NDGS NEWSLETTER

Industrial Commission of North Dakota
North Dakota Geological Survey

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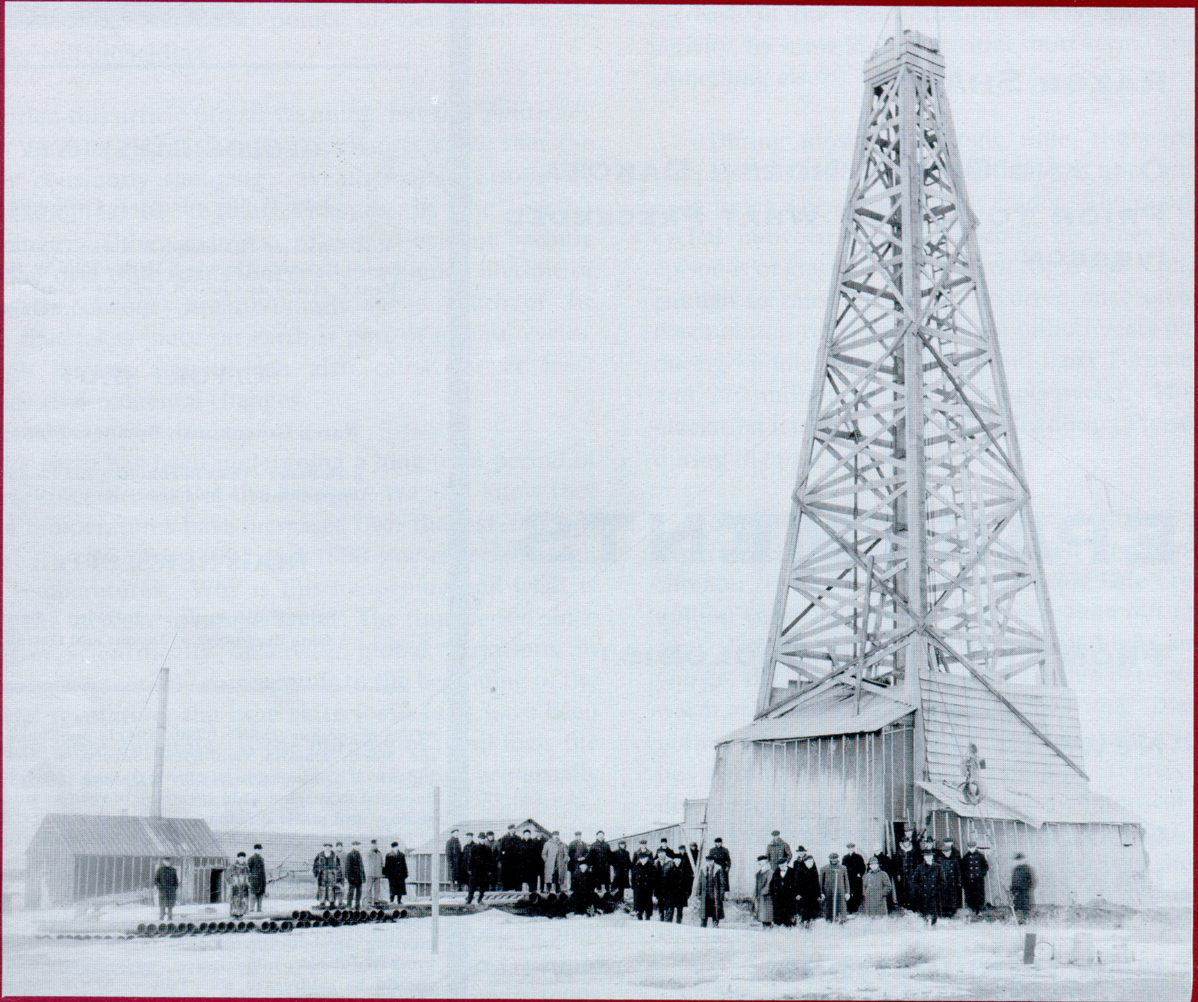

Spectators gathered around a drill rig near Des Lacs, North Dakota, circa 1915.
"Oil and Gas in North Dakota prior to 1951" is featured on page 14.

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FROM THE STATE GEOLOGIST

By John. P. Bluemle

In this issue of the *NDGS Newsletter* I want to comment on the concept of global warming and the so-called greenhouse effect. It's a "hot" topic, a kind of "buzz word" guaranteed to elicit a lively reaction from either an environmentalist or an industrialist. Unfortunately, in both instances, that reaction is likely to be extreme and the respective points of view tend to be opposing and unyielding.

I titled this article Global Warming, but the "politically correct" term is global change. Geologists know that the earth is constantly changing. Weather and seasons are clear examples of regular changes in the earth's environment. Other changes are not so evident because they occur over time spans longer than a human lifetime or because the changes are not easily seen. Much of the change that takes place on earth is part of natural cycles, although human activity can also cause, or at least influence environmental changes.

The earth has been undergoing a long-term period of warming since the end of the Ice Age. We also know that average temperatures have increased over the last hundred years or so - the years 1981 and 1990 saw especially high global temperatures. Why is this happening and what is causing the increase in temperature? The time period since we began scientifically observing global variations in temperature essentially corresponds to the beginning of the industrial revolution, the time since fossil fuels have been burned in large amounts. Is the burning of fossil fuels the main reason for the warming? That's what we are usually told.

We commonly hear that global warming is being caused by human activity, by carbon dioxide (CO_2) being produced by the burning of fossil fuels such as coal, by auto exhaust emissions, etc. This is the way most people understand the problem and it is the way the media tends to present the idea. The earth is often compared to a gigantic greenhouse. Energy in the form of sunlight passes through the atmosphere. Some of it strikes the land and water and is reflected back into space. Most of the rest is absorbed by the land and water, converted to heat, and radiated into the atmosphere. This radiated energy is mostly absorbed by CO_2 and other atmospheric gases, which act much like the glass in a greenhouse, warming the atmosphere.

According to the "greenhouse effect" theory, increasing levels of CO_2 in the atmosphere will trap more and more heat, raising the planet's overall temperature and affecting regional climates, sea levels, distribution of arable land, animal and human habitats, and more.

For about the last 40 years, the average concentration of CO_2 has risen about 40 parts per million (as measured on top of Mauna Loa, a 13,700-foot volcano in Hawaii). Is this increase in the concentration of CO_2 caused by human activity, by some kind of natural short-term variation, or by something else?

During most of geologic time, the earth's average temperature has been warmer than it is now, but there have been times when it was much colder. The temperature has cycled between warm and cold, at times so cold that episodes of glaciation have been triggered. Conditions cold enough to cause glaciation occurred once or more during Precambrian time, more than a billion years ago, and also during Middle Pennsylvanian and Early Permian time (300 and 270 million years ago, respectively). More recently, glaciation has occurred repeatedly during Pleistocene time, during the past two million years.

Similarly, we know that the earth has periodically experienced periods of pronounced greenhouse (warm) climate. Two of these occurred during Late Cretaceous (70 million years ago) and late Eocene time (40 million years ago). I could go on, reciting previous highs and lows, but you get the idea. The climate has cycled between periods of warm and cold throughout geologic time. During the last million years or so, the basic rhythm of the cycle seems to be about 100,000 years, though there have been divergences, and the cycle is not symmetrical as the cold typically takes a long time to build up, while the subsequent recovery to warmth is relatively short. We also know that the climate can flip-flop quickly from temperate to glacial conditions.

We are currently emerging from the most recent glacial episode, the Late Wisconsinan Epoch, which resulted in much of North Dakota being covered by glaciers. The coldest temperatures associated with the Late Wisconsinan glaciation probably occurred between about 18,000 and 15,000 years ago, a time when glaciers covered much of North Dakota and other parts of the earth's surface. Sea level was at its lowest level then because so much of the earth's water was tied up as ice. About 40,000 years ago, prior to the Late Wisconsinan glacial maximum, temperatures were as warm or warmer than they are now. Sea level was as high then as it is now. Prior to that, during Early Wisconsinan time about 70,000 years ago, temperatures were probably colder and glaciers were more widespread than they were during the Late Wisconsinan glaciation. Before that, 120,000 years ago, prior to the next-to-the-last glacial maximum, sea levels were higher than they are today (and temperatures were even warmer).

Since about 15,000 years ago, temperatures have been rising, although not necessarily at a steady rate. For example, during the "altithermal" interval (the time of maximum temperature - the so-called "thermal maximum") temperatures were generally considerably warmer than they are today. The altithermal interval occurred between about 7,500 and 4,000 years ago. North Dakota was much drier and warmer during most of that time, nearly a desert.

What causes the earth's temperature and climate or the climate of any particular area such as North Dakota to fluctuate between such extremes? There are a variety of factors and I won't go into many of them here. One of them relates to the frequency and severity of volcanic eruptions, which spew large amounts of dust and gas into the atmosphere. On June 15, 1991, Mount Pinatuba (a volcano near Manila in the Philipines) erupted. Two months later, the space shuttle Atlantis sailed above the dirtiest atmosphere ever documented. The dust took several years to dissipate.

Another longer-scale factor affecting climate is continental drift which can move any given area on the earth's crust from the equator to the poles. North Dakota's climate over the past couple of hundred million years has generally become cooler as the state has moved from the equator to higher latitudes. Furthermore, when a continental area is situated over a polar region, such as Antarctica is today, the whole earth tends to experience a more extreme climate and repeated glacial conditions.

Are global warming and the greenhouse effect a result of the industrial revolution when we began burning large amounts of coal, oil and gas? Are auto emissions and all the rest causing a change in the climate? Possibly in part. But to insist, as some people do, that human-induced factors such as these are responsible for most of the changes in climate is to ignore the overall, natural cycles that the earth undergoes. Our modern, post-glacial climate is almost entirely the result of natural, long-term warming as we emerge from the last ice age (or, perhaps, as we enjoy a brief respite from the glacial conditions that may return soon!).

I noted at the beginning of this article that the people holding opposing points of view (whether most of the global change/warming is being caused by human action or by natural factors) tend to be dogmatic and unyielding. To quote from one of the papers I read before writing this article, "those who hold that increasing carbon dioxide [caused by man's action] should cause a period of global warming, but one probably smaller than the estimates which have commonly been accepted" represent a "small but vocal band of anti-greenhouse 'contras' who are, in the main, ill-informed and ideologically motivated." In other words, if you question my point of view, there must be something wrong with you. I wonder who it is that is really more ideologically motivated?

We have a saying in North Dakota, "wait a day and the weather will change." As a geologist, I suggest instead, "wait a few thousand years and the climate will change."

So, in closing, the lignite we burn to make electricity in North Dakota, the gasoline we consume in our travels, the natural gas with which we heat our homes - are these significant contributors to global warming? This question remains unanswered, but such human-induced factors probably pale compared to much larger global forces such as volcanic eruptions, movement of the continents, and other natural phenomena that have brought about massive and repeated heating and cooling throughout the earth's history.

Certainly, until someone comes up with a reasonable alternative, we have to rely on our energy resources. It isn't logical to stop using them or to restrict their use unreasonably. We should be thankful that North Dakota is blessed with an abundance of clean coal, oil, and gas.

NEWS IN BRIEF

Compiled by Ann M.K. Fritz

Various Meetings Attended

John Bluemle, State Geologist, attended the annual meeting of the Geological Society of America (GSA) in Denver in late October. Held in conjunction with this were meetings of the Association of American State Geologists and the annual meeting of the North American Commission on Stratigraphic Nomenclature. John also addressed the 1996 Annual Meeting of the North Dakota Association of Soil Conservation Districts in Fargo on November 19.

Randy Burke also attended the annual GSA meeting in Denver as well as the annual Society of Exploration Geophysicists meeting where he was invited to present a paper on the Lodgepole play.

John Hoganson attended the annual meeting of the Society of Vertebrate Paleontology in New York City, NY, in October. He co-presented a paper with J.M. Erickson and F.D. Holland, Jr. titled "Vertebrate Paleontology of the Timber Lake Member, Fox Hills Formation (Maastrictian), North Dakota".

Fritz Joins Survey

Ann Fritz recently joined the North Dakota Geological Survey staff as our new Geologist. Her duties include geologic mapping and editing the newsletter. Ann is a native of St. Paul, Minnesota, but has lived for the past two years in Madison, Wisconsin, where she was completing her Master's Degree in Geology. Prior to entering graduate school at the University of Wisconsin, she was employed as an environmental consultant in Minneapolis. Ann and her husband, Greg, who is a native of South Dakota, are happy to be living in the Dakotas where "the trees don't get in the way of the spectacular views ".

New Oil Plays

By Paul Diehl

While most of the exploration attention in North Dakota in the past two to three years has been focused on the Lodgepole "mound" play, other significant plays have been quietly taking shape. Two such plays are the Red River Formation B horizontal well play in Bowman County and the recent re-entry and completion of a Cambrian Deadwood Formation sand well in Renville County near the Canadian border.

The Red River "B" horizontal play sprang to life with the completion of the Burlington Resources Oil and Gas Company (then Meridian Oil Co.) Larkin 14-18H in Section 18 T131N R105W. Through September 1996, the Larkin 14-18H had produced 122,652 barrels of oil (BO) and 14,720 barrels of water (BW)*. Having started in Bowman County, the play has expanded to the north into the western portions of Slope County and into South Dakota to the south. By the end of September 1996 there were 92 productive Red River B horizontal wells in the Cedar Hills Red River B Field. Three dry holes have been drilled. Cumulative field production through September 1996 stood at 3,826,000 BO and 1,407,000 BW with approximately 470,000 BO* having been produced in the month of September. Conservative estimates of ultimate recovery is currently at about 500,000 BO per section although operators in the play have suggested the ultimate recovery may be as much as 800,000 BO per section. Since late 1994, there have been 492 drilling locations permited*. In November 1996 seven rigs were active in the Cedar Hills Red River "B" Field; earlier in the summer and fall as many as 13 rigs were running.

Another significant development has been the re-entry and recompletion of a formerly plugged and abandoned well in Newporte Field, Renville County. Eagle Operating, Inc. re-entered the old Shell Oil Co. Larson 23X-9 well in Section 9 T163N R87W and perforated Deadwood Formation porous sands in the interval from 9552' to 9592'. According to the Rocky Mountain Oil Journal, the well flowed naturally at an initial rate of 1025 barrels of oil per day (BOPD) on a 24/64" choke. Reported flowing tubing pressure was 700 psi, with shut-in tubing pressure of 2600 psi.

In the period of November 1977 through February 1978, Shell Oil Co. tested all but the uppermost eight-foot sand and squeezed all but five feet of perforations at the base of the sand interval. Shell reported gas-oil ratios as high as 24,000:1. The Shell well produced 13,497 BO and no water before it was plugged and abandoned in 1980. Although the re-entry well won't be released from confidential status until December 3, 1996, NDIC Oil and Gas Division production reports show it has produced 37,112 BO from June through September 1996 averaging about 250 BOPD for the month of September. Perhaps this successful re-entry points to the oil potential of the little-explored Deadwood Formation in North Dakota. With the Deadwood sands having been deposited on the irregular Precambrian surface, the existence of stratigraphic as well as structural traps should be expected.

* Data provided by the North Dakota Industrial Commission Oil and Gas Division.

The "Birth" of a Concretion

By Robert F. Biek

One of the simple joys of fieldwork, and especially of geologic mapping, is that I am constantly faced with new exposures and new rocks to study. These glimpses into the geologic past are like newly found pieces of a puzzle - a puzzle that is missing far too many pieces to begin with and for which there is no picture but the one that is constantly evolving in my mind, but a puzzle nonetheless. Once in awhile, I stumble across an important piece that holds more information than its size would suggest. Other times, the piece of the puzzle is simply a detail of the background, an ornament that gives authenticity to the picture.

Last fall I stumbled across one such "ornament" in the North Unit of Theodore Roosevelt National Park. I was working on a geologic map of the park, struggling to complete my work before the land was buried under the season's first snow. What I found was an unusual cluster of three-foot diameter sandstone concretions commonly called "cannonballs." The cannonballs were eroding out of a gray, crossbedded, fine sandstone that belongs to the Paleocene-age Sentinel Butte Formation. The sand itself was probably deposited in a river channel that, about 60 million years ago, meandered across a forested alluvial plain not unlike those of coastal Louisiana today.

These particular cannonball concretions are not uniformly cemented, but consist of alternating layers of well cemented and poorly cemented sandstone. A hole in the outer shell of one concretion revealed a "concretion within a concretion" and looked for all the world like an oversized hard-boiled egg.

Concretions form by the selective precipitation of minerals, such as calcium carbonate, from groundwater. Often the concretions have a nucleus of organic matter, such as a shell or plant fragment, upon which crystallization is initiated. The concretions are nearly spherical because the sandstone in which they are formed is of uniform permeability. Had impermeable layers constrained the movement of groundwater, the resulting concretions would likely be elongated in the direction of groundwater flow.

For those who are interested, we hope to have the 1:24,000 scale geologic map and report of the park available sometime in 1997.

More Concretions

By John P. Bluemle

I had a call in September from Peter Elichuck, who is mayor of Wilton, North Dakota. He asked about an unusual rock formation -- a monument -- that was recently placed at the south side of Wilton, in front of the *"Welcome to Wilton"* sign (see photos). I stopped to look at the monument one afternoon on my way through town. It consists of a nest of intergrown sandstone concretions. At first glance, the concretions appear to be individual bodies stacked against one another, fitted and cemented into a curious conglomerate. However, closer inspection reveals that the thing is really a single body, with sandstone bedding that cuts nearly horizontally through the whole thing.

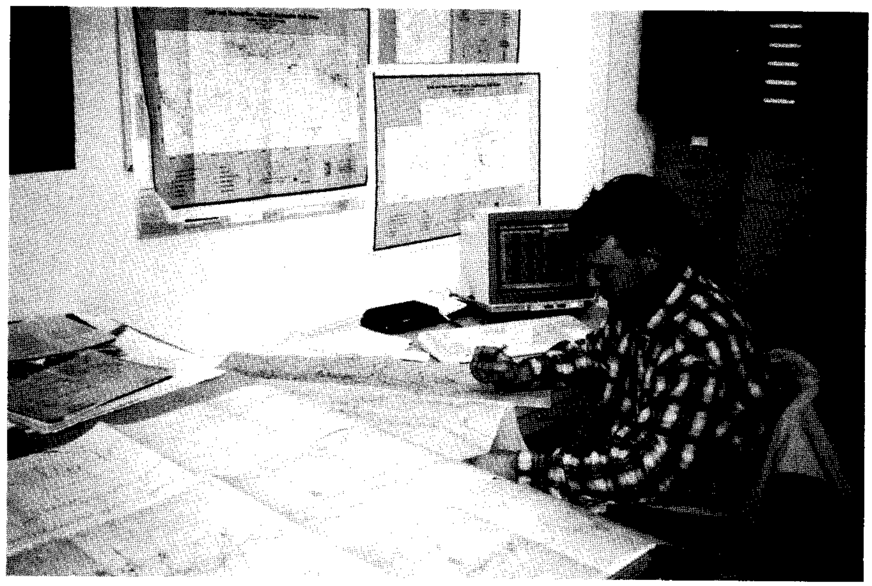
The monument rock was found several miles north of Wilton and probably formed within sandstone of the Bullion Creek Formation, which is Paleocene in age, about 55 million years old. However, the concretions themselves may have formed then or at any time since then, at some time when groundwater was circulating through the porous sandstone.

Apparently, the individual semi-spherical concretions grew through and across the original horizontal sandstone bedding; the bedding did not affect how they grew.

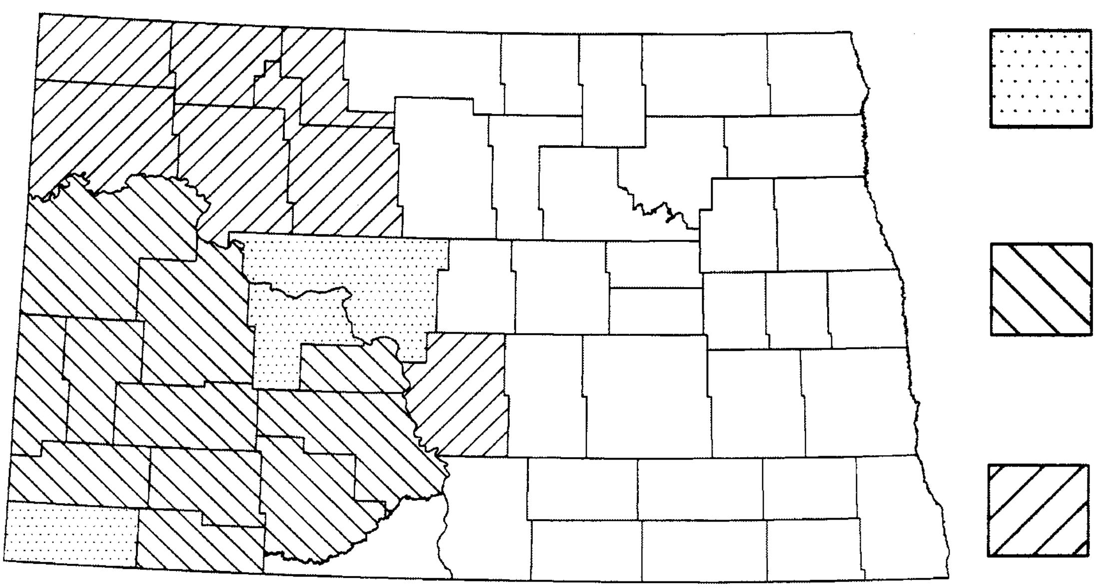
North Dakota Geological Survey Awarded NCRDS Grant

By Edward C. Murphy

The North Dakota Geological Survey was recently awarded a two year grant from the U.S. Geological Survey through their National Coal Resources Data System (NCRDS). The grant will enable us to enter geologic information from over 20,000 electric logs from our coal and subsurface mineral programs onto a computer spreadsheet. Placing this data into the computer will enable us to respond more quickly to public inquiries concerning the presence or absence of coal or other minerals on private and public lands. It will also enable our agency to revise the 40-year-old estimates of lignite resources and reserves of North Dakota. This NCRDS grant complements the National Coal Assessment Program, a cooperative NDGS/USGS project that we have been involved with for the last two years. Falkirk Mining Company, Coteau Properties Company, Knife River Coal Company, and BNI Coal are participating in both of these programs.



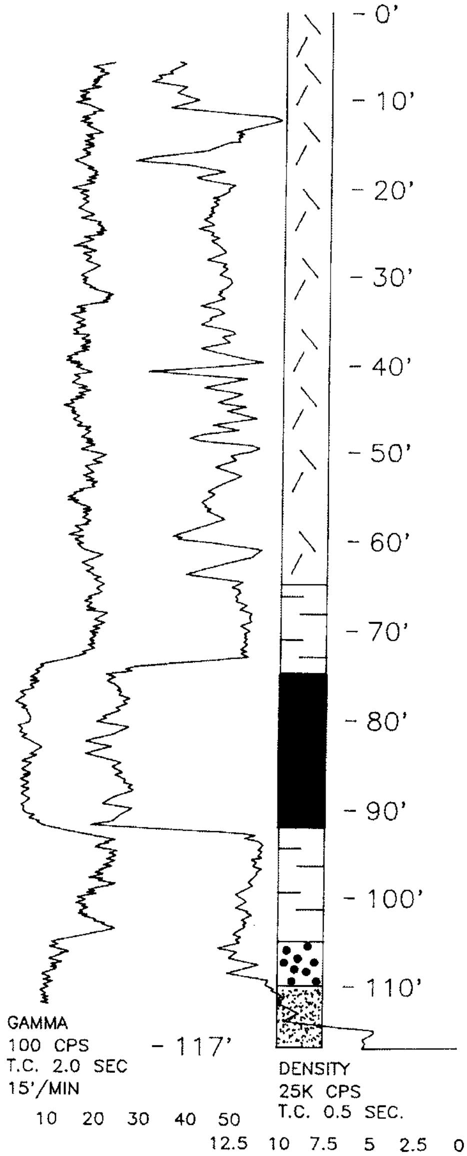
Gerard Goven (pictured at right), a native of Turtle Lake and a recent graduate of the Department of Geology and Geological Engineering at the University of North Dakota, has been hired to help transfer the geologic data onto the computer. Gerard gained valuable experience in coal geology while working with Terry Rowland and Eileen Hertel, Coteau Properties Company, at the Freedom Mine near Beulah.



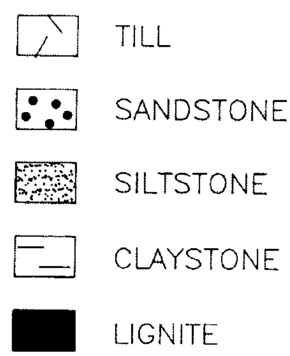
All subsurface data for these counties was entered into the National Coal Assesment (NCA project during 1995 & 1996.

Counties from which drillhole data is proposed to be entered into the NCRDS during October, 1996 - September, 1997.

Counties from which drillhole data is proposed to be entered into the NCRDS during October, 1997 - September, 1998.



The first required step is to interpret the geology from the electric logs. After this has been completed, the tops and bottoms of each lithologic unit are entered onto the computer spreadsheet.



Computer Spreadsheet

PntId	Stateplane n	Stateplane e	Elevation	TD	Quad	County	Province	Coal Field	Collector	Source	Data Type	Collected	Top. Interc	Btm. Interc	Thickness	Lith Code
M7866	636356	1690617	2035.7	120.0	BEULAH N	MERCER	N GREAT PLAINS	WILLISTON BASIN	GOVEN	COTEAU	201	1978	0.00	65.00	65.00	TILL
M7866	636356	1690617	2035.7	120.0	BEULAH N	MERCER	N GREAT PLAINS	WILLISTON BASIN	GOVEN	COTEAU	201	1978	65.00	75.00	10.00	CLST
M7866	636356	1690617	2035.7	120.0	BEULAH N	MERCER	N GREAT PLAINS	WILLISTON BASIN	GOVEN	COTEAU	201	1978	75.00	93.00	18.00	COAL
M7866	636356	1690617	2035.7	120.0	BEULAH N	MERCER	N GREAT PLAINS	WILLISTON BASIN	GOVEN	COTEAU	201	1978	93.00	105.00	12.00	CLST
M7866	636356	1690617	2035.7	120.0	BEULAH N	MERCER	N GREAT PLAINS	WILLISTON BASIN	GOVEN	COTEAU	201	1978	105.00	110.00	5.00	SS
M7866	636356	1690617	2035.7	120.0	BEULAH N	MERCER	N GREAT PLAINS	WILLISTON BASIN	GOVEN	COTEAU	201	1978	110.00	120.00	10.00	SLST

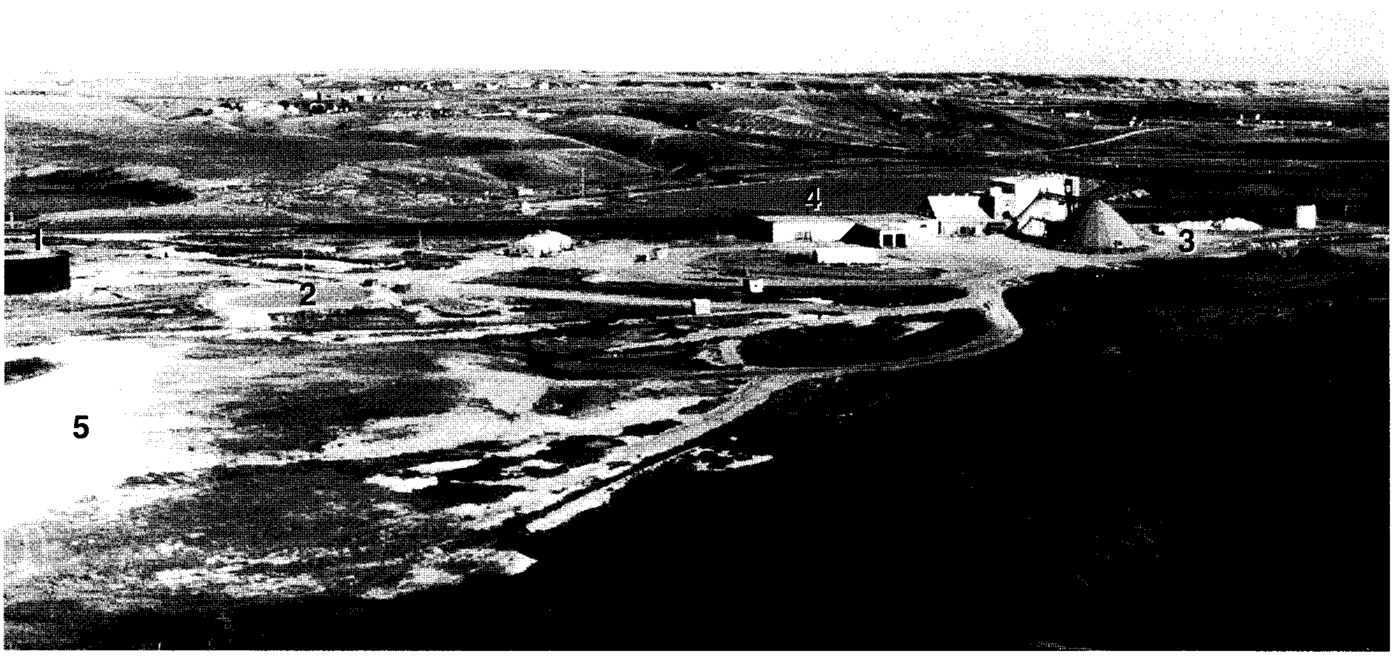
Salt Plant in Williston

By Edward C. Murphy

The Dakota Salt and Chemical Company began operating a brine solution mine on 300 acres just east of the city of Williston in 1960. The facility produced salt by injecting water into evaporites in the Charles Formation at a depth of 9000 feet and pumping the resulting saturated brine through a series of withdrawal wells. The brine was then processed through a multi-effect evaporator and the resulting crystallized salt was dewatered, dried, and packaged. The plant produced several products; the brine was used by the oil industry, and the salt was used for table salt, pellets for water softeners, and salt blocks for livestock. Over the life of the facility, approximately 1.3 million tons of salt were produced. As a result of company buyouts and mergers, the facility has been owned and operated by Hardy Salt (1972-1985), Diamond Crystal Salt Company (1985-1987), International Salt Company (1987-1988), and Akzo Salt Company (1988-present). The plant ceased operation in 1988.

The salt plant was regulated by the Geological Survey under the State's Subsurface Mineral Program (NDCC 38-12) and later by our agency under the Class III (solution wells) portion of the State's Underground Injection Control Program. The state Health Department also had broad jurisdictional powers over operation of the site under their mandate to protect the waters of the state (NDCC 61-28). For several years, Steve Tillotson (Health Department) and I discussed our concerns for potential salt degradation of the shallow groundwater and Stony Creek in the vicinity of the plant site. Most of our concerns were focused on a large salt waste dump located in an abandoned meander of Stony Creek and several saltwater impoundments at the facility. The salt dump contained a mixture of contaminated salt, broken salt blocks, floor sweepings, sulfates, office garbage, etc. In addition, an eight-acre cooling pond containing elevated chloride levels was suspected to be leaking into the shallow groundwater. To address these concerns, the North Dakota Geological Survey installed 15 monitoring wells in and around the salt facility and took numerous water samples of Stony Creek in the summer of 1987. Unrelated to this monitoring effort, the salt facility was shut down by Akzo Salt Company in the fall of 1988.

During the summer of 1989, the Survey oversaw the closure and cleanup operations of the site as all of the salt and salt-contaminated soil from the waste impoundments were removed. An additional cleanup task was performed by the reworking of one of the Charles wells. Water from the cooling pond and underlying shallow aquifer was injected into the Dakota Group at 5400 feet. Over the next 6 months approximately 22 million gallons of cooling pond water and degraded



The salt plant in Williston under operation by Diamond Crystal Salt in the summer of 1986. Photo taken looking southeast, Stony Creek is in the foreground. The following were removed during closure and cleanup: 1) large tanks, 2) brine pit, 3) sulfate pit, 4) the cooling pond, and 5) the salt dump.

The Akzo salt plant in Williston following completion of closure in the spring of 1996. A fire that winter severely damaged the main building.

groundwater were injected into the Dakota (the horizon into which most oil field brines are injected in the Williston Basin). During this time, chlorides in the groundwater beneath the cooling pond decreased from 40,000 to 16,000 mg/l. Unfortunately, the Dakota Group in this area is not very permeable (containing only a few thin sandstone beds) which resulted in injection pressures exceeding those allowed under the company's Class 1 UIC permit and injection had to be discontinued.

Although the majority of the cleanup had gone smoothly, one issue, the final disposition of the salt pile, remained to be resolved between Akzo Salt and the state. For the last seven years, the Geological Survey, Health Department, and the North Dakota Attorney General's Office jointly negotiated with Akzo Salt to remove the pile in an effort to avoid court proceedings. These drawn out negotiations were the result of two different scientific interpretations of the geotechnical and geochemical data and an ensuing debate about where the cleanup dollars would do the most good. The company agreed to remove the 46,000 tons of waste salt and salt-contaminated soil at the salt dump after countless hours spent collecting and analyzing environmental data from the site; reviewing geotechnical consultant reports; meetings with the company, other agencies, and the Industrial Commission; conference calls; and correspondence. As a result, by the spring of 1996, all of the requirements of the Subsurface Mineral permit had been fulfilled and the performance bond covering the site was released.

Initially, interest was expressed by several individuals for the purchase of the site to use the brine and geothermal heat from the Charles wells to run a brine shrimp operation or to utilize just the geothermal heat (220 to 240 degrees Fahrenheit) to run greenhouses or to heat a fish farm throughout the year. Several companies also expressed interest in storing natural gas in the 22 million cubic foot cavern within the Charles Formation. This cavern was created by the injection and removal of approximately 4 million barrels of brine over three decades of solution mining. Unfortunately, detailed work by at least one of the interested companies revealed several potential problems related to cavern stability.

The cleanup of the site cost Akzo hundreds of thousands of dollars but was necessary to protect both the surface water and groundwater in the area. Now that all waste has been removed from the plant area, it is hoped that a company will purchase and utilize this prime industrial site.

Razor Sharp?

By Mark R. Luther

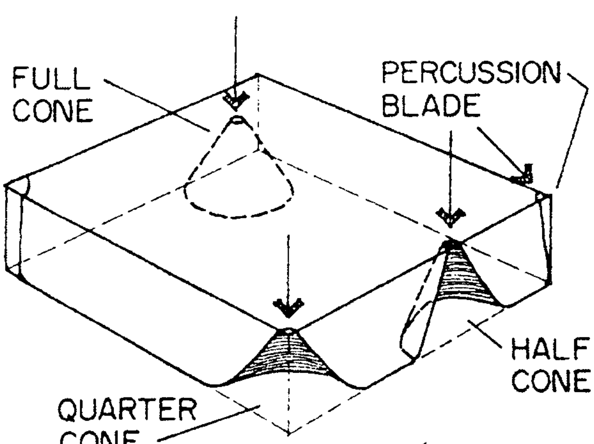
One often hears the term "razor sharp". This term usually conjures up the image of a modern, steel razor blade, the ultimate in sharpness or cutting capability, or just the ultimate of something, period. However, I'm not sure the facts support the image associated with this term.

In general, the redefinition of terms or standards is an ongoing process that has accelerated in modern times. For example, the term calculator once brought to mind the image of an abacus, and only a few years ago the image would have been of an adding machine. The same term, calculator, now brings to mind an image of an electronic, handheld calculator or computer. Typically, through time, we have seen improvement of performance in almost all things humans manufacture. These nearly continuous improvements, in turn, require a modification to existing standards, and thus an increase in what people expect or consider normal. To see if the term "razor sharp" follows this generalized trend of increasingly stringent standards through time, let's look at some ancestral razor blades (i.e. flaked-stone blades), and compare them to modern razor blades.

Flaked-stone tools, made from rocks or minerals that have the tendency to fracture in a conchoidal manner when force is applied to them, very likely formed the earliest cutting tools that humans used. Flaked-stone tools have been found associated with some of the earliest-man sites in Africa, and of course flaked-stone tools are commonly found at locations occupied by prehistoric American Indians (i.e. arrowheads and knives). In order to compare "ancestral" vs. "modern" razor blades, it is useful to understand the different technologies used to create them.

The most important characteristic that a rock or mineral needs if it is to be made into a flaked-stone tool is the tendency to fracture in a conchoidal manner. The word "conchoidal" itself is derived from the appearance of this type of fracture to the curvature of a conch shell. Unfortunately, most of us are all too familiar with conchoidal fractures, though we may not realize it - rock chips in our windshields! We are also inadvertent spectators to the mechanics of conchoidal fracture that allow the controlled shaping of stone, that is, the "cone of force".

Don Crabtree, one of the most renowned of the modern "flintknappers" - or people who make flaked-stone tools - did an enormous amount of work studying the physics involved in the controlled, conchoidal fracturing and flaking of stone. He stresses that one of the most important principles that must be understood before one can effectively knap (flake) stone, is the "cone of force" (cof). The principle of the cof on materials with properties of conchoidal fracture is illustrated in Figure 1a. When an object moving in the direction indicated by the arrow impacts a material with enough force to exceed the elastic limits of the material, a fracture in the shape of a cone will radiate through the material. This cof is what causes the "bulls eye" in your windshield when it is struck by a piece of



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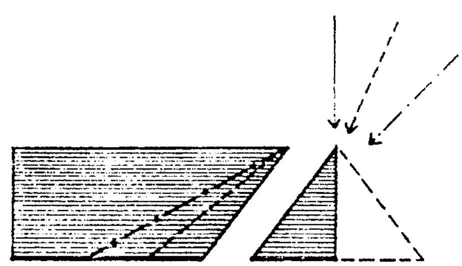
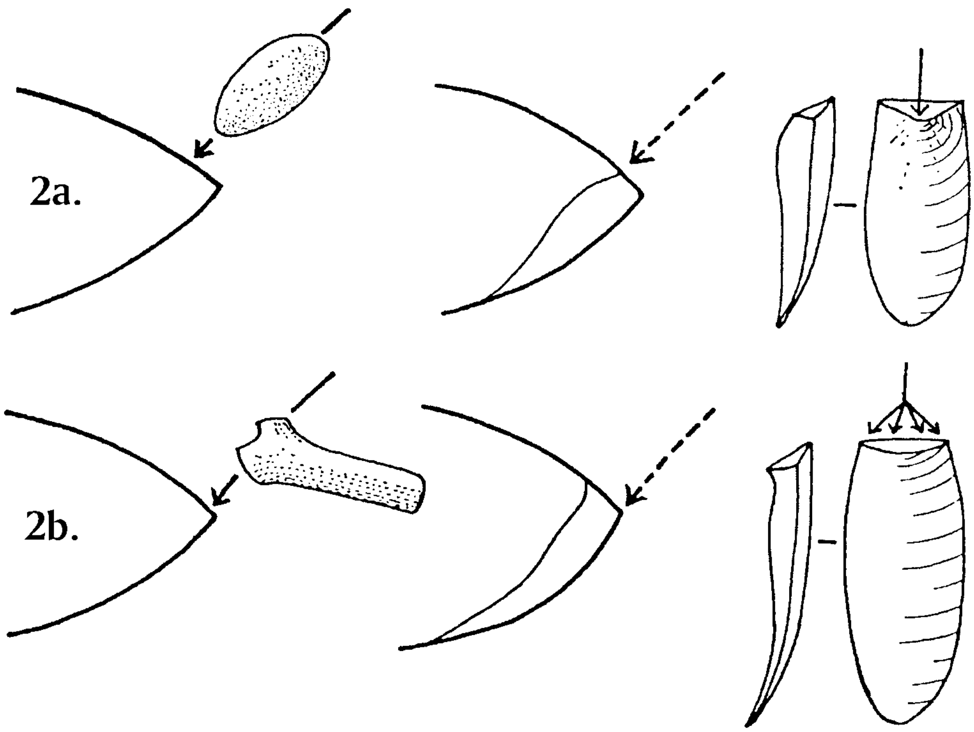


1b.



gravel. The principle of the cof fracture can also be observed when a piece of plate glass is hit by a BB, popping a uniform glass cone off the backside of the pane. If the force impacts the edge of the material, then a partial cone will be fractured and detached (Figure 1a).

By using the principle of cof, and varying the angle with which the force is imparted to the material (Figure 1b), flintknappers are able to remove (by conchoidal fracture) material (flakes) from a larger piece (core) in a controlled manner and thus shape and manufacture flaked-stone tools such as arrowheads and knives. As indicated in Figure 2a and 2b, the force typically consists of hitting the material with another material that doesn't itself fracture. This might be a piece of sandstone or elk antler.

In addition to conchoidal fracture, other important material considerations for creating flaked-stone tools include hardness, lack of cleavage, and homogeneity of the rock or mineral. The widespread mineral quartz, and rock derivatives of quartz such as chert, chalcedony, flint, and quartzite, all typically have the characteristics needed to make flaked-stone tools. Other regionally important rocks used for flaked-stone tools are the natural glasses associated with volcanoes, such as obsidian and ignimbrite, which though lacking the hardness of the quartz-based materials, were extensively used because of their ease of flaking.

Now, I said I would discuss the different technologies used to create ancestral versus modern razor-blades. The discussion about "cone of force", conchoidal fractures, and flintknapping leads to this: ancestral razor-blades were created by a cone of force fracturing and detaching a stone flake or blade (Figure 3c) from a larger stone core (Figure 3b). The edges of the freshly detached stone blade do not require any further sharpening as they are as sharp as they will ever be (anyone who has broken a glass knows this!). Modern razor-blades, on the other hand, are made with a hardened steel alloy that is ground against an abrasive surface until a sharpened edge is created. Which is sharper?

Don Crabtree knew, which is why he made the obsidian blades that a surgeon used during his successful open-heart surgery. Don knew from experience (as does any flintknapper cut while knapping) that cuts made with the extremely sharp edges of flaked-stone blades seem to heal much faster than cuts made by metal objects. Of course, that is just empirical evidence that flaked-stone is sharper than steel. To really prove it, I used a Scanning Electron Microscope (SEM) to study the edges of flaked-stone blades that I knapped from three different kinds of stone, and the edges of an unused, modern disposable razor blade. It is now obvious to me why after-shave lotion became a necessity to modern man!

The four SEM images (Figures 4-7) show the sharp edges of the blades at a magnification of 1000 times. Figure 4 illustrates the edge of a never used, modern, disposable-razor blade. The other three images (Figures 5-7) are of the edges of flaked-stone blades. I have to admit that I was shocked at the difference in sharpness between the modern and ancestral razor blades. The metal razor blade is rough, jagged, and looks like a dull saw blade compared to the sharp, stone blades!

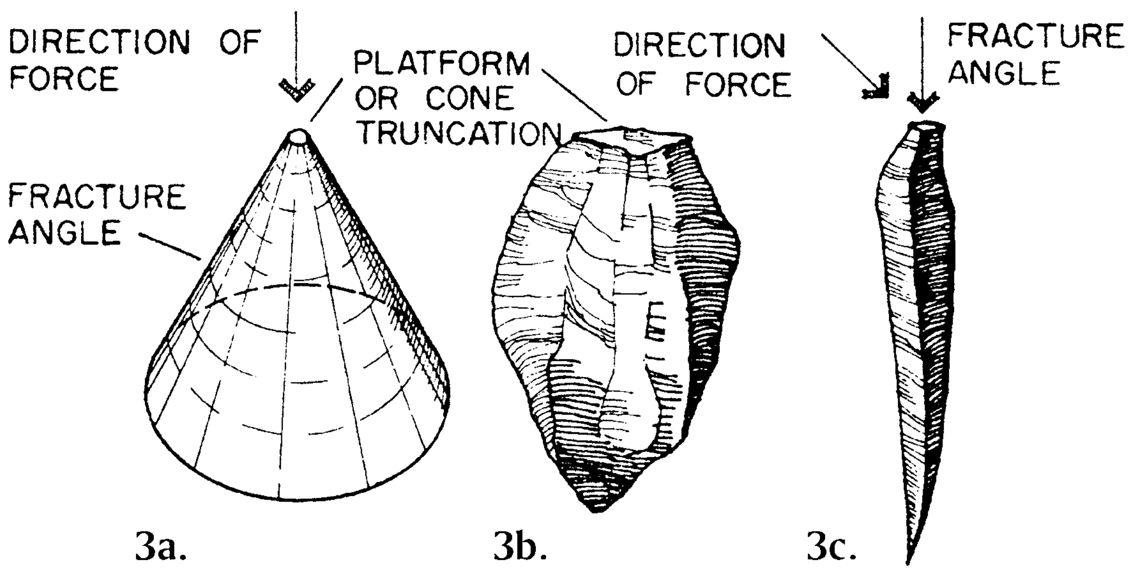
Anyway, back to the original question: Does the image of a modern razor blade now support the term "razor sharp" as being the ultimate in sharpness or cutting capability, or just the ultimate of something? Not in my mind! A more supportive image of the term "razor sharp" might be the image of a bear-skin clad person sitting in a cave with a newly manufactured flaked-stone blade in hand. That's the sharper image!

Reference

Crabtree, Don E., 1972, The cone fracture principle and the manufacture of lithic materials: Tebiwa, v. 15, no. 2, p. 29-42.

Acknowledgment

I would like to thank Microbeam Technologies Inc., Grand Forks, North Dakota, for the use of the SEM image of the modern razor blade.



3a. 3b. 3c.

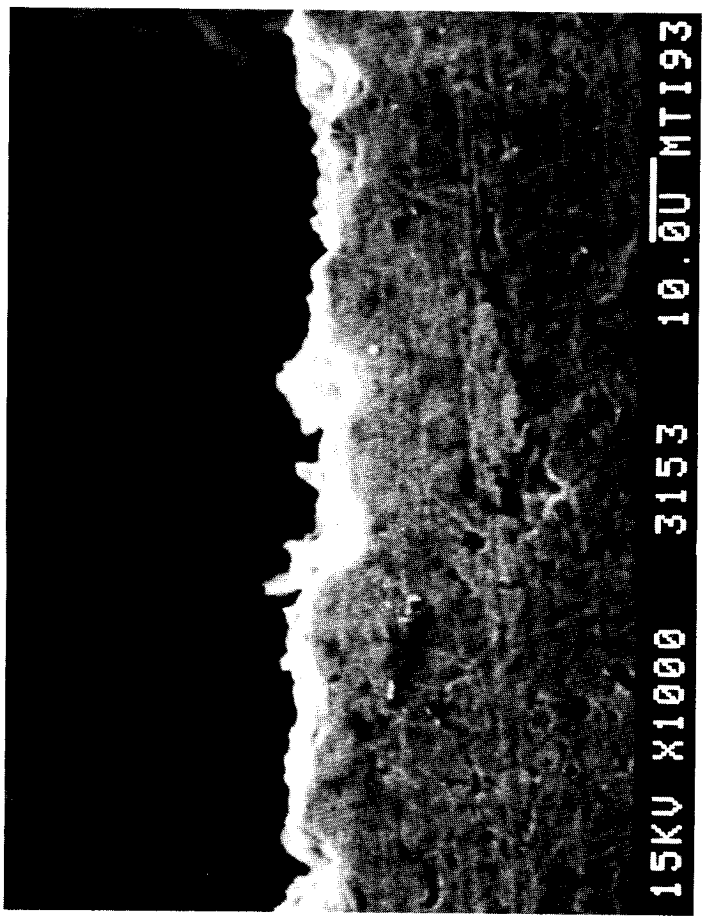


Figure 4 (top)

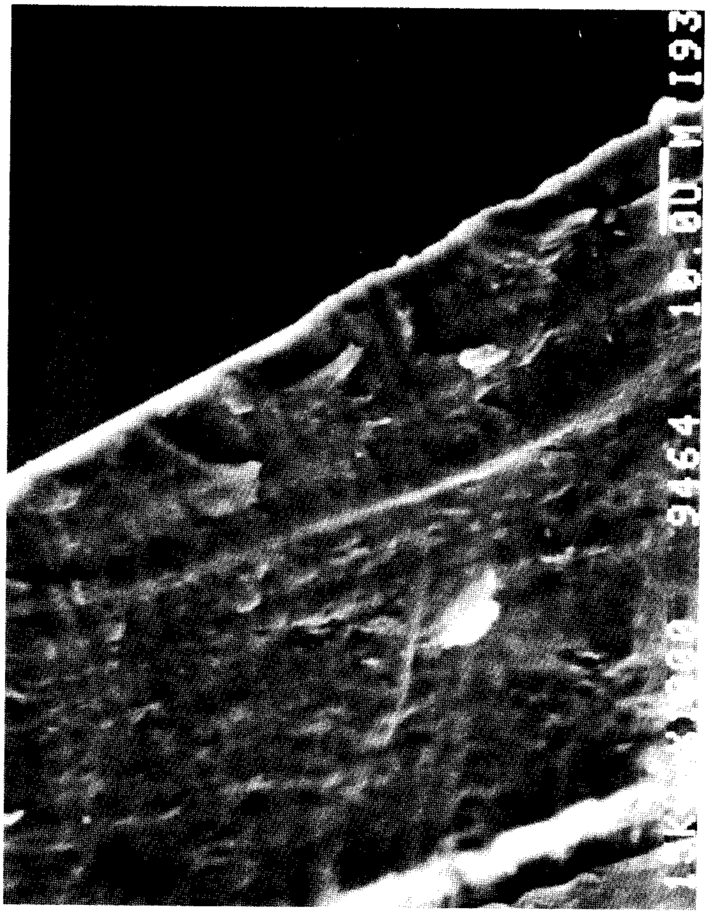


Figure 5 (top)

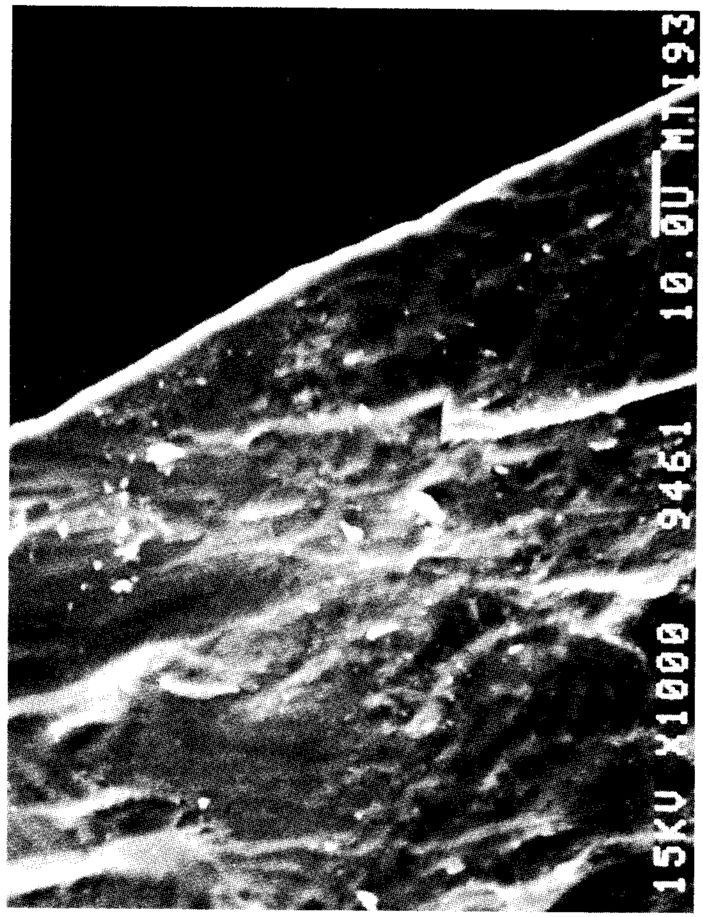


Figure 6 (bottom)

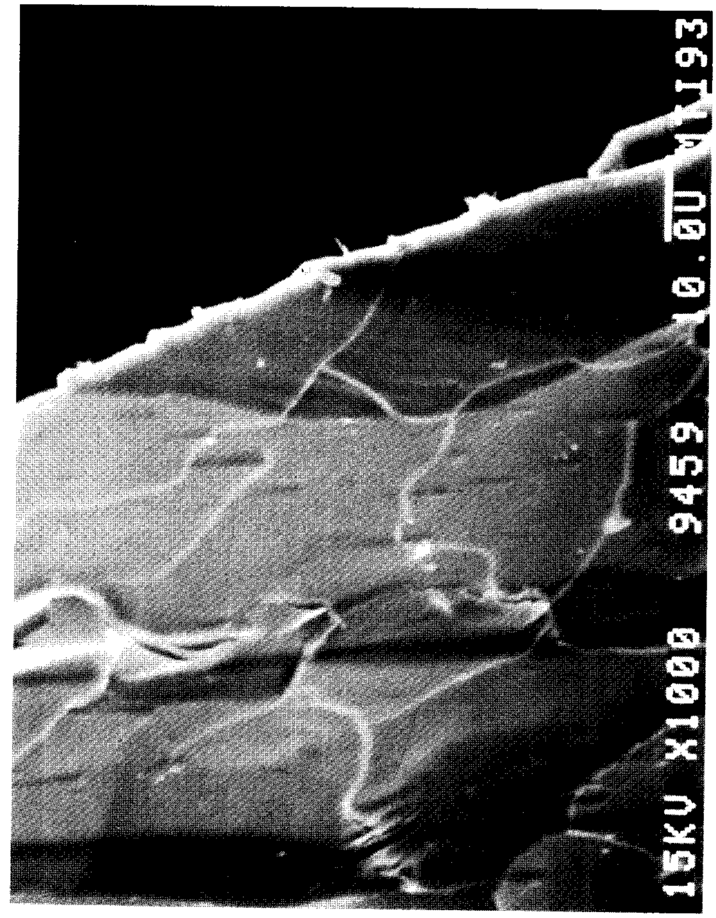


Figure 7 (bottom)

Oil and Gas in North Dakota Prior to 1951

What Preceded Iverson

By John P. Bluemle

[Note: *The first part of this article, up to the part that begins dealing with early North Dakota oil exploration, is adapted from an essay by Philip LaMoreaux, former State Geologist of Alabama. The remainder of this article is from a new publication on the history of the North Dakota Geological Survey by John Bluemle.*]

Oil and gas were known to ancient man 5000 years ago in Mesopotamia. The Greek Historian Diodor of Babylon described large numbers of asphalt seeps with gases that burned continuously. It's been speculated that the parable of Lot's wife in the Bible was related to rift valley faulting and escaping gases ignited by lightning in the Red Sea near Sodom and Gomorrah.

Asphalt was used in the Middle East as a sealant in the walls of Jericho, and it floated the basket of Moses. The Roman historian, Pliny, a few years after the birth of Christ, stated that asphalt "would heal wounds," could be applied to aching teeth, as a cough syrup, for treating diarrhea and rheumatism, and as a treatment for hair. The original "snake oil!"

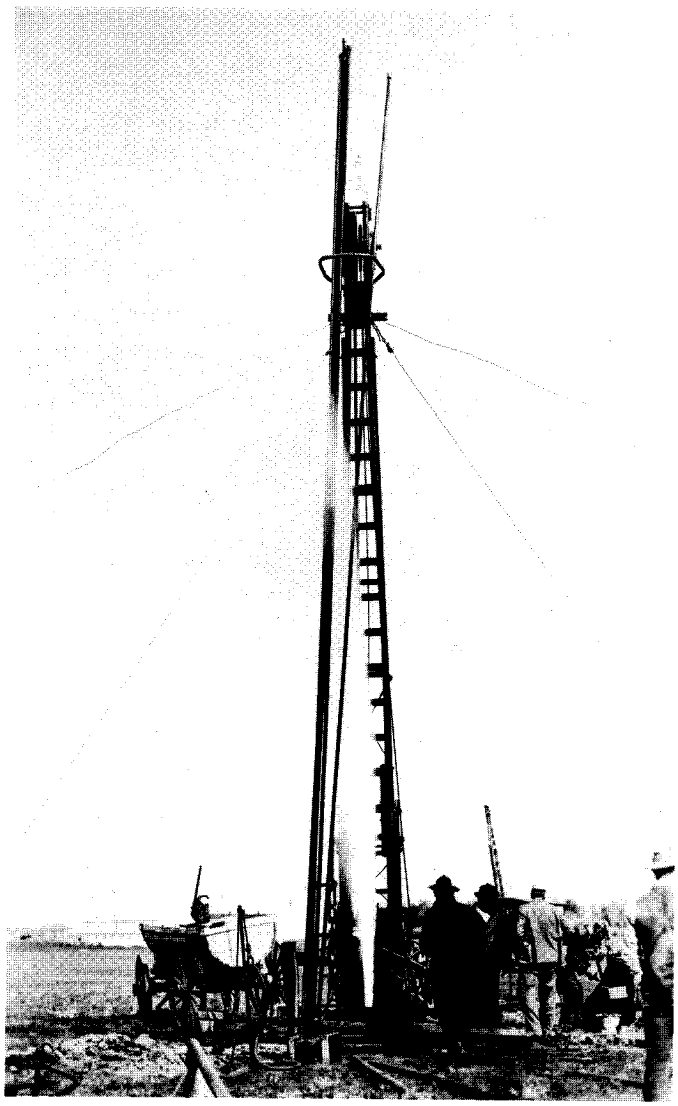
Oil seeps were known in ancient times in the Po Valley, Alsace, Galacia, Sicily, and Bavaria. The first refining technology was developed by the Arabs and imported to Europe.

In the United States in 1854, a professor at Yale University, Benjamin Silliman, was retained by a group of businessmen to do laboratory experiments on "rock oil." The group was led by a Mr. George Bissell, and they were interested in developing an inexpensive, high-quality burning fluid to compete with whale oil.

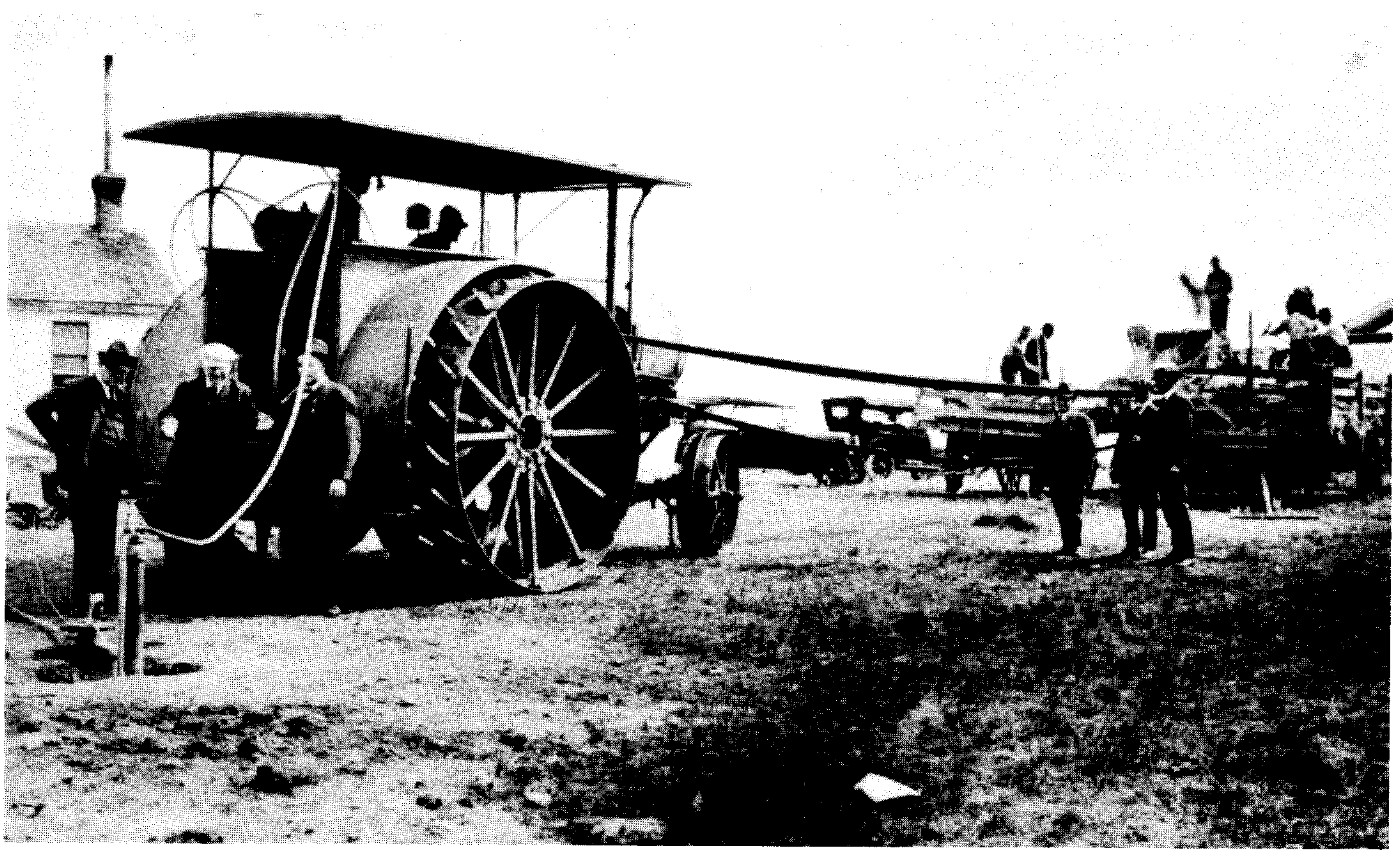
On completion of his work, Silliman did not get paid and withheld his report. However, the businessmen worked out a "deal" and Silliman's report, dated April 16, 1855, was released. Based on that report, a new refining company was formed, "The Rock Oil Company of Pennsylvania."

Bissell and fellow investors were now faced with the need for new sources of "rock oil" and came up with the idea of boring a well. Bissell employed Edwin L. Drake, an out-of-work railroad conductor. Bissell "created" the title "Colonel" for Drake and, in 1858, sent him to Titusville, Pennsylvania, as General Agent of the first oil-drilling company, the "Seneca Oil Company." Colonel Drake's initial efforts were failures; however, in 1859, with the help of "Uncle Billy" William Smith, a blacksmith, they started drilling. Unfortunately, the investors' money dried up, and Drake was notified by letter that there would be no more funds. The letter was not delivered, however, until August 29, 1859. On August 27, at 69 feet, the drill dropped into a crevice and the following day, a Sunday, a dark fluid started to flow from the well. Tubs, wash basins, and barrels were filled with oil and the rush was on. The oil sold for $18.00 per barrel; considering the value of a dollar at the time, a pretty hefty price.

The oil industry in America started in the hard-rock areas of Pennsylvania. The early oil fields were rapidly depleted because of overproduction. New fields were discovered in Ohio and, in 1865, in Cleveland, John D. Rockefeller bought out



This picture appears on many pieces of promotional literature circulated during the 1920's. It is referred to in one place as *"One of Mohall's gushers"*, on the Mohall Anticline.



Threshing scene in 1919 near Mohall, North Dakota. A 60 hp. gasoline engine is pulling a 42" separator, the engine being operated by natural gas from the wellhead at left.

his partner in two refineries for $75,000. Soon thereafter, Rockefeller's organizational capabilities resulted in refineries, pipelines, exploration, development, and production. The company became known as The Standard Oil Company of America, the first big monopoly.

In the late 1800's, the Standard Oil Co. was producing most of the exported kerosene in the world. But at this time the first foreign competition occurred with the oil fields in Russia at Baku on the Caspian Sea. The Nobel Brothers, Robert and Ludwig, developed these fields and, in 1878, Ludwig was the first in the new oil industry to create a permanent position for a professional petroleum geologist.

Anticlines were recognized by T. Sterry Hunt as potential locations for oil pools as early as 1861. However, the concept was not fully developed until 1882, by I. C. White of the Pennsylvania Geological Survey. White located the early oil fields of West Virginia in 1884-85, long before they were successfully drilled. Thus, there was established the new science of petroleum geology and the need for geologists to find oil in the United States.

Early North Dakota Ventures

The existence of the Cedar Creek Anticline in southwestern North Dakota was apparently known as early as the late 1800's. In 1920, A. G. Leonard, the third State Geologist of North Dakota, wrote about several anticlines in North Dakota, including the Nesson Anticline, which was, as nearly as I can tell, first described by A. J. Collier in 1918, although Lewis & Clark had also noted its existence.

Natural gas was generally the preferred target of the early ventures in North Dakota because it could be used essentially as it came out of the ground. One of the earliest gas discoveries in North Dakota was in Bottineau County in 1907. In the Fifth Biennial Report of the North Dakota Geological Survey, published in 1912, NDGS geologist John Barry noted that gas had been struck on the Parker farm, nine miles south of Westhope on July 3, 1907. The gas came from a 19-foot-thick sand bed at the base of the glacial deposits, at a depth ranging from 175 to 210 feet. When the first well was opened, sand, small rocks, pieces of lignite, and twigs were blown out forming a dune 100 feet in diameter and six feet high around the well. The initial pressure was 64 psi, but this soon declined to about 20 psi. Barry also noted that Lansford, in southwestern Bottineau County, was supplied for a time with gas piped from wells located five miles to the northeast. He noted too that similar gas discoveries were made at Maxbass, and at several other farms in the Mohall area.

A company known as the North Dakota Gas Company was formed to supply gas to the town of Westhope through a

20-mile pipeline. The eight gas-company wells cost 13.6 cents per foot to drill. Charges to the townspeople were 30 cents per 1,000 cubic feet in summer, and 40 cents in winter.

The 1911 Legislature passed North Dakota's first oil and gas conservation law (S. L. 1911, ch. 195). It prohibited the production of gas from natural gas wells unless they were tied to a distribution system. Apparently, the law was enacted in response to complaints from neighbors who were disturbed by the noise resulting from the practice of promoters opening up wells for the benefit of potential investors. The 1911 law was the first attempt at regulating oil and gas in North Dakota.

One of the first serious attempts to drill a real "oil well" in North Dakota took place in 1916. In 1912, the Pioneer Oil & Gas Company had been formed and, after three years of fund raising, it began drilling the Pioneer Oil & Gas No. 1 near Williston in September 1916. The well drilling was a major topic of interest in the Williston area for four years, until the well was abandoned as a dry hole at a depth of 2,107 feet in 1920. The company announced it had a producing well in November of 1919, and although this may have attracted some additional investors, about all the well ever produced was some water.

About the same time the Pioneer well was being drilled, a North Dakota corporation calling itself the Des Lacs Western Oil Company was organized at Minot. Officials of this company attempted to drill several wells in northwestern North Dakota; however, it is difficult to be certain just what was going on much of the time, as the various press releases and reports were sometimes a blend of hearsay, promotional statements, and facts. The quote that follows is from a prospectus of the Des Lacs Western Oil Company. It dates to about three years after the first attempt by the company to drill a well.

> *July 14, 1919*
>
> *"The Des Lacs Western Oil Company is a North Dakota Corporation, incorporated for 275,000 shares, all common stock and non-assessable.*
>
> *We now have a Lease acreage of more than 60,000, located favorable for both Oil and Gas by prominent Geologists and Oil Men.*
>
> *We encountered showings of Oil in seven test wells and also established our "Blum Anticline." We are encountering some very nice seepages of Oil and Natural Gas in "BLUM WELL" which has now reached a total depth of 2125 feet. We are still carrying 8¼ Casings and have sufficient casings now on ground for a 3000-foot well. Yes, Blum Well will be carried down to 3000 to 3500 feet or even deeper in order to bring in Commercial production, which we sincerely believe will be encountered when the big Drill taps the proper formation.*
>
> *This is a North Dakota proposition. Commercial Oil has been encountered in our sister state, South Dakota, and we believe that it will be only a matter of reaching the proper formation to put North Dakota in the Oil producing column.*
>
> *A small block of stock is being offered at $5.00 a share. All stock participates in Lease holdings and other property of the company.*
>
> *We are now below Sea Level and nearing formations which have been known to be productive of commercial Oil and Gas. You can help develop the natural resources of your home state by becoming a stockholder with us now."*

In 1915, a wildcat oil well was started by the Des Lacs Western Oil Company on the farm of A. F. Blum, 1½ miles southeast of Lone Tree, Ward County. The well was abandoned at 2,125 feet in October 1916. Interestingly enough, the hole was located approximately two miles from current production in Lone Tree Field. Wells in Lone Tree Field produce from the Sherwood (Mississippian Madison) at a depth

Gas flare on the Mohall Dome. Photo taken in the early 1920's.

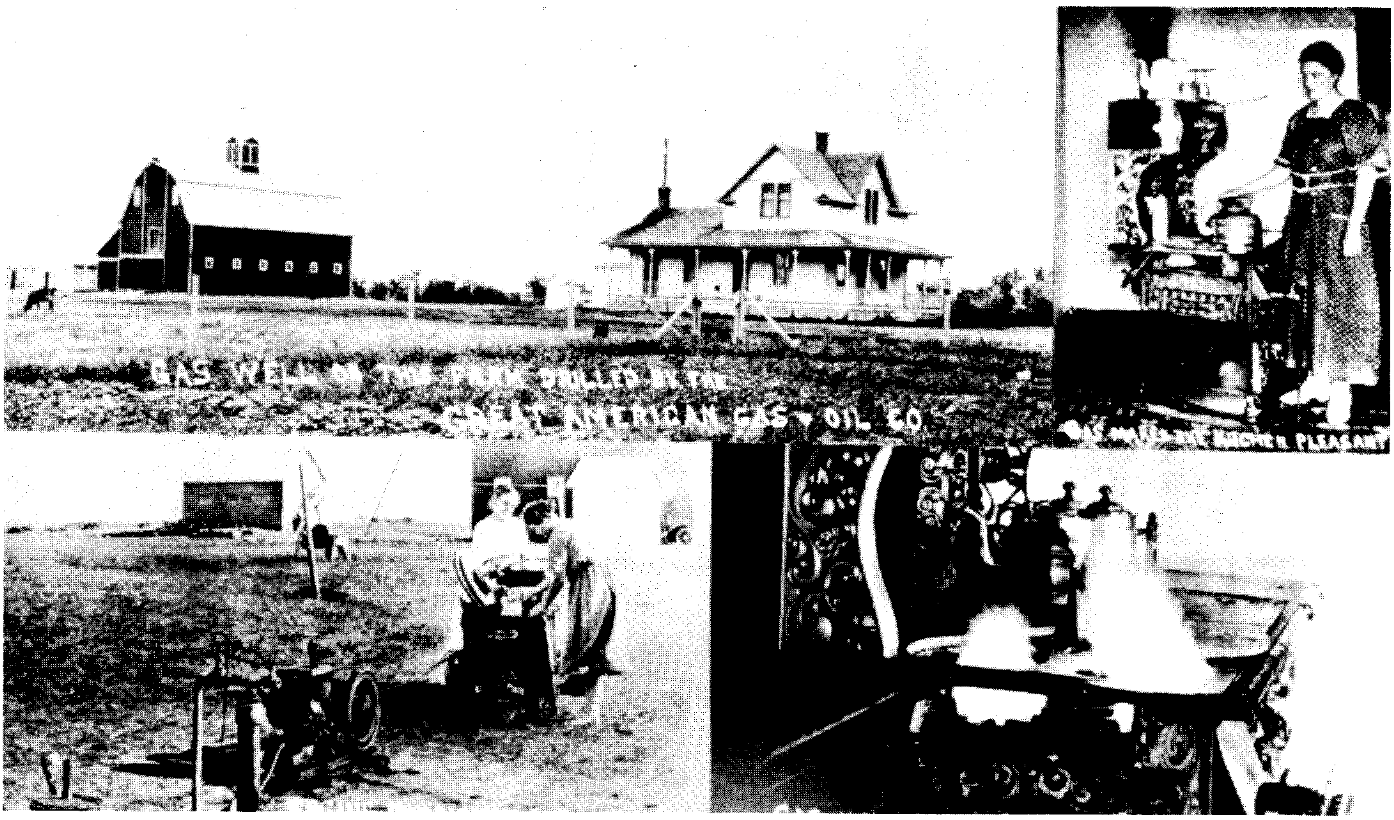
of approximately 6,500 feet, so the choice of a location was really not too bad, and if the well had been drilled another 4,000 feet or so, it is possible it might have been a success.

In December of 1916, L. L. Colby of the Des Lacs Western Oil Company of Minot visited Earle Babcock, Dean at the University of North Dakota, asking his advice about drilling an oil well at Des Lacs. Babcock had also been the first State Geologist. In a letter written in the spring of 1917, he advised against drilling. At that time, Colby, who had been the original promoter, resigned from the company. However, his successors, H. S. Johnson (a United States Geological Survey geologist) and Blum continued to promote the proposed well. In September 1917, they asked the Survey to investigate the possibilities of finding oil and gas in the Minot area. It's not clear what Leonard or Simpson actually said, but neither of them apparently recommended drilling a well. Even so, according to Des Lacs' advertising, Leonard and Simpson found enough evidence to recommend further exploration.

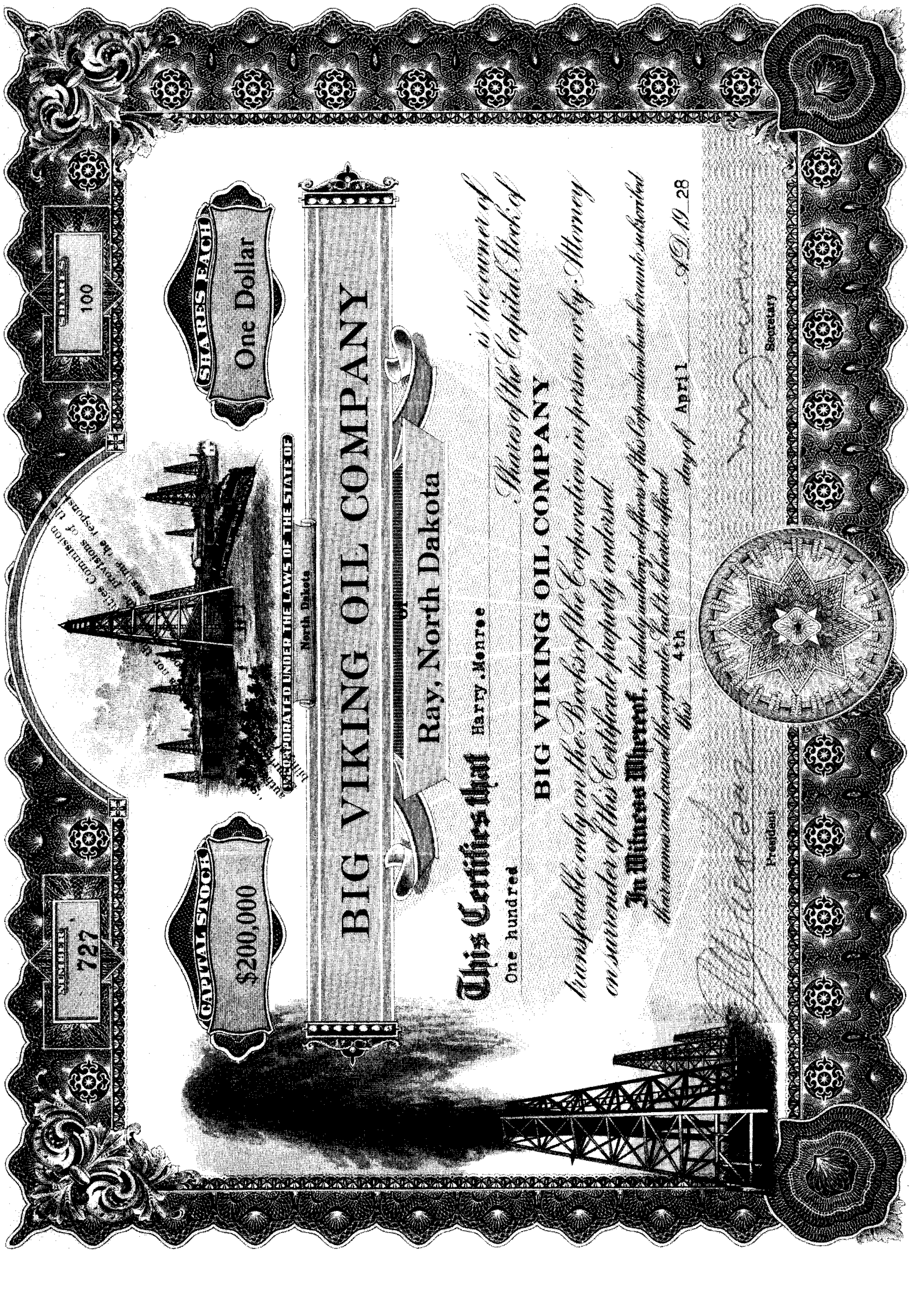
A couple of the other more important attempts at finding oil occurred in 1927 and 1937. Both were drilled on the Nesson Anticline in a location that had been recommended by A. G. Leonard. The Big Viking Oil Company No. 1 and the California Co. Nels Kamp No. 1 were drilled within yards of each other. Both resulted in dry holes, but the location was sound and oil was eventually found there in Silurian rocks in 1985 by the Amerada-Hess Kamp No. 3-21. Either of the early wells might have been North Dakota's discovery well, had they been drilled deep enough.

Finally, in 1951, oil was discovered by the Amerada Petroleum Corporation at their No. 1 Clarence Iverson well located a few miles southwest of Tioga in Williams County. Oil was recovered in commercial quantities from this well for the first time in North Dakota.

[Next Issue: *Oil and Gas in North Dakota prior to 1951: Prospects and Swindles.*]



Composite photo of several activities relating to the uses of natural gas. The scenes were probably taken in 1919, on the Ole Hellebust farm, near Mohall, in Renville County, but I cannot verify this. The pictures were used in a prospectus extolling the use of gas for farm usage. The gas well was drilled by the Great American Gas & Oil Co.



NUMBER 727
SHARES 100
CAPITAL STOCK $200,000
SHARES EACH One Dollar
INCORPORATED UNDER THE LAWS OF THE STATE OF North Dakota

BIG VIKING OIL COMPANY
of
Ray, North Dakota

This Certifies that Harry Monroe is the owner of One hundred Shares of the Capital Stock of BIG VIKING OIL COMPANY transferable only on the Books of the Corporation in person or by Attorney on surrender of this Certificate properly endorsed.

In Witness Whereof, the duly authorized officers of this Corporation have hereunto subscribed their names and caused the corporate seal to be hereto affixed this 4th day of April A.D. 19 28

President

Secretary

Example of "stock certificate" for oil companies. Certificate courtesy of Ken Schmidt, Williston, North Dakota.

Geologic Projects in North Dakota - 1996

Compiled by Gina K. Buchholtz

In the Spring issue of the *NDGS Newsletter*, we requested information about areas in North Dakota - and nearby areas of adjoining States and Provinces - currently being studied by government, university, and industry geoscientists. The reasons for the request were simple: *To keep one another apprised of current geologic projects and to stimulate interaction among geologic researchers in North Dakota.*

We intend to solicit this information in the Spring and publish it in the Summer or Fall on an annual basis. Thank you to everyone who responded to the survey.

COUNTY CODES

County	Code
Adams	AD
Barnes	BA
Benson	BE
Billings	BI
Bottineau	BO
Bowman	BW
Burke	BU
Burleigh	BL
Cass	CA
Cavalier	CV
Dickey	DI
Divide	DV
Dunn	DU
Eddy	ED
Emmons	EM
Foster	FO
Golden Valley	GV
Grand Forks	GF
Grant	GR
Griggs	GG
Hettinger	HE
Kidder	KI
LaMoure	LM
Logan	LO
McHenry	MH
McIntosh	MI
McKenzie	MK
McLean	ML
Mercer	ME
Morton	MO
Mountrail	MR
Nelson	NE
Oliver	OL
Pembina	PE
Pierce	PI
Ramsey	RA
Ransom	RN
Renville	RE
Richland	RI
Rolette	RO
Sargent	SA
Sheridan	SH
Sioux	SI
Slope	SL
Stark	SK
Steele	ST
Stutsman	SM
Towner	TO
Traill	TR
Walsh	WA
Ward	WD
Wells	WE
Williams	WI
Statewide	SW
Minnesota	MN
Montana	MT
South Dakota	SD
Manitoba	MB
Saskatchewan	SK

TYPE OF STUDY CODES

Type of Study	Code
Economic Geology:	
a. General	EC
b. Coal	CG
c. Nonfuel Minerals	NF
d. Petroleum	PG
Engineering Geology	EG
Environmental Geology	EV
Geochemistry	GC
Geochronology	GR
Geologic Hazards	GH
Geologic Mapping	GM
Geomorphology	GO
Geophysics	GP
Hydrogeology	HG
Mineralogy	MN
Paleomagnetism	PM
Paleontology	PA
Palynology/Paleobotany	PY
Petrology	PT
Quaternary Geology	QG
Sedimentology	SD
Soils	SO
Stratigraphy	ST
Structural Geology/Tectonics	SG

Investigator(s)	Organizations	County(s)	Location	Type of Study
Aber, James	Emporia State University	RA	Devils Lake	Satellite remote sensing
Bartelson, Norene ; Hansen, Jeff	ND Dept. of Health, (Division of Water Quality)	BU, DV, LM, WE, WI	Selected release sites	EV, HG
Bartelson, Norene ; Gunnerson, Bill	ND Dept. of Health, (Division of Water Quality)	BE, BA, BL, FO, KI, ML, MK, PE, PI, TR, WE, SM, WI	Esmond, Glencoe Channel, Heimdal, Hillsboro, Horseshoe Valley, James River, Kilgore, Lower Apple Creek, Streeter, Pembina River, Pipestem Creek, Pleasant Lake, Rusland, Seven Mile Coulee, Stoney Slough, Tappen, Trenton, Tokio, Yellowstone-Missouri Aquifers	EV, HG
Berkas, Wayne ; Komor, Steve	U.S. Geological Survey	ML, SH, WE, ED, SM, LM, DI	James River Basin	GC
Bickel, David	ND Public Service Commission	DU, ML, ME, OL, SR	Active surface mining areas	EC, CG, HG
Biek, Robert F.	North Dakota Geological Survey	BI, MK	Theodore Roosevelt National Park	GM
Biek, Robert F. ; Bluemle, J. P.	North Dakota Geological Survey	SW	Statewide	GE
Biek, Robert F. ; Murphy, Edward C.	North Dakota Geological Survey	SR, DU	Dickinson	GM
Clausen, Eric	Minot State University	SW ; all adjacent states and provinces	North America	GO
Cowdery, Tim	U.S. Geological Survey		Red River of the North Basin	HG
Ellingson, Jonathan B. ; Reid, John R.	University of North Dakota	MO	Lynwood Quadrangle	NF, QG
Fullerton, Dave	U.S. Geological Survey	SW ; Canada	ND ; East of 102^0 W longitude and North of 48^0 N latitude (Winnipeg Quadrangle) ; West of 102^0 W longitude (Regina & Big Horn Quadrangle)	QG, GM
Fulton, R. J.	Geological Survey of Canada	MB, SK	49^0-50^0 N 100^0-102^0 W	QG, GM
Gilboy, Chris	Saskatchewan Energy & Mines	SK	SW Saskatchewan	GM, ST
Gilboy, Chris	Saskatchewan Energy & Mines	SK	Saskatchewan	PG, GM, SD, ST

Title/Subject	Date of Inception	Scale of Map
	1991	
Study of release sites to determine if natural bioremediation is occurring	April 1996	
North Dakota Groundwater Minitoring Program - 1996 Report	May 1992 (ongoing)	
Arsenic and Selenium in soils and shallow ground water in the Turtle Lake, New Rockford, Harvey Pumping, Lincoln Valey and LaMoure irrigation areas of the Garrison Diversion Unit, North Dakota		
Characterization and Modeling of Water Resources		
Geologic maps	1995	1:24,000
Profiles of North Dakota geology	1995	
Geologic map and report	1994	1:62,500
North American Landforms	1980	
National Water Quality Assessment of the R.R.N. Basin (Ground Water)	1992	
U.S.G.S. EDMAP	July 1996	1:24,000
Quaternary Geologic Maps of Winnipeg, Regina, and Big Horn Mountains		1:1,000,000
Surficial Geology of the Virdem Map Area, Manitoba-Saskatchewan	1991	1:100,000
The Colorado Group; Southern Saskatchewan	1991	1:2,000,000 (initially)
Geology of Colorado Group Strata in Southwestern Saskatchewan	1987	

Investigator(s)	Organizations	County(s)	Location	Type of Study
Haidl, F. M.	Saskatchewan Energy & Mines	SK	Saskatchewan	ST, SD
Harris, Ken ; Bauer, Emily ; Knaeble, Alan ; Lusardi, Barb	University of Minnesota ; MN Dept. of Natural Resources (Waters Division)	MN	46^0 & 47^0 N latitude and 95^0 & 96^0 W longitude MT counties: Otter Tail & Becker, Douglas, Grant, Todd, Wadena.	GD, GM, HG, QG
Harris, Ken ; Luther, Mark	Minnesota Geological Survey; North Dakota Geological Survey	MN; CA, RN, SA, RI, ST, TR, BA, GF, NE	Southern Red River Valley 46^0-48^0 N latitude & 96^0-98^0 W longitude ; MN counties: Clay, Norman, Polk, Wilkin, Becker, Grant, Mahnomen, Otter Tail, Pennington, Red Lake, Traverse. ND counties: Cass, Ransom, Sargent, Richland, Steele, Traill, Barnes, Grand Forks, Nelson.	GM
Heaton, Timothy H.	University of South Dakota	BW	Badlands (southwest North Dakota)	PA, SK, SL
Hoganson, John W. ; Murphy, Edward C.	North Dakota Geological Survey	SW	Statewide	GE
Hopkins, David G. ; Richardson, Jim ; Barker, Bill	North Dakota State Univ. (Dept. of Soil Science) (Dept. of Animal & Range Science)	RN	W ½ Sec. 7 T 134 N, R 53W	SO, ST, HG Botanical Studies
Horner, Jim ; Gunnerson, Bill	ND Dept. of Health (Division of Water Quality)	SW	Statewide wellhead protection area delineations	HG
Hubbard, Trent	University of North Dakota (Dept. of Geology & Geological Engineering)	GR, SI	Cannonball River	GO
Jefferis, Lee H.	Bureau of Land Management	Western ND	In-house geologic evaluations for Oil & Gas	PG
Johnson, Kirk	Denver Museum of Natural History	BW, SL	Near Marmarth	PA
Johnson, Mark D.	Gustavus Adolphus College	MN	Minnesota River Valley	GO, QG, ST, SD
Klassen, H. J.	Manitoba Energy & Mines	MB	TWP 6 RGE 22 WIM (Manitoba)	PG, ST
Klassen, H. J. ; Martiniuk, C. D.	Manitoba Energy & Mines	MB	SW Manitoba	ST
Kreis, L. K. ; Haidl, F. M.	Saskatchewan Energy & Mines	SK	Saskatchewan	GM

Title/Subject	Date of Inception	Scale of Map
The Geology of the Interlake Formation in Saskatchewan	September 1986	
Otter Tail Regional Hydrogeologic Assessment (RHA)	July 1996	1:200,000
Surficial Geology of the Southern part of the Red River Valley, North Dakota and Minnesota.	1993	1:500,000
Quaternary Stratigraphy of the Southern Part of the Red River Valley, North Dakota and Minnesota		
The Terrestrial Eocene-Oligocene Transition in North America The Terrestrial Eocene-Oligocene Transition in North America (with Emry, R.J.)	1986	
Roadside geology of North Dakota	1993	
Hydrologic and Abiotic Constraints on Soil Genesis and Natural Vegetation Patterns in the Sandhills of North Dakota	June 1990	
Wellhead Protection Area	1989	
Nickpoints: Causes (ND and SD rivers)	August 1985	
In-house Geologic Evaluations for Oil and Gas	Continuing	
Description of Seven Common Fossil Leaf Species from the Hell Creek Formation (Upper Cretaceous: Upper Maastrichtian), North Dakota, South Dakota, and Montana	1981	
Stratigraphy of Pleistocene Deposits, Southern Minnesota	Summer 1996	
Petroleum Geology of Souris Hartney Area	March 1996	
Lodgepole Project	March 1996	
Computer-generated Regional Isopach and Structure Maps of L. Paleozoic Strata	1994	1:2,000,000

Investigator(s)	Organizations	County(s)	Location	Type of Study
Lively, Richard S. ; Morey, G. B.	Minnesota Geological Survey	MN ; CA, PE, RN, SA, RI, ST, TR, WA, BA, GF, NE	Minnesota ; Eastern North & South Dakota	GM
Lopez, David A.	MT Bureau of Mines & Geology	MT	South central Montana	GM, PG
Lorenz, Dave ; Stoner, Jeff	U.S. Geological Survey	Eastern ND ; Western MN	Red River of the North Basin	GO
Martin, James E. ; Sawyer, J. F.	South Dakota Geological Survey	SW	South Dakota	GM
Murphy, Edward C.	North Dakota Geological Survey	DV, WI, MR	Northwest corner	NF
Murphy, Edward C.	North Dakota Geological Survey	DU	County wide	GM
Murphy, Edward C.	North Dakota Geological Survey	SW	Western North Dakota	EV
Murphy, Edward C. ; Fritz, Ann	North Dakota Geological Survey	GL, MO	Bismarck, Schmidt, Sugerloaf quads	GM
Murphy, Edward C. ; Goven, G. ; Flores, R. ; Keiguin, W. ; Strickel, G. ; Nichols, D.	North Dakota Geological Survey USGS	SW	Western North Dakota	CG
Patterson, Carrie ; Knaeble, Alan ; Lusardi, Barb	Minnesota Geological Survey	MN	Between 45.5^0 & about 45.3^0 N latitude and 95^0 W longitude and the SD border ; MN counties: Swift, Chippewa, Lac Qui Parle, Yellow Medicine, Big Stone, Lincoln, Lyon, Redwood, Renville.	GD, GM, HG, QG
Radig, Scott	ND Dept. of Health (Division of Water Quality)	BE	Warwick aquifer (northeast of Warwick)	EV, HG
Reed, Carol	USDA (Natural Resources Conservation Service)	WA	Sec. 18, T. 158N, R. 55W	EG
Reid, John R. ; Beck, Deborah	University of North Dakota	ML	Douglas Creek, Lake Sakakawea	QG, SO, GO
Reiten, Jon	MT Bureau of Mines & Geology	MT (Richland Co.)	Sidney, Montana	HG
Reiten, Jon	MT Bureau of Mines & Geology	MT (Sheridan & Roosevelt Co.)	Parts of northeast Montana between Medicine Lake & Westby	HG
Richardson, J.	North Dakota State Univ.	BA, BL, BO, BU, CA, DV, FO, GG, KI, MI, ML, NE, SH, SM, WE; MN		SO, HG

Title/Subject	Date of Inception	Scale of Map
Aerial Gamma-ray Maps of Minnesota and Adjacent Areas of North and South Dakota	August 1996	1:3,000,000
STATEMAP Billings 1^0 x 2^0; Valleyfills in Kootena; FM, Crow Indian Reservation (D.O.E,)	1992	1:100,000
Sampling Design for Assessing Water Quality in the Red River of the North Basin	1995	1:750,000
Geologic Map of South Dakota	1984	1:500,000
Sodium Sulfate	1995	
Geologic Map	1982	1:125,000
Uranium in Southwest North Dakota	1991	
Geologic Maps	1996	1:24,000
Coal in North Dakota	1995	
Upper Minnesota River Basin Regional Hydrogeologic Assessment	July 1995	1:200,000
LEPA Irrigation and Groundwater Monitoring Project	October 1992	
Geologic (Geotechnical) Investigation of Middle Branch Park River Proposed Dam #5	January 1996	
Cyclicity of Paleosols in Alluvial Fills	June 1996	
	July 1996	
Hydrogeology and Wellhead Protection Plan for Sidney, Montana	September 1995	1:24,000
Hydrogeology of the Clear Lake Aquifer System, northeast Montana	May 1995	1:100,000

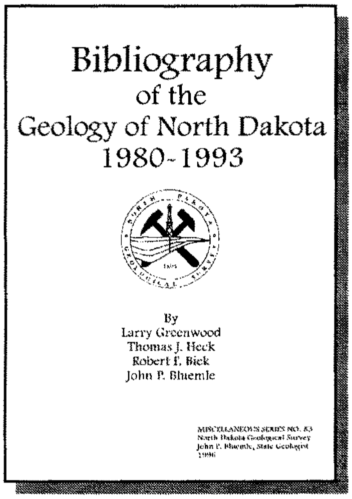
Investigator(s)	Organizations	County(s)	Location	Type of Study
Trojan, Michael ; Falteisek, Jan	MN Dept. of Natural Resources (Division of Water)	MN	S ½ Red River Valley in Minnesota	HG
Vuke, Susan M. ; Wilde, Edith M. ; Colton, Roger B. ; Bergantino, Robert N.	MT Bureau of Mines & Geology ; USGS	BW, GV, SL	Eastern Montana Western North Dakota	GM
Warwick, P. ; Flores, R. ; Nichols, D. ; Murphy, Edward C.	USGS ; North Dakota Geological Survey	MO, GR, HE, BW	Southwestern North Dakota	ST
Wollenzien, Tom	Terminal Minerals	WY, MT	North & east of Sheridan, Wyoming	CG
Young, Graham	Manitoba Museum of Man and Nature	MB	Southern MB; Churchill area, northern MB	PA, ST

Title/Subject	Date of Inception	Scale of Map
Regional Hydrogeologic Assessment - Southern Red River Valley, Minnesota	1992	1:200,000
Geologic map of Sidney, Wibaux, Baker, EkaLaka 30' x 60' quads		1:100,000
Stratigraphy of the Lower Fort Union		
Northern Powder River Basin Study	1995	1"=2,000' (coal bed mapping)
Ordovician and Silurian Corals (also Stromatoporoids, Sponges)	1993	

NEW PUBLICATIONS

Bibliography of the Geology of North Dakota 1980-1993

Larry Greenwood, Thomas J. Heck, Robert F. Biek, and John P. Bluemle

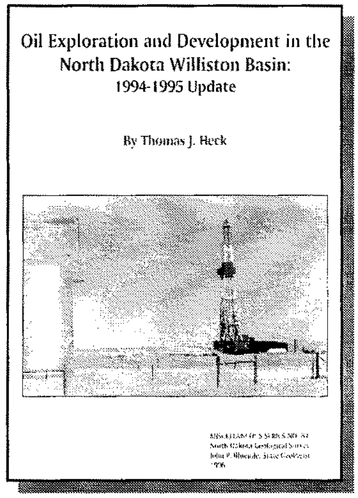


Miscellaneous Series No. 83, the *Bibliography of the Geology of North Dakota: 1980-1993*, contains an alphabetical author index, containing the necessary data to locate the paper, for all the available references that applied to the geology of North Dakota during the period 1980-1993. It also contains a subject index that refers users to the citations that address a particular topic. M.S. 83 is an important reference for geologists working in North Dakota. At 370 pages long, this will be one of the longer publications the survey has published in recent years. The NDGS published an earlier bibliography (M.S. 60) for the period 1960-1979 that was approximately 290 pages long. The volume of geologic research that is being published is rapidly expanding as illustrated by the fact that are approximately 100 more pages of data presented for a six years shorter time-period. Naturally, we expect an immediate rash of orders as shoppers buy a copy for the geologists on their Christmas lists.

Miscellaneous Series No. 83 $10.00

Oil Exploration and Development in the North Dakota Williston Basin: 1994-1995 Update

Thomas J. Heck

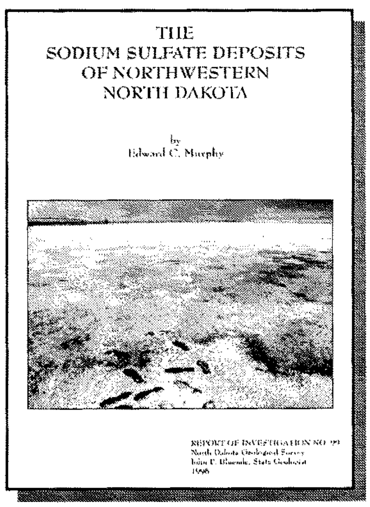


Miscellaneous Series No. 84, entitled *Oil Exploration and Development in the North Dakota Williston Basin: 1994-1995 Update*, will soon be available. This publication is the most recent in a series extending back to 1979 that reviews oil industry activity and discoveries. Each issue in the series gives a short historical review of the 1980's and 1990's but focuses on the events during the most recent two-year period. During 1994 and 1995, exciting new field discoveries were made in North Dakota that drew the attention of oil companies from many different parts of North America. This publication will be available after January 1, 1997.

Miscellaneous Series No. 84 Cost to be determined

The Sodium Sulfate Deposits of Northwestern North Dakota

Edward C. Murphy



A detailed account of the Recent lacustrine stratigraphy and sodium sulfate (Glauber salt) reserves at 15 lake basins in northwestern North Dakota. This 73-page report incorporates new drillhole information on the salt-bearing strata with information from previous government and industry studies, some of which had previously been unavailable.

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