Year	Wildcats Drilled Oil/Gas	Wildcats Drilled Dry	Success Ratio	Dev. Wells Oil/Gas	Dev. Wells Dry	Total Wells	Total Footage
1975	16	95	17%	53	42	206	1,347,675
1976	18	83	22%	89	54	244	1,750,147
1977	12	63	19%	108	64	247	1,928,644
1978	20	98	20%	162	60	340	2,886,532
1979	29	91	32%	252	50	422	*4,000,000

*Estimated

NORTH DAKOTA STILL NEEDS MORE EXPLORATORY DRILLING--

Four and a half years ago we published an article in the NDGS Newsletter (December, 1975) showing why North Dakota at that time needed more exploratory drilling. We pointed out that large areas of the Williston Basin remain virtually untested, in spite of the apparently large total number of holes that had been drilled.

Since 1975, the situation has changed. We are experiencing a boom in oil exploration far bigger than anything earlier. Exploratory drilling has been extremely successful; 114 exploratory wells were drilled last year and we can expect, perhaps, 150 wildcat wells to be drilled in 1980. But, in spite of this, the surface has only been scratched. Large areas of potential production remain untested.

In 1975, we reported that "only a handful of exploratory wells have been drilled in Williams County off the Nesson Anticline." Today, 19 townships in Williams County still haven't had a single wildcat well drilled to any depth. Even so, an important difference is that Williams County now has eight more oil fields than it did in 1975, and nearly all of these new fields are in areas that in 1975 we noted were totally unexplored (either no wells drilled to any depth, or no wells drilled to the now-producing horizons). So, we were right about Williams County; it was essentially unexplored, a lot of oil remained to be found, and, through determined exploration efforts, a lot of oil was found in the past five years. But, with 19 undrilled townships, a lot of oil still remains to be found in Williams County.

The same is true east of the Nesson Anticline in Mountrail County. Here, about 20 townships of a total of 50 are still completely untouched and many of the "explored" townships have had only one dry hole that, in many instances, is no deeper than Mississippian. However, the one new successful field discovered since 1975, the Stanley Field, is located in the part of Mountrail County we identified in 1975 as being unexplored. I think it is safe to say that more oil will be found when additional drilling is done in other parts of Mountrail County.

We stated in 1975 that Adams County, an area of nearly 1,000 square miles, had had only four exploratory wells drilled, none deeper than the Cretaceous. Today, six wells have been drilled in Adams County and two more have been permitted for drilling. Adams County still has no producing wells, but is remains virtually unexplored. Hettinger County, just north of Adams County, is also relatively unexplored, but it did recently become an oil-producing county with a well completed near New England. In fact, Adams and Hettinger Counties, with 60 townships, still have 47 townships in which not a single exploratory well has been drilled. Or, viewed in another way, all the test holes drilled in Adams and Hettinger Counties were located in a total of 19 sections and we have issued permits for wells in an additional four sections in the two counties. So, of the 2,125 square miles in the two counties, 23 sections have had, or will soon have, test holes drilled. Most of these wells were drilled only to the Cretaceous. It's hard to believe that these two counties are so poor a prospect.

Since 1975, an entirely new geologic trend has been "discovered," and it is on this trend, the "Billings Nose," that many of the more outstanding discoveries have been made. The "Billings Nose" is located mainly in Billings and McKenzie Counties, and it apparently extends northward into Williams County. I wrote "discovered" in quotes, because as long ago as 1966, Sid Anderson of the NDGS showed it on his "Fryburg Pay" structure map.

In my 1975 article, I did a statistical exercise (as you all know, anything can be shown if you choose your statistics carefully) proving that, in Divide County, something less than ½ of 1 percent of the area had been adequately tested (I assumed that a test well effectively tests a 40-acre area) as deep as the Mississippian. Of the deeper horizons, less than 1/20 of one percent had been tested. Since then, some additional drilling has been done and two new fields have been discovered, the Daneville and Writing Rock Fields. Both of these fields produce from the Ordovician Red River Formation and would have been overlooked a few years ago because few wells in that area were being drilled deeper than Mississippian.

Burke County offers an even more striking example of the extent of the untested, deeper horizons. The county has had considerable test drilling and appears, on our large wall map, to be well covered and explored. But, in 1975, of the 653 wells that had been drilled in Burke County, only 7 had penetrated horizons deeper than the Mississippian. Now, five years later, Burke County has had 3 wells drilled to Red River, 7 to or through Silurian, and 12 to or through Devonian. Therefore, only 12 wells have penetrated deeper than the Mississippian; two of these wells were drilled as potash test holes.

I think I can close this article with the same paragraph I used to close my 1975 article.

"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 been found."

HYDROTHERMAL RESOURCES IN NORTH DAKOTA (Ken Harris) --

For the past year, the North Dakota Geological Survey has been working under a cooperative agreement with the Department of Energy, Division of Geothermal Energy (DOE-FC07-79ID12030) to evaluate North Dakota's hydrothermal resources. Our first year of work resulted in the development of a computer data management system and a computer graphics system which enabled us to use the information of the state's hydrothermal resources.

Our computer management system, called GEOSTOR, is a location-oriented library of oil and gas well data. GEOSTOR was developed by Laramie Winczewski, a University of North Dakota geologist, with funds provided by the Surface Environment and Mining research group of the U.S. Forest Service. The data from each oil and gas well drilled in North Dakota, contained in GEOSTOR, consists of owner-operator, location, reference elevation, deepest formation penetrated, total depth, bottom-hole-temperature, production information, available samples and cores, available geophysical data, and selected formation tops.

Our computer graphics system, consisting of a SURFACE II program developed by the Kansas Geological Survey, was purchased by the NDGS. Howard Umphrey, NDGS computer programmer, modified SURFACE II so that it is compatible with the IBM-370 equipment available for our use through the University of North Dakota Computer Center.

Our goals for the first year of our study were to construct a geothermal gradient map of North Dakota and to evaluate potential hydrothermal reservoirs, particularly the Mississippian Madison Formation, based on the data contained in GEOSTOR.

Our geothermal gradient map (fig. 1) was produced by interrogating GEOSTOR for all recorded bottom-hole-temperature and total depth of wells drilled in the state. Gradients were calculated (fig. 2) and the average gradient for each township was contoured. The geothermal gradient map is displayed in degrees Celsius per kilometre so that it may be easily compared with geothermal gradient maps produced by other workers in the region. The average geothermal gradient for North Dakota is 30.7°C/km (0.0168°F-ft.). Only those values within two standard deviations of the mean (±14.3°C/km or ±0.0078°F/ft.) were used to construct our map.

The important factors in evaluating a potential hydrothermal aquifer include depth, thickness, water temperature, and water quality. GEOSTOR has been interrogated for the depth of the top and base of the Mississippian Madison Formation in order to construct maps showing the depth to and the thickness of the Madison (fig. 3 and 4). An expected water temperature map was constructed by mapping the bottom-hole-temperatures of all wells, on record, that bottomed in the Madison (fig. 5). The Madison Formation water quality map (fig. 6) was produced by mapping the total dissolved solids reported in analyses of water recovered from Madison drill stem tests.

Using the information contained in GEOSTOR, we can summarize the hydrothermal prospects for the Madison Formation. The Madison ranges in depth from about 3,000 feet to about 9,000 feet and is up to about 2,300 feet thick. The expected temperature of the formation water ranges from about 250° F, in the center of the basin, to about 100° F on the eastern flank of the basin. The Madison Formation is a medium- to low-temperature hydrothermal reservoir. The water contained in the reservoir is typically very high in NaCl, with concentrations of total dissolved solids as high as 300,000 mg/1. Although the Madison contains water in a useful temperature range, the generally poor quality of the water and great depth will probably prevent its development as a significant hydrothermal aquifer in North Dakota.

We have started to work on the second year of our study. Our efforts are being concentrated on shallow (< 3000 feet deep) aquifers in areas of higher than average geothermal gradients, the eastern third and north central parts of the state (fig. 1). We are currently running temperature logs on selected groundwater observation wells in these areas of interest. Our goals are to characterize the depth, thickness, water temperature, and water quality for as many shallow aquifers as possible in order to supply the basic data necessary to identify and develop areas with useful water temperatures at economic depths.

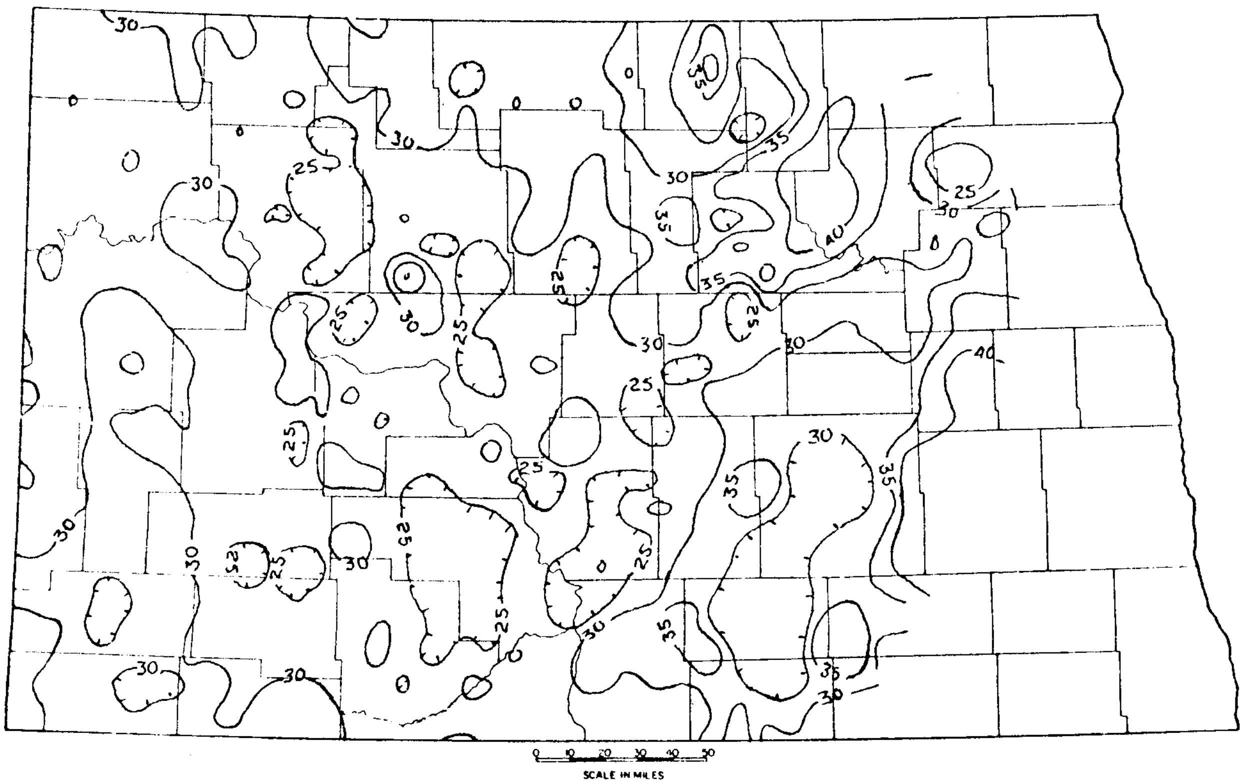


Figure 1. Geothermal gradient. The contour interval is 5^{o} Celsius per kilometre.

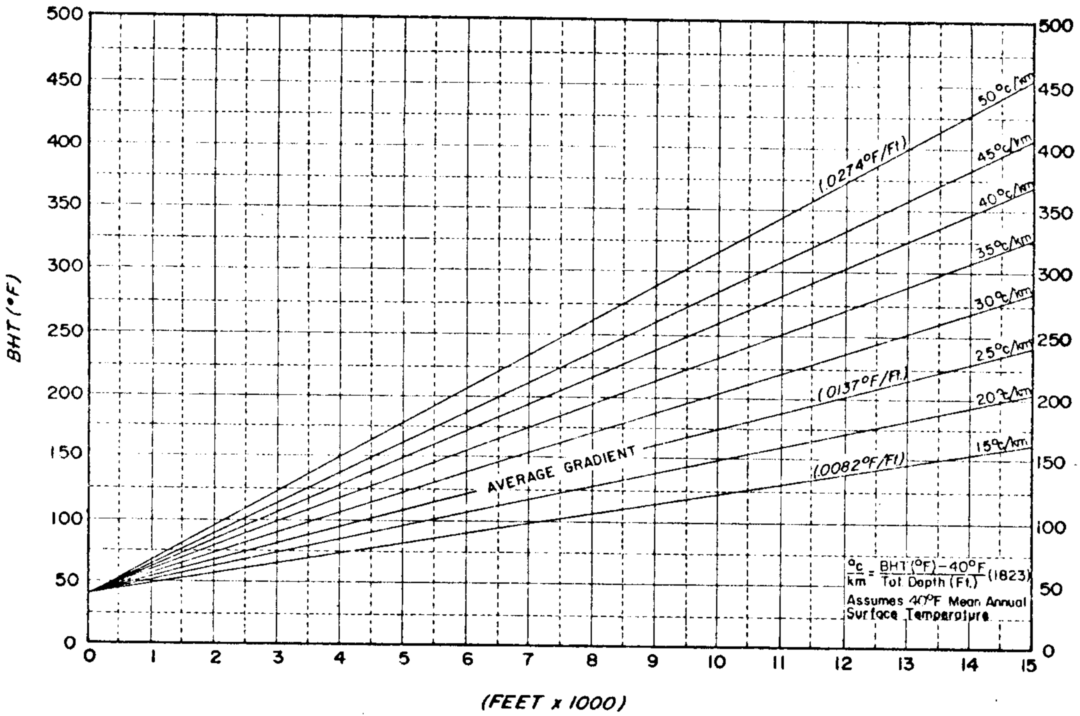


Figure 2. Metric geothermal gradient vs Bottom Hole Temperature (^{O}F) and total depth (feet).

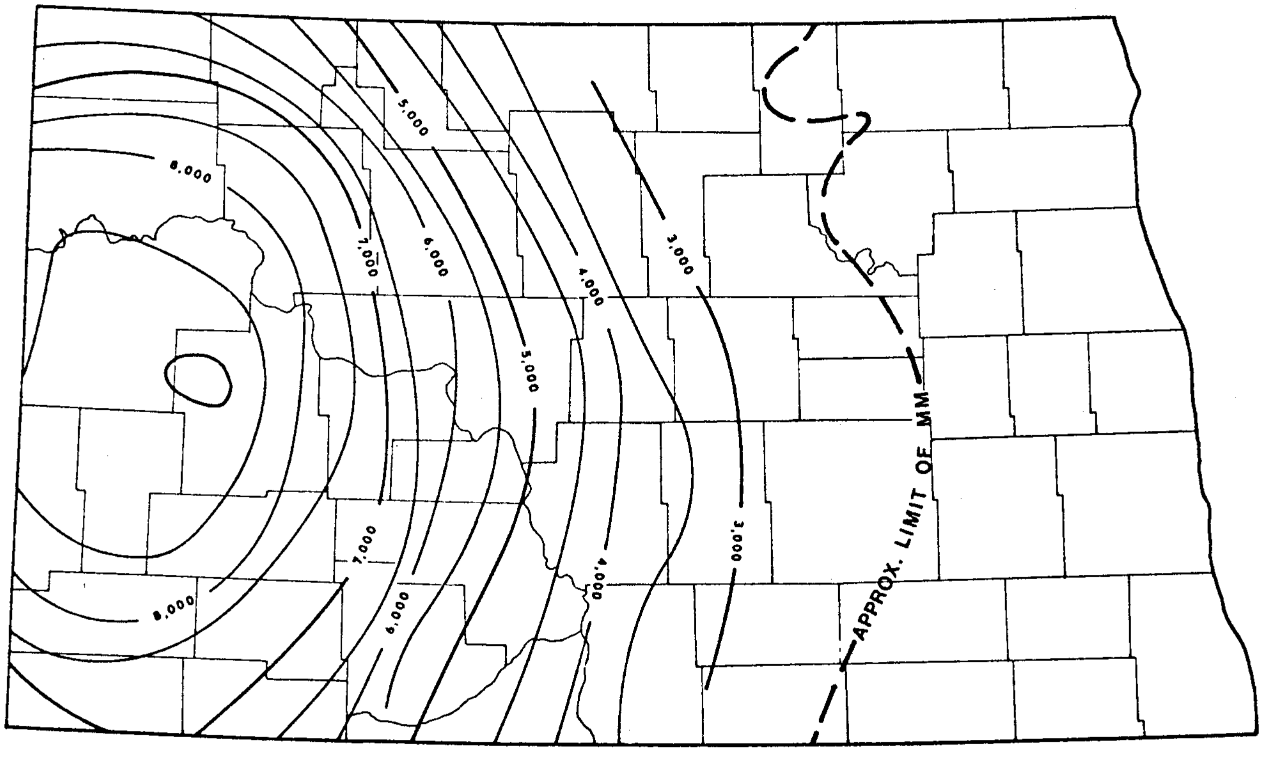


Figure 3. Depth to the Madison Formation. Contour interval is 500 feet.

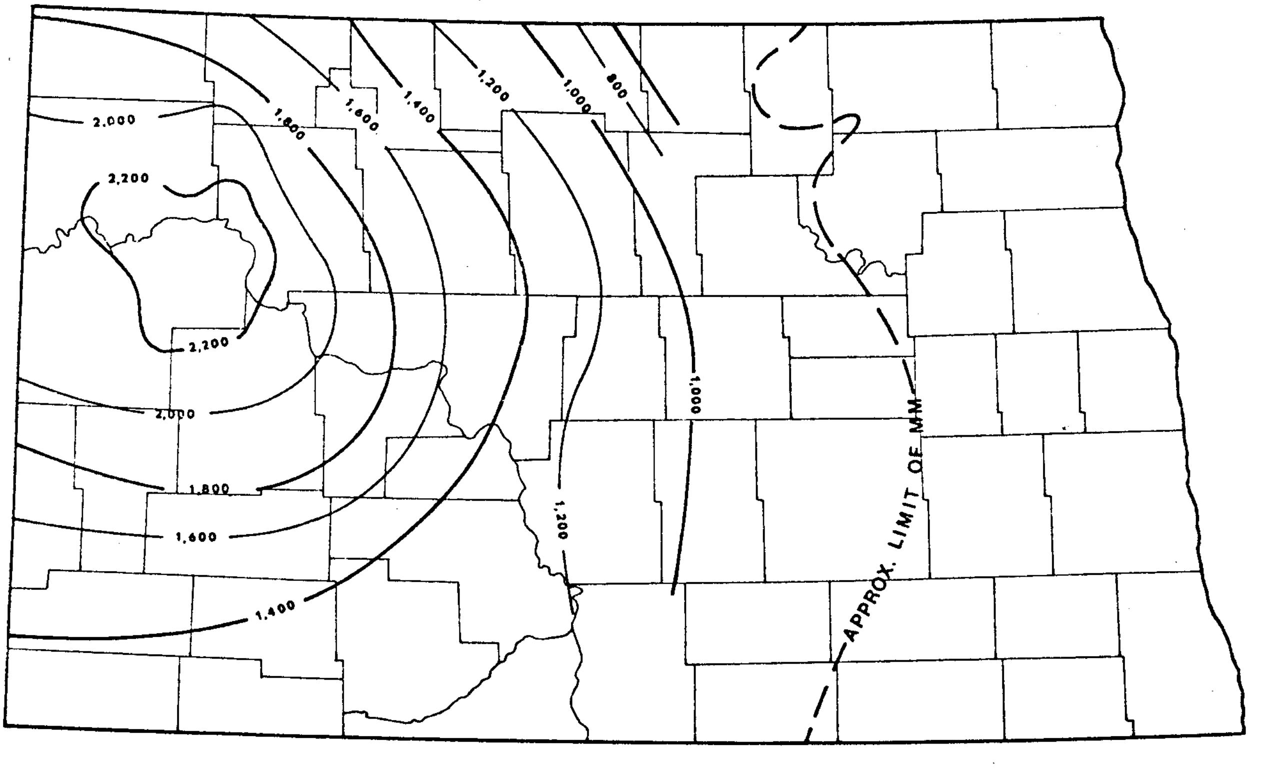


Figure 4. Isopach map showing the thickness of the Mississippian Madison Formation in feet. Contour interval is 200 feet.

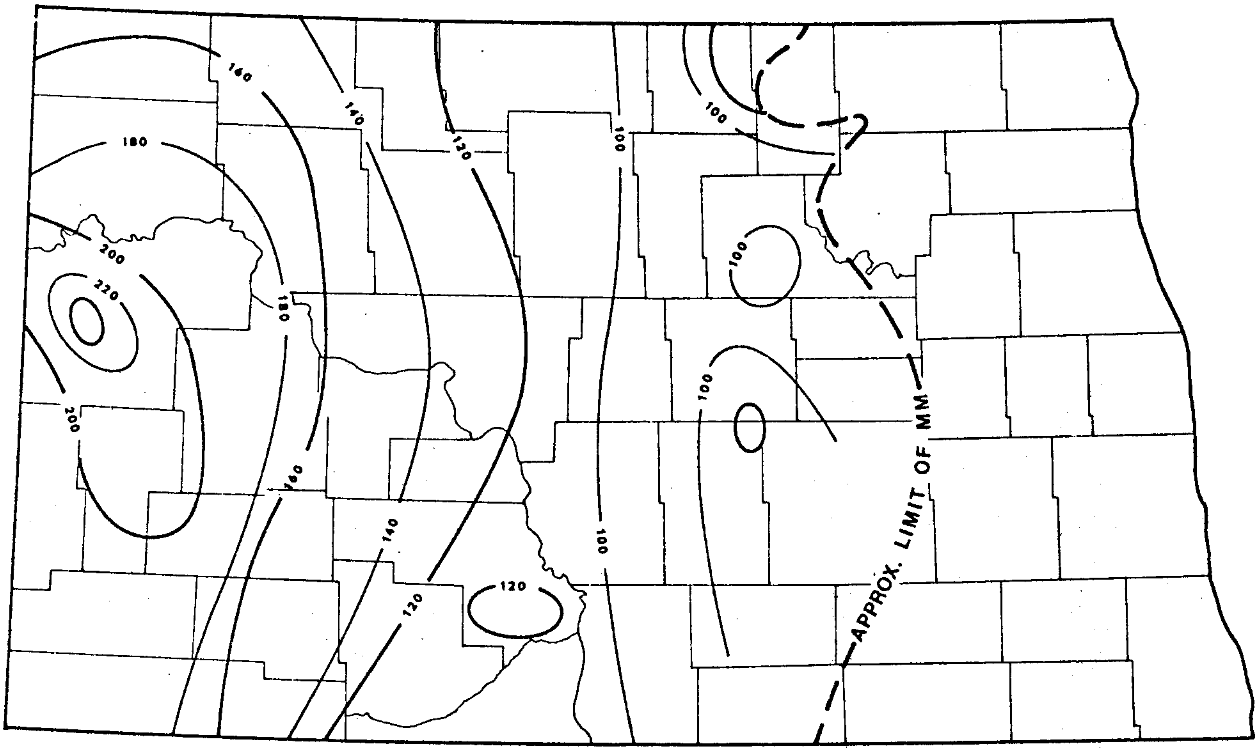


Figure 5. Isotherm map showing the temperature of the water in the Mississippian Madison Formation. Contour interval is 20^{o} F.

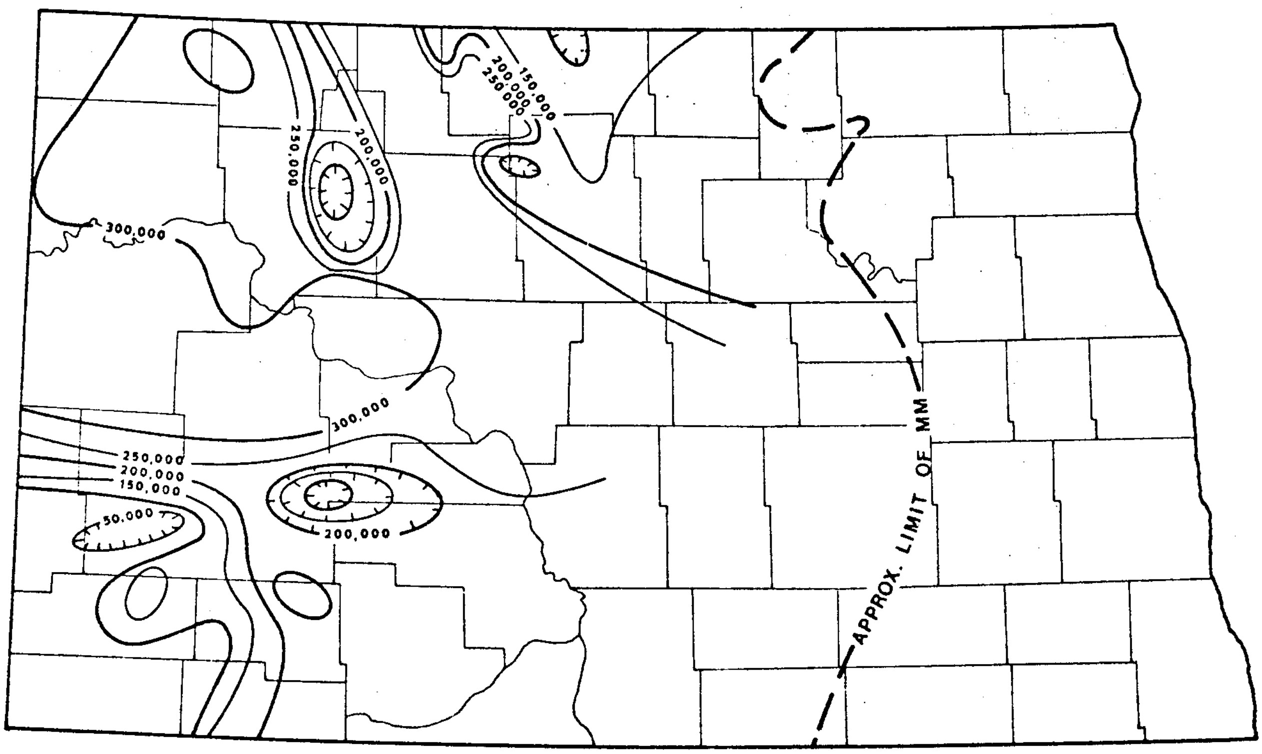


Figure 6. Concentration of total dissolved solids (TDS) in the Mississippian Madison Formation. Contour interval is 50,000 mg/l.

RECENTLY RELEASED PUBLICATIONS--

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

Bulletin 71, Part III -- "Ground-water Resources of Ramsey County, North Dakota" was prepared by R. D. Hutchinson and R. L. Klausing. The report describes the hydrology and chemical quality of groundwater in Ramsey County. Several major aquifers have been identified in the glacial deposits and potential water yields and quality of water in these aquifers have been determined. Aquifers in the pre-glacial (bedrock) materials, the Pierre and Dakota aquifers, have a greater areal distribution than do those in the glacial drift, but those in the drift provide higher yields of better quality water to individual wells. The report is 36 pages long and includes a map showing groundwater availability in Ramsey County. It is available free of charge from the North Dakota Geological Survey.

Bulletin 72, Part III -- "Ground-water Resources of Morton County, North Dakota" was prepared by D. J. Ackerman. The report describes the occurrence and characteristics of aquifers and the movement, quantity, and quality of water in aquifers in Morton County. The findings set forth in the report will help in the efficient development of the groundwater resources for irrigation, domestic, industrial, and municipal purposes. Aquifers in the glacial drift and alluvium underlie only 10 percent of the county, but these have the greatest potential for large-scale development. These aquifers, composed of sand and gravel, occur in buried valleys and in major river valleys. Bedrock aquifers, consisting of fine-grained sandstones, contain generally soft, moderately saline water useful for domestic, livestock, and some industrial uses. The report is 51 pages long and includes three plates, one of which shows the groundwater availability in Morton County. The report is available free of charge from the North Dakota Geological Survey.

Bulletin 75, Part II -- "Ground-water Data for Sheridan County, North Dakota" was compiled by M. R. Burkart. The report includes geologic and hydrologic records for 320 wells and test holes, water-level measurements in 61 observation wells, lithologic and geophysical logs of 308 test holes and wells, and chemical analyses of 93 ground-water samples. The data may be used in evaluating geologic and ground-water conditions in Sheridan County. The report is 302 pages long and is available free of charge from the North Dakota Geological Survey.

Educational Series 12 -- "Flooding in the Grand Forks-East Grand Forks Area" was written by Samuel S. Harrison and John P. Bluemle. The booklet was prepared to provide information on flooding not otherwise readily available to the public. The booklet includes a history of flooding in the two-city area, it identifies areas subject to future floods, and it provides probability figures on the likelihood of future floods. The report is 66 pages long and includes 48 illustrations, 6 tables, and a colored map of the two cities showing areas that are subject to flooding at various river levels. The booklet is available for $1.00 from the North Dakota Geological Survey.

The Official Oil Production Statistics and Engineering Data for the First Half of 1979" contains the oil and water production by individual wells along with other pertinent information. This report is 322 pages long and is available for the price of $5.00.

"North Dakota Stratigraphic Column" by John P. Bluemle, Sidney B. Anderson, and Clarence G. Carlson has just been published. This colored stratigraphic column shows all North Dakota Williston Basin geologic units. It includes descriptions of each formation, group, and member, and columns for mineral resources, maximum thickness, and other information. Geophysical logs are included for four wells from various parts of the state. The Stratigraphic Column, measures 45" by 35" and is available from the North Dakota Geological Survey for $2.00.

"Geologic Map of North Dakota" was authored by Lee Clayton with assistance from S. R. Moran, J. P. Bluemle, and C. G. Carlson. It was published by the U.S. Geological Survey at a scale of 1:500,000 (1 inch equals about 8 miles).

The surface geology of North Dakota has been divided into about 50 units on the map. An additional 20 symbols are used to identify specific types of geologic features. For the Tertiary and Cretaceous units, descriptive lithology is emphasized on the map and each formation is indicated by a different color. In the Quaternary units, interpretive and descriptive sedimentology and geomorphology are emphasized and each sediment or topography is indicated by a different color.

The map explanation includes a chart showing how the various map units correlate, according to both time and origin.

Where possible, the colors of pre-Pleistocene map units reflect the actual outcrop color of the formation. The colors of the Pleistocene map units also reflect field colors. The generally finer grained units (offshore and glacial) are indicated by cooler colors (blue and green), and the coarser grained units (eolian, shoreline, and fluvial) are indicated by warmer colors (yellow, orange, and red) because finer grained sediment more easily retains water and has more reduced colors (blue and green), whereas coarser grained sediment more easily drains and has more oxidized colors (red and yellow).

Units that are more conspicuous in the field are made more conspicuous on the map. For example, eolian sand, which is often in the form of conspicuous dune fields, is shown in bright yellow, whereas eolian silt, which is generally an inconspicuous blanket draped over the pre-existing landscape, is shown light yellow.

Field units with more hilly topography (and therefore with abundant dark shadows) are shown darker than units with flatter topography (and therefore few shadows). For example, collapsed fluvial sediment is shown darker than uncollapsed fluvial sediment. Badland areas (with abundant shadows) are indicated by a dark dotted pattern.

The map that has resulted by applying this unique color scheme is an unusually detailed one showing complex surface geology, but at the same time, it is an unusually easy map to use. Planners, legislators, and scientists in various fields, as well as construction people, engineers, hydrologists, geologists, and miners, should find the map useful.

Copies of the new 40-by-49-inch (102-by-125 cm) map may be purchased for $3.50 each by mail from the Branch of Distribution, U.S. Geological Survey, Box 25286, Denver Federal Center, Denver, CO 80225. The map may be purchased over the counter at the North Dakota Geological Survey office in Grand Forks.

Report of Investigation 69 -- "Explanatory Text to Accompany the Geologic Map of North Dakota" was written by Lee Clayton, S. R. Moran, and J. P. Bluemle. This report outlines the background and history of the new Geologic Map of North Dakota and provides explanations and illustrations of the various map units. RI 69 is 98 pages long and will soon be available from the North Dakota Geological Survey.

We also have a new List of Publications available. This listing, dated March, 1980, is available free on request. It is more complete than previous listings and features improved cross-indexing according to subject.

CHANGES IN SURVEY STAFF--

Dr. Alan Kehew, who has been with the NDGS since July 1977, has taken a professorial job with the University of North Dakota Geology Department. Alan has been our environmental geologist, involved in studies of sanitary landfills and lagoons and, most recently, disposal of oil well drilling muds. He has worked closely with the State Health Department on these projects. Alan has also conducted a study of the environmental geology of the Minot area.

The Survey's new Core and Sample Technician is Rod Stoa, who replaced Dan Walker in April. Rod is from Fergus Falls, Minnesota and he has been a geology student at the University of North Dakota.

Beginning July 1, Don Halvorson will assume a half-time position with the NDGS as a Senior Geologist. Don will continue half time as an Assistant Professor with the UND Geology Department, teaching mineralogy, until the department finds a replacement. He earned a B.S. degree from the University of California in 1965, an MST from the University of North Dakota in 1971, and he is a PhD candidate at UND. Don is from Wildrose, North Dakota.

The Survey's new receptionist is Audrey Schmidt, who replaced Donna Beaudry in April. Originally from LaMoure, North Dakota, Audrey has made her home in Grand Forks since 1968.

In Bismarck, Roger Borchert, a field inspector, resigned in February to accept a position with a group of independent consulting geologists.

James C. Dufty was hired in May as a new field inspector for the Survey. He has a B.S. degree from Central Michigan University. He is from Caseville, Michigan.

Ed Murphy, a Bismarck, North Dakota native, has assumed a half-time position as a coal geologist. He is also presently completing his requirements toward a M.S. degree in Geology at the University of North Dakota.

GERHARD PRESIDENT-ELECT FOR THE ROCKY MOUNTAIN SECTION OF AAPG--

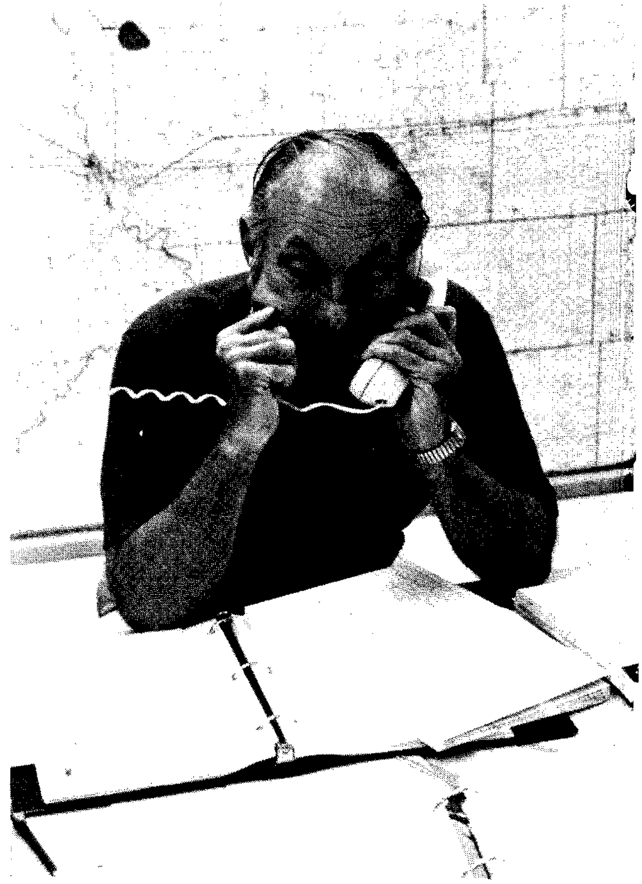
Dr. Lee Gerhard, State Geologist of North Dakota, is the president-elect for the 1982 Rocky Mountain Section of the American Association of Petroleum Geologists. The 1981 meeting will be April 12-16 in Albuquerque, New Mexico and the 1982 meeting will be in Calgary, Alberta. Dr. Gerhard is shown on page 18.

SURVEY PROFILES--

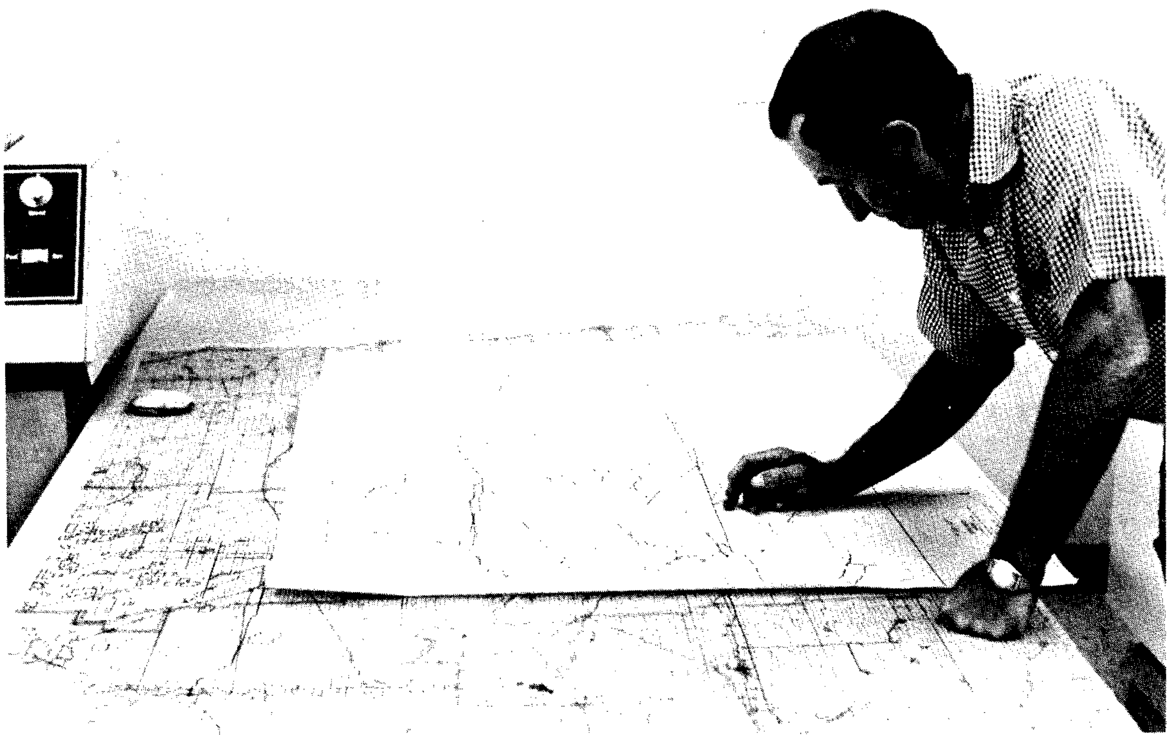
SID ANDERSON

Sidney B. Anderson is from Finley, North Dakota, a town about 70 miles southwest of Grand Forks. He has been with the North Dakota Geological Survey since 1952, when he received his PhB in geology from the University of North Dakota. Prior to joining the Survey, Sid worked for the Groundwater Branch of the USGS. He is currently chief of the Survey's Subsurface Section.

Dr. Lee Gerhard, newly elected president-elect for the Rocky Mountain Section of AAPG.



Sid Anderson, is shown here in a familiar pose, answering a request for information Sometimes it seems as though we spend all day on the phone.



Here, C. G. Carlson, Senior Geologist with the NDGS, checks the locations of pipelines on a new 1:125,000 (¼" to a mile) map of North Dakota that will be used in Bismarck for State Industrial Commission hearings. The mylar map shows oil field and gas field boundaries as well as crude, gas, and products pipelines.

It isn't really possible to describe what Sid does for the Survey and what he has done. Without a shadow of doubt, he knows more about the subsurface geology of North Dakota than any other person. It doesn't really matter what the question might be; if you want the correct answer, "ask Sid." He is a veritable walking encyclopedia of information on nearly every well that has been drilled in North Dakota, every log that was run, every piece of core we have, and every report ever written. He has a truly phenomenal understanding of what is really going on in the subsurface of the Williston Basin.

Although he has published, perhaps 30 or 40 reports, most of Sid's work has never been published. He is just too busy to take the time to get his research into print and he has never been interested in amassing large numbers of publications. His fund of knowledge is available for the asking. Sid has "given away" more oil, simply by answering questions about the geology, traps, etc. (much of which only he knows about), than any other geologist working in North Dakota can hope to find in a lifetime.

Sid and his wife Mary have two daughters, Jennifer and Karen, both excellent swimmers and musicians. Sid is a hunter and fisherman and he also enjoys trapshooting.

KELLY CARLSON

Clarence G. ("Kelly") Carlson is originally from Cloquet, Minnesota, near Duluth. He has been with the NDGS since 1954, since receiving his B.A. in geology from the University of North Dakota in 1960.

Kelly is a versatile geologist who has worked on virtually all aspects of North Dakota's geology, including numerous subsurface stratigraphic studies of oil- and gas-bearing strata and studies related to uranium, cement rock, potash, and spoil piles associated with strip mining. He has mapped the surface geology of about 15 counties in southwestern North Dakota as part of the Survey's groundwater studies. For the past several years, Kelly has been involved in field evaluations of lignite reserves in North Dakota.

Kelly has studied North Dakota's pre-Mississippian strata in more detail than any other person and he has published his findings in various professional journals and NDGS publications. His numerous Survey publications include detailed reports of the Winnipeg and Deadwood Formations in North Dakota and on the Stony Mountain, Stonewall, and Interlake Formations. He has studied the micropaleontology, particularly the conodonts, of the Ordovician formations in considerable detail. Many of Kelly's subsurface stratigraphic studies have led us to a much better understanding of regional geologic relationships in North Dakota. His studies have resulted in valuable publications that are always in demand. Among others, these publications include studies of North Dakota's sedimentary and tectonic history, and cross sections of Paleozoic rocks in western North Dakota. His surface stratigraphic studies have resulted in a bedrock geologic map of North Dakota that remains our standard reference.

THE SEPARATION OF SURFACE MINERAL ESTATES--THE SEVERED MINFRAL RIGHTS--

North Dakota has over 4.2 million acres of federally owned minerals beneath nonfederal surface. This acreage includes reservations of coal, oil and gas, and other minerals such as potash, uranium, and phosphate. Some of these reservations are for only one mineral, some are for certain combinations of minerals, and some are for all minerals.

This is a brief account of the actions occurring early in the century that resulted in the separation of the mineral estate from the surface estate in large parts of the United States. Later actions resulted in federal acquisition of minerals (approximately 300,000 acres in North Dakota--mostly a percentage ownership) but these are not discussed. These later acquisitions are, however, included in the 4.2 million acre total. Most of the information in this article was gathered from a paper entitled "The Separation of Surface Mineral Estates in Public Land Disposition," which was written in 1964 by Tadd Linsenmayer, who was then a research assistant in the Office of Chief of Legislation and Cooperative Relations, Bureau of Land Management.

As early as 1901, Congress was concerned about the problem of agricultural claims on lands believed to contain minerals. By 1905, two bills were introduced in Congress authorizing the president to reserve all coal and lignite found on the public lands for future disposal; however, neither of these bills was reported out of committee. Members supporting the bills were worried about the coal lands falling under the control of the monopolies. They were also concerned with the rate at which the Nation's fuels were being consumed.

President Theodore Roosevelt also voiced these concerns. In a message to the 59th Congress, he pointed out that the amount of coal used in the most recent ten years was equal to that used during the preceding 50 years. "If we dispose of all the coal lands now we can be well assured that 25 years hence the generation then coming into manhood will regret our shortsightedness and lack of provision for the future," he warned.

Because Congress had not acted on the coal legislation, Roosevelt instructed the Secretary of Interior to withdraw the remaining public coal lands from homestead entry. Between July 26, 1906, and December 13, 1907, 66,938,800 acres of coal land were withdrawn by executive order, and on August 15, 1907, the first oil lands were withdrawn.

The withdrawal prevented those settlers who had selected coal and oil lands (prior to the withdrawal) from obtaining patents. In 1909, a law was enacted that allowed these settlers to obtain a patent to the lands with a reservation of the coal deposits to the United States. This was the first legislation establishing the separation policy.

The following congressional actions followed the same concept and expanded the separation policy to cover more lands.

1910 - Law enacted that allowed <u>new</u> agricultural entries on coal lands (with coal reserved to the United States).

1914 - Law enacted that allowed agricultural entries on lands containing phosphate, nitrate, potash, oil, gas, and asphaltic minerals, with these minerals reserved to the United States.

1916 - Stockraising Homestead Act passed. It required that <u>all</u> minerals in lands be reserved to the United States.

Most of the federal mineral reservations in North Dakota are in the western part of the state. There are two reasons for this: first, most of the land in the eastern half of the state had already been settled--with patents granted--prior to the establishment of the separation policy, and much of the western half of the state was settled after the policy was in effect; second, all of the significant coal resources are located in the western half of the state.

The federal reservations are checkerboarded among minerals owned by the State of North Dakota, railroads, and banks, as well as private individuals. North Dakota is not unique in this; Montana and Wyoming, for example, have larger acreages of federally reserved minerals than North Dakota.

THE EFFECT OF WETLANDS DRAINAGE ON FLOODING--

The NDGS recently released a nontechnical publication detailing the flood problem in Grand Forks and East Grand Forks (see the item describing new publications, page 15 of this newsletter). As I write this, we are in the midst of what seems to be developing into a serious drought and it may seem pointless to think about flooding. Even so, we can probably expect to be confronted with flooding problems again, perhaps as soon as next spring.

In our flood report, we pointed out some of the measures that could be taken to deal with flooding and the economic losses due to flooding in the Red River Valley. Among these measures were the restoration of drained wetlands; the removal of agricultural dikes; a halting of, or at least better control over, drainage ditch construction; conservation measures such as shelterbelt plantings; and the adoption and enforcement of strict, informed land-use controls in towns for flood-plain development.

I'd like to comment further on one aspect of the problem, the drainage of wetlands. A report supplied to me by the U.S Fish and Wildlife Service convincingly documents, I think, the relationship between wetlands drainage and flooding.

In North Dakota, the Fish and Wildlife Service studied the effects of wetland drainage on flooding on the J. Clark Salyer National Wildlife Refuge in the Souris River basin north of Minot (study dated December 1979). One of the study areas, which included 205 acres of natural, undrained wetland basins, had an inflow of 109 acre-feet, but only 46 acre-feet were measured as outflow. The basins retained all of the runoff from within the 5-square mile block and also reduced stream flow by 53 percent. By contrast, in a drained study area, 46 acre-feet of water entered, but outflow was 74 acre-feet. The storage capacity of wetlands in the second study area was eliminated by artificial drainage and stream flow increased 61 percent. The study concluded that drained wetlands contributed more to streamflow than undrained wetlands, despite some significant differences in other land-use practices. The Fish and Wildlife Service suggested that wetland drainage is the most important land-use practice with a bearing on flooding problems.

In a 1971 study involving the Pembina River basin in North Dakota, two time periods (1904-1932; 1945-1970) were studied. Both time periods had nearly equal precipitation in that area, but annual flows were significantly greater in the second period with approximately 54,100 acre-feet of additional annual runoff. During the second time period, 23,720 acres of wetlands had been drained. The study concluded that good land management and restoration of drained wetlands could have reduced runoff by an average of 54,100 acre-feet annually (I think this figure may be high because other changes in land use have also taken place.

According to the Fish and Wildlife Service, data from studies of other areas support the idea that wetland drainage contributes significantly to flooding. In the Stone Creek watershed of North Dakota's Souris River basin near Minot, nearly 50 percent of the total runoff is estimated (by the Fish and Wildlife Service) to be due to wetland drainage. If the wetlands in that watershed had retained a minimum of 1 foot of water in drained wetland basins during the 1979 flood, when 585,000 acre-feet of water passed down the Souris River near Westhope, then 200,000 acre-feet (more than one-third) could have been retained on the land rather than contributing to downstream flooding (the conclusions are those of the Fish and Wildlife Service, not mine).

Many conflicting opinions have been offered about the capacity of wetlands to retain large quantities of runoff since their storage capacity appears to be fixed. The Fish and Wildlife Service is compiling data to show that wetlands can store large amounts of water. As part of a planning effort in the Devils Lake basin, the FWS is exploring the water storage capabilities of wetlands. They believe that almost 2 acre-feet of water could be stored per wetland-surface acre. Given the large acreages of wetlands in the basin, these can provide substantial water storage.

Wetlands restoration can be important in a flood reduction plan, according to the FWS, which believes that restoration and improved land-use practices could go a long way toward reducing flood damages and related problems.

Whatever the flood reduction potential achieved by wetland protection, the important point is that it is a factor that man can control. We have no control over a rapid melt, spring rains, or heavy snows, but we can control the impact of drainage and poor land use. By protecting existing wetlands, restoring drained wetlands, and practicing good land use, we may be able to gain some measure of flood control and reduce the escalating economic losses.

THE EFFECT OF THE MT. ST. HELENS' ERUPTION ON NORTH DAKOTA--

The eruption of Mt. St. Helens had only a minor immediate effect on North Dakota. We saw some ash in the air a few days after the May 18 explosion, a small amount of ash fell in the western part of the state, airports in the state closed for a short while as the ash was passing over, and we had some beautiful sunsets for a few days.

Through geologic history, since late Cretaceous time when the Rocky Mountains began to form, volcanoes have erupted regularly and often, pouring forth lava, steam, and ash. Lava flows built up to substantial depths in parts of the mountain states near the volcanoes. Volcanic eruptions have probably been a fairly regular event in North America, occurring, perhaps, every few hundred years. They have emitted large quantities of ash, which has blown mostly eastward, settling over broad areas, including North Dakota.

Most of the volcanic ash that has blown over North Dakota in the past 135 million years or so, since the beginning of the Laramide orogeny ("orogeny" means "mountain-building eipsode") in mid to late Cretaceous time, settled to the ground and was then washed away by rain and carried down the rivers. In some cases, however, when volcanic ash settled to the bottoms of large lakes and seas, it was preserved as layers or beds.

In North Dakota, some of the better occurrences of preserved volcanic ash are found in Emmons County, in south-central North Dakota. At one of the best exposures, a mile southeast of Linton, a 26-foot thick ash bed is found. This volcanic ash is known as pumicite, and it consists of finely divided, angular (sharp) glass particles that are less than 4 millimetres in diameter. Pumicite formed when pumice was subjected to additional explosive volcanism so that the cells were broken. Pumice is an aluminum silicate with a cellular structure formed as a result of explosive volcanism, just as the Mt. St. Helens ash.

Of course we don't know just where the volcano or volcanoes that blew out the Linton ash were located, but they were probably closer than Mt. St. Helens, perhaps in the Devils Tower area or elsewhere in Wyoming or Montana. In any event, they must have provided much more ash to North Dakota than did the recent Mt. St. Helens eruption. The Linton ash bed is within the Cretaceous Fox Hills Formation and is probably about 70 million years old. It was deposited when ash blew eastward to North Dakota and settled into a sea or lagoon in the Linton area.

Several beds of weathered volcanic ash are found in the lower part of the Pierre Formation. This ash is more widespread than the Linton deposit, but the beds are generally not so thick. Ash beds exposed near Walhalla in the Pembina Hills are all less than 5 feet thick. The weathered ash is known as bentonite. Some bentonitic clays tend to swell when they get wet, but others are nonswelling. Bentonite is derived from the alteration of volcanic ash and is composed principally of montmorillonite. Only the type of montmorillonite that contains sodium as an exchangeable ion will swell much; if the sodium has been replaced by calcium, the clay loses its swelling characteristics.

The weathered volcanic ash (bentonite) found in the lower part of the Pierre Formation is perhaps 90 or 100 million years old, and it is therefore completely unrelated to the Linton ash.

Most of the Cretaceous shales are more or less bentonitic throughout, indicating that volcanic activity was nearly continuous for many millions of years, beginning about 135 million years ago, and lasting until the end of Cretaceous time, about 65 million years ago.

A single volcanic ash bed, formed from one eruption, is sometimes widespread, even though it may not be thick. In some cases, a discrete, thin layer of volcanic ash can be identified from many locations. In such an instance, the geologist can accurately determine the relative ages of the sediments, because a bed of volcanic ash represents a precise, extremely short moment in geologic time; it is exactly the same age everywhere it is found. For example, when Mt. Mazama (now Crater Lake in Oregon) erupted 6,500 years ago, it deposited a layer of ash over a broad area of the Pacific Northwest. This ash bed is used to help date and correlate post-glacial sediments. Another ash bed, the Pearlette Ash, found mainly in the central plains, apparently had its source in a volcano or volcanoes in New Mexico. It marks a discrete event in Kansan time, perhaps 600,000 years ago.

The amount of ash emitted from Mt. St. Helens is considerable. Possibly, some of the ash may have accumulated in some ponds and lakes in North Dakota; some ash may accumulate in Lake Sakakawea and, if it does, it will serve to record the Mt. St. Helens eruption in North Dakota's geologic history.

COST OF HEATING FUEL AND THE VALUE OF INSULATING A HOME--

This article is certainly not intended to be a definitive statement regarding the savings to be realized by insulating a home; it is simply a story of two houses, my own and my next door neighbor's (owned by Ken Harris, another NDGS geologist). But I will include some facts on our experience, here in Grand Forks, North Dakota, an area noted for having somewhat colder than average winters.

Last summer, Ken and I both insulated our homes. Both houses are about 43 years old, two story, wood-frame, about 1,500 square feet plus basement. We had foam insulation (urea-formaldehyde) blown into the walls, cellulose in the attics, and fiberglass batts and two-inch thick styrofoam beadboard put in along the roof rafters in the attics. The cost of insulating my house came to approximately $1,200 and Ken's was just slightly more, Both houses already had some rock wool in the walls and newspaper batts along the roof rafters before we did our insulation jobs.

My family has lived in our home for 12 years, Ken's has lived next door for 3 years. I heat with fuel oil, Ken uses natural gas (both forced-air furnaces). Both of us keep reasonably accurate records of our fuel usage, and I think some of our statistics may be interesting as background information. I have compiled my fuel oil usage since the winter of 1971-72 (table 1) and Ken has calculated his gas usage since Jan., 1978 (table 2). If nothing else, the rising cost of energy is apparent from these tables.

We have calculated the number of degree days in Grand Forks over the past three winters. The 1978-79 winter was unusually severe for this area; the 1979-80 winter was unusually mild. Degree days are calculated by subtracting the temperature, in degrees Fahrenheit, from 65°. Thus, an average daily temperature of +10° works out to 55 degree days for that day. This determination does not account for the effect of wind chill, so if the temperature is +10° for the day, the degree days are 55 whether the wind is blowing 30 mph or whether it is calm. It has always seemed to me that a strong wind must have an important effect in chilling the walls and thereby removing heat form the house, but, as far as I know, we don't have any accurate method to measure the effect wind chill has on fuel consumption.

Now, a little more about the results of insulating these homes. Table 3A shows my fuel oil usage over the past three winters, along with the number of degree days each winter. I've also calculated a gallons per degree day figure--the actual amount of fuel oil needed to heat the house. As you can see, during the two winters preceding the insulation job, the fuel required was over 0.12 gallons per degree day. Last winter, after insulating, the cost was less than 0.10 gallons per degree day (it works out to between 20 and 25 percent less fuel per degree day). Assuming that an "average" winter heating season in Grand Forks might acculuIate 9,500 degree days (and assuming my figures are accurate), I can expect to use approximately 912 gallons of fuel oil a year (9,500 x 0.096 = 912) instead of 1150 gallons (9,500 x 0.121 = 1150), a 238 gallon saving in fuel each winter. With fuel oil currently at $1.00 a gallon, it will take me five years to get my insulation money back in fuel savings. (If fuel oil rises in price, it will take less time, but I'm not hoping for that). I should add that our house has been much more comfortable with less drafts and more even temperatures upstairs and downstairs since I insulated.

Table 3B shows Ken's gas consumption for two full winters, 1978-79 and 1979-80. Using the same degree-day comparisons as I used above, I calculate that his gas

TABLE 1
Fuel Oil Usage--Bluemle residence

Year	Gallons	Cost
1971-72	1339.9	$226.80
1972-73	1128.4	$194.51
1973-74	1204.3	$372.93
1974-75	1071.0	$409.72
1975-76	1149.0	$480.98
1976-77	1031.6	$470.50
1977-78	1139.3	$560.57
1978-79	1309.3	$740.54
1979-80	811.3	$773.82

TABLE 2
Natural Gas Usage--Harris residence

Year	CCF	Cost
1978-79	1476	$504
1979-80	901	$560

TABLE 3

A BLUEMLE

(1) Year	(2) Degree Days	(3) Gallons of fuel oil	(4) Total Btu	(5) Gallons per degree day	(6) Btu per degree day	(7) Total Heating Cost (at then-current rates)
1977-78	9359	1139	1.59×10^8	0.121	17038	$561
1978-79	10129	1309	1.83×10^8	0.129	18067	$740
1979-80	8441	811	1.13×10^8	0.096	13387	$774

B. HARRIS

Year	Degree Days	CCF gas	Total Btu	CCF per degree day	Btu per degree day	Total Heating Cost (at then-current rates)
1978-79	10129	1476 (1761-300)	1.47×10^8	0.146	14512	$504
1979-80	8441	901 (1201-300)	9.01×10^7	0.106	10674	$560

consumption dropped about 26 percent as a result of insulating (he also uses gas for his drier and water heater, but that amounts to a nearly steady 25 CCF of gas each month, so I've subtracted it in calculating the totals).

Ken can expect to use 1007 CCF of gas to heat instead of 1264 CCF each average (9,500 degree day) winter. That's a savings of 257 CCF a year, or about $150 a year at the current (0.5782¢/CCF) cost for natural gas. Ken decreased his natural gas usage by about 26 percent as a result of insulating, about the same savings as I made. As I mentioned earlier, the two houses are about the same size, Ken's just slightly larger. Even so, his total heat requirements are about 20 percent less than mine. I'm not certain of the reason for this; my family of 5 may be less careful about conserving heat than his family of 3.

Ken has calculated the thermal efficiency of his home for two consecutive winters, the one immediately prior to insulating, the other after insulating (table 4). The results are, at first glance, somewhat ambiguous. The graph shows CCF per degree day plottted on a monthly basis. The greater the thermal efficiency, the lower the curve. It appears, on inspection of the curves for the two successive winters, that during the coldest months, the effect of insulation was less than it was during the fall and spring. We tentatively interpret this to mean that the presence of snow on the roof is almost as good a form of attic insulation as is the blown-in type.. Notice that the 1978-79 winter curve jumps up in March, the same time the snow was cleaned off the roof (Ken says he pushed off about 2 feet of snow at that time). It is also possible that we are seeing some otherwise unmeasureable chilling effect of wind.

One final comparison that may be interesting is the relative costs of heating with fuel oil, gas, or electricity. I've included a nomogram to compare the costs of these three fuels (table 5). Currently, the cost of fuel oil and natural gas are both rising rapidly. Electric rates have been relatively stable for some time. At the present time in Grand Forks, the cost of heating with gas is about 25 percent less than with fuel oil and electricity is about 35 percent less expensive than fuel oil. (Incidently, the Grand Forks natural gas price is currently a point of considerable controversy. Along with Fargo, Grand Forks is supplied with natural gas purchased from Canada by Northern States Power Company, a Minnesota-based utility. Natural gas in most other North Dakota cities is domestically produced and costs the consumer about half as much as it does in Fargo and Grand Forks.)

About all I can safely conclude from all this is that both Ken and I realized a 20 to 25 percent real savings in our heating bill the first winter after we insulated our houses.

TABLE 4 THERMAL EFFICIENCY - HARRIS RESIDENCE

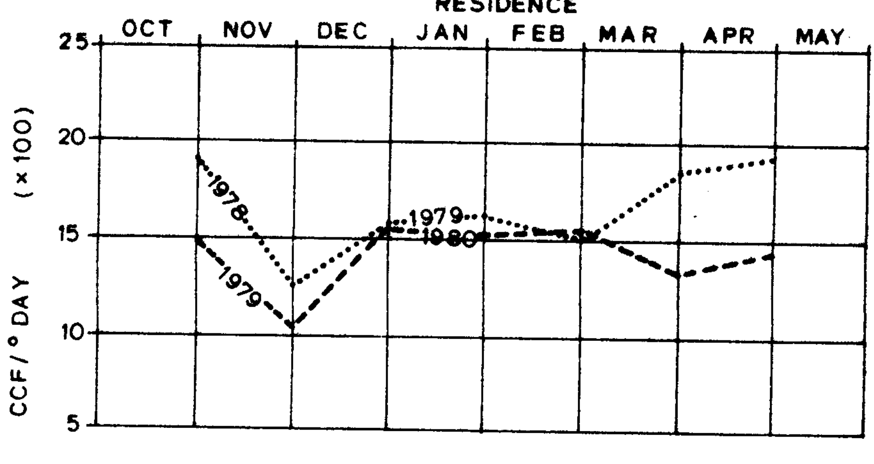
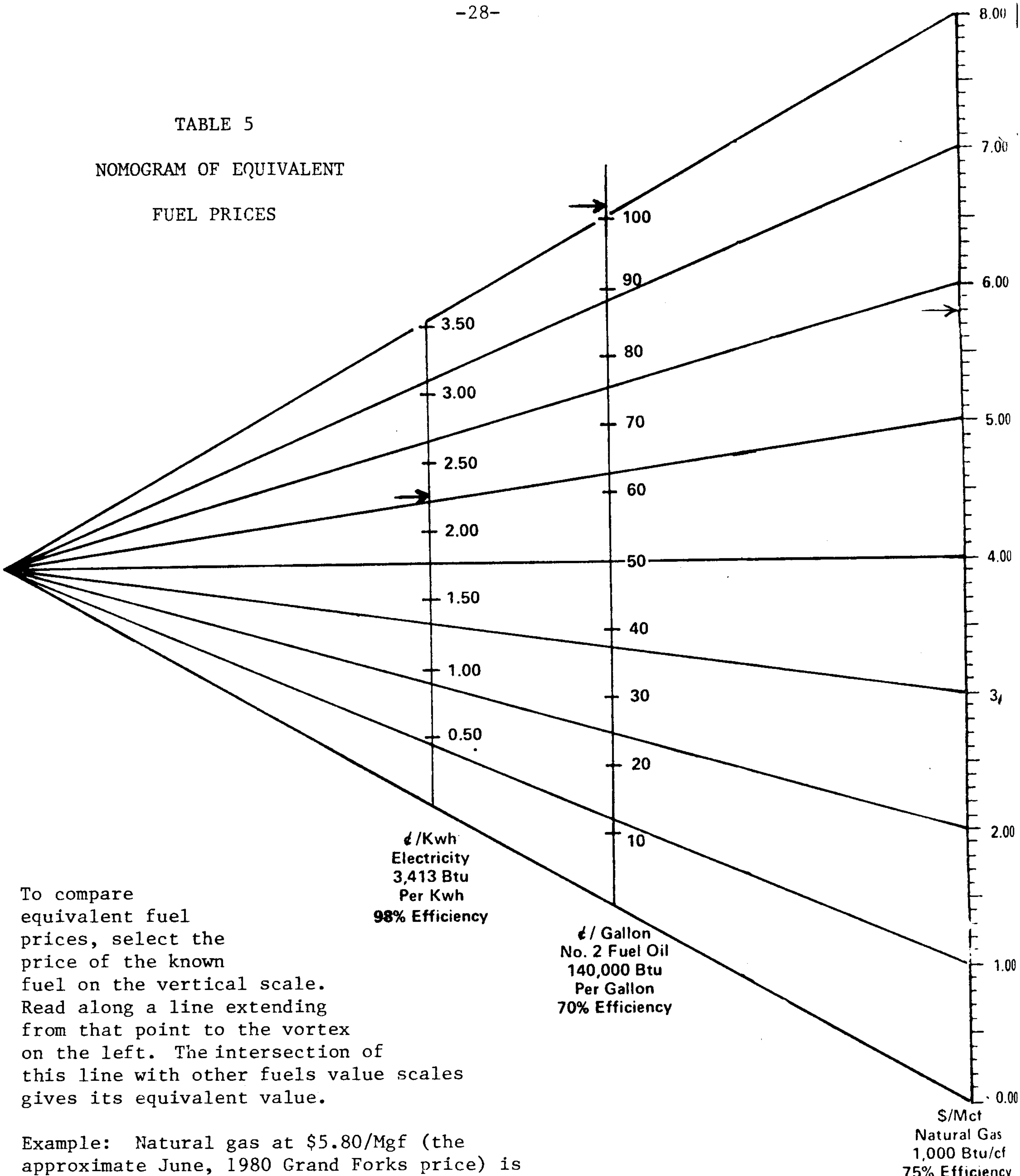


TABLE 5

NOMOGRAM OF EQUIVALENT

FUEL PRICES



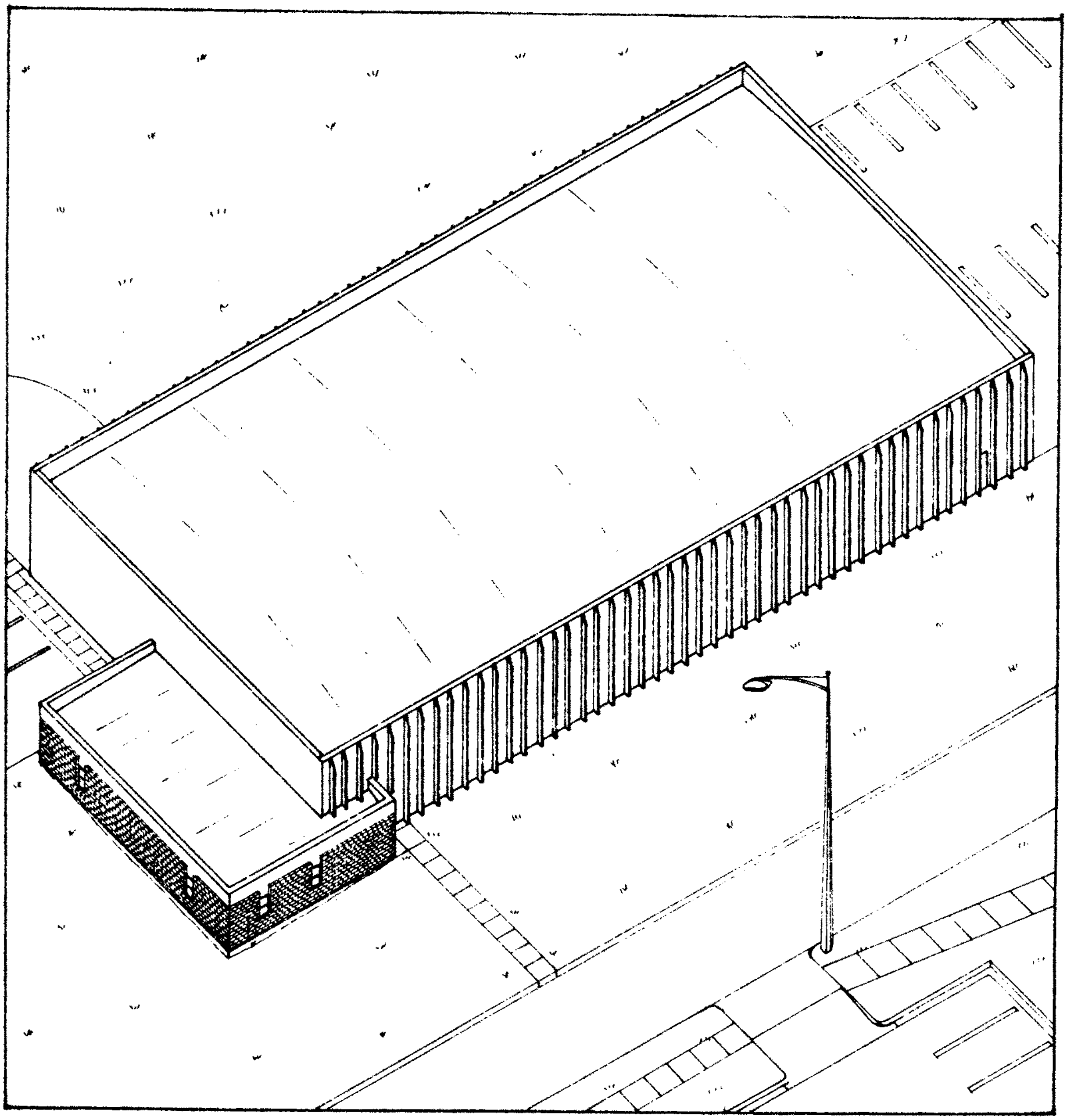
To compare equivalent fuel prices, select the price of the known fuel on the vertical scale. Read along a line extending from that point to the vortex on the left. The intersection of this line with other fuels value scales gives its equivalent value.

Example: Natural gas at $5.80/Mgf (the approximate June, 1980 Grand Forks price) is equivalent to fuel oil at $0.73/gallon or electricity at $2.60/Kwh. Actual prices in Grand Forks are currently about $1.00/gallon for fuel oil and $2.00/Kwh for electricity used in heating--other electricity is about $3.46/Kwh.

WILSON M. LAIRD CORE AND SAMPLE LIBRARY--

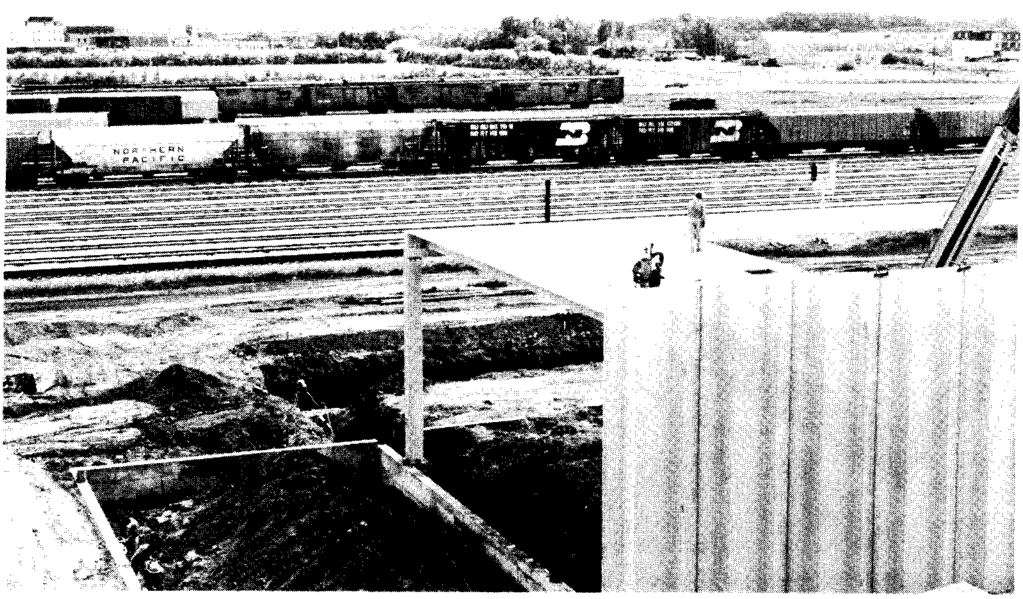
Construction is progressing rapidly on the new Core and Sample Library, located just across the street from our main offices. The pre-cast concrete structure will provide over 18,000 square feet of storage space and 2,000 square feet of laboratories and office space. We hope to be able to move our core and samples into it by the end of the year, in time for the visiting geologists to study them this winter in heated comfort. The building will be dedicated on Friday, October 3, 1980.

The accompanying pictures show construction in progress on the building during late June, 1980.

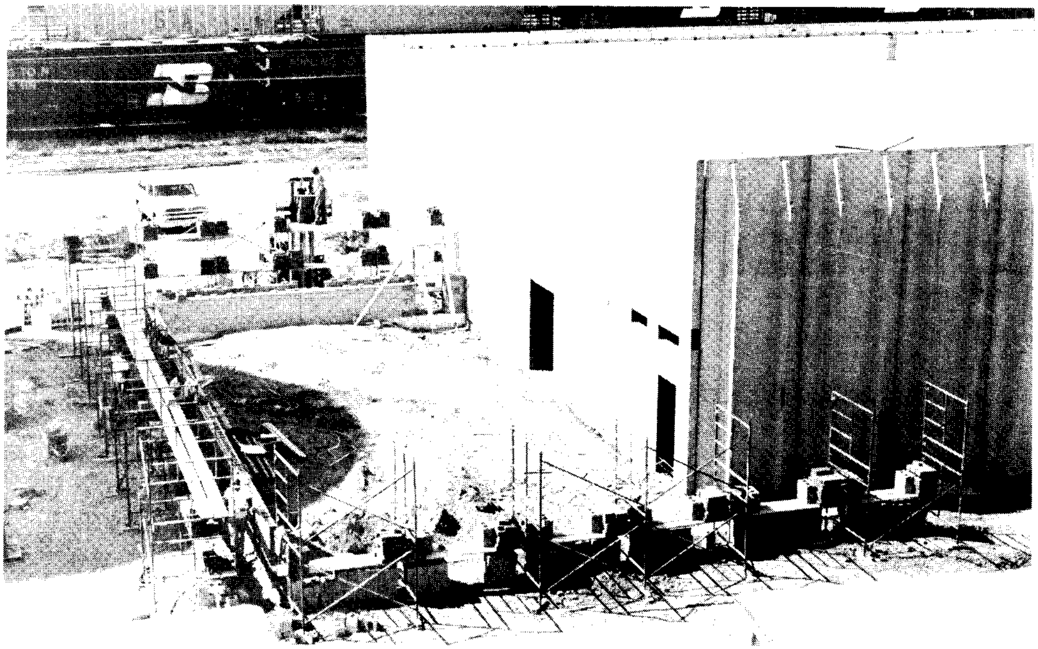


Wilson M. Laird Core and Sample Library

Construction underway on June 16, 1980



Construction underway on June 18, 1980



Construction underway on July 3, 1980.

MISCELLANEOUS NOTES--

We are installing a new compact filing system for our log library. The new system should help to alleviate some of our space problems and make the logs more easily accessible. The logs, which are now in filing cabinets, are threatening to burst out of the room. With the new system, much more space will also be available for studying the logs. A similar system being installed in our vault will be used to store our complete well file.

The Survey has a new copy machine, a GAF Print Vac, for copying maps and other large materials. The new machine is much more compact than the old one, requires no warm up, and produces a high-quality, blue-line print. It replaces our old copy machine which, because it required a long warm-up period, was run only once a day or less often. The old machine occupied an entire room, an office that is now being used by a geologist.