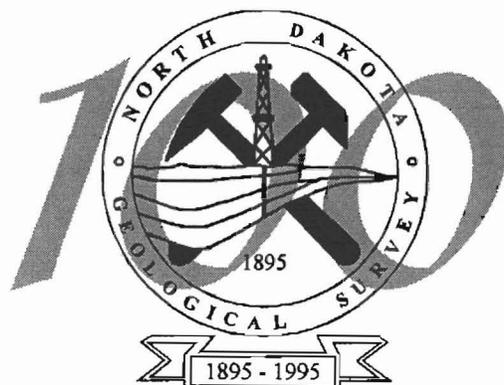


THE FIRST 100 YEARS

THE HISTORY OF THE NORTH DAKOTA GEOLOGICAL SURVEY 1895-1995

By
John P. Bluemle



MISCELLANEOUS SERIES NO. 81
North Dakota Geological Survey
John P. Bluemle, State Geologist
1996

1895

1995

North Dakota Geological Survey Centennial Year

The North Dakota Geological Survey was created by an act of the North Dakota Legislature in 1895 - six years after statehood. The Geological Survey was directed to make a

“. . . complete account of the mineral kingdom . . . including the number, order, dip, and magnitude of the several geological strata, their richness in ores, coals, clays, peats, salines and mineral water, marls, cements, building stones and other useful materials, the value of said substances for economic purposes and their accessibility”.

Such studies continue, but over the years, the Geological Survey's mission has grown and is now three-fold: 1) to investigate the geology of North Dakota; 2) to administer regulatory programs and act in an advisory capacity to other state agencies; and 3) to provide public service and information to the people of North Dakota.

The Geological Survey serves as the primary source of geological information in the State. A large amount of geological information can be obtained from: NDGS publications; comprehensive collections of cores, samples, and fossils; oil and gas records; coal and subsurface mineral records; and through our affiliate office of the nationwide Earth Science Information Center.

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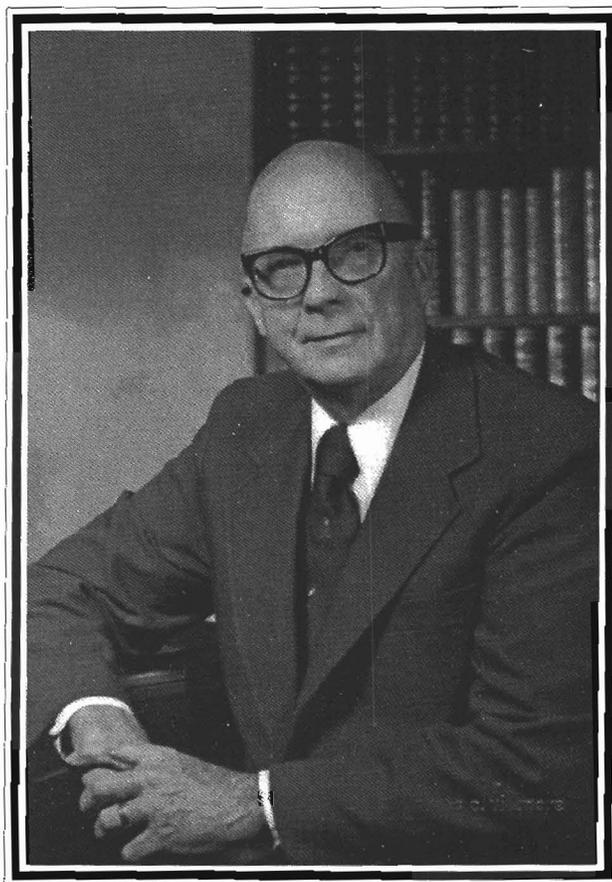
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Dedication



Wilson M. Laird, State Geologist of North Dakota, 1941-1969.

This volume on the history of the North Dakota Geological Survey is dedicated to Wilson M. Laird, who served as State Geologist from 1941 until 1969. Wilson was the sixth person to serve as State Geologist and his 28-year tenure in the position is second only to that of A.G. Leonard, who was State Geologist for 29 years.

Wilson Laird came to North Dakota in September, 1940, from the University of Cincinnati. Born in Erie, Pennsylvania, in 1915, he received his B.A. from Muskingum College in 1936, his M.A. from the University of North Carolina in 1938, and his Ph.D. from the University of Cincinnati in 1942. He was also awarded honorary D.Sc. degrees by Muskingum College in 1964, and by the University of North Dakota in 1980.

In addition to his service for the North Dakota Geological Survey, Wilson worked for Carter Oil Company in Montana during the summer of 1948, and was employed as a geologist for Hudsons Bay Oil & Gas (Continental Oil Co.) in Calgary during the summer of 1949. He also consulted for the USGS in 1944-45, and for Beers and Heroy in 1950.

Wilson is nationally known and respected for his work in geology. His research included work in Ohio, Pennsylvania, North Dakota, Minnesota, Alaska, southern Manitoba, southern Germany, and central Turkey. His work resulted in the publication of more than 100 papers on subjects as diverse as biostratigraphy, regional geology, limnology, mineral deposits, glacial geology, groundwater geology, and petroleum geology. His

work included a great number of diverse geologic projects in the Williston Basin of North Dakota involving rocks ranging in age from Paleozoic through Cenozoic.

Wilson has received many honors during his long and distinguished career. In 1948, he shared (with his friend and colleague, L.L. Sloss) the President's Award of the American Association of Petroleum Geologists for work on Devonian stratigraphy in Montana and received the AAPG Public Service Award in 1981. Wilson served as Second Vice Chairman of the Interstate Oil Compact Committee (IOCC) and as Chairman of the Research Committee of the IOCC.

In 1948, Wilson was elected Vice President of the Association of American State Geologists and in 1950, he was elected President. He is currently an honorary member. Wilson was also elected President of the North Dakota Academy of Science for the 1952 term.

Wilson is credited with the foresight that oil would one day be discovered in the Williston Basin in North Dakota. To insure that North Dakota avoided the problems that had beset some oil-producing states, Wilson introduced legislation in 1941, that resulted in a model oil-and-gas conservation law being in place ten years prior to the discovery of oil in North Dakota. Dr. Laird also recognized the necessity of establishing a facility for the storage and study of oil and gas core and samples.

In 1980, the State of North Dakota recognized Wilson Laird's diligent efforts in collecting the information obtained from oil and gas wells by naming a new core repository the Wilson M. Laird Core and Sample Library. This North Dakota Geological Survey building is located on the campus of the University of North Dakota.

During his tenure, the North Dakota Geological Survey grew from a staff of one

(himself) to over 40 employees. The larger staff, necessitated by the discovery of oil, was needed to enforce the oil and gas rules and regulations and to provide information and answers to the increasing number of questions concerning the geology of the state. He initiated several new programs during the 1950's, including the innovative County Geology and Groundwater Resource Bulletins, a cooperative program with the U.S. Geological Survey and the State Water Commission. He also began many subsurface studies of the oil-productive Paleozoic and Mesozoic rocks and economic studies of the mineral resources of the state.

In 1992, Wilson received the first Arthur Gray Leonard Medal. This award is presented in conjunction with an annual All Alumni Reunion of the Department of Geology and Geological Engineering at the University of North Dakota. The Leonard Award recognizes important contributions made to the geoscience field by alumni, faculty, and friends of the Department of Geology and Geological Engineering. It is the highest honor awarded by the Department.

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

More than any other person, Dr. Wilson M. Laird shaped the North Dakota Geological Survey into the kind of agency it is today.

Introduction

The first state geological survey was established in 1823, in North Carolina. By 1840, there were at least 15 state surveys, most of which were concerned with the discovery of mineral, energy, land, and water resources in their state or territory.

The North Dakota Geological Survey was established in 1895. The Legislators who founded the Survey envisioned an agency dedicated primarily to identifying the mineral wealth of the new State of North Dakota and devising ways to exploit it. Certainly they knew something of some of the kinds of minerals that could be found here - coal, clay, and gravel for example - but they had very little idea about much else. They probably hoped that gold would be found, as it had recently in South Dakota, Colorado, and California. Oil and gas were of little or no concern in 1895, although interest in these resources grew rapidly during the first half of the 20th century.

The idea of producing mineral resources in an environmentally sound way was not a big concern, nor was there much concern about any of the other environmental problems we worry about today. The early legislators were most interested in learning what would provide revenue to the new state.

Over the years, the North Dakota Geological Survey has done the job that was envisioned for it, and much more. Much of the state's mineral wealth has been identified, but our geologists continue to find new resources - things that were entirely unknown a year earlier - and they continually update our understanding of those resources. Our role in understanding and protecting the environment has also grown as we realize how much more there is to mineral exploration and development than simply digging the coal out of the ground or pumping the oil.

The Geological Survey has had a number of regulatory responsibilities assigned to it over the years, most of them related in various ways to protecting the environment. Our understanding of the extent and richness of the state's fossil resources has grown immensely in the last ten years. Our geologists have continually studied the basic geology of the state - its geologic history, glacial geology, depositional environments of the various Tertiary formations, and many other things. And, we have been forced to react to a greatly growing demand for educational materials relating to the state's geology.

As a small state agency dedicated to being the principal source of geologic information in the state, the North Dakota Geological Survey is one of the few state agencies that, by its nature, returns far more revenue to the state than it takes to operate it. Increased mineral production, the availability of geologic data for planning and environmental assessments, and a variety of educational materials - all of these generate tremendous revenues for the state. Over the years, the North Dakota Geological Survey has returned revenue to the state hundreds of times over what it has cost the state.

My purpose in writing this report is to recount something of the history of the North Dakota Geological Survey in this, the Survey's Centennial year. I've not attempted to construct a rigorous historical document and the reader will quickly note that my report contains no footnotes and few references. Although I've included a short listing of selected references, much of the material I drew on to write this history is from the archival files of the North Dakota Geological Survey and the University of North Dakota. I have not made any effort to list all of these sources.

I have drawn freely from Clarence B. Folsom's 1980 report, "*A History of the North Dakota Geological Survey*" (North Dakota Geological Survey Miscellaneous Series 58, 1980) and I need to acknowledge the important role Folsom's report played in the current account.

I wish to thank Dr. Wilson M. Laird, State Geologist Emeritus, for reviewing the manuscript of this report and making numerous corrections and suggestions. This volume is dedicated to Wilson Laird.

Also, I would like to sincerely thank Clara B. Laughlin, Administrative Officer for the North Dakota Geological Survey from 1965-89, for critically reviewing the manuscript. Many thanks to Dr. E.A. Noble, former State Geologist, for his suggestions. Survey geologists Bob Biek, Ed Murphy, and John Hoganson reviewed various versions of the manuscript and I am grateful for their help.

Thank you to Karen Gutenkunst for proofreading the manuscript and Gina Buchholtz for formatting it in preparation for printing. Sandra J. Beidler, Head of the Elwyn B. Robinson Department of Special Collections at the Chester Fritz Library, University of North Dakota, provided biographical information on people associated with the Geological Survey in its early years. I thank her for all her help.

If I have left out anything that is important to someone or if I have included something that might have been better left unsaid, I sincerely apologize.

John P. Bluemle
December, 1995

A Survey Is Born!

The North Dakota State Constitution in 1889, directed that a University and School of Mines be situated in Grand Forks (Session Laws for 1895, Chapter 66). The position of State Geologist, and with it the North Dakota Geological Survey (NDGS), was created by an act of the North Dakota Legislature in 1895, six years after statehood. This position was to be held by the Professor of Geology at the University. Dr. Earle Babcock (*Figure 1*) was appointed to the post of State Geologist/Department Chairman in 1895, and he continued in the position until 1901. The Geological Survey was directed to make a:

" . . . complete account of the mineral kingdom . . . including the number, order, dip and magnitude of the several geological strata, their richness in ores, coals, clays, peats, salines and mineral waters, marls, cements, building stones and other useful materials, the value of said substances for economical purposes, and their accessibility".

The Legislature made a generous provision for the university that included \$5,000 to launch the School of Mines; however, Governor Shortridge vetoed that portion of the bill.

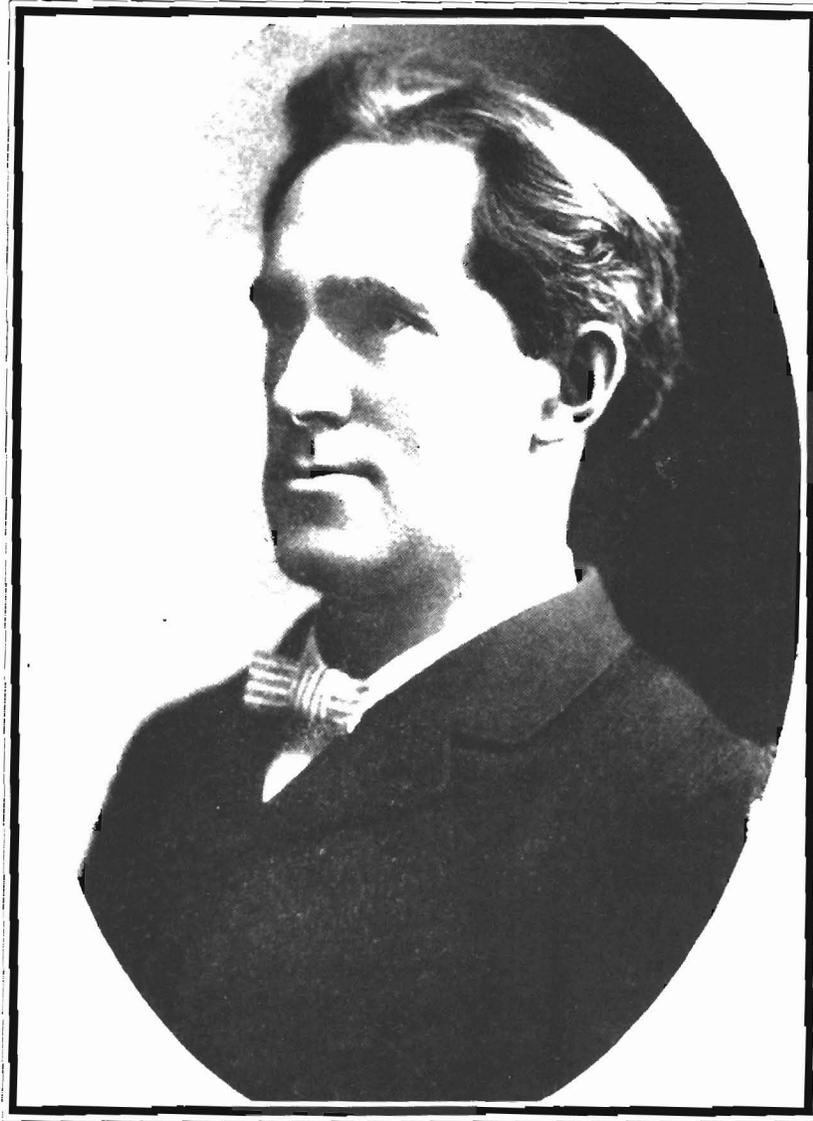


Figure 1. Professor Earle Jay Babcock, first State Geologist of North Dakota, 1895-1902. E.J. Babcock graduated with a B.S. in chemistry from the University of Minnesota in 1889, was appointed an Instructor in Chemistry in 1890, and a Professor of Chemistry and Geology in 1891. When the University of North Dakota obtained a Post Office (in 1890), Babcock became its first Postmaster. In addition to his duties as State Geologist, Babcock served the university in a variety of positions over the years: Professor of Chemistry and Geology from 1891-94; Director of the School of Mines from 1898-1901; Dean of the College of Mining Engineering from 1902-16; Professor of Chemistry, Mining, and Metallurgy from 1910-25; Dean of the College of Engineering from 1917-25; Director of the Mining Experiment Station from 1910-25; and Acting President of the University of North Dakota in 1917 and 1918. Babcock received an honorary Doctorate of Science from the University of North Dakota in 1914. Born in 1865, at St. Charles, Minnesota, Babcock died in 1925, at Bemidji, Minnesota.

The Pioneers - Babcock and Wilder

The economic "Panic of 1893" and the collapse of agricultural prices in that year pointed up the need for diversification in the state's economy, and Babcock argued repeatedly for the need for the practical development of mining and geology. He had published two pamphlets, in 1890 and 1892, outlining studies he had made on the clays and coals of North Dakota, and these were used as a basis for a request for \$10,000 to open the School of Mines. The appropriation was refused, but Babcock utilized the title of State Geologist to expand his laboratory facilities in the Chemistry Department where he studied the combustion of fuels.

In the 1890's, Babcock discovered lime-rich shales exposed at the surface in Pembina County. In 1899, Babcock, his brother Otto, and Webster Merrifield (President of the University of North Dakota from 1892-1909) incorporated the Pembina Portland Cement Company. A zone of calcareous shale, that occurs in scattered outcrops along the valley of the Tongue River in the vicinity of the cement plant near Concrete, were extracted through mine tunnels (approximately 900 feet of tunnels were dug into outcrops along the valley of the Tongue River). The calcareous shale was baked in kilns at the plant, ground into a fine powder and packaged as a natural (non-portland grade) cement.

As State Geologist, Babcock would appear to have had a potential for a conflict of interest with this arrangement. However, prior to 1899, no appropriations had been made to the Geological Survey and Babcock (in his own words and writing in the third person):

" . . . devoted most of his summer vacations for eight years to geological investigations of the state and in efforts to encourage the

development of the mineral resources . . . during six years of this time the state paid nothing for the work, the expenses were borne by the writer, and his time during these vacations cheerfully contributed for the good of the cause."

The natural cement produced at the plant had a difficult time competing with the superior grades of portland cement and ceased operation in 1909, as a result of problems in production and marketing (Figure 2).

In 1897, the School of Mines was formally opened with Babcock as its first director. Even without appropriated funds for the North Dakota Geological Survey, Babcock continued to work, donating his time and expenses. In 1899, the Legislature recognized that the time had come to provide support to the Geological Survey and a small appropriation was made for that purpose.

Babcock used the results of his early studies as the framework for the First Biennial Report of the Geological Survey. In cooperation with the U.S. Geological Survey, several hundred samples of water from various sources were collected and examined. This information was included in the report. Analyses of the water samples were carried out by Marcia Bisbee, an instructor in the Chemistry Department. Babcock viewed the First Biennial Report as preliminary and incomplete.

At the turn of the century, the Geological Survey devoted much of its effort to identifying the state's lignite deposits. Babcock provided the first detailed studies of lignite and recognized the important role that lignite would eventually play in the development of the state. He encouraged the use of coal rather than wood in this land of few trees and stated:

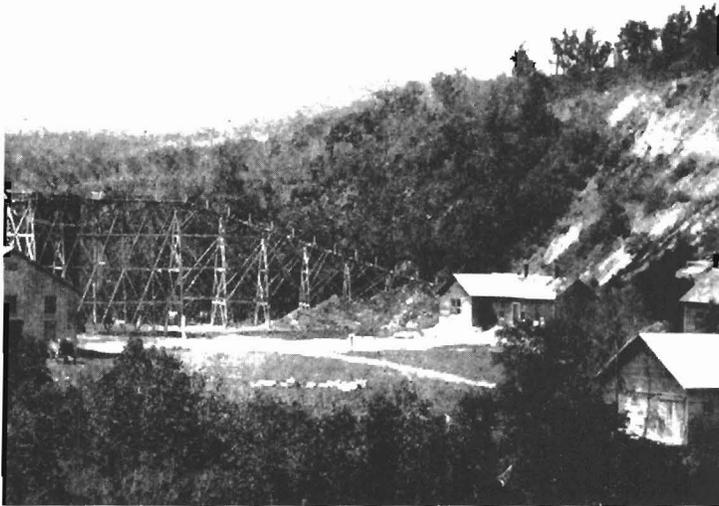
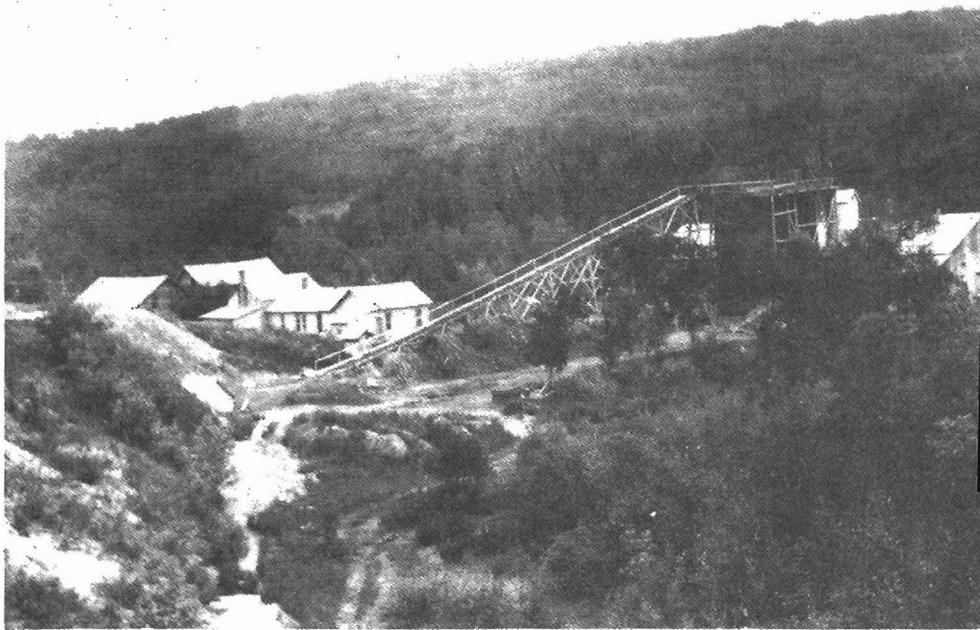


Figure 2. Northern Plaster and Cement Company plant at Concrete, North Dakota. The top and middle photos were taken between 1902-09; the lower photo of the plant ruins was taken in 1992. E.J. Babcock, his brother Otto, and Webster Merrifield, President of the University of North Dakota, incorporated the plant in 1899.



"In some localities it is sad to notice how much wood is cut for fuel. Every tree should be encouraged to grow."

During 1901, L.H. Wood, a graduate student at the University of Chicago with an M.A. degree from the University of Michigan, was named a special assistant. Professor Babcock was listed as Chief Chemist and Professor E.F. Chandler was named Surveyor of Irrigation. In the early years, the Geological Survey was overseen by a Geological Board, which was, in fact, the Board of Trustees of the university. The members of the professional staff of the Survey were referred to as the "Geological Corps."

Elwyn Francis Chandler came to the university from Wisconsin, where he had taught high school and served as City Engineer of Ripon, Wisconsin. He taught in the Mathematics Department from 1900-14, was appointed Professor of Civil Engineering in 1915, and continued in that position until 1944, the year of his death. He also served as Dean of the College of Engineering from 1927-32. Chandler was closely associated with the North Dakota Geological Survey for a long period of time.

Chandler was also appointed to the position of State Engineer by Governor Frank White on July 7, 1904. This was at a time prior to the enactment of any legislation defining or providing for that position. As State Engineer, Chandler dealt mainly with stream measurements and discharge. He also did an investigation to determine the most suitable areas for irrigation in North Dakota. Legislation authorizing the Office of State Engineer was enacted in 1905, for the purpose of appropriating water. However, the State Water Commission was not created until 1937, to foster development of North Dakota's water resources.

During the 1901-03 biennium, the activities of the Geological Survey grew so rapidly that Babcock could no longer handle the duties of

both the State Geologist and the Director of the School of Mines. He turned the work of the State Geologist over to Dr. Frank A. Wilder in June of 1902 (Figure 3). Wilder was the first professionally trained geologist to be involved with the Survey. Although he was in North Dakota for only a year, Wilder accomplished much, both in the Department of Geology and the Geological Survey.

Wilder, working with L.H. Wood, studied the lignites in Ward County and on the Fort Berthold Reservation (at that time, Ward County was much larger than it is today and included all of modern-day Ward, Burke, Renville, and Mountrail Counties). Wilder commented that the state had been saved considerable expense since Wood's field work was accomplished by bicycle. Wilder and Wood visited the larger mines in Ward County and then traveled to Williston to study the exposures of lignite and clay along the banks of the streams and rivers in the area. The samples of lignite that Wilder and Wood collected were later analyzed by Babcock and Bisbee, who provided chemical and calorimetric tests.

Wilder investigated opportunities for irrigation along the Missouri River and collected data for a report to the state and federal governments. He also spent a month studying the valleys of the Little Missouri, Heart, and Green Rivers as a part of his irrigation studies.

In the Second Biennial Report, published in January, 1903, Wilder summarized the proposed scope of the Survey as follows:

" . . . As definitely stated in the law under which the Survey was organized, it is entrusted with those lines of research that promise to develop the state's mineral wealth. Theoretical problems, however, are not to be neglected. The stratigraphic and topographic features of the state are to be studied and properly mapped, and the historical

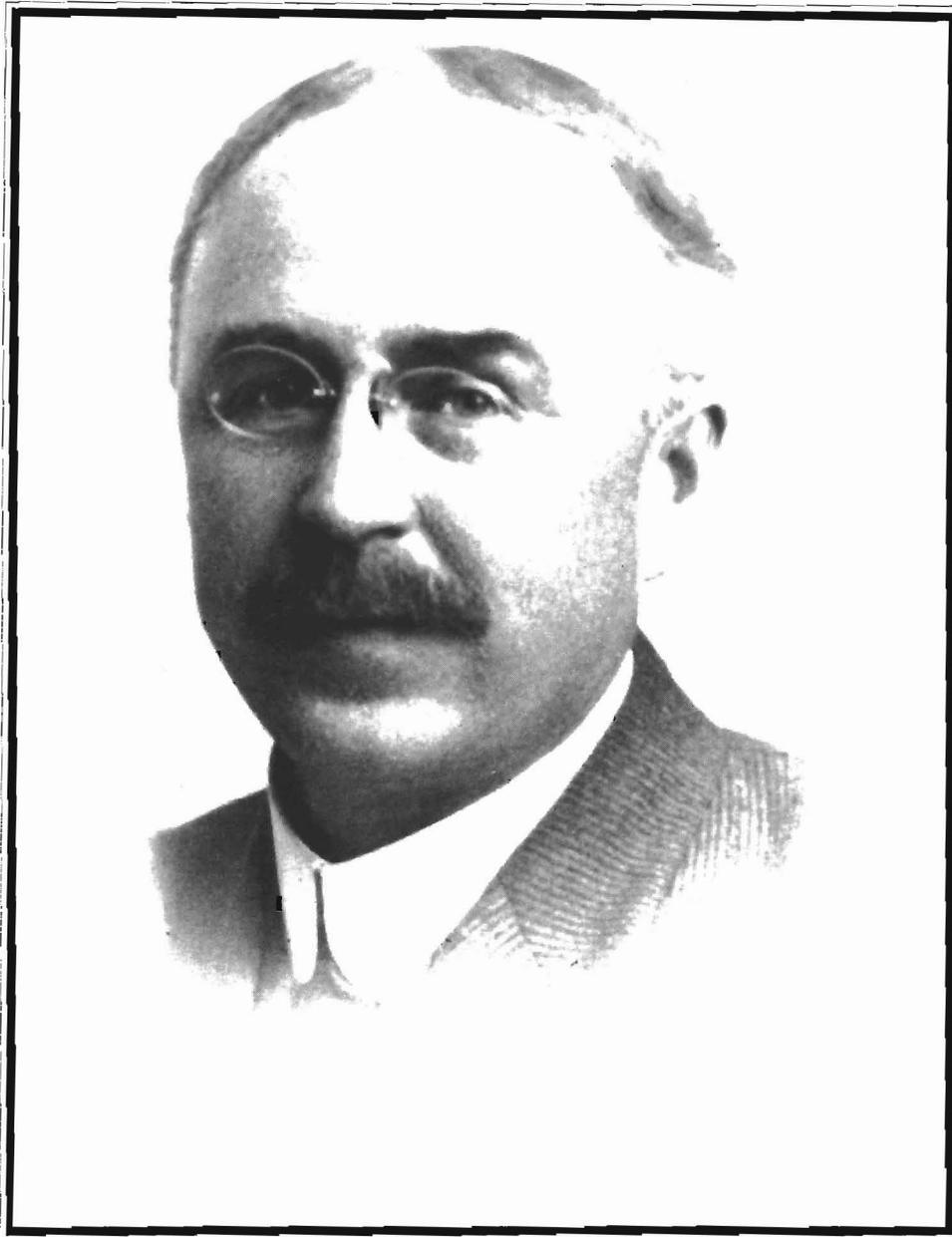


Figure 3. Frank A. Wilder, State Geologist, 1902-1903. Frank A. Wilder was born in Ohio, in 1870. He received his B.A. from Oberlin in 1892, his M.A. from Yale in 1893, and his Ph.D. from the University of Chicago in 1902. Wilder came to North Dakota from Des Moines, Iowa, where he had been a high school instructor. When he left North Dakota in 1903, he returned to Iowa, serving as State Geologist there until 1907, and then as President of Southern Gypsum Company in Virginia until 1927. Wilder died in 1930. Photo courtesy of the Iowa Geological Survey.

development of each is to be explained. A proper order for work is suggested in the statute of organization in which primary stress is laid in the economic problems, to which the attention of the Survey is specifically directed. It shall be my endeavor, therefore, to direct the initial work of the Survey so that the value of the natural resources of the state may be known, and at the same time, so far as practicable, to collect other data bearing on the theoretical problems that the state presents, which shall furnish matter for the later publications.

With the consent of the Board of Trustees, the first bulletins of the Survey will treat of the coals and clays, the water resources with special reference to irrigation, the building stones and cement materials; probably in the order named. Preliminary reports as thorough as the time and means available allow will be made, and these will be followed by more minute studies in which the convenient unit of area will be the county. After the completion of the series of county reports, material will be available for exhaustive topical papers.

In addition to what may fairly be termed the positive work of the Survey, namely the pointing out of the mineral resources of the state which justify investment, a great deal of survey work, just as important in its bearing on the development of the state, is negative in its nature, consisting of making examinations for interested citizens which results in assuring them that the proposition which they have submitted will not warrant development. In this way, the survey saves to the state large sums of money and prevents many hopeless speculations which would delay the development of justifiable projects".

The first edition of the Geological Survey's Second Biennial Report (1,500 copies) was quickly exhausted and the Legislature authorized a second edition of 2,500 copies. It was designated Volume 1, Number 1, and was printed at Bismarck. The report dealt primarily with lignite deposits and included Wilder's ideas about irrigating large areas of western North Dakota, using water to be obtained by damming the Missouri River into reservoirs. The water would be moved from the reservoirs by lignite-powered pumps. The report also included a study by Babcock on the water resources and geology of the Devils Lake area.

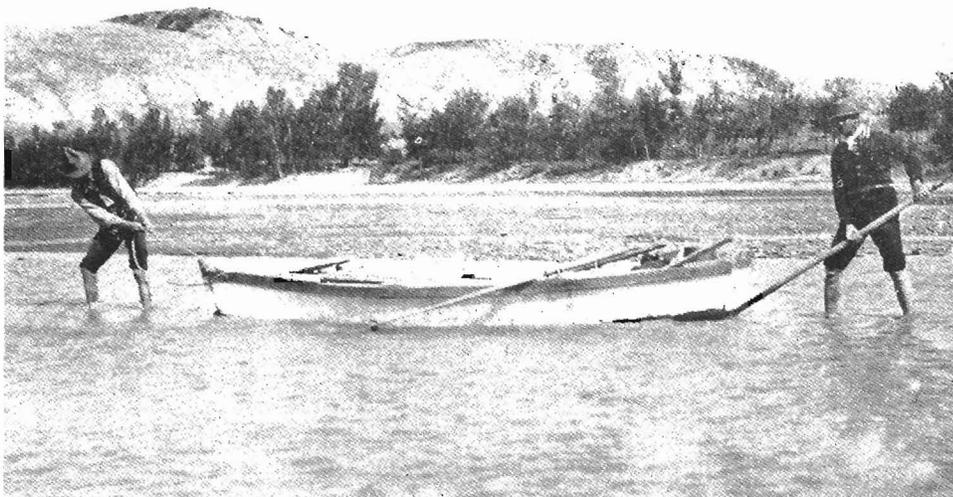


Figure 4. Hauling a boat over a rapids in the Little Missouri below Johnson Ranch, 1903. The field party included L.H. Wood, party chief, and University of North Dakota students Harry Pease and Herbert Goodall, who was also the photographer.

In 1901, the Legislature had established an Agricultural and Geological Survey at the Agricultural College in Fargo. The first director was Daniel E. Willard, a geologist and author of a book entitled *The Story of the Prairies*, which was highly recommended by Wilder. Both the Grand Forks and Fargo agencies came to be referred to as the "Geological Survey," and this led to some confusion. However, the problem was resolved when the Legislature disbanded the Fargo group in 1913.

Wilder continued to pursue his idea of utilizing lignite to run irrigation pumps. E.J. Babcock had already demonstrated that a gaseous fuel could be derived from the coal - something that would finally happen on a large scale 80 years later at the Great Plains Gasification Plant near Beulah. Results of Babcock's studies were included in the Third Biennial Report. Beginning with the 1903-04 fiscal year, the Legislature increased the Survey's appropriation to \$1,000 per year and this remained fixed through fiscal year 1917.

L.H. Wood continued as an assistant to Wilder in 1903, along with Henry Hinds,

Windsor R. Holgate, Herbert A. Goodall, and Harry Pease, all of whom served as field assistants. All were students at the university. Wood's party started from Medora with two of the students and followed the Little Missouri to its mouth where it was met by Wilder's party, which had followed the main stream of the Missouri from the Montana state line in a small boat (*Figure 4*). After a conference at Mannhaven (a small river town on the west bank of the Missouri River in Mercer County; Mannhaven was abandoned when river boat traffic ceased), Wood's party started up the Knife River valley by wagon while Wilder's party continued downstream to the mouth of the Cannonball River.

Wilder followed the Cannonball, by wagon, upstream to its forks at Wade and then along Cedar or South Fork to the Standing Rock Indian Reservation. His main observations were of the occurrences of lignite, although he also noted the limit of glacial deposits in these areas. On the return trip, the party made similar observations along the Upper Heart River. The two parties prepared separate reports.

The Leonard Era

At the close of the 1903 field season, Wilder announced that he would be leaving the state and was resigning his post as State Geologist. Dr. Arthur Gray Leonard (*Figure 5*) was named to the vacant position and assumed his new duties at the beginning of the new school year. Leonard was to be State Geologist for the next 29 years, longer than any subsequent person.

Leonard spent the summer of 1904, becoming familiar with North Dakota. He visited areas where he could observe outcrops of various formations and noted their characteristics. Because of his religious convictions, Leonard usually refrained from work on Sunday, even in the field, although he might use the opportunity to move camp, which was no easy task, traveling by horse and wagon through a country with few roads. Leonard decided to continue Babcock's work on the clays of the state. The North Dakota exhibit at the St. Louis World's Fair in 1903, stressed the value and possibilities of clay found in the state. A variety of beautiful and artistic kinds of pottery made from clays in the Dickinson area were featured in the exhibit (*Figure 6*).

The possibility of finding lignite deposits in the Turtle Mountain area was a prime objective for Leonard during his first years as State Geologist. Glacial materials covered the coal-bearing beds known at the time as the Laramie Formation and no outcrops were observed. Later, in 1907 and 1908, Leonard rejected the broad term "Laramie," and concluded that the beds above the marine Cretaceous belong to the Fort Union Formation (*Figure 7*). Leonard also searched for possible sites for quarrying building stones during the 1904 field season. He determined that stones found in the Velva, Sentinel Butte, and Dickinson areas would make good dimension materials. Stone was quarried at Dickinson, from a butte southwest of town and

also at Davis Buttes. Leonard also made a trip to the Pembina Mountains to study the brick clays and cement rock in that area.

In 1904, Leonard initiated a program of exchange of North Dakota Geological Survey publications with other agencies and societies. The exchange publications became the basis of a large library that was shared by the Geological Survey and the Department of Geology at the university until 1989, when the Survey moved to Bismarck. At that time, the Geological Survey's library was turned over to the university.

The work of the previous biennium was reviewed in the Geological Survey's Third Biennial Report, which was published in Bismarck in early 1905. To expedite its publication, Dr. Leonard spent considerable time in Bismarck proofreading and correcting the manuscript. The report dealt largely with the geology and topography of the western part of the state, continuing Wilder's and Wood's work on lignite and irrigation. The report included discussion of the possibility of using lignite-powered centrifugal pumps for irrigation. It included a chapter by Leonard on the general stratigraphy of the state, the first published report of its kind.

During the summer of 1905, due to the shortage of state-appropriated funds, Leonard took charge of a field party for the U.S. Geological Survey. The party studied the lignite deposits in eastern Montana, as well as in western North Dakota (*Figures 8 and 9*). In preparation for his field season, Leonard bought nine blankets at Fort Lincoln, obtained horses from Custer Trail Ranch, and rented a new wagon at Dickinson. According to Leonard's field notes, September 10-19 were spent looking for the horses after they had strayed away. Most of



Figure 5. Arthur Gray Leonard, State Geologist, 1903-1932. Leonard was born in Clinton, New York in 1865. He received degrees from Oberlin (B.A., 1889 and M.A., 1893), and a Doctoral Degree from Johns Hopkins University in 1898. Prior to coming to North Dakota, Leonard had served as a Professor of Geology at Western College in Toledo, Ohio (1894-96) and at the University of Missouri (1899-1900). He had been Assistant State Geologist with the Iowa Geological Survey from 1893-97 and 1900-03. According to records on file at the University of North Dakota, Leonard served as State Geologist of North Dakota from 1904-09 and as Director of the State Geological Survey from 1910-32; however, it's unclear just what the difference was at that time as the State Geologist was also Director of the NDGS.

Leonard's field notes are stored in the University of North Dakota Geology Library (Figure 10).

Leonard's 1905 field party included two students from the university. It is not clear who these students were since the names of Innis Ward, H.L. McDonald, Windsor R. Holgate, and W.H. Clark are all included in the list of Survey personnel at that time. Dr. Charles Horace Clapp had been appointed Assistant State Geologist at about this time and he headed a 1905 field party that conducted further studies of the clay deposits in the Dickinson area. Clapp, a graduate of Massachusetts Institute of Technology, was assisted by Herbert A. Goodall and J. Marshall Brannon of the university. They reported that white, high-grade clays covered a wide area extending north to the Fort Berthold Reservation, east beyond Hebron, south to the forks of the Cannonball, and west to the divide between the Missouri and Little Missouri Rivers (we know now that these clays occur in the Bear Den Member of the Golden Valley Formation).

Clapp served from 1905-07, as the Geological Survey's Assistant State Geologist. After leaving North Dakota, he taught at Massachusetts Institute of Technology for three years, then worked for a time for the Geological Survey of Canada. He was also a Professor of Geology at the University of Arizona and at the Montana School of Mines, and later served as President of the Montana School of Mines as well as President of the University of Montana for 14 years. Clapp died in 1935.

In the early summer of 1906, Leonard made another visit to the Pembina Mountains before going to Dickinson to resume his work with the U.S. Geological Survey on the lignite beds in the area. The results of this work later appeared in a U.S. Geological Survey publication on the lignites of North Dakota. Leonard's field notes state that, on August 6, a gale caused severe damage to their camp at Sather. This has not been positively identified with a present-day site. At the time, the

field party was in the vicinity of Glendive, Montana, collecting fossils from the Eagle Bluffs. There is a Sather Lake (a reservoir) in McKenzie County, North Dakota, that was probably named for M. Sather who at one time owned most of the land now covered by the lake.

Clapp visited the various clay plants in the state and collected specimens which were tested and analyzed by Professor Babcock in his laboratory at the School of Mines. Most of the plants produced brick. One clay plant was operated by the state at the penitentiary in Bismarck. By 1906, approximately 26 clay plants were operating in North Dakota, primarily for the manufacture of brick for local construction (Figure 11).

Following a directive of the Legislature, the Board of University and School Lands requested that the State Geologist examine certain lands in McLean County to determine if they were coal-bearing. Leonard made two trips to McLean County for that purpose. He prepared a report and submitted it to the Board. He concentrated mainly on coal occurring in the Underwood area, but he also worked in the Wilton, Washburn, Coal Harbor, and Garrison areas.

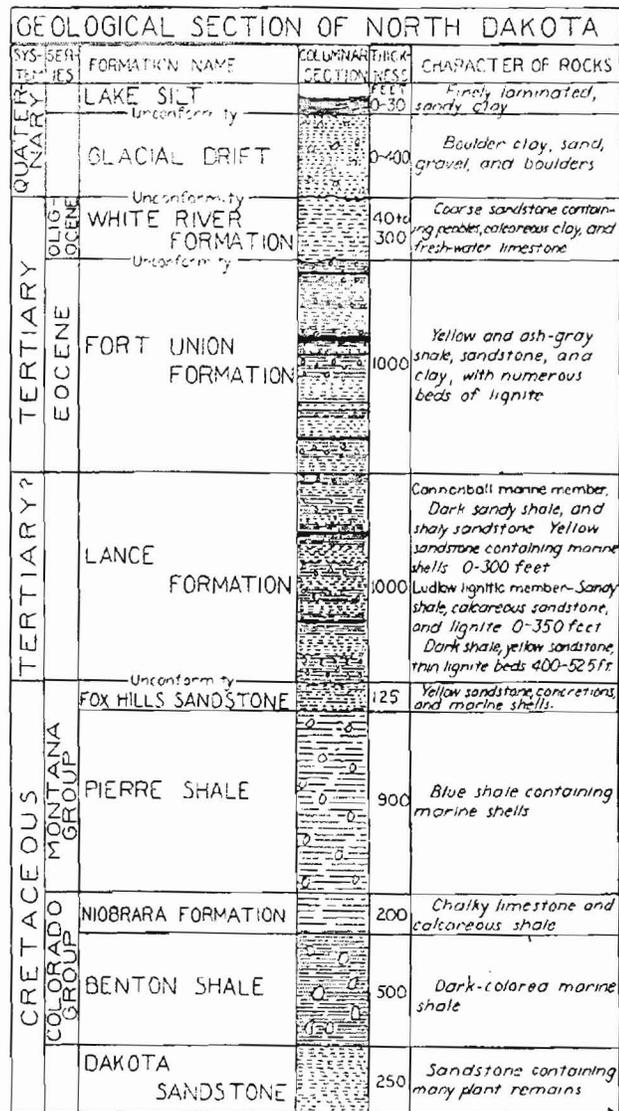
During the summer of 1906, the topography of a quadrangle just east of Williston and another in the Bismarck area were mapped by parties from the U.S. Geological Survey. The expense of this work was borne, in its entirety, by the federal government since the State Legislature had made no matching funds available.

The Fourth Biennial Report, published in 1906, was devoted entirely to results of the Survey's clay investigations. Because of the large number of clay samples that were analyzed, publication of the Fourth Biennial Report was delayed somewhat beyond the usual date of publication. The report included a geologic map of North Dakota, compiled by Leonard in about 1906 (Figure 12).

Figure 6. Pottery made from Tertiary clays near Dickinson. This pottery was displayed at the St. Louis World's Fair in 1903.



Figure 7. Geologic section of North Dakota drawn by A.G. Leonard (probably about 1908) and published in the April, 1917, issue of the *Quarterly Journal of the University of North Dakota*.



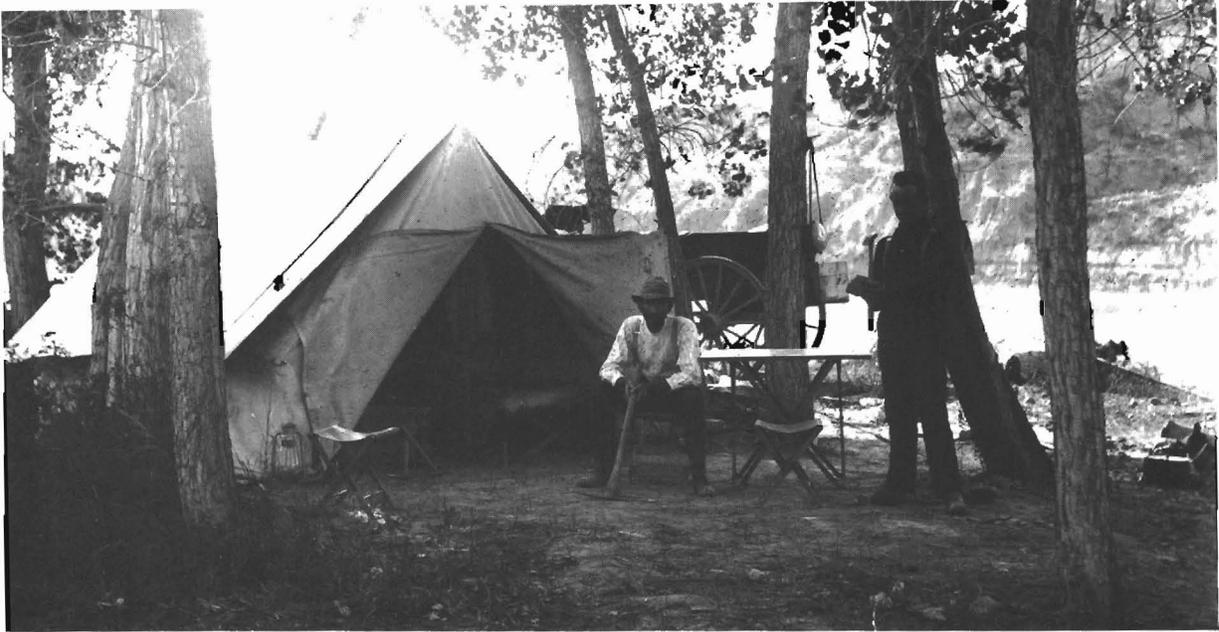


Figure 8. Camp at Miles City, Montana, on the Yellowstone River. Leonard led a field party for the United States Geological Survey during the summers of 1905 and 1906. The objective of the work was to study the lignite deposits in western North Dakota and eastern Montana. Note that camping gear hasn't changed much in 90 years! The unidentified geologist at the right appears to be demonstrating the proper technique for splitting rocks with his hammer.



Figure 9. Camp on the North Dakota prairie, circa 1905-08. The field party is unidentified, but the NDGS had one or two field geologists on staff and hired a few students for the summer. Judging by the shadow length, the photo was taken around evening meal time. The firewood must have come from some other area.

The Director of the U.S. Geological Survey, in May of 1907, invited all of the State Geologists to Washington to confer on plans to coordinate the work of state and federal surveys in hopes of eliminating duplication. A.G. Leonard attended the meeting and made arrangements to continue previous cooperation in gathering mineral statistics and water well records, with the Federal Survey bearing all of the expenses. However, new provisions requiring that the states bear one-half the expense involved in topographic mapping precluded any of that work in North Dakota during the biennium.

During the 1907 field season, Leonard, in association with Carl D. Smith of the U.S. Geological Survey, led a party of five in completing the work of the previous two years. While the U.S. Geological Survey party was camped near Medora, in 1907, they were almost wiped out by a flood, one of the worst since 1880 (Figure 13). The water rose to within a few inches of the tents (it's not recorded why they didn't move the tents). U.S. Geological Survey geologists had joined the state party to collect fossils that might determine the true age of the coal-bearing strata. They found the beds to be a more recent formation, the Fort Union (Tertiary), rather than Laramie (Cretaceous) as had been supposed. Leonard's field notes also indicated finding an unconformity in southern Billings County, which he believed substantiated this interpretation.

Leonard appears to be the first Survey employee to recognize the biostratigraphic and biochronologic importance of fossils and their use in determining environments of deposition (freshwater as opposed to marine sediments). This shows up in Leonard's early writings, such as *The Geologic Formations of North Dakota* (Leonard, 1904 - the Third Biennial Report). He routinely gathered fossils during his field work. He apparently sent most of these fossils to paleontologists with the U.S. Geological Survey at the U.S. National Museum for identifications,

which he published. It appears though that he may have worked with the foraminifera from the Niobrara Formation himself.

Later in the summer of 1907, Leonard took charge of a North Dakota Geological Survey party to extend the investigation beyond the area covered by the federal party. He was accompanied by J.W. Bliss and W.J. Smith, students from the university (Bliss later became City Manager for Minot, North Dakota). Additional work was carried out in 1907, in the Pembina Mountains by V.J. Melsted, a student assistant who mapped the bedrock outcrops in the area.

On Little Beaver Creek, in Bowman County, Leonard's party collected a large number of fossil shells from the Pierre Formation shale. These, together with fossil leaves from the Medora area and some fossil fish from the top of Sentinel Butte, were sent back to the university to be included in the Geology Department's collection. In the vicinity of White Butte, near the Sand Creek Post Office, the party studied Oligocene Formations, which had yielded an extinct three-toed horse and a rhinoceros a few years earlier. While the party did not find many new fossils in the area, they did discover several dens of rattlesnakes, which provided a change of routine.

In 1908, John Gerald Barry replaced C.H. Clapp as Assistant State Geologist. His work consisted of mapping portions of Pembina, Cavalier, Walsh, and Ramsey counties, detailing the larger deposits of sand and gravel and adding to data that had been obtained by Melsted the previous year. Later in the season Barry made a trip to the Bottineau area to investigate reports of natural gas in the area.

Like Clapp, Barry was born in Boston and educated at Massachusetts Institute of Technology (B.S., 1907). In addition to his duties with the Geological Survey, he served as an instructor in geology and mineralogy during 1908

and 1909. After leaving the Survey, Barry taught at Massachusetts Institute of Technology for several years and became a consulting geologist. He later served as President of Texas College of Mines from 1931-34.

In 1908, a party consisting of Leonard, assisted by two university students, Edgar H. Wells and Harry A. Hanson, completed an appraisal of the coal resources of Billings County. The party arranged for three horses from George Donaldson at the Custer Trail Ranch in Billings County. The Custer Trail Ranch eventually became the first dude ranch in the United States. The field party rented a wagon from George Dremkil for \$3 per month and purchased harnesses for \$43. At the end of the season, Leonard stored the party's field equipment at the Heaton Lumber Company in Dickinson.

Leonard's crew borrowed a boat from Charles Clark who lived about 1¼ miles south of the Mikkelson Post Office. The boat was used to inspect the banks of the Little Missouri River for coal beds. Leonard stopped to take pictures of the remains of Roosevelt's Elkhorn Ranch cabin. He reported that it was made of logs based on blocks of sandstone and measured 60 feet by 36 feet.

Leonard's party identified 21 coal beds, many of them previously unknown, aggregating as much as 100 feet thick, and covering extensive areas (Figure 14). At this time, the U.S. Geological Survey estimated the reserves of lignite coal in North Dakota at more than 500 billion tons.

The discovery of the remains of dinosaurs in the vicinity of Marmarth, at the mouth of Bacon

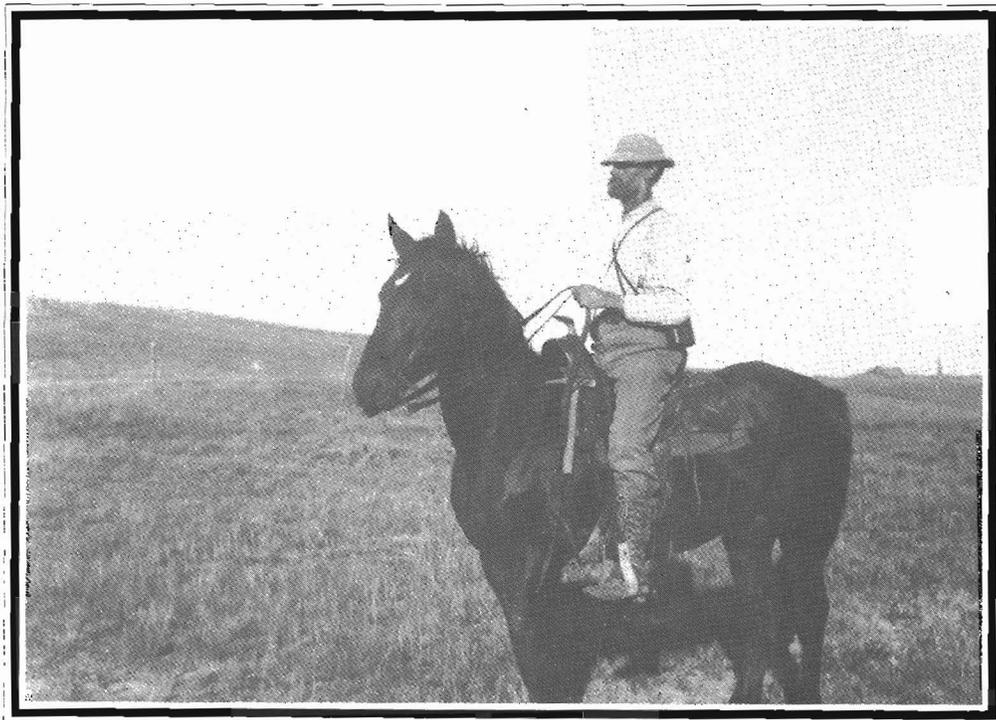


Figure 10. A.G. Leonard on his horse at Kern's Ranch in 1906.

Creek (Sec. 20, T. 133 N., R. 105 W.) was an important result of the summer's work in 1908. In the Fifth Biennial Report, published in 1908, Leonard reported finding dinosaur bones in the Marmarth area. He discussed the importance of the finds and how they might be used to help determine the age of the rocks, which at that time was still in doubt. This is probably the first report of dinosaur fossils by a Survey employee. In the same report, Leonard listed a diverse fauna from the Pierre Shale in Bowman County and he also reported the occurrence of White River mammal fossils. Leonard was interested in the utility of all fossils, including vertebrates, invertebrate megafossils, microfossils (foraminifera and calcareous nannoplankton) and plant megafossils. Several specimens of the Marmarth fossils were shipped to the university but apparently they are no longer there.

Toward the end of the summer of 1908, another effort was made to determine the source and extent of the natural-gas-producing areas of Bottineau County. The area was found to be restricted to the general vicinity of the Parker Farm, about ten miles south of Westhope. The gas came from the base of the glacial deposits and was considered to be a form of marsh gas. It occurred in a 19-foot-thick sand at the base of the glacial sediment and had been used to heat and light 13 homes in Lansford by way of a 20-mile-long underground pipeline system. Many local farmers in that area had installed separators and used the gas to heat barns and other structures, apparently for several years prior to 1910.

By this time, near the end of the first decade of the 20th century, the North Dakota Geological Survey was receiving increasing numbers of

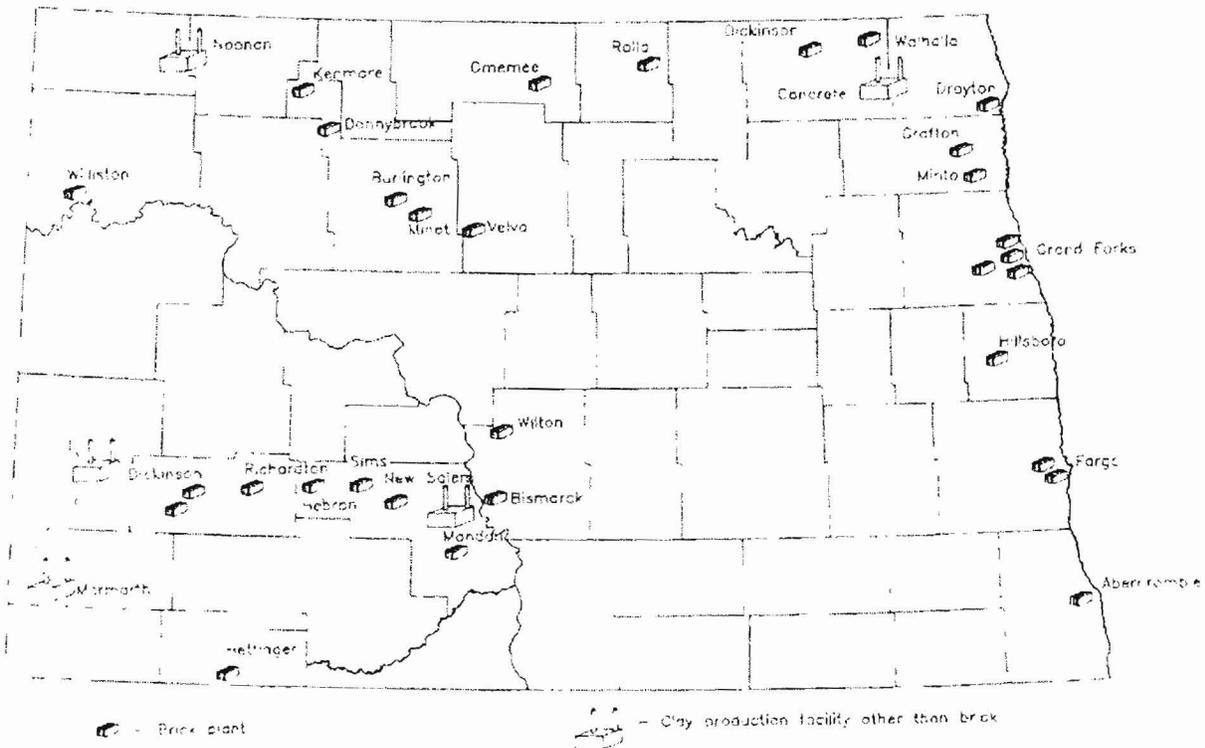


Figure 11. Map of North Dakota showing the locations of clay production facilities that have operated in the state. Most of the commercial brick-making facilities shown operated during the late 1800's and early 1900's. The only plant left today is located in Hebron.

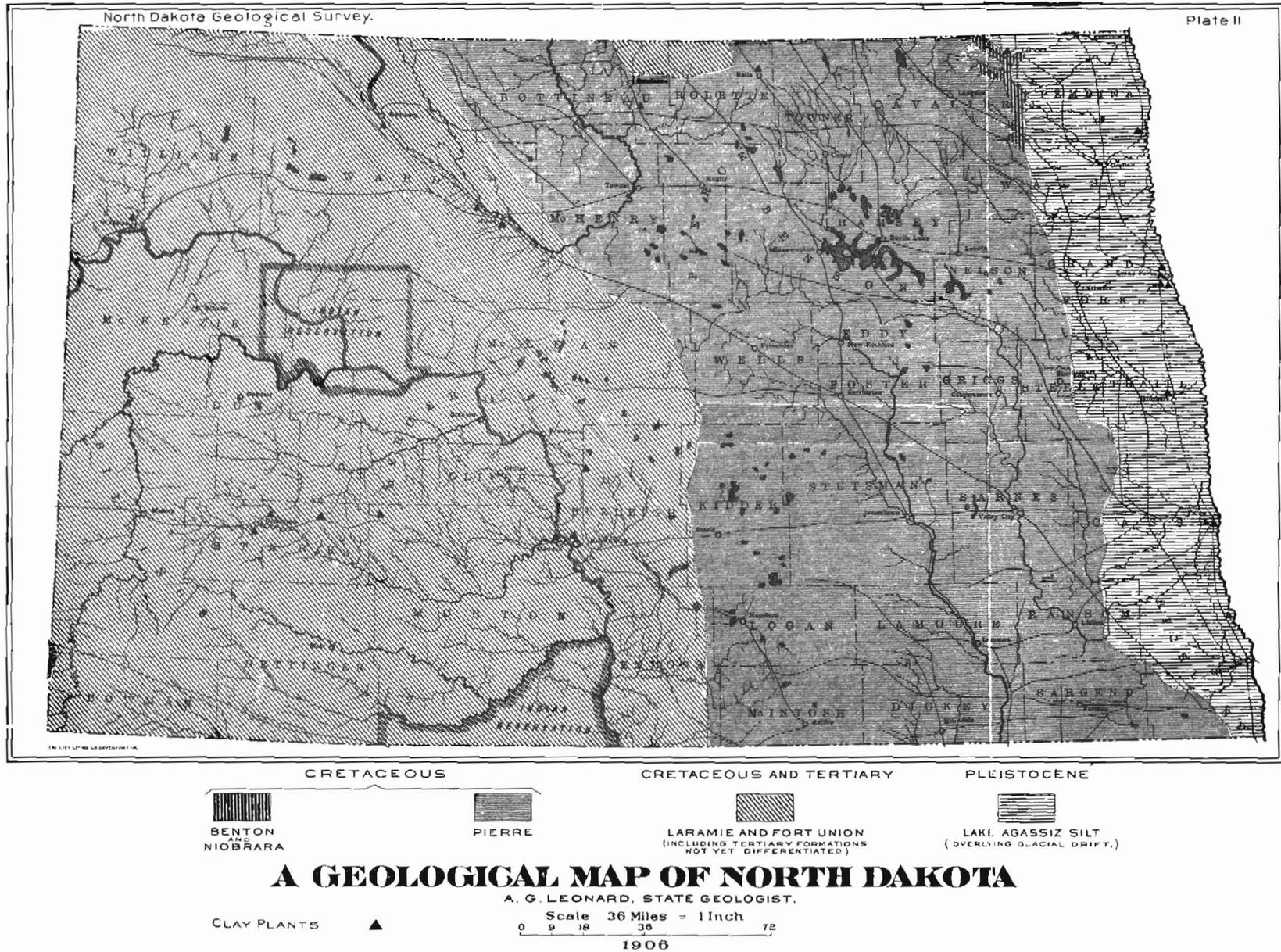


Figure 12. Geological map of North Dakota drawn by A.G. Leonard and published in 1906. The map shows bedrock, except in the Red River Valley where Lake Agassiz Silt is shown. The map also identifies clay plants.

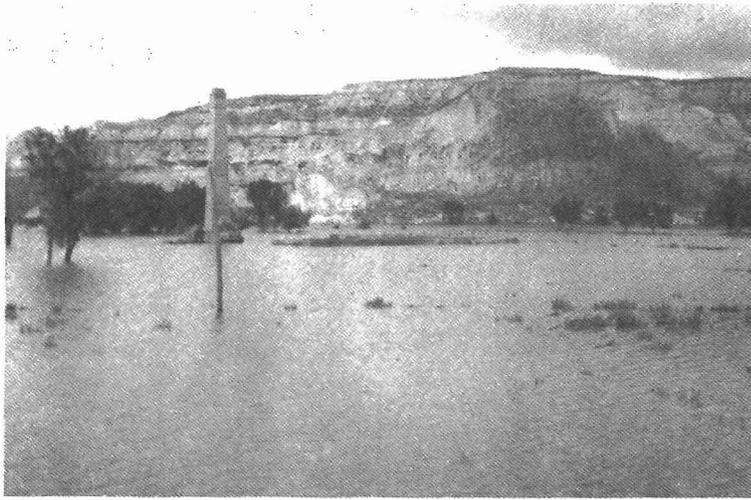


Figure 13. The flood at Medora in 1907. The smokestack marks the site of the DeMores packing plant. The waters of the Little Missouri River rose almost to the Survey's camp.

inquiries about the mineral resources of the state. The problem of answering the correspondence was becoming an increasing burden on the time of the State Geologist who also had to attend to his teaching duties at the university and prepare reports on his fieldwork, as well as discharge the various duties a department head in a university must accept. Leonard was diligent in performing all of his duties in these areas and he maintained a scholarly bearing throughout his life.

Leonard recognized that the Geological Survey had a duty not only to promote the development of the existing natural resources of the state but also to discourage investment in proposals that had little chance of success. He also recognized the educational responsibility of the Survey. He worded many of his publications so they were understandable to teachers. This goal was not always attainable, but Leonard was patient with teachers who inquired about details.

Leonard also demonstrated an understanding of the concept of land-use, which placed him well ahead of his time. He recognized the practical needs of people like water-well drillers for information on the conditions they might expect to find in certain areas and he made an effort to respond to and satisfy each inquiry in detail. He earmarked about 700 copies of each biennial report for distribution to schools and set

aside additional copies to answer inquiries from people involved in the direct development of natural resources.

In 1908, a railroad was built from the site of the cement-rock mine, near the present site of Concrete, to Edinburg, a distance of 21 miles. The Northern Dakota Railway Company was formed by Thomas D. Campbell and Daniel F. Bull, along with subscriptions from local farmers, for the purpose of hauling the products of the mine, as well as agricultural goods. It made its last run in November, 1919, and the rails were removed in 1921. The locomotive was purchased from the Minneapolis, St. Paul & Pacific Railroad and was known, locally, as "Maude."

Up to this time, the U.S. Geological Survey had published topographic maps of 11 - 15-minute quadrangles in North Dakota. The geology of these areas could now be mapped in detail. A nominal charge of five cents per sheet was made for the maps. Leonard continued to point out to the Legislature that much more could be accomplished if matching funds were provided for this work.

Leonard spent much of his time during the early months of 1908, preparing the Fifth Biennial Report, which was published in Bismarck. His report contained a chapter on

southwestern North Dakota emphasizing lignite and a chapter on northeastern North Dakota summarizing cement possibilities. Printing was completed in May, but the report was not bound and ready for distribution until later in the summer.

In 1909, Leonard brought in Howard E. Simpson as Assistant Professor of Geology and Simpson was appointed Assistant State Geologist in 1910. Simpson was interested in physiography and geography and his earliest work in North Dakota involved Devils Lake. His report on the Devils Lake-Stump Lake region, published in 1912, in the Sixth Biennial Report of the North Dakota Geological Survey was exceptionally thorough and showed that he had a good understanding of the hydrology of the lake. Simpson soon became interested in groundwater. Later, during the 1930's, Simpson did a great deal of groundwater work for the Survey. Simpson eventually succeeded Leonard as State Geologist.

Leonard and a field party, which included W.H. Clark and R.L. Sutherland, spent most of the summer of 1909, mapping the geology of the Bismarck quadrangle, which the Topographic Division of the U.S. Geological Survey had completed the previous year. The geologic work on the Bismarck quadrangle, undertaken in 1909, was extended in 1910, to include all of Morton and parts of adjacent counties. Leonard reported the occurrence of a mosasaur tooth in the 1912 text for the Bismarck folio. This was the first report of marine reptile fossils in the Cannonball Formation. Leonard's party also attempted to determine preglacial and glacial drainage patterns and the limit of glacial activity in southwestern North Dakota.

In June of 1910, Leonard spent several days in Bottineau County preparing a report for the U.S. Geological Survey on natural gas occurrences in the area (*Figure 15*). 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 was in Bottineau County in 1907. In the Fifth Biennial Report of the North Dakota Geological Survey, published in 1908, 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 supplied 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 per 1,000 cubic feet in summer, and \$.40 in winter. W.H. Williamson was manager of the company.

The 1911 Legislature passed an oil and gas conservation law (S.L. 1911, ch. 195) which prohibited the production of gas from natural gas wells unless they were tied to a distribution system. Apparently, the law was passed 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.

Also in 1910, Howard Simpson and W.R. Holgate spent a month in the Devils Lake and Stump Lake area investigating the old lake beaches, islands, and former outlets. In addition

to the earlier personnel, M.A. Brannon (who later became president of the University of Montana) was added as a biologist, R.T. Young as a zoologist, T.R. Atkinson as a consulting engineer, and W.H. Greenleaf and F.B. Farrow as field assistants. Dr. S.L. Ruediger, director of the State Public Health Laboratory, was added to the staff as a consultant.

Leonard spent the early months of 1911, completing the manuscript for the Bismarck quadrangle. During the summer, a party consisting of Leonard, T.T. Quirke, and O.A. Baarson studied the coal deposits of McKenzie County as they related to the geology and topography of the area and located the coal outcrops on the map. Simpson spent the summer investigating the underground waters of the Red River Valley.

Leonard continued his investigations in McKenzie County during the 1912 field season with assistance from Quirke and Theodore Bay. The crew identified a number of preglacial river valleys in the area.

The manuscript of the Geological Survey's Sixth Biennial Report was prepared in April, 1912, and submitted to the printer in December of that year. It was distributed in the spring of 1913, (after publication of the Sixth Biennial Report in 1912, subsequent Biennial reports were mimeographed until 1942). The 1912 report contained information on the geology of south-central North Dakota. Enough work had been done by this time to allow construction of a preliminary geological map of the state, which was published separately. The map was reprinted in the Quarterly Journal of the University of North Dakota, Volume 7, No. 3, published in 1917.



Figure 14. NDGS crew measuring coal outcrop (eight feet thick) opposite Burgess' Ranch, five miles north of Medora, circa 1902.

The communities of Carrington, Cooperstown, Casselton, Max, and New Rockford consulted Professor Simpson regarding water supplies and he spent considerable time preparing reports for them. He also began preparation of a report on the three seasons of field work which he and Ruediger had completed. They analyzed more than 800 water samples and the results were included in their final report.

Professor Herbert A. Hard, former director of the Agricultural and Geological Survey of the Agricultural College, requested appointment to the North Dakota Geological Survey staff in order to complete his work on the Edgeley and LaMoure quadrangles. This request was approved and Frank Leverett, of the U.S. Geological Survey, supervised the work under a cooperative agreement.

During August of 1913, Leonard attended the International Geological Congress and toured the eastern Canadian provinces studying the geology and the mining operations in the area.

The Seventh Biennial Report, which Leonard prepared in December, 1913, was devoted entirely to the underground water resources of the state. Leonard reiterated his contention that North Dakota was among the lowest of the states in financial support of its Geological Survey. He pointed out that Oklahoma provided 15 times as much for its Geological Survey and that one-third of the area of the United States had been covered by topographic mapping, but only 13 percent of the area of North Dakota. He attributed this to the fact that matching funds had not been provided by the Legislature as required by the federal legislation. Leonard asked for an annual appropriation of at least \$5,000, but he was turned down and the annual appropriation remained at \$1,000.

Leonard spent a part of the summer of 1914 in McKenzie and Dunn Counties with Theodore

Bay and J.B. Johnson. Using horses and a wagon they had purchased for \$80, they mapped the terminal moraine of the continental glacier and the bed of the glacial lakes which had occupied the valleys of Cherry and Tobacco Garden Creeks. It was while they were in camp in McKenzie County that Leonard's party got news of the outbreak of war in Europe.

Leonard spent the 1915 field season mapping the geology of the Ray 15-minute quadrangle in Williams County. During the course of his mapping, he located the ancient valley of the Missouri River. A group of water well drillers held a convention in Grand Forks in June of 1915, and Leonard addressed them, pointing out the services the Geological Survey could provide. He asked for their cooperation in providing the Survey with well logs. Also in 1915, Simpson, accompanied by chemistry professor, F.H. Heath, visited the Turtle Mountains to study the springs that occur in the region and the mineral deposits connected with them, including iron and manganese-rich minerals.

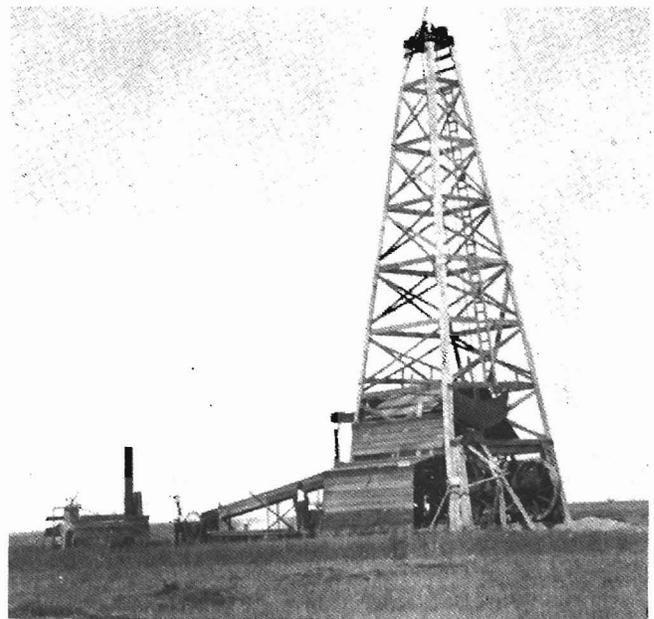


Figure 15. Standard cable-tool rig drilling for natural gas on the Parker Farm south of Westhope, Bottineau County, on June 15, 1910. The operator was the North Dakota Gas Company. The boiler was fired with gas from nearby wells.

Early Oil Exploration Efforts

Even though shallow gas was utilized in parts of northwestern and southeastern North Dakota before 1910, the low-heating value gas was obtained from glacial deposits and no serious attempt was made to drill a real "oil well" until about 1915 (Figure 16). In 1912, the Pioneer Oil & Gas Company was 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.

At 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 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 2,125 feet. We are still carrying 8¼ Casings and have sufficient casings now on ground for a 3,000-foot well. Yes, Blum Well will be carried down to 3,000 to 3,500 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 of

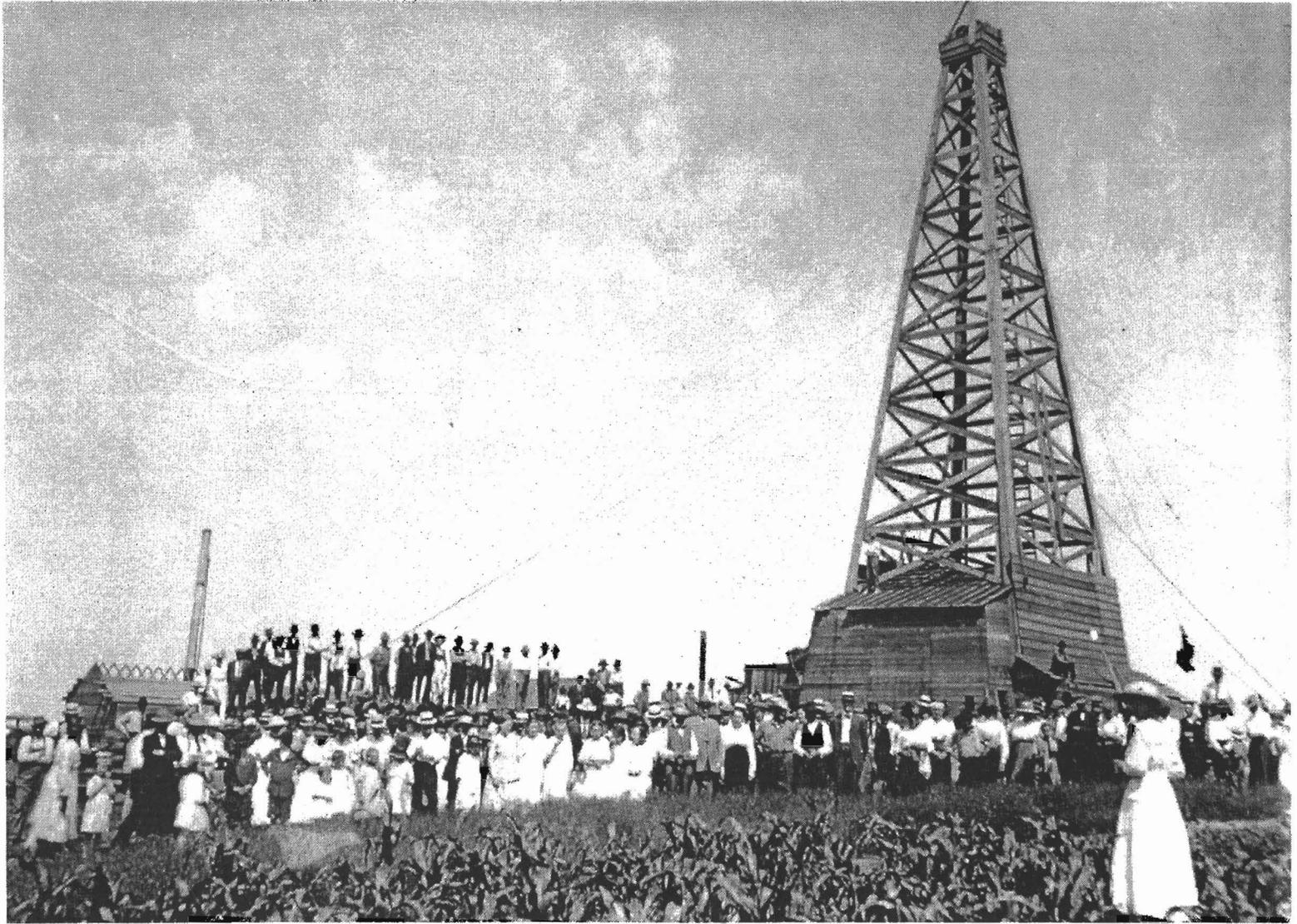


Figure 16. Spectators gathered around a drill rig near Des Lacs about 1915.

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 April, 1916, Leonard visited the Williston area to determine the probability of finding oil or gas in that vicinity. He reported his findings to John Bruegger, a local merchant, and advised against going to the expense of drilling a well. The following month he visited Marmarth for a similar purpose at the request of Governor Hanna and recommended drilling in that area (it's not clear why he made this recommendation, but he was certainly aware of the Cedar Creek Anticline). Leonard spent June and July in Dunn County with Ralph Roy and Lyle Helmkey, studying the margin of the glacial drift in an attempt to determine its age.

In December of 1916, L.L. Colby of the Des Lacs Western Oil Company of Minot visited then Dean Earle Babcock at the University of North Dakota, asking his advice about drilling an oil well at Des Lacs. Babcock, in a letter written in the spring of 1917, advised against drilling. At that time, Colby, who had been the original promoter, resigned from the company. However, his successors, H.S. Johnson (a U.S. Geological Survey geologist) and A.F. 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. According to Des Lacs' advertising, Leonard and Simpson found enough evidence to recommend further exploration. It's not clear what Leonard or Simpson actually said, but neither of them apparently recommended drilling a well. The Des Lacs Western Oil Company drilled a well in 1923, in the NW ¼ NE ¼, Sec. 9, T. 155 N., R. 85 W. The well, which was nonproductive, was drilled to a depth of 3,980 feet at a location four miles east of modern production in Lone Tree Field (modern production is from a depth of 6,500 feet).

At the time the Blum Well was being drilled, and for a period of about five years from 1916 to 1921, Assistant State Geologist Howard Simpson provided technical services to the Des Lacs Western Oil Company by traveling to their well sites and observing and advising on the tests being conducted by the company. In one handwritten letter, Simpson submitted an itemized statement for his services (dated February 9, 1917):

February 7

Taxi, baggage, Grand Forks	.50
Checking baggage	.20
Breakfast	.50
Chair, GF to Minot (train fare)	1.00
(Illegible entry)	.80
Lodging, Minot	1.00

February 8

Taxi to depot	.20
Breakfast	.55

February 9

Lunch	.50
Checking baggage	.20
Supper on train	.85
Seat, Minot to GF (train fare)	1.00
Taxi, baggage	.50
Express	<u>.50</u>

<i>Expenses</i>	9.20
<i>Three days services @ 10.00</i>	<u>30.00</u>
	<u>39.20</u>

The addition is off slightly. A letter written a few months later to Simpson from the oil company secretary, notes that they apologize for a delay in paying the bill, but they will be paying it as soon as they raise more money. Following a similar billing by Simpson a few years later, Simpson subsequently agreed to deduct \$7 from his bill as a sort of contribution to the cause.

Another series of letters written in 1921, is interesting in its dogged persistence at a single topic - attempts to measure the temperature of samples obtained during the drilling of a 4,000-foot hole by the Des Lacs Western Oil Company in the same general area as the 1916 well. The letters span all of the year 1921. The first letter is dated January 31, 1921, and is addressed to H.S. Johnson, Secretary of the Des Lacs Western Oil Company (I have not included the entire content of some of these letters; in this and other quotes, I have left the spelling as it is in the original).

January 31, 1921 - Letter to Johnson from Simpson:

"I have thought often of the temperature test we made on the muds. I am anxious to secure from you or Mr. Blum, if he owns it, the little thermometer with the blue colored wood back which we used in taking the temperature of 110° at that time, in order that I might test out the instrument at the same temperature to see what the reading would be for this on a standard thermometer. I should greatly appreciate therefore, your sending me that thermometer the next time you are at the well and have the opportunity, in order that I may make the proper correction. I will return it to the owner."

The letter is signed by Howard Simpson, Assistant State Geologist.

February 14, 1921 - Letter from V. Smith to Howard Simpson:

"Mr. Johnson has instructed Mr. Blum to send you the thermometer used in your test of December 6th out at the well and will be pleased to receive your thermometer."

April 30, 1921 - Letter from Simpson to Johnson:

"Accept my thanks for the thermometer which was sent from Mr. Blum's residence . .

I should like very much to get some additional data on the temperature of the sludge as it comes up, and will try and provide you with a special thermometer which could be used for getting the temperature, in case you are still drilling. Regarding the bill on December 7, amounting to \$29.76, permit me to make a contribution to the work of the company as I did in the earlier work, and deduct \$7.00 from that portion of the bill rendered for service."

May 5, 1921 - Letter from Simpson to the Director of the U.S. Bureau of Mines, Washington, DC:

"I visited the well in December when a depth of approximately 3,800 feet had been reached, and the temperature of the sludge, indicated on the crude thermometer available, was over 100 degrees in Fahrenheit. I have just secured the thermometer used and hope to compare it with standard instruments in order to determine the true temperature as nearly as we may from thick sludge removed by a sludge bucket . . . I am very desirous of securing more satisfactory temperature data in case the well is drilled further . . . I would request your advice with regard to what type of thermometer should be used in getting the temperature and what method you found most suitable for this purpose . . . Is the high temperature due to friction in the drill? Have you a thermometer suitable for deep well work which could be loaned to the North Dakota Geological Survey for a time for use in this well?"

May 5, 1921 - Letter from Simpson to the Director of the U.S. Geological Survey:

(Dr. Simpson wrote essentially the same letter to the USGS as he did to the Bureau of Mines.)

June 6, 1921 - Letter from Simpson to Johnson:

" . . . the Director of the U.S. Geological Survey, George Otis Smith, has assigned Mr. C.E. Van Orstrand, Physical Geologist of the U.S. Geological Survey, to work with me in securing a series of temperature observations upon the deep well."

The letter goes into more detail about how to obtain temperature readings in deep wells.

June 17, 1921 - Letter from Philip Smith, Acting Director of the USGS, to Simpson:

"I am pleased to learn from your letter of June 6 that you are making final arrangements for a temperature test of the deep well being drilled near Lone Tree, North Dakota . . ."

July 29, 1921 - Letter from Johnson to Simpson:

"I am starting out on the road again and will send you your expenses on last year's trip just as soon as I can raise the money."

October 25, 1921 - Letter from Johnson to Simpson:

". . . we enclose your expenses for \$30.00. I am sorry that I have been unable to send this to you before . . . Before sending the samples to you, it will be necessary for us to have some more of the little bags as I notice that several of the little bags have dry rotted and can not be handled."

December 19, 1921 - Letter from Director of USGS to Simpson:

". . . we enclose the results of the temperature test taken on the well . . ."

Even as late as 1926, the Des Lacs Western Oil Company, which by then was \$40,000 in debt (although it's not clear whether Johnson and Blum suffered any loss) was promoting the idea that Simpson and Leonard had endorsed the drilling of the well. Leonard, in a letter written on March 3, 1926, to L.L. Colby, said:

"So far as we know the statement of Professor Simpson made several years ago still holds true, 'so far as I know, at no time was there a measurable amount of oil nor a sufficient amount of gas to produce a flame higher than a few inches.'"

Prospects and Swindles

In the early years of this century, numerous efforts were made to find oil and gas in various parts of North Dakota. However, it's likely more energy was expended soliciting for investments in stock in the small corporations formed to explore for the oil and gas than in actually looking for oil. These solicitations invariably involved testimonials from eminent people: geologists, engineers, and other "credible" people. Even the State Geologist of North Dakota sometimes supplied letters of reference for use by the stock companies, and these testimonial letters were exploited extensively for advertising purposes.

A series of letters written in 1921 and 1922, between Leonard and William Langer (who went on to become Governor of North Dakota, and later, a Senator) begins with a letter from Langer to Leonard, dated December 7, 1921. I'll quote the letter in its entirety:

"While I was Attorney General and on the Blue Sky Board the records will show that I repeatedly, in fact almost invariably insisted that before Gov. Frazier, Sec'y of the State, Thos. Hall and myself would permit an oil or gas company to operate in North Dakota that either your personal approval, or that of some member of your department be secured.

I mention the above simply as introductory. I now have the time to become personally and actively interested in the development of oil and gas prospects of North Dakota.

Several of us University graduates, including Tom Johnson of Dunn County, John Williams of Washburn, Fred Graham of Ellendale and others are uniting our efforts and abilities in bringing North Dakota resources to the front and incidently or rather not entirely incidently, but as a major by product, making some money for ourselves.

I should like to know how much it would cost us in case we could get your time and you could so arrange your work so as to have it at your disposal, to give us ten days or two weeks in various parts of North Dakota and also what it would cost us to get you for thirty or forty days this coming summer. We do not wish to presume in any friendship and it is strictly a business proposition."

The letter is signed by William Langer. Leonard responded, pointing out that his normal fee was \$25/day, but for over a week he could drop that to \$20/day. He suggested waiting until the next spring to do the work. Ensuing correspondence consisted of some negotiations about the fees and attempts to set up a time when Leonard could do the work. Leonard pointed out that he couldn't do worthwhile work when there was a heavy snow cover. Langer agreed, commenting (December 27, 1921) that:

"At the present time we have considerable snow. I drove out in the country yesterday and feel satisfied that you could not do careful and worthwhile work under the present conditions."

I cannot find any reports that Leonard may have made as a result of his work for Langer, but it appears that he did actually do the work. In a letter dated May 29, 1922, Langer writes:

"I have your telegram of May 27th and will expect you here Friday night, June 2nd, for four days. I will pay you while you are here so I will not inclose a check now."

Time has shown which of the oil-exploration ventures were realistic ones, which were misguided, and which were out-and-out swindles. Almost all of them were wildly optimistic in their claims and promises, with pictures of "gushers"

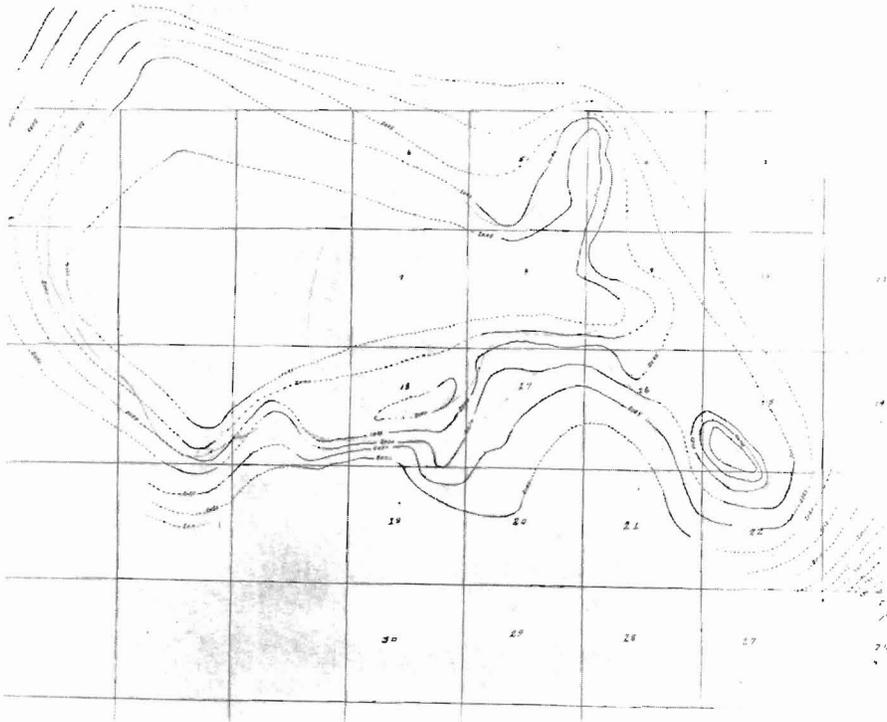


Figure 17. "Geologist's map" of the New England structure, supposedly an anticline, that appears on many promotional brochures in 1923. On the brochures, the map is always less clear and much harder to read than is the copy I've reproduced here. I can't guess what geologic information was used to compile the map, and the geologist who compiled it is not identified.

The Mohall oil play of 1919, is quite well documented in our files. It involved a feature referred to as the "Mohall Anticline," which was described in one ad as "about 60 miles in length, beginning just across the Canadian line, northwest of Loraine, and extending in a southeasterly direction about 70 miles just a little to the west of Mohall and Loraine, thence about 40 miles in a southeasterly direction." State Water Geologist Howard E. Simpson, who also served as Assistant State Geologist and as a UND Geology Professor, in a letter and report dated March 31, 1919, to the Great American Gas and Oil Company in Mohall, described the general geology of the area. I'll quote from part of his report:

"The bed-rock in this part of the state is very nearly level, the (sic) having a very slight dip to the southwest. That there is a broad and gentle anticline trending from northwest to southeast and extending from Canada into the United States is very strongly suggested by the topography of the region. The great broad loop of the Mouse River suggests that this

stream is turned from its general easterly course in Saskatchewan by an elongated dome or anticline, which extends southeast along the axis of the loop, and that, having slipped off the slopes of this very gentle uplift, the stream follows around the base of the slope, regaining its easterly direction again, in Manitoba.

The great amount of erosion, which has taken place in this region in such a way as to separate the Turtle Mountain outlier from the main front of the Missouri Plateau, also strongly suggests an arching of the earth's crust from the northwest to the southeast along the general line of the axis of the loop and parallel to the Coteau du Missouri, as the front portion of the Missouri Plateau is called.

Further evidence of the anticlinal structure is seen in the occurrence and pressures of the gas in the wells of the region. Traces of gas are found in most of the wells over 150 feet

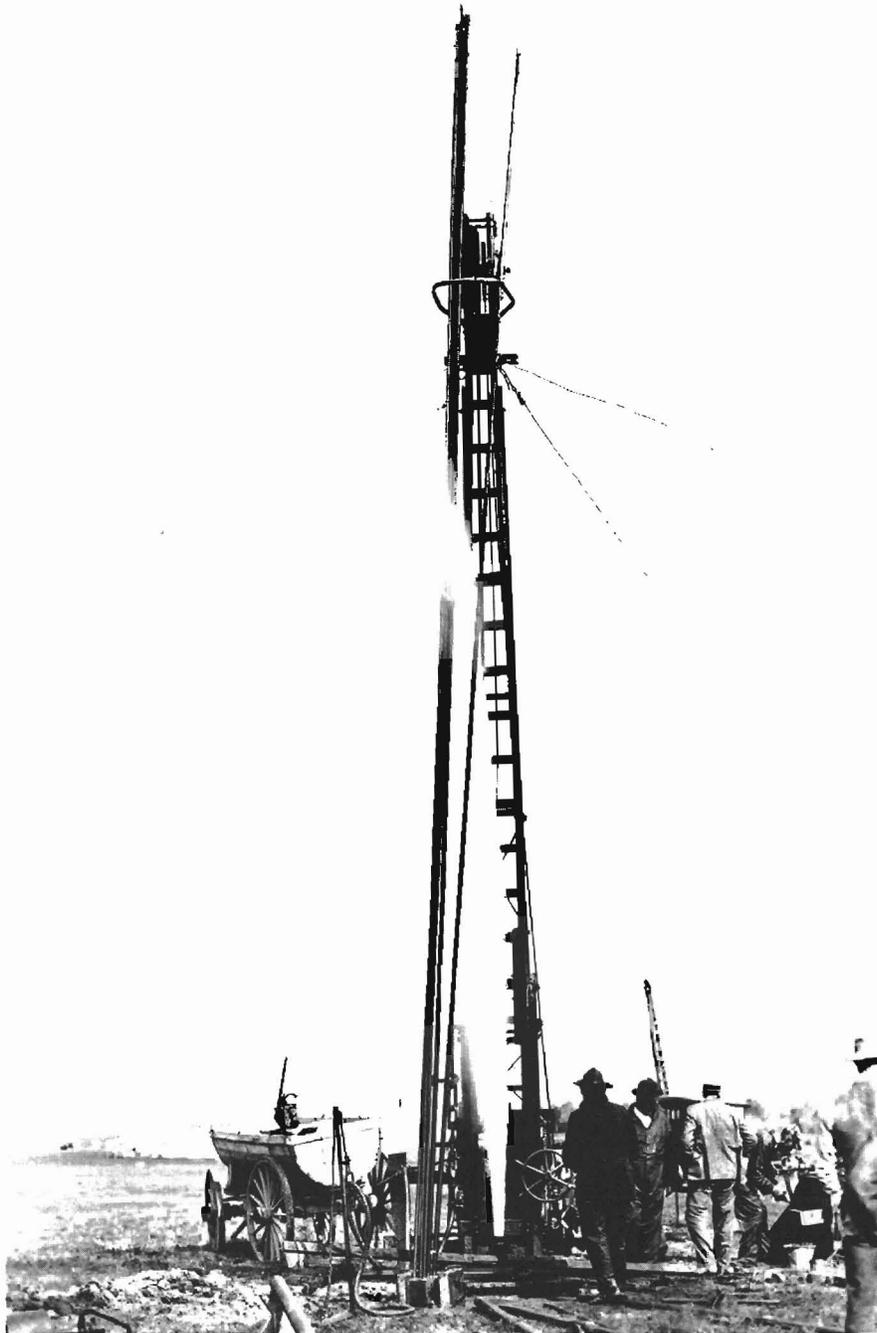


Figure 18. This picture appears on many pieces of promotional literature circulated during the 1920's. It is referred to in one place as "One of Mohall's gushers", on the Mohall Anticline.

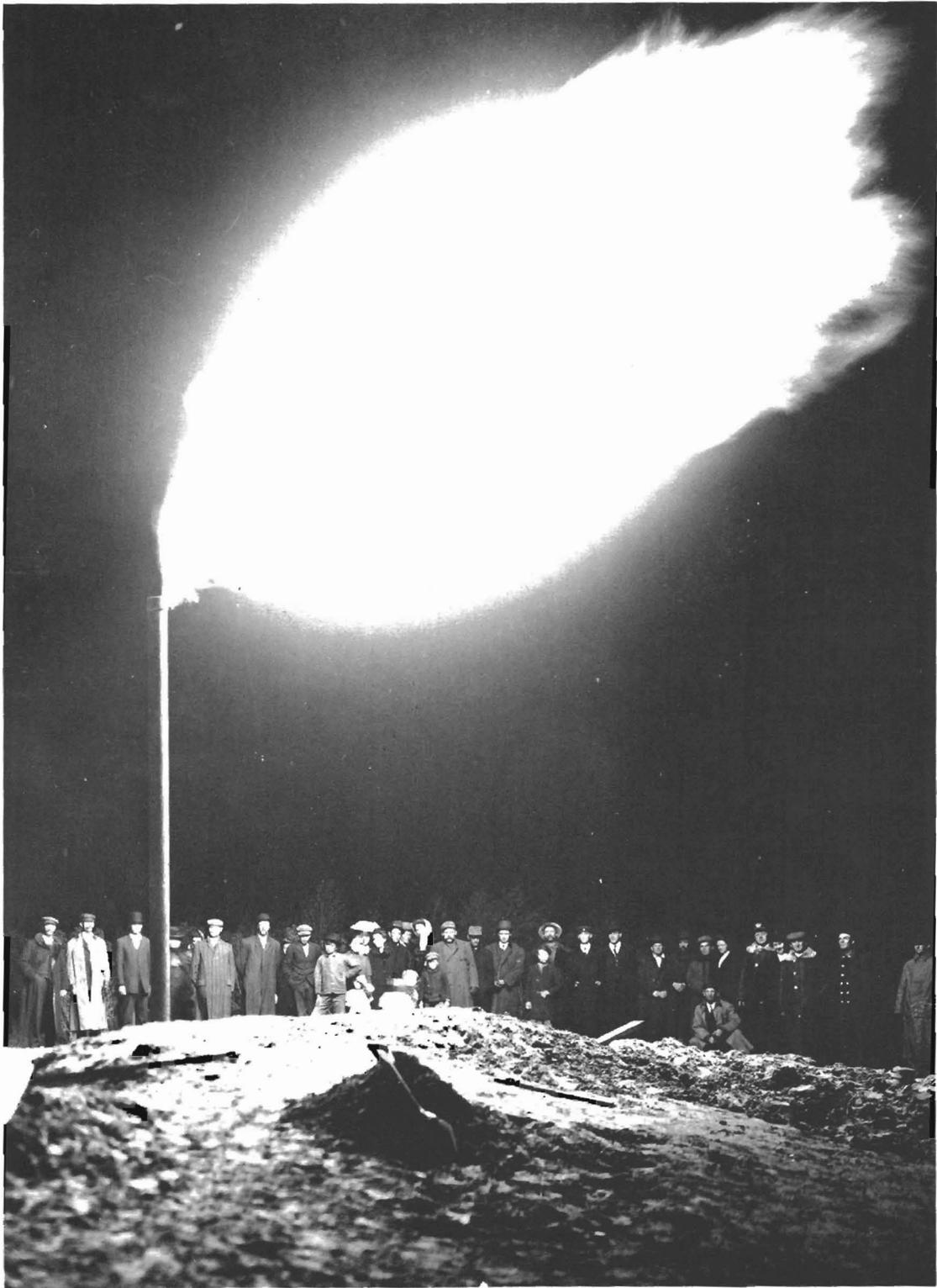


Figure 19. Gas flare on the Mohall Dome. Photo taken in the early 1920's.



Figure 20. 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 the left.

in depth in the east central portion of the loop district and in all wells over 200 feet deep in the west central portion. The abundance and pressure of the gas in two nearly parallel belts extending from northwest to southeast indicates a possible secondary anticlinal structure within the area of the uplift. The longer of these belts passes west of Loraine, near Mohall, east of Lansford and Glenburn, and appears to die out at a point about 6 or 8 miles east of Deering. About 10 or 12 miles east of Mohall is a small area in which occur two or three artesian wells, which flow without evidence of gas. These must lie to the east of the Mohall anticline and mark a slight syncline, though their flow may be due to the pressure of gas in the water bearing stratum at some distance away."

I am not sure what to make of the Mohall Anticline (Simpson later referred to it as the "Mohall Dome"). I don't know of any modern geologic evidence that might confirm its existence; certainly it's not an anticline that accounts for the route of the Souris River, as was suggested by Simpson; rather the river probably owes its route to the effects of glaciation. For what it's worth, on one of the pieces of promotional material referring to the Mohall Dome, someone has scrawled the word "Bunk" -

the handwriting looks like that of A.G. Leonard. As I noted earlier, the gas that had been used in the Mohall-Lansford area occurred in a sand at the base of the glacial deposits and was not related to any significant geologic structure like an anticline (Figures 19 and 20). Even so, Leonard made the following statement in 1920:

"With its crest about three miles west of Mohall, near the eastern border of Renville County, a . . . quite well defined anticline has been located, its axis trending north-northwest and south-southeast. Within the area covered by the Mohall anticline a large number of wells yield gas under pressure of over 100 pounds, the gas being found in sandstones of the Fort Union formation at a depth of 200 to 300 feet. A company has been formed to drill on this anticline, the well to reach the Dakota sandstone in search of oil and gas."

The Great American Gas and Oil Company eventually ran into other troubles with the state "Blue Sky Commission," which regulated and supervised the sale of these stocks. The following quotation is from a newspaper clipping dated April 3 (but I can't find either the year or the name of the newspaper):

"A well was started near Mohall, Renville County. A mammoth sales campaign was inaugurated. Autos met prospects at the train and took them to the well. Gas had been found, it is said, and wells burned brightly at night when prospective buyers for stock were on hand.

When the well was only partly down to the depth it was planned to drill, the contract with the well drillers was broken. The Great American sued the drilling company. The company sued the well drillers. An attempt was made by some parties to remove part of the equipment to Montana, it is charged.

It is also charged by the state that stock salesmen sold stock to some people at the par value of \$1.00 a share and would sell stock to others the same day for as high as \$5.00 a share."

Except for exorbitant salaries and commissions paid officials of the company, the commission charged that nearly all of the remaining money was spent on promoting the venture and almost nothing was actually spent in exploring for oil.

An interesting part of all this is the way these early North Dakota oil companies went about promoting stock sales. One example I found in our files includes a composite picture extolling the use of gas for farm use. The farm was probably that of Ole Hellebust in Renville County, but it's impossible to be certain. The photo was made in 1919, about the same time that Great American Gas and Oil Company hired a firm called Publicity Film Company to make some movies along Mohall's Main Street. According to a Mohall newspaper clipping (it's undated, but apparently is also 1919), these movies showed the exterior and interior of the office as well as the officers of the oil company. They also showed a threshing scene on the Mohall Anticline of a 60 h.p. gasoline engine

pulling a 42-inch separator, the engine being operated by natural gas in place of gasoline. I'll quote part of the article (Figure 21).

"No important changes were made on the carburetor and the pressure from the gas wells forced the natural gas into the carburetor and the engine worked perfectly and seemed to handle its load as easily as it would on gasoline. This is probably the first time in history that such a threshing rig has ever been operated by natural gas power. They also photographed a washing scene, the gasoline engine being operated by natural gas coming direct from the well. The pictures taken of the tapping of one of the company's wells which they have put down since they began operating this Spring will also be a very interesting scene to theater goers. Then they photographed the cooking and lighting with natural gas and also the operation of the large standard oil drillers outfit operating southwest of this city.

The company has gone to considerable labor and expense having this film company come to the Mohall fields and we hope the pictures will do the different scenes photographed justice. If they do, this will be one of the most unique advertising films ever produced."

These are just a few of the many examples of the early oil exploration promotional efforts in our files. All of the old photos I've included here were used in brochures promoting sales for the Great American Gas & Oil Company in Mohall.

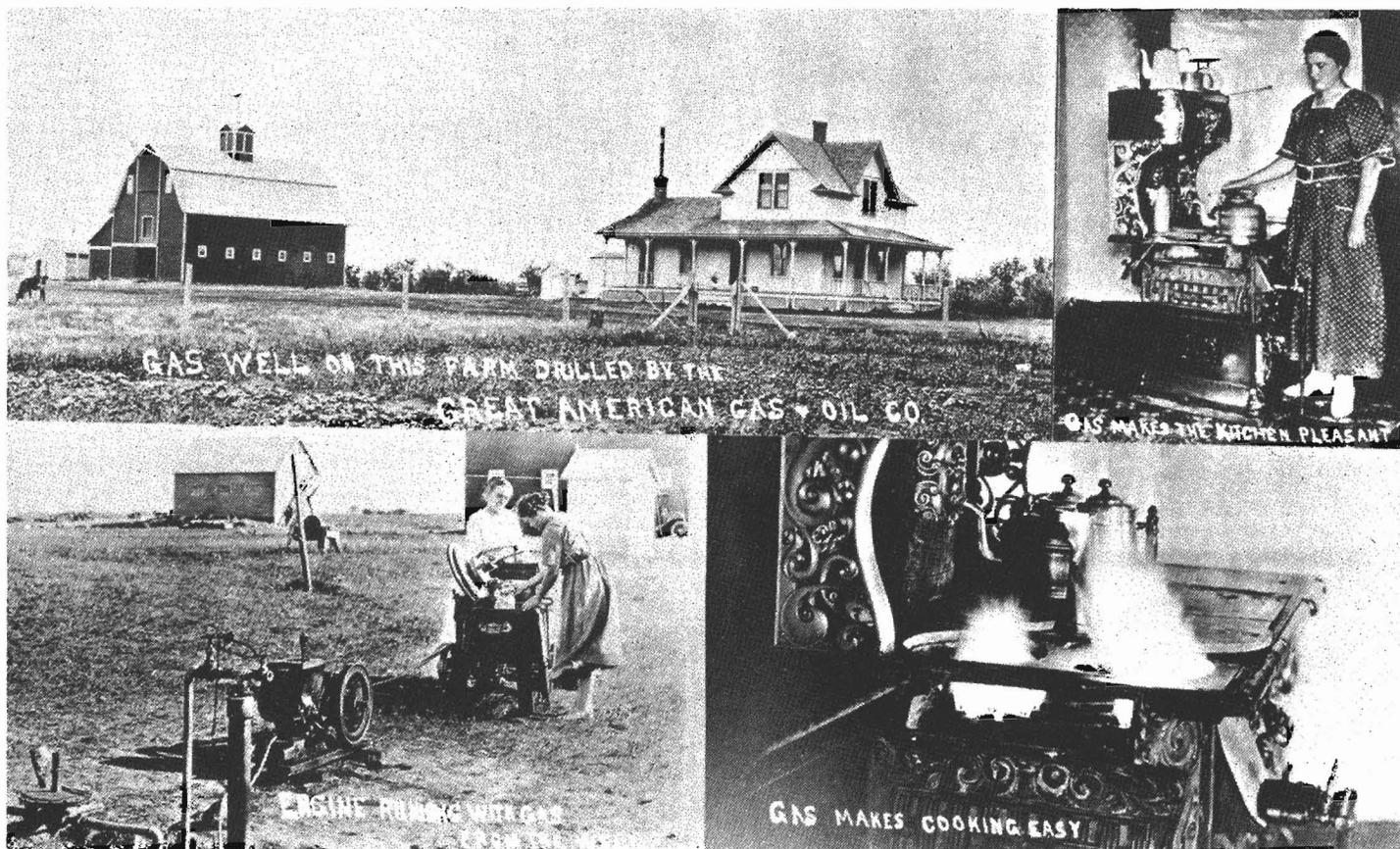


Figure 21. Composite photo of several activities relating to the uses of natural gas. The scenes were probably taken in 1919, on the Ole Hellebust farm, near Mohall, in Renville County, but I cannot verify this. The pictures were used in a prospectus extolling the use of gas for farm usage. The gas well was drilled by the Great American Gas & Oil Co.

Mapping In The Early Years

Leonard's earliest work in the vicinity of Sentinel Butte (about 1908) indicated that Sentinel Butte was the highest point in the state with an elevation of 3,350 feet above sea level. However, controversy continued for many years as to which butte was highest. A letter to Leonard dated December 1, 1923, from H.R.S. Diesem, editor of the Fargo Forum, reads as follows:

"An article in a recent issue of the Marmarth Mail again raises the question of what is the highest point or elevation of land in North Dakota. It occurred to me that it might prove interesting if we gave for the reader's benefit an array of such authorities and data on the point as are available.

My examination of data and authorities reveals many conflicts, vaguities and uncertainties.

I wish to check up with you principally upon statements contained in the fifth annual report of the state geological survey, 1908.

One paragraph refers to Sentinel Butte, evidently meaning the butte and not the town, as being the highest point in North Dakota, and gives its elevation as 3,300 feet.

The report also refers to Black Butte (championed in the last year or so as the highest North Dakota point), but does not give the elevation of Black Butte.

Another paragraph of the state report says: 'So far as known, the highest point in North Dakota is found in Billings county. The top of Sentinel Butte has an elevation of 3,350 feet above sea level.'

The report further says: 'Bowman ridge probably attains its greatest height in

northwestern Bowman county on the divide between Deep creek and Spring creek. A large area is 3,000 feet above sea level.'

It occurred to me that errors may have crept in during the course of compilation and printing of the state report. My understanding is that Sentinel Butte (the butte or peak) is in Golden Valley county, while the language of the state report conveys the impression that Sentinel Butte (the butte not the town) is in Billings county. Furthermore the reference to Sentinel Butte as having an elevation of 3,300 feet, made in one paragraph, and the reference giving the 'top as having an elevation of 3,350 feet,' are somewhat confusing.

As far as Black Butte is concerned, I conclude it is in Slope county, where it appears on the map as the 'H.T. Butte.'"

Leonard replied to Diesem in a letter dated December 5, 1923:

"Replying to your letter of December 1 regarding the highest point in North Dakota; since the appearance of the fifth biennial report of the North Dakota Geological Survey, the U.S. Coast and Geodetic Survey has published a report in which they give to within the fraction of a foot the elevation of a number of buttes in western North Dakota. These elevations were secured in connection with the triangulation carried on some years ago from Colorado to the Canadian line along the 104th meridian. The exact elevation of all buttes which were used for triangulation stations is given in this report. Black butte, or HT Butte, as it is given on many maps, in Slope county about 7 miles southwest of Amidon, is given as having an elevation of 3,468 feet. So far as I know this

is the highest point in North Dakota. The same report gives the elevation of Sentinel Butte as 3,430 feet, or about 700 feet above the town of Sentinel Butte. The elevation of this butte as given in the fifth report was determined with an Aneroid barometer, and this instrument often varies with the changing weather conditions and is not always reliable as in this case. West Rainy butte is given as having an elevation of 3,440 feet. The highest town in the state is Rhame, 3,178 feet, and there is quite an area in Bowman and Slope counties which has an elevation of 3,000 feet and over. I may say that since the preparation of the fifth report Slope and Golden Valley counties have been made from old Billings county. At the time the report was written Sentinel Butte and Black or HT Buttes were in Billings county."

Today, White Butte in Slope County, just a few miles east of Black Butte (at 3,506 feet), is recognized as the highest point in North Dakota (Figure 22).

During the summer of 1916, the North Dakota Geological Survey entered into an

agreement with the U.S. Geological Survey to map the geology of the Ray quadrangle. The U.S. Geological Survey party, under the direction of A.J. Collier, mapped the coal outcrops in the badlands along the Little Missouri River, while the North Dakota Geological Survey party studied the geology in the rest of the quadrangle. The federal government paid half of the expense. The North Dakota Geological Survey party in 1917, consisted of Leonard and two university students, J.D. Leith and Doyle Watt. His party visited Collier's camp on Willow Creek (August 10), with field equipment stored at Smith's ranch five miles from Manning. Leonard used Smith's Ranch as a base of operations for several years.

In April of 1917, Leonard attended a conference in Washington, D.C. of federal and state geologists called by the Director of the U.S. Geological Survey. Thirty states were represented by their state geologists. Leonard noted that the Association of State Geologists held several sessions while its members were in Washington, discussing a number of subjects of common interest. Also in 1917, Leonard published a new geologic map of North Dakota (Figure 23). This map shows detail not included on his earlier map, published in 1906 (page 17).



Figure 22. Aerial photo of the Chalky Buttes in Slope County. White Butte (the highest point in North Dakota at 3,506 feet) is in the center of the photograph. View is to the north. Photo by Ed Murphy.

At the start of the 1917 field season, Leonard bought a team of horses from P. J. Reagan, a rancher on the Knife River. He paid \$325 for Rowdy, a seven-year-old Bay Gelding, and Rocky, a six-year-old that was lighter in color and larger than Rowdy (the field notes for the season are reprinted in the *North Dakota Quarterly for Spring, 1970, Volume 18, No. 2, pages 56-80*) (Figure 24).

The Survey had also obtained an automobile about this time, which Simpson used to study the artesian water basin in the Mouse River loop. With Walter Belyea, he constructed cross sections from Bottineau to Crosby, Kenmare to Kramer, and from Bottineau to St. John. The automobile enabled them to cover more territory than had been possible before.

Natural gas occurrences had been reported in water wells in northwestern North Dakota. During August of 1917, Simpson and Harry Polk, a former university student, investigated occurrences near Lansford and Westhope. Simpson included data obtained during the investigation with his continuing study of underground waters.

The study of the Ray quadrangle continued in 1918, with Doyle Watt, Douglas Leith, and Lyle W. Bittinger assisting Leonard (Figures 25 and 26). Simpson was teaching summer school at the university and was unable to do any fieldwork. Leonard noted that he spent much of the summer mapping the terminal moraine of the continental ice sheet. He determined that the moraine was an extension or lobe of the main Altamont moraine, the margin of the Wisconsin drift. He spent several days mapping the very rough, hilly moraine topography in the vicinity of Wildrose.

The 1919 Legislature increased the Survey's appropriation to \$3,000 and this allowed an expansion of activities. In 1920, Leonard Percy Dove was employed for part-time work with the Survey in addition to his teaching duties in the

Department of Geology. He began his fieldwork in 1919, but was forced to stop his work when the car, in which he was riding, overturned. He suffered a broken ankle. On August 1, Leonard and a "Dr. Ray" put a plaster cast on Dove's foot and he left for Grand Forks the next day. Dove had intended to attempt a correlation of the various coal beds in the Garrison area.

Dove was born in Iowa, in 1883, and educated at Simpson (B.S., 1909) and the University of Chicago (M.S., 1922). After teaching several years in various high schools in Iowa and South Dakota, and at Northwestern University, he came to North Dakota in 1919. Dove was appointed an Instructor in Geology at the University of North Dakota in 1920, and Assistant Professor of Geology as well as Assistant Director of the Geological Survey in 1921 - a position he held until 1925. Dove left the Geological Survey in 1925, to manage Dakalite Products, Inc. in Minot until 1930. After that, he served as a staff engineer for Mariner & Hoskins in Hinsdale, Illinois.

Leonard, assisted by Wesley R. Johnson and Lester T. Sproule, continued his investigation of the state's lignite resources, concentrating his efforts during the 1919 field season in Ward and Mercer counties. Leonard's work in the Garrison area led to a request that the U.S. Geological Survey map the topography of the area. The 1919 Legislature had made a special appropriation for lignite investigations, and Leonard was able to draw \$18,000 against this fund during the biennium. Of this amount, \$3,000 (\$1,500 each year) was used as matching funds for topographic mapping by the U.S. Geological Survey. The results of the investigation can be found in NDGS Bulletin 4. The work was carried out by a party under the direction of J.E. Blackburn and two assistants from the U.S. Geological Survey.

Dove and H.N. Eaton extended the lignite study into the northwestern counties and mapped the extent and thickness of the major beds,

GEOLOGICAL MAP OF NORTH DAKOTA

COMPILED BY
A. G. LEONARD, STATE GEOLOGIST

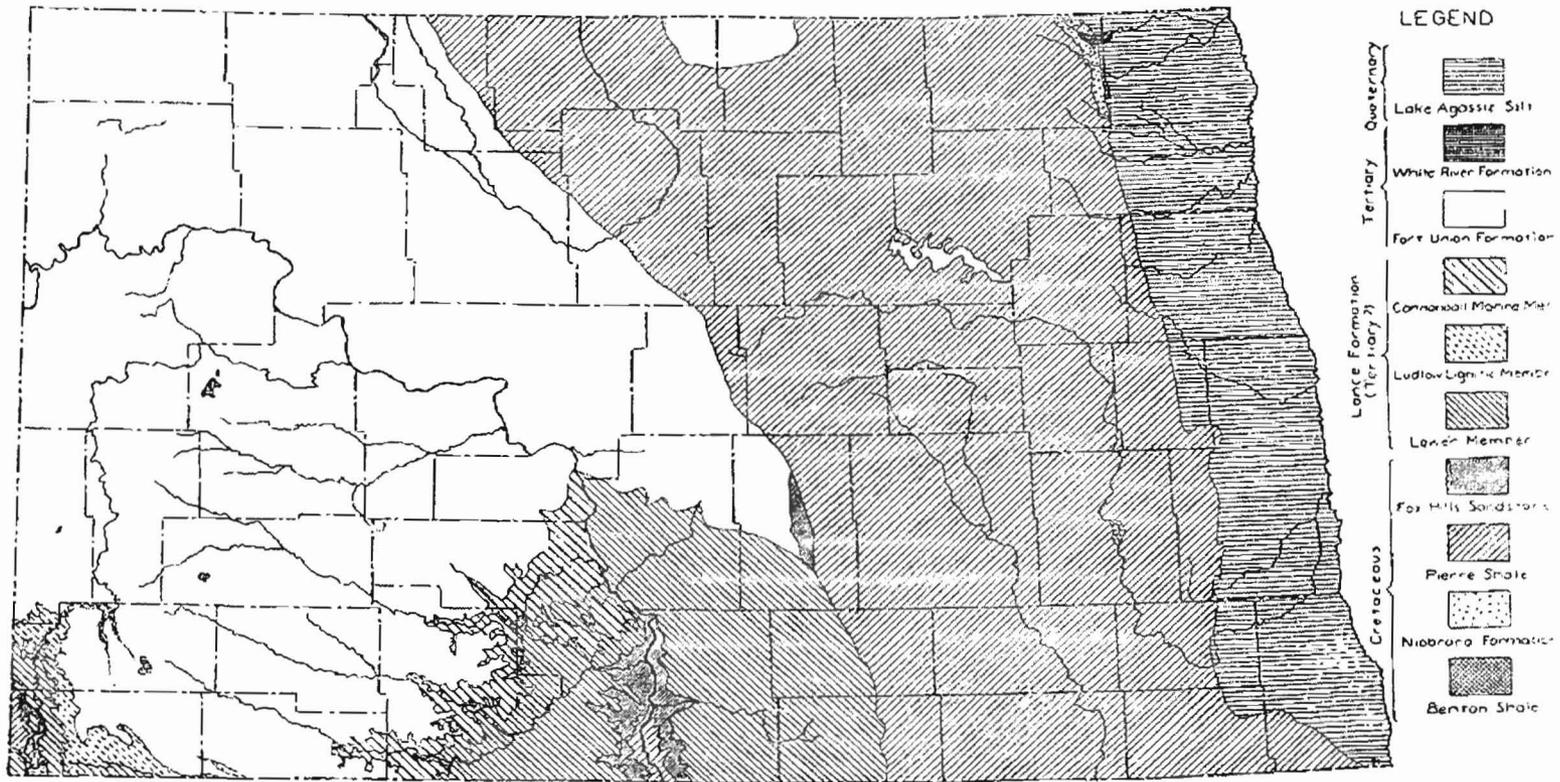


Figure 23. Geologic map of North Dakota compiled by A.G. Leonard in 1916. This map shows considerably more detail than does his previous map, drawn ten years earlier (Figure 12).

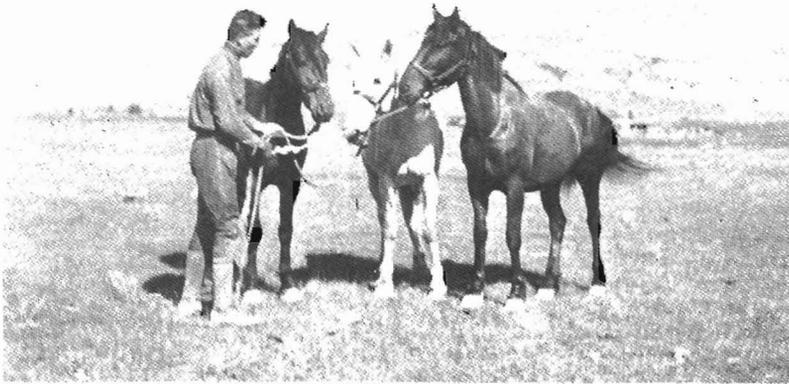


Figure 24. Three horses at the Little Missouri camp on August 28, 1918. The white horse was ridden by Leonard. The camp was on the Dave Warren Ranch in McKenzie County.

Figure 25. Dr. Leonard with a party from the USGS at their camp four miles southeast of Springbrook, Williams County, on August 15, 1918. Seated (left to right) are two members of the USGS party (unidentified), Leonard, C.K. Wentworth, and A.J. Collier. The man in the rear is presumed to be either J.D. Leith or Doyal Watt, Leonard's assistants (both UND students).

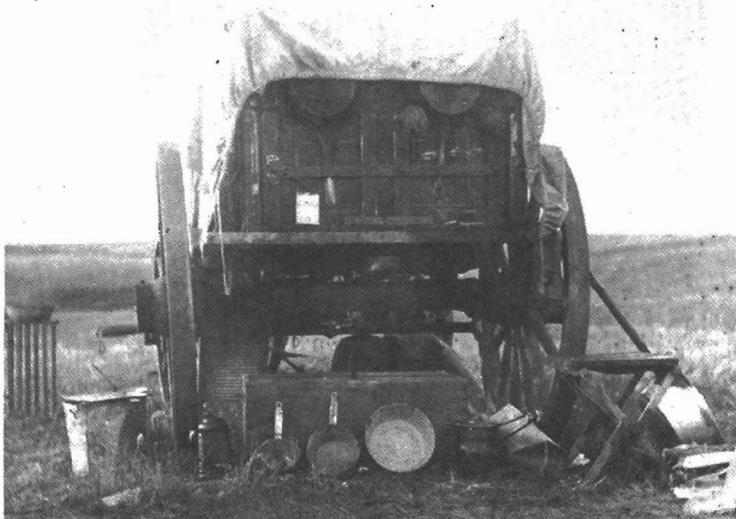


Figure 26. The Survey party's camp kitchen at Cusick's Spring, Williams County, on August 23, 1918.

collecting samples for analyses. A main criterion of the importance of a particular deposit was its proximity to railroad facilities.

Leonard continued his work on the Ray quadrangle manuscript, but took time to prepare a report titled "Possibilities of Oil and Gas in North Dakota." This report, published in 1920, as North Dakota Geological Survey Bulletin 1, was the result of the numerous inquiries received during the previous two years.

During the summer of 1921, Leonard and his two assistants spent two months in Bowman and Slope counties studying the lignite deposits. They also spent a short time in Stark and Slope counties mapping Oligocene formations and collecting fossil mammals, including a number of fossil skulls for the university. Although Leonard listed mammal fossils from the White River Formation in earlier reports, his 1922 report on the formation in North Dakota is a comprehensive treatment of the White River and its fauna. Perhaps the most important part of that study was the report of brontothere fossils from beds now identified as the Chadron Formation in the Medicine Pole Hills area of Bowman County.

Also in 1921, Dove made a plane-table map of southeastern Williams County with the assistance of W.F. Key. He selected this area because of the extensive lignite beds previously found there and the apparently favorable structural conditions for the accumulation of oil and gas. The area covered by Dove's map is now a major oil and gas producing area in the state. Dove's map is reproduced in North Dakota Geological Survey Bulletin 4 on page 162.

Dove also carried out an investigation in 1921, in cooperation with the State Highway Department, to locate suitable supplies of gravel in the vicinity of highways under construction. The Highway Department paid the expenses of the investigators while the Survey paid their

salaries. Dove concentrated his investigation on the central and eastern parts of the state and found ample supplies of gravel. The Highway Department was sufficiently impressed by the results that it agreed to extend the arrangement for another year and allocated \$1,000 to pay the expenses of the investigators. This was double the amount contributed in 1921.

Dove was somewhat of a promoter and spent much of his time while working for the Survey finding things to invest in, both in North Dakota and elsewhere. Several of his letters to Leonard refer to speculative stocks, but the letters generally don't give much of an idea what the investments involve. During the summer of 1924, Dove apparently invested in a gold mine in Idaho; his letters offered to let Leonard in on a good thing. He seemed always to be on the verge of something really big, but in need of a small amount of money to make it go. During his last year with the Survey, Dove was preoccupied with establishing a business in Minot (Dakalite Products Co. Inc.) to make and market a wood dye from weathered lignite (leonardite). The plant apparently became operational in 1925, and Dove was involved in it for at least another five years.

The 1921 Legislature had passed the Artesian Water Conservation Law and appropriated \$2,500 for the conservation and control of artesian waters in the state. The State Geologist was given the responsibility for carrying out the provisions of the act. Since Professor Howard Simpson had devoted many years to the study of the state's water supplies, he was appointed State Water Geologist and placed in charge of the work and, with an assistant, he covered an area six miles wide from Fargo to Jamestown, checking and testing each flowing well. Simpson made a census of all flowing wells in the state and compiled an index that showed the location of 5,000 artesian wells. Six artesian basins were identified as a result of pressure and flow rate tests. John P. Buchanan collected 200

typical samples of well waters, which were analyzed and reported in a publication of the U.S. Geological Survey.

The 1921 Legislature continued the \$3,000 appropriation for the Survey, but added, for the first time, \$1,250 for matching funds to continue the topographic mapping of the state. In addition, the State Highway Department provided \$1,000 toward the expenses of a party to study the clinker deposits between Sentinel Butte

and Glen Ullin. This material was (and still is) widely used for road surfacing material in the western part of the state where gravels are scarce.

The Geological Survey purchased a new Ford touring car in March, 1922. The car is described on an invoice from Moore Automobile Company of Grand Forks, as being equipped with a starter and demountable rims. The price was \$532, plus \$2 for license and transfer. The car was assigned to A.G. Leonard (*Figure 27*).



Figure 27. North Dakota Geological Survey's Ford Touring car (purchased in 1922, from Moore Automobile Company, Grand Forks, at a cost of \$534). The car came equipped with a starter and demountable rims. The top photo shows the car in the field somewhere in western North Dakota. The bottom photo shows Leonard with the car and two assistants.



Budget Problems

The 1923 Legislature made no appropriation for the Geological Survey, although it continued an appropriation of \$1,250 for matching funds for the topographic mapping program. A thousand dollars, which had been set aside for the topographic mapping program, was used instead to continue the lignite investigation. Funds provided by the Highway Department permitted Leonard, assisted by Herbert A. Hard, to continue the survey of gravel deposits.

Leonard protested to Governor Nestos about the lack of funding for the Geological Survey in 1923, and received the following reply from the governor, dated March 13, 1923:

"The statement from the appropriations committee was that they desired all appropriations to be made thru the budget as far as possible and that was the reason that they were repealing all of these small standing appropriations. This repeal was signed. I discover, however, in looking over the budget that there is no provision made for the survey, and I assume therefore that we shall have to defer that service until after the next legislative session."

During the early 1920's, both Leonard and Dove spent several months doing oil and gas evaluations in various parts of the state. The areas studied included Bismarck, Turtle Lake, Kathryn, Cooperstown, Marmarth, and McClusky. Leonard reported that he spent a week in Bottineau County in 1925, at the request of the Turtle Mountain Oil Company, investigating conditions reported favorable for oil and selecting a site for an oil well south of Ray on the Nesson Anticline. He also noted that he examined a reported oil structure in Divide County, but found that the investors had been misled by a fake geologist.

An automobile had been purchased by the Artesian Water Fund in 1921, and Simpson used it to conduct well measurements during the summer of 1924. He advised several cities regarding the best water supply available; they included Crosby, Harvey, Fargo, the State Hospital in Jamestown, and Lisbon. Simpson was also able to complete the inspection of all artesian wells, flowing and non-flowing, in about 40 townships in eastern and southeastern North Dakota.

By utilizing sleeping adjustments in the car, as well as tents and doing their own cooking, Simpson and his assistant, Robert B. Simpson (who was Simpson's son) were able to reduce their expenses to a minimum. The areas surveyed included portions of Grand Forks, Cass, Richland, Ransom, and LaMoure counties.

From 1925 to the 1934-35 biennium, the Legislature made no appropriation for the Geological Survey or for topographic mapping matching funds. During this period, the office expenses of the Survey were borne by the UND Geology Department. Professor Simpson was out of the state during the 1925 field season and fieldwork stopped on the artesian well inspection program since no one could be found to do the work for the nominal per diem which was all that was allowed by the Legislature for this work.

Due to the lack of funds, the only work carried out in the 1927-28 biennium, was the inspection of artesian wells, which was done with funds allocated specifically for groundwater work. Simpson was assisted in this work by Robert B. Simpson and Herbert H. Sand. Simpson completed his inspection of 2,800 flowing and non-flowing artesian wells in about 135 townships during the biennium. In 1929, Simpson became the official State Water Geologist for North Dakota.

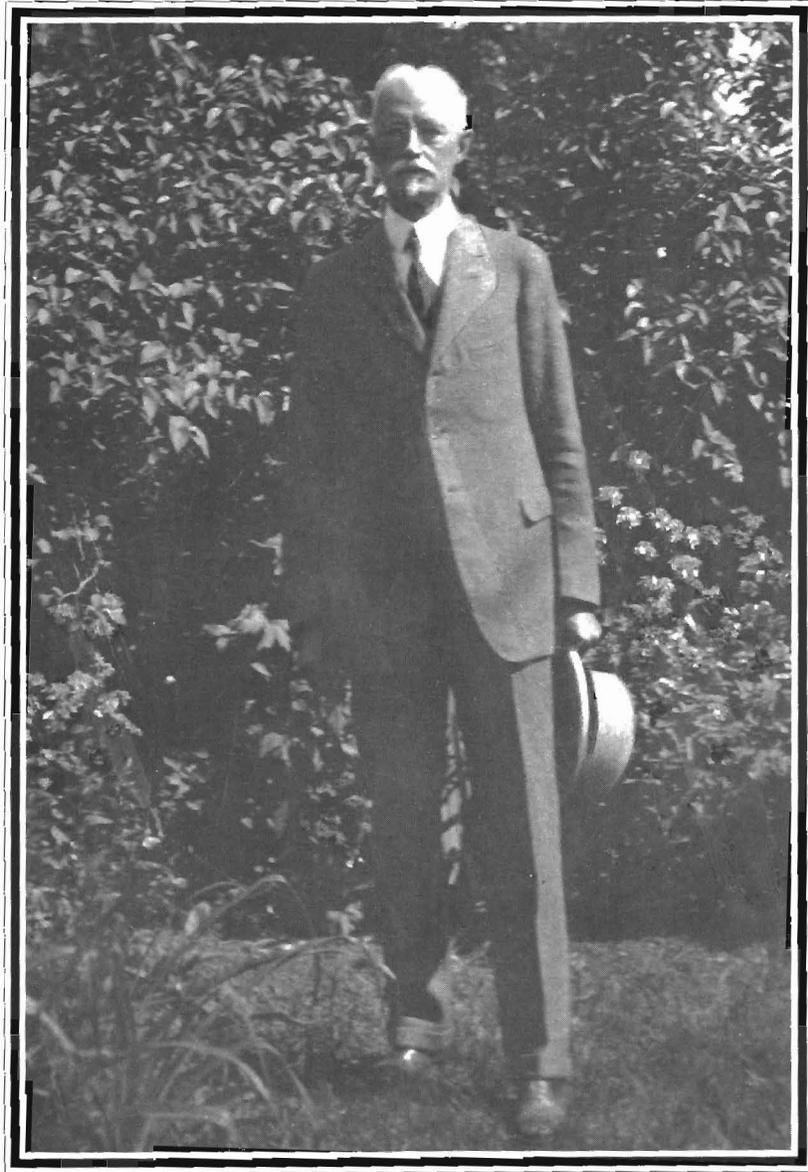


Figure 28. A.G. Leonard at home in his yard in Grand Forks, circa 1930.

The U.S. Army Corps of Engineers held a hearing at Jamestown, on May 9, 1930, to consider the Missouri River Diversion project. Simpson testified at the hearing. In July he accompanied Secretary of War, Patrick J. Hurley, on an inspection of the Devils Lake basin. On the recommendation of the U.S. Geological Survey, he carried out a groundwater study for the Canadian Geological Survey in Regina, Saskatchewan.

On December 17, 1932, Arthur Gray Leonard died in Grand Forks (Figure 28). He had served as State Geologist for 29 years. For nine of those years, the Legislature had withheld appropriations for the Geological Survey and during 14 of those years the appropriation had been restricted to \$1,000 per year. Yet, Leonard was able to keep the Survey a working agency. It was said of Leonard, by one who knew him well, that "*Dr. Leonard was always a gentleman.*" He was a scholarly geologist who left behind many high-caliber geologic reports. Professor Howard Simpson was appointed Acting State Geologist in January of 1933, and State Geologist in June of the same year (Figure 29).

The 1933 Legislature did not provide any funds for the Geological Survey and it was necessary to discontinue all active work during that time. All field operations were discontinued and no reports were published. In November, 1933, the Civil Works Administration, the Federal Emergency Relief Administration (FERA), the Emergency Administration of Public Works, and the National Resources Board had begun their activities in North Dakota. They utilized the Geological Survey as the key to their programs and the Survey soon became more active than at any time in its prior history.

Since the federal funds for these activities became available after December 1, 1933, after the close of the field season, the first months of 1934, were spent in repairing the ravages of the years without funding (it's not clear who did this

work). The time was spent cleaning, repairing, cataloging and shelving the Survey's library of more than 16,000 items. The Survey's museum was reorganized with 5,900 items cleaned, sorted, and labeled. New material, accumulated over the years, was prepared and catalogued. The collection of 15,000 maps was cleaned and repaired and many were mounted on cloth. The Geological Survey's field notes were indexed and all material relating to the artesian well survey was rearranged in permanent files.

Beginning in 1933, the federal government began providing financial aid to the state through the development of several federal programs (some of which I've noted above). The State Geologist was made Principal Water Geologist for the Mississippi Valley Committee of the Public Works Administration. Herbert H. Sand was designated Deputy State Geologist and Frank C. Foley, Assistant Professor of Geology, was given the job of directing groundwater investigations in the northwest part of the state, which had experienced severe drought for the previous five years.

In 1934, the Governor appointed State Geologist Simpson a member of the State Planning Board and assigned him the chairmanship of the Committee on Water Conservation. Simpson worked closely with the State Engineer on this committee. The total amount of funds expended through the State Geological Survey in 1933-34, on these federal projects was approximately \$70,000 and another \$30,000 was provided by the U.S. Geological Survey for projects done by the State Geological Survey. This was far more money than the Geological Survey had expended during any previous period and it was used to accomplish work that would have been impossible under state appropriations because of the financial condition of the state.

Illness, brought on by the strain of years of keeping the Survey going without state support,

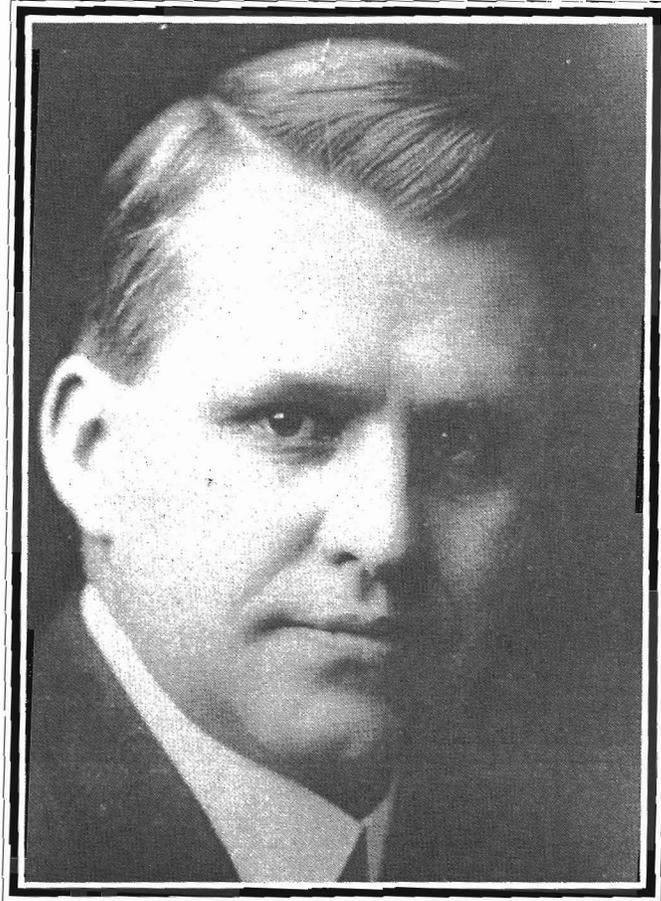


Figure 29. Howard Edwin Simpson, State Geologist, 1933-1938. Simpson was born in Iowa in 1874, and died in 1938. He was appointed Assistant Director of the North Dakota Geological Survey in 1910, replacing John G. Barry, and he held this position until 1921. Simpson came to the Survey from Colby College, Waterville, Maine, where he had served as an instructor in geology and as a field assistant to the U.S. Geological Survey in groundwater studies in Iowa during the summers. Simpson had received a Ph.B. (Bachelor of Philosophy; a degree that is seldom offered today) in 1896, from Cornell College (Iowa), and a B.A. from Harvard in 1905. He also received an honorary Science Doctorate from Cornell College in 1930. Simpson served as State Water Geologist from 1929-1933 and as Director of the State Geological Survey from 1933-38. During his tenure with the Survey, Simpson also served the University of North Dakota as an Assistant Professor of Geology and Physiography and as a Professor of Geographic Geology.

caused State Geologist Simpson to request a leave of absence during the 1935-36 academic year. His duties were assumed by Frank C. Foley, Assistant State Geologist (Figure 30). During the summer months, Dr. Foley took charge of a field party for the Newfoundland Geological Survey. While he was away, Herbert H. Sand was Acting State Geologist.

During August of 1935, Foley, assisted by a student, Andrew G. Alpha, made a study of the sodium sulfate deposits in Divide and Williams Counties. Philip W. West analyzed the samples. The fieldwork supplemented the work of Dr. Irvin Lavine done in 1934, as a FERA Project. During the same years, Herbert Sand, assisted by Sverre Scheldrup and Alpha, studied pressure changes in deep artesian wells near Edgeley and Ellendale.

Work also continued during this period on the occurrence of fluorides in the groundwater, although funding for the project, which had begun in 1934, was canceled at the beginning of the biennium. Dr. G.A. Abbott of the University of North Dakota Chemistry Department, was Supervisor of the fluoride project. The Survey compiled maps correlating the occurrence of fluorides with the incidence of mottled teeth, which was considered to be a "severe malady."

The State Geologist maintained an active interest in the Missouri River Diversion Project and presented briefs and testimony at various hearings concerning the proposal. As a result of the interest shown, the federal government allocated \$100,000 in 1935, for a study by the Survey of the economic benefits of the project. The project was done under the supervision of the Corps of Engineers.

The 1935 Legislature had appropriated \$1,725 per year, and this was increased to \$3,750 by the 1937 Legislature, which also added \$1,250 as matching funds for topographic mapping. Simpson resumed his duties in September, 1936,

except for his ex-officio membership on the State Planning Board, where he was represented by Foley.

In 1933, Professor William E. Budge, of the School of Mines, had taken an interest in the occurrence of oil shale and oil seeps along the Sheyenne River south of the Devils Lake Sioux Indian Reservation. These had been called to his attention by interested citizens of Warwick. He made several trips to the area and attempted to get an appropriation from the 1935 Legislature to make further studies of the area in Secs. 20 and 21, T. 151 N., R. 65 W., but he was unsuccessful. Since the area is covered by glacial drift, Professor Budge felt that only seismic methods could determine the structural features of the area.

Earlier, A.G. Leonard had responded to a letter dated April 19, 1922, from W.M. Anderson, a lawyer from Devils Lake. Anderson referred to "oil indications" south of Warwick on the Reservation. In his letter he stated:

" . . . oil is present in a creek coming from a ravine and running into the Sheyenne. I do not know how extensive this is but others have reported what they deemed to be oil indications . . ."

Leonard's response to Anderson, dated May 3, 1922, notes that:

" . . . the Geological Survey made a rather detailed survey of the Devils Lake regions some years ago but found no evidence of oil in any quantity. The shales of that district do in places contain a trace of oil but in the absence of sandy layers it would not be found in commercial quantity . . . There is no evidence of any anticlines in the eastern part of the state and, therefore, practically no chance of finding oil in any quantity."

Much later, in the late 1960's, Survey geologist John Bluemle re-visited the purported

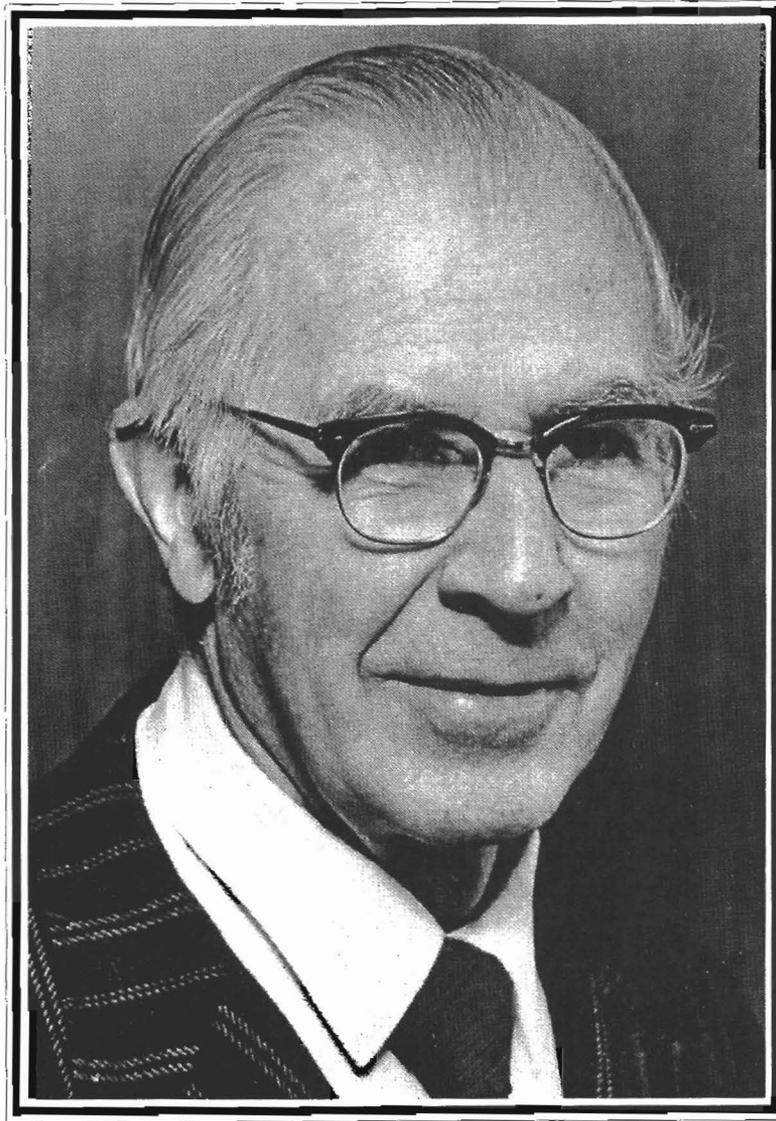


Figure 30. Frank Clingan Foley, State Geologist, 1938-1941. Foley came to the University of North Dakota and Geological Survey in 1933, with a B.A. from the University of Toronto and a M.A. and Ph.D. from Princeton University. He was born in 1906, in Belleville, Ontario. Foley taught geology at Dartmouth from 1929-30, Princeton from 1930-33, and the University of North Dakota from 1933-41.

When Foley took over as State Geologist in 1938, he was the only person on the Survey staff and was also expected to teach full-time for the UND Geology Department. Foley left North Dakota in 1941, and served with the U.S. Army Corps of Engineers in Morocco and Italy until 1945. He worked for the Wisconsin Geological Survey from 1946-51 and for the Illinois Geological Survey from 1951-54. He became State Geologist of Kansas in 1954, and Chairman of the Geology Department at Kansas University in 1957. Foley published numerous papers on groundwater geology. He served as a consultant on water resources in Saudi Arabia, West Africa, and Uganda for the United Nations. Foley died in 1985. Photo courtesy of the Kansas Geological Survey.

oil-seep areas near Warwick. He found no oil, but many springs that had a film of iron oxide and manganese dioxide, which can be mistaken for an oil slick. It is unclear whether this is what had been identified as oil in the 1920's and 1930's, or if Budge had found something Bluemle didn't see.

On August 15, 1938, the California Company abandoned its Nels Kamp #1 Well, an oil-exploration attempt located in the NW ¼ NE ¼, Sec. 3, T. 145 N., R. 96 W., Williams County. This well would prove to be only 1,866 feet from a producing well drilled in 1956. At 10,281 feet, total depth, the Kamp well had penetrated the Madison Formation, which is the productive formation in the area. It appears that the Kamp Well was circulating mud at the time and any shows were overlooked.

Upon Simpson's death in 1938, Foley became State Geologist. In April, 1939, Foley constituted the entire Survey staff and he was also supposed to be teaching full time. In a letter to C.B. Folsom, dated November, 1977, Foley wrote the following:

"I arrived in Grand Forks on January 31, 1933 on a bright morning with the temperature well below zero. I had come directly from graduate school at Princeton. Fortunately, my credit was adequate but I was glad when the first of March arrived and I appeared at the Business Office to collect my first paycheck. It was a real blow to be told, 'sorry, Mr. Foley, but the State was unable to meet December payroll and the checks we are issuing now are salary for the month of January.' I started work only on February 1. The State caught up with salary payments in July, 1933."

The 1939 Legislature made no appropriation for the Survey, but the 1941 Legislature did allocate \$3,365 per year plus \$5,000 per year for topographic mapping.

Foley and Robert B. Witmer, of the Physics Department at the university, constructed an instrument for the measurement of resistivity and conducted a geophysical survey in the vicinity of West Fargo. They used a Model A panel truck and were accompanied by Allen Byers, a geologist with the U.S. Geological Survey. The study was undertaken in cooperation with the city of Fargo in an effort to solve Fargo's water-supply problems. The instrument was not very successful. Byers drove the truck back to Grand Forks where it was allowed to sit outside until the radiator froze.

In 1939, a party composed of E.E. Tisdale and Bert Timm did some fieldwork in the Heart Butte area. Their work culminated in the publication of Bulletin 13 of the Survey (The Geology of the Heart Butte Quadrangle). This bulletin appeared in 1941, after Foley had left the Survey. It was the second publication, since Bulletin 4 (1925), which had been published by using State Water Geologist's funds. Bulletin 12 (Selected Deep Well Records, compiled by Wilson M. Laird) was published earlier in 1941.

Table 1 (on the following page), illustrates the changing budget of the North Dakota Geological Survey. Except for an influx of federal money in the mid-1930's, the first significant appropriations were made after oil was discovered in 1951. Exact annual appropriations are listed in Appendix D, at the end of this report.

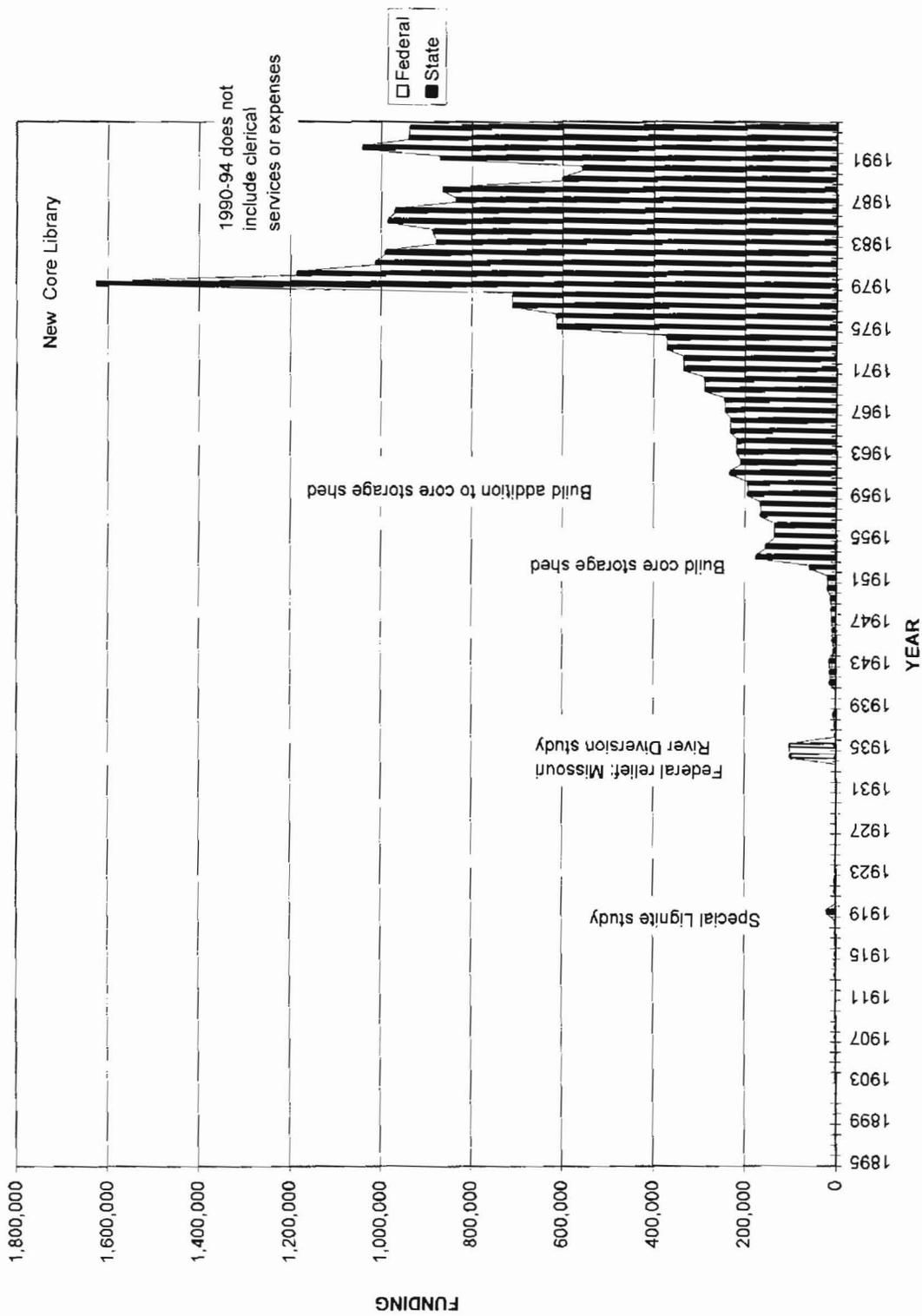


Table 1. Graph showing annual funding for the North Dakota Geological Survey.

The Laird Era

Frank Foley resigned as Department Chairman/State Geologist on February 1, 1941, and Dr. A. Russell Oliver became head of the university's Geology and Geography Department. Wilson Laird, who was an Assistant Professor of Geology, was made State Geologist at about the same time (Figure 31). Then, in the fall of 1942, the Geology and Geography Departments were separated and the Geology Department, with Laird as Chairman, was placed in the College of Engineering.

In 1941, the Survey's old, broken-down Model A panel truck had been traded for a 1934 Plymouth and this vehicle was used to transport a field party consisting of Laird, E.E. Tisdale, Howard A. Garaas, and Kenneth Peterson to the mouth of the Cannonball River where they camped on the John Sullivan ranch (the Cannonball Ranch). The Plymouth developed tire and fuel pump troubles that detracted from an otherwise successful field season.

Dr. J. Stevens Templeton was hired to replace Tisdale, when Tisdale left the Survey to take a job with an oil company. Templeton was interested in glacial geology and set out to study the leaching of calcium carbonate in the glacial till. He found the depth of the leaching to be, generally, less than eight inches. Templeton also completed the geologic mapping of a quarter of the Emerado quadrangle. In 1942, Laird and Professor Robert H. Mitchell, of Muskingum College, completed the mapping of southern Morton County and began the manuscript that would become Bulletin 14 (The Geology of the Southern Part of Morton County, 1942).

An Oil and Gas Conservation Law was enacted by the 1941 Legislature, although the only production in the state at that time consisted of a minor gas field in the Eagle Sand Pool on the

Cedar Creek Anticline, Bowman County. Laird and an attorney with the Carter Oil Company, Forrest Dartough, were active in seeking the passage of this legislation. They received vigorous support from such members of the Legislature as Clyde Duffy, of Devils Lake, and George Saumur, of Grand Forks County. The Industrial Commission enacted rules based on those recommended by the Regulatory Practices Committee of the Interstate Oil Compact Commission.

The Survey had no full-time employees in 1941, (the State Geologist was half-time Geology Department, half-time Geological Survey), and all the work done then was as a cooperative venture with the U.S. Geological Survey, which published any reports that resulted. All of the work involved general water studies such as the augmentation of supplies for Oakes, Fargo, and Camp Grafton. Observation of wells and study of Pembina County continued.

The Survey's budget problems continued. During the late fall and winter of 1942, Laird prepared a report outlining what he thought should be the long-term program of the North Dakota Geological Survey. He presented this report to various persons in the state, primarily the members of the State Board of Higher Education, the Budget Board, and other state officials. Quoting Laird:

"My report was so impressive that the Budget Board saw fit to cut the appropriation of the Survey \$1,100 from what it had enjoyed (?) during the biennium of 1941-43. At the time of this writing [on February 12, 1943] \$500 has been placed back on the budget by the House Appropriations Committee. The State Geologist is advised that Senator Watt - the 'watch-dog of the treasury' - does not wish any more to be added to the budget of the

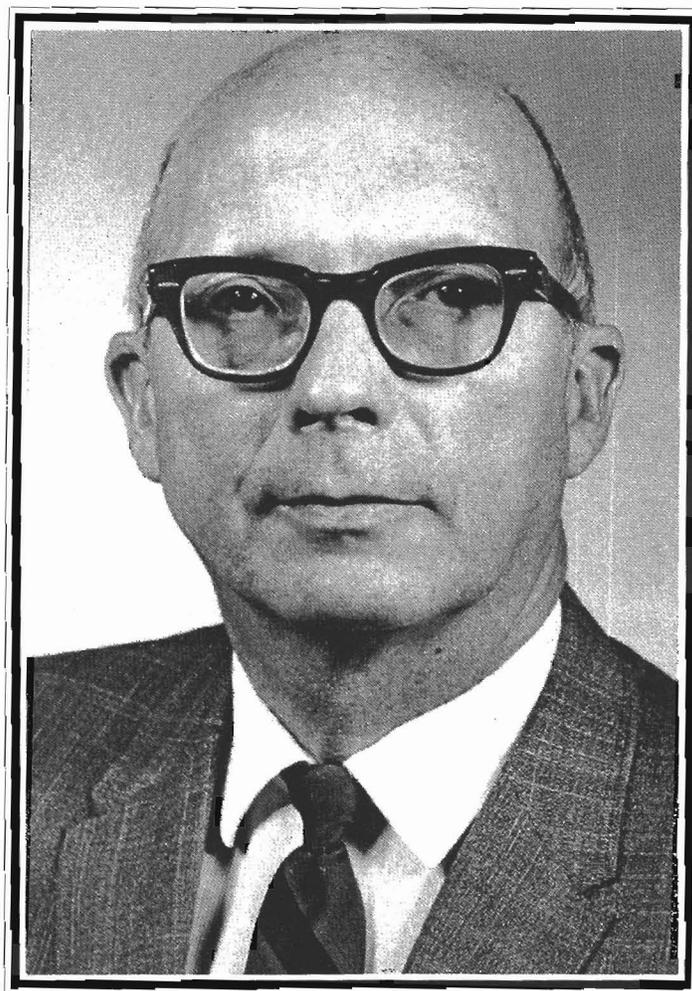


Figure 31. Wilson M. Laird, State Geologist, 1941-1969. Wilson Laird came to North Dakota in September, 1940, from the University of Cincinnati. Born in Erie, Pennsylvania in 1915, Laird received his B.S. from Muskingum College (1936), his M.A. from the University of North Carolina (1938), and his Ph.D. from the University of Cincinnati (1942). He received an honorary D.Sc. from Muskingum College in 1964, and an honorary D.Sc. from the University of North Dakota in 1980. Laird was appointed Assistant State Geologist in January, 1941, and served as Acting State Geologist from February 1, 1941-July 1, 1941, when he was appointed State Geologist.

In addition to his service for the North Dakota Geological Survey, Laird worked for Carter Oil Company in Montana during the summer of 1948, and was employed as a geologist for Hudson Bay Oil and Gas (Continental Oil Co.) in Calgary during the summer of 1949. He also consulted for the USGS in 1944 and 1945 and for Beers and Heroy in 1950. His research also involved professional work in Ohio, Pennsylvania, North Dakota, Minnesota, Alaska, southern Manitoba, southern Germany, and central Turkey. His work resulted in the publication of more than 100 papers on subjects as diverse as biostratigraphy, regional geology, limnology, mineral deposits, glacial geology, groundwater geology, and petroleum geology. In 1948, Laird shared (with L.L. Sloss) the President's Award of the American Association of Petroleum Geologists for work on Devonian stratigraphy in Montana. In 1981, Laird received the AAPG Public Service Award.

Laird was elected Vice President of the Association of American State Geologists in 1948, and President in 1950. He is currently an honorary member of the Association. Laird was elected President of the North Dakota Academy of Science for the 1952 term. In 1969, Laird moved to Washington, D.C., to become Director of the Office of Oil and Gas in the Interior Department. He subsequently served the petroleum industry as Director of the Committee on Exploration of the American Petroleum Institute. Following retirement from his position in 1979, he has continued to be active as a consulting geologist from his home in Kerrville, Texas, and his summer home near Bemidji, Minnesota.

North Dakota Geological Survey in the Senate Committee, so there the matter rests."

During the fall of 1942, the 22nd Biennial Report was prepared for publication. The Army Specialized Training Program at the university began in 1943, and the Geology Department became involved in the program. As a result, all fieldwork was restricted to the area near Grand Forks.

The appropriation for the 1943-45 biennium was \$3,467 per year plus \$5,727 for topographic surveying. Beginning on July 1, 1944, the state

contribution for topographic mapping was made through the State Water Commission. This program, initiated by Leonard, continued until the completion of the topographic mapping in North Dakota.

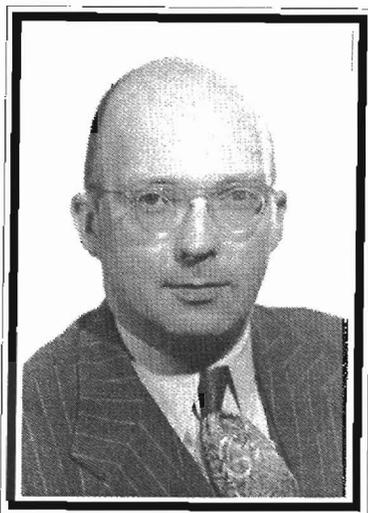
During part of the second year of the 1943-45 biennium, Laird began detached service with the U.S. Geological Survey in Montana. However, he returned to the state and presented the Survey's budget request. His presentation resulted in an appropriation of \$7,575 per year for the 1945-47 biennium.

North Dakota's oil and gas conservation law has undergone several transformations over the years. The North Dakota Oil and Gas Conservation Law was amended several times by succeeding legislative assemblies. The 1941 act was preceded by earlier acts in 1911, 1929, and 1937. Since 1941, the act has been amended several times, most notably in 1951, 1953, and 1981.

- ♦ The act of 1911 was designed to protect adjacent landowners and the public from the escape of natural gas from open or improperly abandoned gas wells. A penalty for violation of the statute was provided, but no regulatory authority was specifically charged with enforcement duties.
- ♦ The 1929 act was the first statute that required the permitting of wells and the filing of basic data. The State Geologist was named as the regulatory authority and a penalty was provided for violation of the statute. Because of lack of funds, the State Geologist was not able to enforce the law and it was repealed in 1937.
- ♦ The 1937 act provided for the conservation of oil and gas, and it provided that the State Geologist was to prescribe rules and regulations. Such rules and regulations were to be the same as those adopted by the Bureau of Mines or the Secretary of the Interior, pursuant to an act of Congress approved on February 24, 1920.
- ♦ In 1941, the legislature passed the first comprehensive oil and gas conservation law, ten years before oil was discovered in North Dakota. At the time the 1941 act was enacted, the only commercial production in the state consisted of a minor gas field in the Eagle Pool on the Cedar Creek Anticline in Bowman County. The 1941 law was based on the then Model Act that had been drawn up by the Legal Committee of the Interstate Oil Compact Commission. The act placed the supervision and control over crude petroleum oil and natural gas with the Industrial Commission. It made the Industrial Commission the regulatory authority and designated the State Geologist as supervisor, advisor and enforcer of the regulations promulgated by the Commission. Later, in 1953, Laird assisted the Legislative Research Committee in drafting a more modern oil and gas statute.

Since 1911, North Dakota has had the necessary statutory regulatory control in place for the level of oil and gas exploration and development being conducted at any given time. The role of the State Geologist in the regulation of oil and gas exploration and development has been significant since 1929. The Industrial Commission has been responsible for the conservation of oil and gas in North Dakota since 1941 - over 50 years.

North Dakota's Oil & Gas Conservation Law



Dr. Wilson M. Laird
1949

Wilson Laird wrote this account of the discovery of oil in North Dakota and sent it to John Bluemle who made minor revisions before submitting it for inclusion in the *Summer 1993 NDGS Newsletter*.

"If they're for it I'm against it," said Representative Billy Crockett, from Wales, Cavalier County, when I answered a question about who favored an oil and gas conservation bill. I had said that probably all the oil and gas companies operating in the state at the time were for that legislation. So saying, Billy got up, waved his arms and left the room. The place was the Legislative House Committee on State Affairs chaired by Lafe Twitchell of Fargo. The time was about February, 1941, and the subject was the oil and gas conservation bill I had asked George Saumur of Grand Forks to sponsor.

The background of this interesting exchange of views probably is known to only a few people still living, but it played an important part in the oil and gas development in North Dakota. During the fall of 1940, a small oil play had been going on in western North Dakota. It began with the drilling of the California Kamp #1 Well in Williams County in the fall of 1938. This well was a dry hole, but it is interesting to note that it was located in a spot only about a half mile from later production on the Nesson Anticline in the Capa Field.

In the fall of 1940, oil industry individuals working with the oil laws of the state recognized that the laws we had were woefully inadequate and impossible to administer. Therefore, it was suggested that my predecessor, Dr. Frank Foley, investigate what could be done about getting better legislation on the books should there ever be a time when there would be production in North Dakota. Accordingly, Foley contacted the Interstate Oil Compact Commission headquartered in Oklahoma City and obtained a copy of their Model Act for an adequate oil and gas conservation statute.

Conferences were arranged with Governor John Moses, who suggested that, instead of an additional state agency to regulate something not then in existence and because there were already too many state agencies, the regulation of the oil and gas industry should be placed in the hands of the State Industrial Commission, which already handled the State Mill and Elevator and the Bank of North Dakota. Inasmuch as the Commission had no full-time staff capable of handling a technical matter like oil and gas regulation, it was decided that the State Geologist would be the administrator of the act for the Commission. The State Geologist would thus be designated Supervisor of Oil and Gas.

Accordingly, a bill was drawn and introduced into the 1941 Legislative Session. House Bill 210 was sponsored by Representatives George Saumer from Grand Forks, Walter Bubel from Center (Oliver County), Theodore O. Rohde of Van Hook (Mountrail County), and Senator Lars. K. Morland from Scranton (Bowman County). After its first reading, the bill was referred to the State Affairs Committee, which was chaired by Lafe Twitchell of Fargo. Mr. Twitchell, an old timer in the Legislature, didn't suffer fools gladly, and I am sure he thought that anyone sponsoring and supporting such a bill was little short of being demented. In fact, he told George Saumur that he couldn't see why in hell anyone wanted to introduce a bill of that kind as there wasn't any oil in North Dakota now, and that there wasn't going to be any in the future. It is true that no oil was being produced in the state at that time, but some relatively shallow gas was being produced on the Cedar Creek

Anticline from a few wells owned by the Montana Dakota Utilities Co. in the southwestern-most part of Bowman County. The Cedar Creek later proved to be a prolific oil and gas producer in both North Dakota and Montana.

To get back to the hearing of the State Affairs Committee at which I was appearing as the prime witness for this bill: it should be noted that I was only 26 years old at the time and had been in the state for only about five months. I had become State Geologist because of the resignation of Dr. Foley, my predecessor, who went with the U.S. Geological Survey. To say that I was a stranger to Legislative processes, as well as a stranger to the state and to the people in it, would be a gross understatement.

I was questioned about the need for this bill and what it would mean to the state, whether it would involve any additional funds to administer and generally how it would work. I explained that there was a geological chance for oil and gas to occur in commercial quantities in North Dakota. I also pointed out that the present laws were a hopeless mess and that, without the proposed legislation, there would essentially be no state control whatever if oil was discovered. I told them what had happened in other states, notably Texas when oil was discovered in the East Texas Field in the early thirties, and what chaos had resulted. I summarized my remarks with the hope that the Legislature would be foresighted and pass the bill.

After I was finished, the questions again started, and it was at that time that Billy Crockett made his famous statement. Famous, at least to me, as I thought that the whole matter had gone down the drain. I therefore left the hearing, my tail between my legs, and headed for the Grand Pacific Hotel where I packed my bag and prepared to depart on the evening train back to Grand Forks.

As I was checking out, George Saumur met me in the lobby and asked me where I was going. I told him that I felt I had failed and that I was going back to Grand Forks. He asked me to stay, and said that he would see if Mr. Twitchell would give me another hearing. I checked back in and stayed until the next day when I saw George again at breakfast time.

George told me that he had gone to Lafe Twitchell's room the previous evening and said to him, *"You treated my boy kind of rough this afternoon."* To which Lafe had replied, *"Why does the damn fool think we should have that sort of legislation anyway?"* George reasoned with him for some time, and the end effect was that Mr. Twitchell told him to have me up at the hearing again the next day.

I was there, needless to say, and answered more questions. The atmosphere was decidedly more friendly than the previous day. After that, I went home and left the matter in George Saumur's capable hands.

After the second hearing, George circulated around the House, and when the bill came to a vote there was no opposition to the measure whatsoever. I believe it passed without a dissenting vote. I think this was a tremendous tribute to the skill of George Saumur and an acknowledgment of the great affection the members of the House felt for him. George also lobbied the bill through the State Senate, and as I recall, I didn't even have to appear on that side of the Legislature about the bill.

What this legislation did was to provide a logical plan for the development of the state's oil and gas resources should any ever be discovered. It stipulated what the State Industrial Commission and the State Geologist should do. In other words, we were all set for the development which began on April 4, 1951, when the Amerada #1 Clarence Iverson Well officially opened oil development in North Dakota. Very few, if any, states can say that they were so well prepared for the oil and gas industry to come to their respective states as was North Dakota.

The 1941 law was not perfect, but then what law ever is? Any law has to be the distilled opinion of the many people who enact it, and as a result, few laws ever satisfy everybody. The main thing that the legislation did was to provide the base upon which an even better law was passed in 1953, two years after the discovery of oil. Here again, North Dakota was very fortunate in having a Governor, Norman Brunsdale, who was an intelligent and popular man and familiar with the oil industry from business knowledge of it through his banking connections.

Ten years after the initial bill was enacted, the Legislative Research Council assigned a subcommittee to study the matter of oil and gas regulation in the interim between the discovery in 1951, and the session in 1953. This subcommittee was headed by an eminent lawyer and State Senator, Clyde Duffy of Devils Lake. Hearings were held in various parts of the state, primarily in the western part where the oil and gas occurred. Many people testified, and their views were taken into consideration by the subcommittee. Much concern was expressed about the rights of landowners and mineral owners on whose lands the oil and gas had been found or might be found in the future.

The end result of the deliberations was the writing of another law which again was modeled after the then-current model law of the Interstate Oil Compact. This bill passed almost without change except it had to be tailored to the North Dakota situation. It did not contain the section on compulsory field-wide unitization, an omission that I thought was unfortunate, as I regarded it as the best and most efficient way to produce a field which falls under multiple ownership as most United States oil fields do. Unitization also preserves capital as less material is needed to put the field in production. In other words it was, and is, a true conservation measure.

It wasn't until the 1965 Legislative Session that the compulsory field-wide unitization statute was added to the North Dakota oil and gas law. The version of the Unitization Bill that I wanted passed was that which was from the model act of the Interstate Oil Compact Commission as it fitted the rest of the model act that had been passed in 1953. It should be noted that these model acts of the compact were drafted by the best oil and gas legal minds in the country.

As it turned out, the Democrats had drafted a bill modeled after the Oklahoma statute; this was passed by the House. During this session of the Legislature, Arthur Link was Speaker. This was before he went to Congress and subsequently to the Governor's office. Now an impasse existed; the Senate had passed one, and the House another version of the same idea. It was one of those times when an idea's time had come and everyone was for it, but there was no unanimity of how the law should be worded. The end result was that the Senate acceded to the House version as they felt the law was needed, and they felt as that, as the Governor, Bill Guy, was a Democrat, it was the only way a unitization law would come about. The law has stood the test of time and has been used on a number of occasions. Even though it is far from perfect, and while I still think the Compact version was better worded, North Dakota's law works and that is the ultimate test.

I realize that, since the law was enacted, some changes have been made in the administration of the law. For example, the State Geologist has been removed from the supervisory position. This is something that I suppose was inevitable, but the technical advice given the state by the Geological Survey was the best and most unbiased and scientifically oriented possible at the time.

During the summer of 1944, the State Geologist was on leave of absence to work with the U.S. Geological Survey in the studies of oil and gas possibilities in Montana. Dean L.C. Harrington, of the School of Mines, watched after the business of the Survey while Laird was away.

In the summer of 1945, Laird continued his work for the U.S. Geological Survey in Montana. Cooperative work on water supplies continued with the State Geologist representing the State Water Conservation Commission in its dealings with the Groundwater Branch of the U.S. Geological Survey. Projects underway included a study of the Oberon quadrangle, by Paul R. Tetrick (published by the NDGS in 1949); the Flora quadrangle, by John R. Branch (published in 1947); the Maddock quadrangle, by John R. Ball (published by the Geological Society of America in 1947); and the Lake Agassiz Basin, by Wilson M. Laird.

In 1945, Bill Powers, a professor of geology at Northwestern University and a temporary employee of the North Dakota Geological Survey, undertook a study in western North Dakota to determine the feasibility of using the Eocene-age Chadron limestones as a raw material for manufacturing portland cement. The Chadron limestones occur on several small buttes in southeastern Stark and northeastern Hettinger Counties. Powers estimated the amount of available limestone and took samples for analysis. Although the limestones are thin, they generally have thin overburden. Powers' report concluded that the limestone would have to be beneficiated before it could be used. The idea was abandoned.

The appropriation for the 1947-49 biennium was \$8,512.50 annually. Laird continued the practice of hiring graduate students for summer work, paying their expenses and a small stipend in some cases.

In 1947, Irving Grossman was appointed Assistant State Geologist. Grossman worked on a

study of the sodium sulfate deposits in the northwestern part of the state. Also in 1947, the NDGS entered into a joint venture with the North Dakota Research Foundation to determine the feasibility of re-establishing a cement plant at or near Concrete (the Research Foundation was an entity that operated under the Industrial Commission from 1941-57). To assess the viability of a plant, the Survey supervised the drilling of five test holes near the old cement plant at Concrete. Survey geologists analyzed samples obtained from the test holes for concentrations of calcium carbonate, aluminum, silica, iron, magnesium, and sulfur. Miller Hansen later summarized the results of this study in a 1953 report. The drilling program determined that the high-lime zones in the Niobrara Formation area generally occur at depths greater than 150 feet below the surface, but they do not correspond to a particular horizon or given elevation. By 1949, it was determined that the lime content of the shale was not adequate to justify building a new cement plant.

During the summer of 1949, Laird worked in southern Manitoba for Hudson Bay Oil & Gas Company on a study of formations present there. He felt that his work in Montana and Manitoba had given him an unusual opportunity to become acquainted with the strata of the Williston Basin before the advent of oil production in North Dakota. The University of North Dakota Geology Department's collections contain many specimens that he acquired in the pursuit of these projects in nearby states and provinces.

In the late 1940's, Laird and Dr. Alex Burr of Jamestown revisited surface marl deposits south of Devils Lake in Benson County that W.E. Budge had investigated prior to the 1940's. They estimated that seven of the small marl deposits contained 106,000 cubic yards of marl with a lime content ranging from six to 44 percent. They determined that the marl deposits were not suitable for the manufacture of portland cement.

The 1951 Legislature directed the NDGS to investigate the carbonate deposits in the state and report their findings to the North Dakota Research Foundation, which would issue a report to the Legislature. In response to this directive, Assistant State Geologist Miller Hansen conducted a detailed investigation of many of the same buttes that Powers had studied earlier.

Miller Hansen had joined the Survey staff in May, 1951, with a B.A. in geology from the University of Montana (awarded in 1948) and expertise in civil engineering, gained when he served in the Army Corps of Engineers during World War II. He was named Assistant State Geologist in November, 1953. In addition to supervising the work of the geologists, Hansen carried out a number of geophysical studies, primarily geomagnetic, in the Tioga area. He also conducted a study of limestone for a cement plant in southwestern North Dakota, and a study of clays as a potential source of alumina. Other investigations of clays were carried out by Oscar Manz and his students from the Ceramics Department.

Hansen determined that individual limestone beds could not be traced laterally from

butte to butte, but he concluded that approximately 21 million tons of limestone was available for mining from five buttes in Stark and Hettinger counties. Hansen also noted that the thin nature of the limestones, the relatively high ratio of overburden to limestone and the presence of chert in some of the carbonates, may discourage mining of the buttes. In spite of Hansen's reservations, the Foundation Research report to the Legislature concluded that a cement plant was viable and sufficient raw material was present in the buttes to supply a medium-sized portland cement plant for 20 years. The plant was never built and, in fact, North Dakota still (1995) has no cement plant (it may be the only state in the United States without one). Most cement used in North Dakota is imported from Manitoba, the Black Hills and Iowa.

In 1948, the Geological Survey and Geology Department moved from Merrifield Hall (on UND campus) to a woodframe building between Abbott and McCannel Halls (*Figure 32*). Expansion of the Survey staff necessitated the Geology Department to move to Babcock in 1951. The Survey remained in the wooden building until the construction of Leonard Hall in 1964.

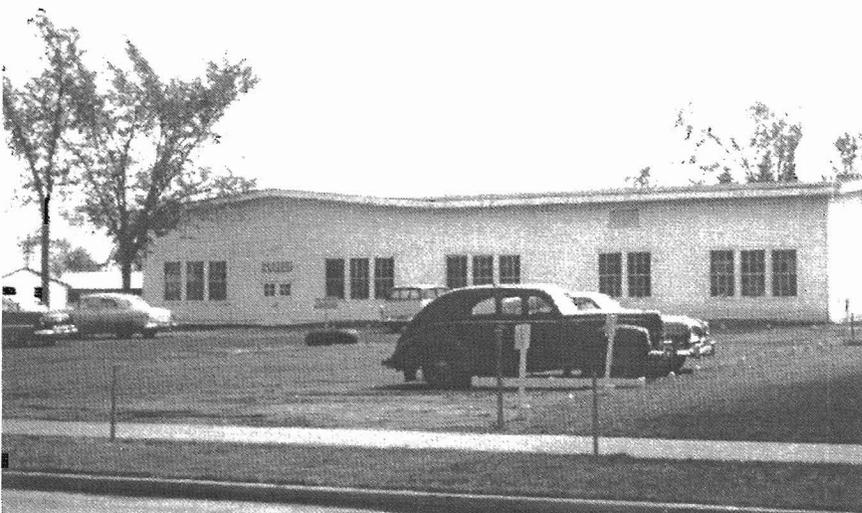


Figure 32. The Survey and the UND Geology Department moved into this building in 1948. The Survey remained in the building until Leonard Hall was built in 1964.

Oil!

In May of 1949, Wilson Laird was granted a leave of absence to carry out a confidential mission for the United States Government in Turkey and Germany. During his absence, Stanley P. Fisher was Acting State Geologist from June 1 to September 1, 1949. Nicholas N. Kohanowski, a mining geologist and engineer who had joined the Geology Department faculty in May, 1949, replaced Irving Grossman as Assistant State Geologist in 1950.

During Wilson Laird's leave of absence, Kohanowski signed the drilling permit for Amerada Petroleum Corporation's No. 1 Clarence Iverson Well to be drilled in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 6, T. 155 N., R. 95 W., Williams County. The permit was issued on August 4, 1950. Drilling began at 6:00 a.m. on September 3, a Sunday. On January 4, 1951, a drill-stem test, from 10,448-10,803 feet, recovered one pint of free oil in the bottom of the test tool. The recovery was from Devonian rocks. However, the hole was carried on down to 11,400 feet without finding additional shows of oil or gas. At that time, the decision was made to core ahead as far as possible, set casing and test all possible shows.

The hole was carried to 11,744 feet where loss of the face off a core bit made further drilling in the unprotected hole too hazardous. At this depth, on February 26, 1951, 11,743 feet of 5½-inch casing was cemented in. Partly because of a renewed siege of winter weather, it took a month to make perforations and tests from 11,678-11,720 feet. These perforations were cemented off and additional ones made from 11,630-11,660 feet. Through these perforations, the well tested two million cubic feet of natural gas, and after another 4,000 gallons of acid, the gas increased to 7,000,000 cubic feet.

The official discovery date of oil in North Dakota, listed as April 4, 1951, records the date when economically producible oil was first recovered (*Figure 33*). This production was from Silurian rocks, not Devonian. Laird was present at the completion of the Iverson well.

The discovery period of the early 1950's, was a time of great excitement, not only in North Dakota, but in oil circles across the country. Survey geologist Sid Anderson relates that he was a student at the University of North Dakota at the time, and he recalls Laird's phone ringing almost constantly following the report of the discovery. A little later that April, several students (including Sid), accompanied Laird on a trip to St. Louis to attend a meeting of the American Association of Petroleum Geologists. At the meetings in St. Louis, there was little doubt about the excitement that the Clarence Iverson had generated. Laird was paged constantly and anyone who attended the meeting certainly didn't leave without knowing who he was. This excitement continued as Amerada followed the Iverson discovery with more discoveries on the Nesson Anticline, quickly extending production 75 miles in a north-south line.

As the discoveries continued, and production and development drilling proceeded, the industry faced a problem that would probably not occur to most people now - markets had to be found for the oil. Foreign oil was slightly cheaper and it displaced domestic production. There was no shortage of oil in the country in the 1950's; plenty of gasoline was available everywhere. This meant that oil, then going to refineries in the area, had to be displaced. Northwest Refining in St. Paul Park, Minnesota, bought North Dakota's first oil. Later, oil also went to the refinery at Wrenshell, Minnesota, as well as to other refineries. When the Amoco refinery in Mandan,

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OIL FLOWING FROM TIOGA WELL TODAY; HEAVY GAS PRESSURE ALSO REPORTED

Rosenbergs Are Sentenced To Death Actual Production Capacity To Take Several Days Observation

Sobell Draws 30-Year Term In Atom Spy Trial

NEW YORK (AP) — Julius and Ethel Rosenberg, husband and wife convicted of stealing American atom bomb secrets for Russia, were sentenced today to death in the electric chair.

"I consider your crime worse than murder," said Federal Judge Irving P. Kaufman. He set the week of May 21 for execution.

He said the trial "indicates quite clearly" that an enemy nation is employing "secret as well as outspoken spies among our own people."

Both Rosenbergs, 32-year-old electrical engineer and his 33-year-old wife, showed little emotion at the sentence. Rosenberg's face was "muscle-bound," he said. His eyes were "glassed" and he gasped a chair and breathed heavily.

The court did not specify the method of execution but stated the executions should be carried out "according to the law."

In a lengthy preliminary discussion before imposing sentence the judge told the Rosenbergs: "I consider your crime worse than murder."

U. S. Attorney Irving R. Saypol said that the federal law, under the judge's sentence, would require the Rosenbergs be executed in the electric chair.

Attorneys for the Rosenbergs and Sobell said they would appeal the convictions and sentences.

In sentencing the Rosenbergs for offenses committed in 1944 and 1945 when the nation was at war, Judge Kaufman appealed to Congress to tighten penalties on espionage laws.

The Ka. judge told the Rosen-



Head Men In Operations

R. G. Fuller, production superintendent for Amerada Petroleum Company, has been at the Tioga well site most of the time since it started.

He has been with the company since 1926. Today Fuller said that the Tioga well was one of the toughest he's brought in as far as working conditions and troubles go.

He came back from the well site this morning after more than 30 hours of steady work to arrange for shipment of more equipment to the well site. "The first thing I'm going to do, though, is get a haircut," he said.



A. D. (Stickle) Davidson, drilling superintendent for the Amerada Company, left, and R. C. Watta, drilling foreman, right, have been at the well site all through drilling operations at the Tioga well.

ALLIES CARRY FIGHT TO HALF MILLION REDS

Forces Advance On Broad Front; Task Unit Eight Miles In

TOKYO (AP) — An American task force thrust nearly eight miles inside Red Korea today at the spearhead of an Allied drive along 40 miles of the western and central fronts.

This was the deepest penetration into Red Korea of the current

Oil is flowing today from the Iverson test well No. 1 south of Tioga.

The output ranging from 10 to 18 barrels an hour with a gas pressure of approximately 6,000,000 cubic feet per day is 55 gravity oil said by oilmen to bear distillate content and well above the average producing fields.

The announcement early this morning by the Amerada Petroleum Company, of Tulsa, Okla., that oil had been encountered at the 11,300 to 11,660 foot perforation touched off in Williston and the entire area a frenzied optimism that the huge Williston basin is potentially an oil producing field, theory long contended by geologists.

R. G. Fuller, production superintendent of the Amerada Petroleum Company, at the well site this morning said production following acidization of the strata was holding between 10 and 12 barrels an hour, or an output in excess of 250 barrels a day.

Whether this flow could be considered a production well was a matter of speculation today.

Oilmen pointed out, however, that the flow now encountered will undoubtedly result in additional testing at the Iverson hole.

Fuller said that in a deep test such as the Iverson well, a five-hundred-barrel production average would be considered a producer.

"We know that we have oil in our test well," Fuller said, "and further results and tests will await arrival of two 2,000 gallon storage tanks from Casper, Wyo."

The production, an estimate said here today, the well would be shut down to allow further tests.

TIOGA OIL WELL CLIMAXES STATE QUEST OF YEARS

First Attempt Made In Adams County In 1922

BISMARCK (AP) — Although still in its infancy, the search for oil in North Dakota.

Reports from a test well near Tioga, N. D., today that crude oil is being obtained from the well is the most encouraging sign since 1922.

Senate Turns From 'Great Activity In'

Figure 33. Newspaper headline noting the discovery of oil.

the Westland refinery in Williston, and the Queen City refinery in Dickinson were completed, this problem was alleviated. However, there still was no shortage of oil in the country, so the production in North Dakota, along with that from the other oil-producing states, was prorated (production was limited to a calculated fraction of production capacity), thereby insuring that all producers received an equitable share of the market.

The 1951 Legislature had raised the Survey's appropriation and had adjourned before the discovery of oil in the Iverson well. They had appropriated \$24,125 per year, but the work of the Survey was so greatly increased in connection with its oil and gas conservation responsibilities that it was necessary to apply to the Emergency Commission for additional funds. The Commission allocated an additional \$19,990 annually to supplement the main appropriation.

Beginning in 1952, the Survey began adding staff to work on petroleum geology, to enforce the Industrial Commission's oil and gas regulations, and to handle the day-to-day additional workload. In 1952, Sid Anderson, Dois Dallas, and William McCabe were hired. Anderson was hired as a subsurface geologist and Dallas and McCabe as field inspectors. In 1953, the Survey added R.J. Cameron (technician), C.B. Folsom (petroleum engineer), and three subsurface stratigraphers, Carole Smith, Morton Strassberg, and John Caldwell. In 1954, the Survey hired Clarence G. (Kelly) Carlson, Dan Hansen, and Laverne Nelson as subsurface stratigraphers, Bill Arneson as a field inspector, and Louis Larson as a statistician. In 1955, the Survey added John Hainer, a subsurface geologist, and Tom Voorhees and Perry Turner, both field inspectors. Three more field inspectors were added in 1956: Bob George, Herb Recktenwald, and Lamont Wilch, as well as three more subsurface geologists, Richard Maywald, James Peterson, and David Johnson. In 1957, three subsurface geologists were added, Jay Garske, Richard Eisenhard, and

Bill Eastwood, along with two field inspectors, Floyd (Jack) Wilborn and Kent Madenwald, and a draftsman, Ronald Guttenberg. Jack Kume joined the Survey in 1958, as a subsurface geologist, although he later moved into surface work. Herb Mendoza was hired in 1959, as a subsurface geologist. In 1960, two field inspectors, Art Carter and Wes Norton were added, along with Alva Caster, a petroleum engineer. John Hunt was hired in 1961, as a subsurface geologist.

In addition to the above people, several secretaries and stenographers were also hired during the years immediately following the discovery of oil.

One of the duties imposed on the State Geologist by the Oil and Gas Conservation Law was the collection and storage of cores and samples from wells in the state. These had been stored in several sheds around the University of North Dakota campus and, in 1953, the Survey asked for funds to provide a steel storage building to be erected east of the football stadium and \$20,000 was allowed for this purpose; the size of the building was doubled in 1961. The 1953 Legislature appropriated \$155,000 per year for the Geological Survey. This sizable increase allowed the State Geologist to expand the Survey staff by 15 people after July 1, 1953. During the period 1952-58, the geological staff was increased by six with the work dedicated primarily to subsurface studies of the information provided by oil exploration.

During this time, the Survey prepared a number of mimeographed circulars for distribution. These consisted of the well history and core and sample descriptions of various discovery wells and important wildcats. These circulars found wide acceptance by prospective drillers. Two hundred seventy-four circulars were compiled before the series was discontinued (in 1967) due to the reduction in exploratory drilling in the state.

The 1953 Legislature had revised the Oil and Gas Conservation Law to conform to a more recent version of the Model Act of the IOCC (Laws of North Dakota, 1953). The Legislature adopted all but the special provision for statutory unitization. The new act included market demand proration. Clarence Burton "Burt" Folsom, Jr., from the New Mexico School of Mines, was appointed Chief Petroleum Engineer for the Survey in September, 1953 (Figure 34). He immediately started to update the rules to reflect the new law. As might be expected, the new rules reflected the rules in effect in New Mexico to a great extent. Exceptions were to be found in the proration allocation formula which included a factor for spacing and in the provision for temporary spacing in a new pool, which would allow time to collect reservoir data before establishing a "proper" spacing. Other differences involved reporting procedures.

Folsom had attended school at the Colorado School of Mines where he received B.A. and M.S. degrees in petroleum engineering. He was employed by Phillips Petroleum Company in

Texas before and after World War II. During the war, Folsom served in the Southwest Pacific Theater as a Captain.

Folsom had acted as Head of the Petroleum Engineering Department at the University of New Mexico, at Socorro, from 1947-53. In addition to his work with the Survey, he also served as an Associate Professor of Petroleum Engineering at the University of North Dakota from 1953, until his retirement in 1981; he died in 1985. Folsom was involved in revising North Dakota's oil and gas rules and regulations for the State Industrial Commission in 1953. He served on the Regulatory Practices Committee of the Interstate Oil Compact Commission. He was a Registered Engineer in Texas, New Mexico, Colorado, and North Dakota.

The new rules were adopted on December 1, 1953. The first spacing order under the new rules provided for 160-acre temporary spacing in the Sanish Pool, McKenzie County (Order 4 - January 19, 1954).



Figure 34. C.B. Folsom, Chief Petroleum Engineer for the Geological Survey, 1953-81.

By including the spacing unit in the allocation formula, royalty owners' interest in well spacing became moot as royalty owners received the same amount of production regardless of the number of wells on the spacing unit.

Over the next two years, a series of hearings set temporary and proper spacing patterns for most of the existing pools. Others were brought up for hearing as they were discovered. Within five years after the Iverson discovery, 30 oil pools had been discovered in North Dakota.

In early 1965, North Dakota became one of the first states to suspect that market demand proration had not preserved the original productive capacities as had been supposed. In November, 1965, proration was halted and operators were challenged to produce the amounts of oil that their records indicated that they could. None could respond and this information was passed on to other states. However, it was not until about 1974, that the last of the states accepted this view and abandoned market demand proration, although some still made a pretense of it even after that.

On October 1, 1964, the well-head price of Grenora-Madison crude oil in Williams County, North Dakota, was \$2.215 per barrel delivered into the pipeline. In 1969, this price was \$2.32 per barrel. When oil was selling for \$2.32 in the field, producers of a similar oil in Saskatchewan and Alberta were selling their oil to refineries in St. Paul, Minnesota, for \$.09 a barrel below that of the North Dakota producers. It was this situation that contributed to the decline of exploratory drilling in North Dakota. It did not recover until 1973, after OPEC had imposed their greatly increased prices. During the summer of 1978, there were more rigs drilling in North Dakota than at any time since the mid-fifties.

During the mid-1950's, the major interests of the Geological Survey focused on subsurface geology as it applied to oil and gas exploration,

but there was also increasing interest in uranium geology and glacial geology. Dan E. Hansen studied the Lower Cretaceous sediments and published several reports on this part of the geologic section. Hansen, primarily a stratigrapher and petroleum geologist, spent 13 years with the North Dakota Geological Survey, from 1954-67. Another Survey geologist, John Hainer, published a non-technical report on the geology of North Dakota for laymen in 1956.

Clarence (Kelly) Carlson was hired originally for subsurface studies. However, he eventually published reports on virtually every aspect of the state's geology. He worked with rocks representing the entire stratigraphic column in North Dakota, Precambrian to Recent, and he mapped large parts of the state. Carlson concentrated much of his work on North Dakota's mineral resources, including such things as potash, cement rock, gravel, coal, uranium, and oil and gas. He worked for the Survey for 27 years, until 1981, when he transferred to the new Oil and Gas Division. He worked for the Oil and Gas Division as a geologist for another 12 years, retiring in 1993.

During the early years of oil development in North Dakota, Bismarck was the active center of the exploration activities. Several major companies, a number of independent producers, and a great many consulting geologists and landmen set up their offices there. Williston remained the center of operations and supplies with a number of company offices located there.

From the time oil was discovered in North Dakota in 1951, the location of the Geological Survey at the university in Grand Forks generated considerable criticism. Because well records and well logs were at the university, it was inconvenient for consultants and small operators to examine them. Each session of the Legislature was faced with requests that the Survey be moved to Bismarck. Laird deflected these proposals by pointing out the advantages of having the

Geological Survey and the Geology Department together at the university. He made it a practice to provide financial aid to graduate students of the Geology Department for North Dakota studies and several theses and dissertations were published by the Survey. He also employed Geology Department faculty during the summers.

Laird also moved to blunt the criticism by setting up branch offices at Bismarck, Williston, and Minot. Field inspectors were stationed at these offices and were furnished with duplicate well files and well logs. As the oil activity waned toward the end of the fifties, most of the companies and independent operators closed their Bismarck offices leaving only a few consulting geologists and some local drilling contractors.

An early conflict arose over the matter of the well-spacing policies of the Industrial

Commission. This controversy was dealt with by the North Dakota Industrial Commission during a hearing in 1952, in which 80-acre spacing for Beaver Lodge Pool was considered. Because of the greater average depth of the producing reservoirs and the low permeabilities and porosities in the limestones, the operators usually requested that initial spacing be set at least no denser than one well to 80 acres. Almost without exception these requests were opposed by the landowners. The operators appeared before the Commission with carefully prepared exhibits and expert witnesses while the landowners generally presented nothing more than their feelings on the matter. When represented by attorneys, they were usually attorneys with limited knowledge of petroleum production. As a result, the Commission usually granted the applications since the only evidence in the record was that which supported the request.

A Day to Remember - The Discovery of Oil in North Dakota

Wilson Laird wrote this account of the discovery of oil in North Dakota and sent it to John Bluemle who made minor revisions before using it in the *Summer 1993 NDGS Newsletter*.

"Light the flare." With those words Blackie Davidson tossed up a lighted, oil-soaked rag and the gas started to burn in a flare 30 feet long. This was the real beginning - the opening of the Williston Basin to oil production on April 4, 1951. The discovery of oil will always be remembered by those who were in North Dakota at the time. Its effect on the State and the Nation can probably never be entirely assessed.

As far as I was concerned, this day had really started ten years almost to the month prior to the actual coming in of the Clarence Iverson No. 1 in Williams County (*Figure 35*). In 1941, the North Dakota Legislature, primarily through the foresight of one man, had passed an adequate oil and gas conservation measure. That man, George Saumer, was a representative from Grand Forks County, about as far from the oil area in North Dakota as one could be and still stay in the same state. Because of that law, the state was in a position to encourage, through proper regulation, the development of a resource that has come to mean so much. Also because of that law, I, as State Geologist, was present at the testing of the Silurian Interlake Formation in the Clarence Iverson No. 1, an event that opened the Williston Basin.

The "why" of my actually being there goes back to my friendship with Clyde Noe, a resident of Williston at the time. Clyde called me about two days before the well came in and told me he thought it was going to come in. He said he thought I should be there. How Clyde knew about the well I don't know, but I suspect he learned of it from Blackie Davidson, who was tool pusher on the rig. Blackie Davidson was someone who was believed by everyone in the area. If Blackie said it was so, it was so. He had far more credibility than any of the technical officials connected with Amerada Petroleum Company or, for that matter, anyone else concerned with the industry.

In any event, I went to the President of the university, Dr. John C. West, and told him that I had heard that the oil well near Tioga was going to come in. He asked me if I was going to be there. I said that I had four classes to teach that particular day and that I thought I had better stay in Grand Forks. Dr. West said, "Laird, you don't get to see an oil well in North Dakota every day - to hell with the classes." With that kind of encouragement, I left for Williston.

I got to Williston on the evening of April 3, contacted the Amerada geologists, and said that I would like to go to the well the next day. They said that was fine. I left Williston about 9 the next morning and arrived at the well site about 10 a.m. There I met Roy Fuller, who was Amerada's district superintendent working out of Casper at the time. He later moved to Williston where he became an institution in himself. Roy explained to me what was being done with the well and the preparations that were being made for the test.

It was a beautiful clear, cool day in North Dakota. The ground was still frozen as the preceding winter had been a cold one. This was not my first visit to the well site as I had been there in January after the famous "pint of oil" had been obtained in a drill stem test of the stratigraphically higher Devonian Duperow Formation. In January, the drifts of snow had been bulldozed as high as the telephone lines along the road coming from Highway 2 to the well site six miles south of the highway. Some of these drifts were still quite apparent on that April day.

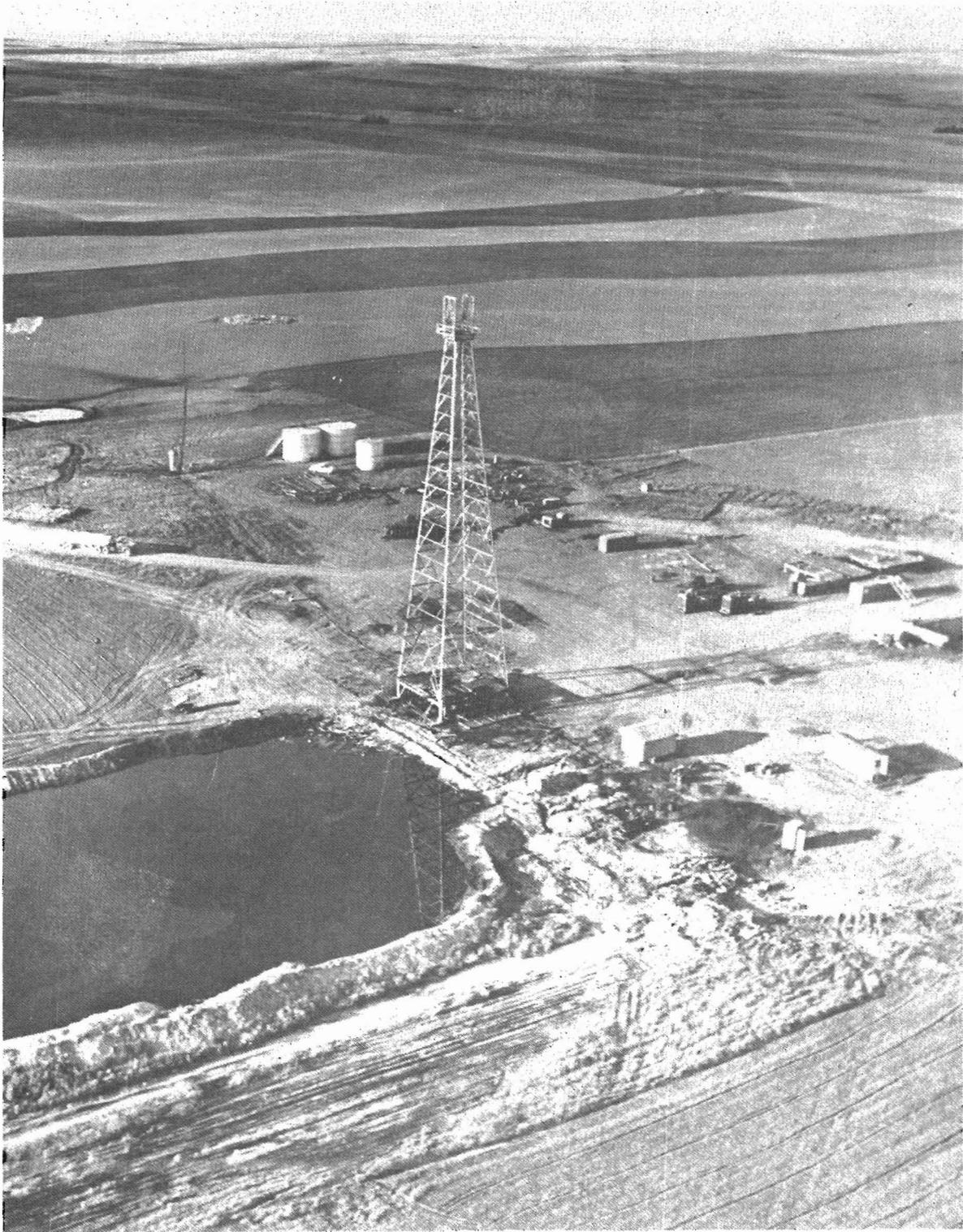


Figure 35. Amerada Petroleum Corporation's Clarence Iverson No. 1 wildcat location, ten miles south of Tioga, as it was rigged up in early September, 1950. Six months later, oil was recovered in commercial quantities from this well for the first time in North Dakota. Photo by Bill Schemorry.

Roy Fuller, Blackie Davidson, the drilling crew and I were about the only people who witnessed this historic event, which began almost exactly at noon on April 4. A few local visitors were there also, but Roy asked me to caution them to stay behind the wire stretched across the access road to the site because of the danger always present when such operations are underway.

On the side of the tank receiving the oil from the well was a trip valve which kept going up and down rather rapidly. Never having seen an oil well come in before, I wanted to know if this was a good sign and if this was really going to make a well. Roy kept telling me he didn't know, but I noted that he smiled a lot when he was telling me that. I knew that he had seen many wells come in during his long career with the industry. In the meantime, the flare was burning, the ground beneath it was beginning to thaw, and the steam was rising in the cool air.

About 4 p.m., I decided it was time to go back to town to get something to eat and to talk to others about this exciting and historic event I had witnessed. Among the first people I met on returning to town were the publisher of the newspaper, Herman Zahl and his wife, who invited me to have a steak at their home.

Along about 11 o'clock, someone decided that it might be a good idea to go and see how the well was doing. That seemed at the time like a capital idea, so Herman, his wife, and I piled into the car and drove to the well site. The flare could be seen for a distance of about 10 miles or more from the location. I forget now where we were when we first saw it, but it was some miles west of the well. We finally got to the well where, by this time quite a crowd had gathered. It was this night that the famous night picture of the well was taken by Bill Shemorry. I also took a color picture of the sight, which was later reproduced and incorporated in a beautiful wooden frame and presented to me by Dr. Rodger Denison, the exploration Vice-President of Amerada.

After that night scene, we drove rather slowly back to Williston, reflecting on what we had seen and what it would mean to Williams County, Williston, and the State of North Dakota.

Like many things human, the discovery of oil in the Clarence Iverson was regarded by many as good luck. Actually it was a combination of good interpretation of the geology of the area, the knowledge and guts of the company, which took a considerable risk in drilling the well, and the vision of many geologists dating back many years who had faith in the area. Notably, in this latter group was Tom Leach, who took the leases on this land, which were later turned to Amerada. However, it is worthy of note that he and others, such as Clyde Noe, and many others associated with the early development, didn't live long enough to see how big it really was. In this respect, I feel unduly fortunate. While I am sure they thought it would be big, I doubt if they could visualize the impact the discovery of oil would have on North Dakota.

Mapping North Dakota

In the late 1950's, Wilson Laird came up with the idea of mapping the geology of North Dakota on a county-by-county basis. He and Milo Hoisveen, who was State Engineer, devised a cooperative program that involved the State Geological Survey, State Water Commission, U.S. Geological Survey, and local representation from the counties involved (County Water Management Board, County Board of Commissioners, etc.). Under the program, a Board of County Commissioners or a Water Management Board, could request such a study of their county and, upon furnishing part of the cost, the study would be undertaken as a joint effort of the NDGS, USGS, and Water Commission.

The Water Commission, which was established in 1937 for the purpose of fostering the development of North Dakota's water resources, had assumed most of the duties that the State Geological Survey previously had relating to water resources.

Except for some of the early county studies, North Dakota Geological Survey geologists mapped the geology of each county, the USGS provided studies of the water quality, and the Water Commission did the test drilling and testing. The reports of each study, done in three parts - geology, basic groundwater data, and hydrology - were published jointly by the Survey and the Water Commission. The first of the new series of studies was undertaken in Kidder County in 1959, with studies in Stutsman, Barnes, Richland, and Burleigh soon to follow. The first report appeared in 1962, as Bulletin 36 of the North Dakota Geological Survey. In the ensuing years, similar studies were completed in all 53 counties. This county-mapping project enabled Survey geologists to build up a huge store of geologic information on the state.

This innovative mapping program, involving a cooperative effort of several state, federal and county agencies, was, I believe, the first of its kind in the United States. Following its successful implementation, many other states followed suit and set up similar programs.

With the beginning of the county-mapping program, the Survey hired several geologists whose main responsibility was mapping surface geology (Figure 36). Dan Hansen switched from subsurface work to surface mapping and Jack Kume, who had been hired in 1958, for subsurface studies, also switched to surface mapping. Kume remained with the Survey until 1966; Hansen until 1967. Hansen and Kume worked together to map three counties: Burleigh, Divide, and Grand Forks.

Ted Freers and John Bluemle were hired in 1962. Freers, who remained with the Survey until 1969, mapped the geology of Williams and Burke counties and helped in mapping Divide, Benson, and Pierce counties. Bluemle eventually mapped 21 counties, most of them in the glaciated part of the state. Clarence ("Kelly") Carlson mapped 11 counties in the part of North Dakota southwest of the Missouri River. Other Survey geologists who contributed to the mapping of North Dakota included Michael Arndt (Cavalier and Pembina counties), Howard Hobbs (Ramsey County), and Ken Harris (Bottineau County). In addition, some counties were mapped by USGS geologists: Harold Winters (Stutsman County); Tim Kelly and Doug Block (Barnes County); Claud Baker (Richland County); Robert Klausung (Cass County); and Henry Trapp (Stark and Hettinger counties). Some counties were mapped by UND faculty or students: Lee Clayton (Logan, McIntosh, and Mountrail counties), Dennis Nielson (Sargent County), and Dwight Deal (Rolette County). All



Figure 36. Wilson Laird (left) with (left to right) geologists John Bluemle, Sid Anderson, Dan Hansen, C.G. (Kelly) Carlson, Ted Freers, and E.A. (Ned) Noble. Photo taken in 1964.

or parts of other counties were mapped by students working on theses at the university, and although these were usually essentially re-mapped later by Survey geologists, the information contained in the theses was useful in the later studies.

It had become apparent that a knowledge of glacial deposits resulting from ablation of stagnant ice was going to be essential to understanding the surficial deposits that covered most of the state and would be of primary importance in the understanding of the groundwater conditions in glaciated areas. The University of North Dakota "Institute for Glacial Research" was informally established in 1961, and the geology department requested a grant from the National Science Foundation to enable them to send an expedition to study modern glacier deposits in Alaska.

The group selected a glacier on the Martin River, east of Cordova, Alaska, and a party, led by Wilson Laird, arrived on the location in the summer of 1962. In addition to Laird, the party included John Reid, from the geology department; graduate students Lee Clayton and Sam Tuthill; and an undergraduate, Gerald McDonald. The group compared the modern Alaska deposits with glacial deposits in North Dakota, an exercise that turned out to be useful in helping to understand the North Dakota deposits. The expedition returned to Alaska again in 1963, to complete its work and, upon its return, filed a request with the U.S. Board of Geographic Names to have a glacier named Sioux Glacier (the request was denied).

Following the Good Friday Alaska earthquake in 1964, Laird, Tuthill, and Ted Freers returned once again to the site to determine the changes the earthquake might have caused in the glacier. They found that a great many landslides had occurred.

In 1963, an opportunity arose to examine the excavations being made in eastern North Dakota for the installation of Minuteman Missiles. John Bluemle, working with Survey geologists Jack Kume and Ted Freers, examined 165 excavations, spaced in an approximate six-mile grid extending north to south from Canada to the Jamestown area and east to west from the western edge of the Red River Valley to west of Devils Lake (*Figure 38*). In many of the excavations, the contact between glacial deposits overlying Cretaceous shale was exposed and in about half of the exposures Bluemle noted evidence of glaciotectionic movement (thrusting of materials by the glacier). The information gained from studying the excavations later proved valuable in understanding the importance of ice-thrusting in constructing the glacial landscape in North Dakota.

Beginning in 1896, when Babcock made his first survey of cement rock potential in the Pembina area, interest in the development of a cement plant in North Dakota has continued. In 1961, Laird proposed that the Survey study any limestones near enough to the surface in eastern North Dakota to be minable. The study included a core drilling program and analyses of the cores. The North Dakota Economic Development Commission provided the necessary funds.

In the fall of 1962, Miller Hansen and a party of Survey geologists made reconnaissance surveys which aided in the selection of specific sites for the test holes. Clarence Carlson and Ted Freers supervised the drilling program. The cores were analyzed chemically and by x-ray diffraction techniques. The results indicated that the best materials encountered were deficient in calcium carbonate and would undergo beneficiation by the addition of imported limestone.

Again, in 1967, at the request of the North Dakota Economic Development Commission, the Survey entered into a contract with the U.S.

Department of Commerce for a further study of possible sources for cement rock. This study was aimed primarily at determining if Ordovician limestone of the Red River or Winnipeg Formations might be available for blending with the Niobrara. The drilling was supervised by Sid Anderson and Harald Haraldson, who had rejoined the Survey after leaving Canada during the decline in oil exploration there. Their study determined that, even though limestone is present at shallow depths in the Grand Forks area, magnesium would make it difficult to manufacture a portland-grade product.

A third drilling program, funded by the Economic Development Commission, had for its purpose the location of possible deposits of gypsum in northeastern North Dakota. The presence of large deposits in Canada, just north of the border, was the catalyst for this program.

The State Water Commission drilling rig was used and several holes were drilled in Pembina County. One of these, near Neche, encountered a heavy flow of water which was contained with great difficulty. Anderson and Noble were in charge of the drilling program. They did not encounter the beds being developed in Manitoba and only thin stringers of gypsum were noted in the older rocks.

During the summer of 1962, a committee consisting of F.D. Holland from the UND geology department, Myron Denbrook, architect, and Laird, went on a tour of university campuses to study their geology buildings. The trip was the result of a Legislative appropriation in the amount of \$1,000,000 which was supplemented by a gift of \$33,000 from Amerada Petroleum Corporation (donated for the purpose of equipping an x-ray laboratory) and a grant of \$117,500 from the National Science Foundation.



Figure 37. North Dakota Geological Survey Staff in 1963.

Seated (left to right): Sylvia Huizenga (Stenographer), Florine Auch (Stenographer), Geraldine Klug (Stenographer), Mary Lou Pflaum (Stenographer), Mary Larsien (Stenographer), Karlyn Gunderson (Bookkeeper).

Standing second row (left to right): Mary Edwards (Assistant Petroleum Engineer), Floyd Wilborn (Statistician), Richard Cameron (Technician), Betty Carr (Stenographer), Jack Kume (Geologist), Clarence Carlson (Geologist).

Standing third row (left to right): Clarence B. Folsom, Jr. (Chief Petroleum Engineer), Miller Hansen (Assistant State Geologist), Ethel Schroeder (Secretary), Wilson M. Laird (State Geologist), Marcella O. Hanson (Administrative Assistant).

Standing fourth row (left to right): Theodore Freers (Geologist), Wesley Norton (Assistant Petroleum Engineer).



Figure 38. Ted Freers in a Minuteman Missile excavation in eastern North Dakota, 1964.

Contracts were let in the summer of 1963, and ground was broken on September 16 of that year (Figure 39). A cornerstone-laying ceremony was conducted on May 8, 1964, by the Masonic Grand Lodge of North Dakota. The Survey and the Department moved into the new structure during the Christmas break in 1964.

The geology building is located on an extension of Cornell street near the southern boundary of the UND campus (Figure 40). Named Leonard Hall, in honor of Arthur Gray Leonard, the building contains 67,000 square feet of area on three floors and a basement. The building committee was made up of F.D. Holland, Jr., Chairman, Wilson M. Laird, Nicholas N. Kohanowski, Walter L. Moore, John R. Reid, Frank R. Karner, Alan M. Cvancara, and C.B. Folsom, Jr. The architects were Wells, Denbrook, and Associates, and the general contractors were Lenci and Englund, Inc.

Leonard Hall was dedicated on October 7-8, 1965, with a Symposium on "Geology in Modern Science." The principal speaker was J. Cordell Moore, Assistant Secretary of the Interior-Mineral Resources. Other speakers included Wilson M. Laird, UND President George W. Starcher, Lt. Gov. Charles Tighe, Martin J. Kruse, President of the Board of Higher Education, and F.D. Holland, Jr. Speakers at the symposium were

William T. Pecora, Director, U.S. Geological Survey; Gerald E. Eddy, State Geologist of Michigan; James W. Snider, Chief Geologist, Amerada Petroleum Corporation; and Carey G. Croneis, Chancellor, Rice University. The North Dakota Geological Survey and UND Geology Department shared Leonard Hall until 1989, when the Survey moved to Bismarck. The Geology Department continues to occupy a major portion of the building.

Miller Hansen resigned the position of Assistant State Geologist on July 24, 1964, to take a job with the State Engineer's office in Helena, Montana. He was replaced by Dr. E.A. Noble in February, 1965. Noble had been with the Atomic Energy Commission prior to coming to North Dakota. At that time some uranium ore was being recovered from lignite in North Dakota by burning the material and recovering the ash. The project was discontinued in 1967, after about 85,000 tons of ore had been shipped. Also in 1967, the Legislature enacted a law relating to the regulation of subsurface minerals. The State Geologist was designated the supervisor charged with the duty of enforcing the regulations and orders of the Industrial Commission.

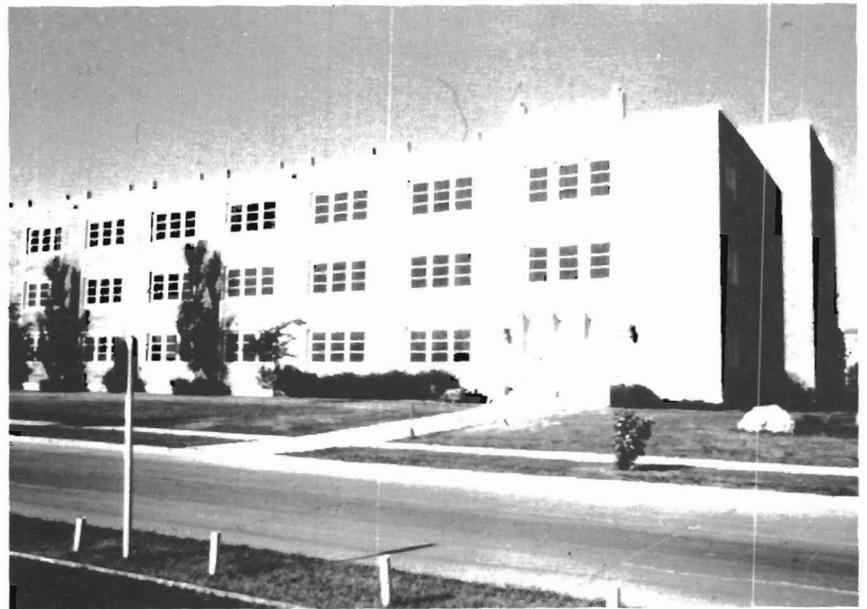
In 1967, the North Dakota Geological Survey and University of North Dakota Department of Geology co-sponsored a "Friends



Figure 39. Wilson M. Laird turns the first shovel of earth for the construction of Leonard Hall on the campus of the University of North Dakota on September 16, 1963.

Pictured (left to right): Myron Denbrook (Architect), F.D. Holland, Jr. (Chairman of the Faculty Building Committee), Sulho Norri (Superintendent Lenci & Englund), George W. Starcher (President of UND).

Figure 40. Leonard Hall on the University of North Dakota campus. Leonard Hall was the home of the North Dakota Geological Survey from 1964-89.



of the Pleistocene" field trip to look mainly at large-scale glacial stagnation features on the Missouri Coteau. Survey geologist Ted Freers and UND geology professor Lee Clayton compiled a field trip guidebook, which the Survey published. The field trip of the Missouri Coteau area of south-central North Dakota highlighted the array of unusual glacial stagnation features in the state as well as bringing attention to North Dakota's county geologic mapping program. At that time, the idea of glacial stagnation and the "dead-ice" landforms that resulted from it, was new and controversial. In 1958, prior to this field trip and prior to the beginning of the Survey's county mapping program, the Survey had conducted a previous "Friends of the Pleistocene" field trip of the state's glacial geology. This trip concentrated on east-central North Dakota.

B. Michael Arndt was hired in 1968, primarily as a surface mapping geologist. Arndt did considerable work over the next several years on environmental concerns. He was the first Survey geologist to study the siting of landfills in the state and report on the hazards associated with them. He wrote reports on the environmental geology of several towns in North Dakota and on issues such as groundwater pollution and land-use planning. Arndt went on to study the stratigraphy and engineering properties of glacial Lake Agassiz sediments, earning a Ph.D. from the University of North Dakota in 1975. He remained with the Survey until 1976.

Dr. Stephen R. Moran joined the Survey part-time in 1969, (he was also a professor in the Geology Department). Moran did extensive work on Pleistocene and Paleocene stratigraphy in North Dakota. He also studied various lignite strip-mine projects in western North Dakota, concentrating on the potential effects of groundwater in mined areas. Moran made especially valuable contributions to understanding North Dakota's glacial stratigraphy. He left the Survey in 1976.

In July, 1969, Laird took a leave of absence from UND and served as a consultant to the State of Alaska, in regard to the proposed oil pipeline from the North Slope. Later that fall, he was appointed Director of the Office of Oil and Gas in the Department of Interior. He later resigned from the faculty of the university to become Director of the Exploration Committee of the American Petroleum Institute. He was given the rank of Professor Emeritus of Geology by the University of North Dakota.

Dr. E.A. Noble (*Figure 41*) became State Geologist when Laird began his leave of absence. During his tenure, the Survey emphasized geologic studies designed to help municipalities respond to increasing pressure for development of environmentally acceptable landfills and sewage disposal. The Survey also moved to require petroleum producers to modify their brine-disposal methods to reduce environmental contamination. These measures kept the North Dakota Geological Survey among the nation's leaders in responding to growing sentiment for environmental protection.

Under Noble, the Survey continued its county groundwater cooperative studies with the State Water Commission and the U.S. Geological Survey. Noble also continued the practice of providing financial assistance for graduate student studies in North Dakota and the use of students by the Survey.

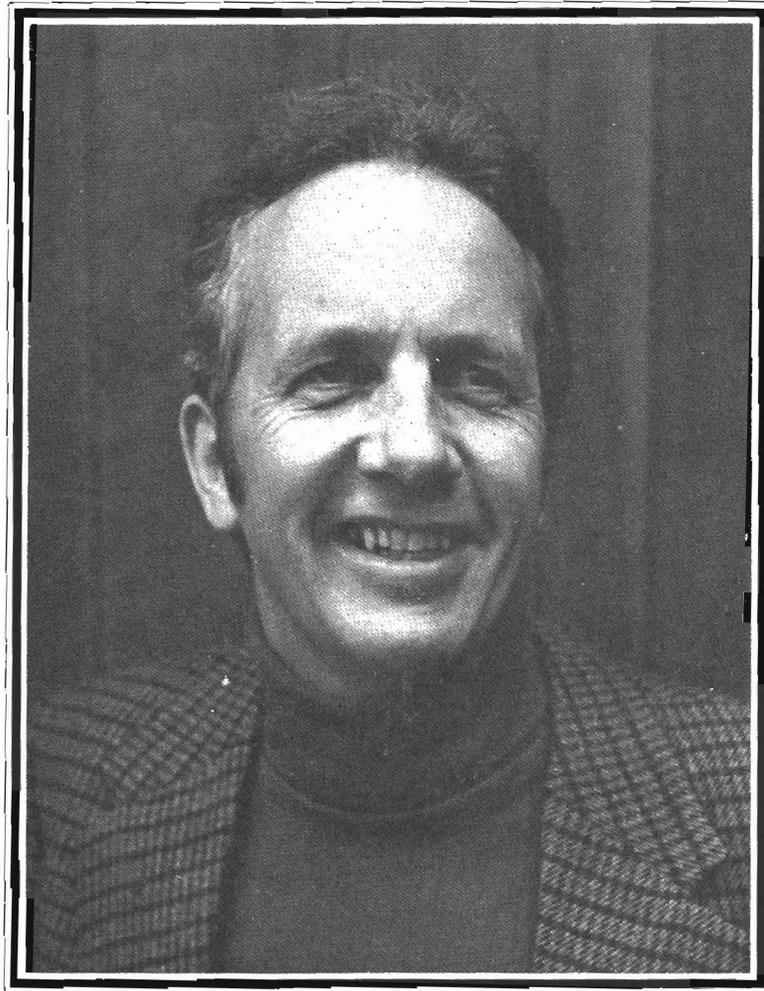


Figure 41. Edwin A. Noble, State Geologist, 1969-1978. Edwin (Ned) A. Noble was born in Vermont in 1922. His studies at Tufts University, interrupted by service in World War II, ended with a B.S. in Chemistry-Biology in 1946. After sampling a year of geology courses and teaching a year of high school, he enrolled in the University of New Mexico and received a M.S. in Geology in 1950. Graduate studies at Harvard and an instructorship at Tufts were followed by his joining the Groundwater Branch of the U.S. Geological Survey. In 1954, he moved to the U.S. Atomic Energy Commission to work in uranium exploration and resource appraisal in the Colorado Plateau states. This work was interrupted for geological studies at the University of Wyoming that resulted in a Ph.D. degree in 1961.

In 1962, Noble again temporarily left the Atomic Energy Commission to work in Argentina for one year as advisor to the government of Argentina in nuclear raw materials (as a contract employee of the International Atomic Energy). In 1965, he was hired as Assistant State Geologist for the North Dakota Geological Survey, serving also as Associate Professor of Geology at the University of North Dakota. He was named State Geologist and Professor and Chairman of the Department of Geology in 1969.

Noble left the Geological Survey on September 1, 1977, to accept a position as Deputy Chief of the Office of Energy Resources at the national headquarters of the U.S. Geological Survey in Reston, Virginia.

Reclamation and Environment

In the early 1970's, the Survey began to put greater emphasis on its activity in the areas of environmental geology and assistance to the state's educators. Members of the Survey had routinely participated in camps and other educational activities, but no effort had been made to cover the field completely. While Noble was State Geologist, Survey geologists wrote a number of guides to the geology of the various regions of the state, together with field trip road log guides designed for use by earth science teachers in the public schools. John Bluemle wrote a non-technical report on the geology of North Dakota entitled "The Face of North Dakota, the Geologic Story." Bluemle also put together a small collection of rocks and minerals that were supplied to schools. In 1974, Bluemle initiated the *NDGS Newsletter*, a semi-annual publication of non-technical essays on North Dakota geology and items of current interest.

In 1974, Bluemle wrote the first of a series of six guidebooks to the geology of North Dakota and these were published with help from the State Department of Public Instruction. The guidebooks were intended to present the geology of North Dakota in a generalized manner, primarily for students and the general public. The guidebooks continue to see widespread use in the state's schools.

With increased interest in the mining of lignite, the Survey turned its attention to problems that would arise from the increased activity including the problems relating to the reclamation of mined lands. In 1964, Assistant State Geologist Miller Hansen had published a brochure reviewing the lignite resources of the state and in the same year, Clarence Carlson made a study of the spoil banks at existing mines in response to a resolution passed by the Legislature. The 1969 session resulted in

Chapter 332, Session Laws 1969, providing that the Public Service Commission would be responsible for regulation of reclamation of mined lands. The Survey has been part of an advisory committee to the PSC on reclamation matters and as such had input in revisions of the reclamation laws in subsequent Legislative sessions. The Survey also conducted studies of problems associated with reclamation, mostly under the supervision of Gerald Groenewold and Stephen Moran.

The 1975 session of the Legislature passed laws providing for regulation of exploration for coal and revised the laws dealing with subsurface minerals (the Survey had undertaken regulation of subsurface minerals in 1967). These laws were similar to the oil and gas law in that they provided that the Survey, acting for the Industrial Commission, has the task of issuing permits and enforcing regulations. They also provide that information obtained from exploration shall be filed with the State Geologist. However, the laws provide for confidentiality periods which, for coal, may extend for as long as seven years.

Between 1969-75, the Survey received funding from the U.S. Energy Research and Development Administration and, in 1973-1974, by the Atomic Energy Commission to conduct several studies of formations in western North Dakota that were thought to have potential for uranium production (*Figure 42*). These studies, which were conducted by University of North Dakota geology professors Walter L. Moore, Alan M. Cvancara, and Arthur F. Jacob, helped the Survey to establish stratigraphic relationships among several late Cretaceous and Paleocene formations.

Exploratory drilling for oil and gas provided a great deal of information on the subsurface geology, which had not been available before.

From this information it appeared that salt and potash might be mined by solution methods if the economics were favorable. A salt plant, operated by the Dakota Salt and Chemical Company, had been established at Williston in 1960, dissolving salt of the Madison Formation. Potash development in Saskatchewan led to interest in this resource in North Dakota and Carlson and Anderson published a study on North Dakota potash possibilities in 1965. At about the same time, an oil test in Burke County was deepened to look at potash, but the results were not forwarded to the Survey.

Anderson continued with studies of the potash potential in North Dakota and when Saskatchewan began to push for greater participation with the mining companies, many of them began to take a serious look at the possibilities of potash production in North Dakota. This resulted in a number of coring operations to determine the character of deposits in the northwestern part of the state. Depending on the potash market situation, interest in North Dakota's potash resource comes and goes, but the resource has never actually been developed.

Dr. Lee C. Gerhard (Figure 43) joined the Survey as Assistant State Geologist in September, 1975. Gerhard, a carbonate geologist, came to the Survey from the directorship of Fairleigh Dickinson University's West Indies Laboratory on St. Croix, United States Virgin Islands. He was educated at Syracuse and Kansas Universities, receiving his Ph.D. from Kansas.

Dr. Alan E. Kehew joined the Survey as an environmental geologist in 1977. Kehew had a Ph.D. from the University of Idaho, a M.S. from Montana State University, and a B.S. from Bucknell University. He worked full-time for the Survey until 1980, inventorying and evaluating 76 sanitary landfills in the state according to their geologic setting. He also studied landslides, a widespread problem in North Dakota. In addition to his work with oil-field reserve pits, landfills, and sewage lagoons, Kehew did considerable innovative work in the field of Quaternary geology while with the Survey. He was particularly interested in large-scale flooding relating to glacial lake outbursts. Among Kehew's North Dakota Geological Survey reports were studies of the geotechnical conditions in the

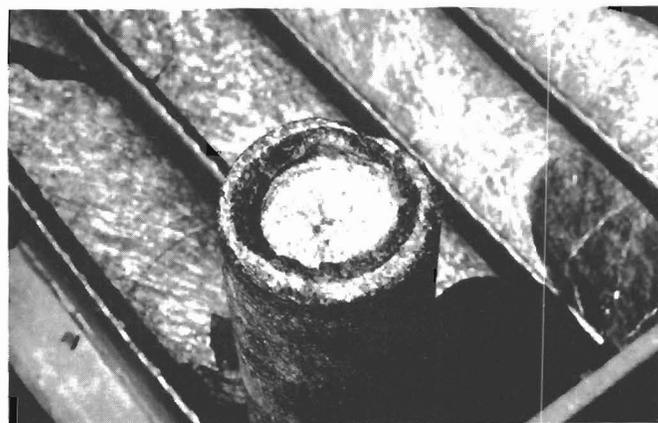


Figure 42. Drilling for uranium in the Red River Valley. The photo on top shows the North Dakota Geological Survey rig drilling for uranium in the southern Red River Valley in 1973. The photo on the right shows core collected during the uranium exploration project.

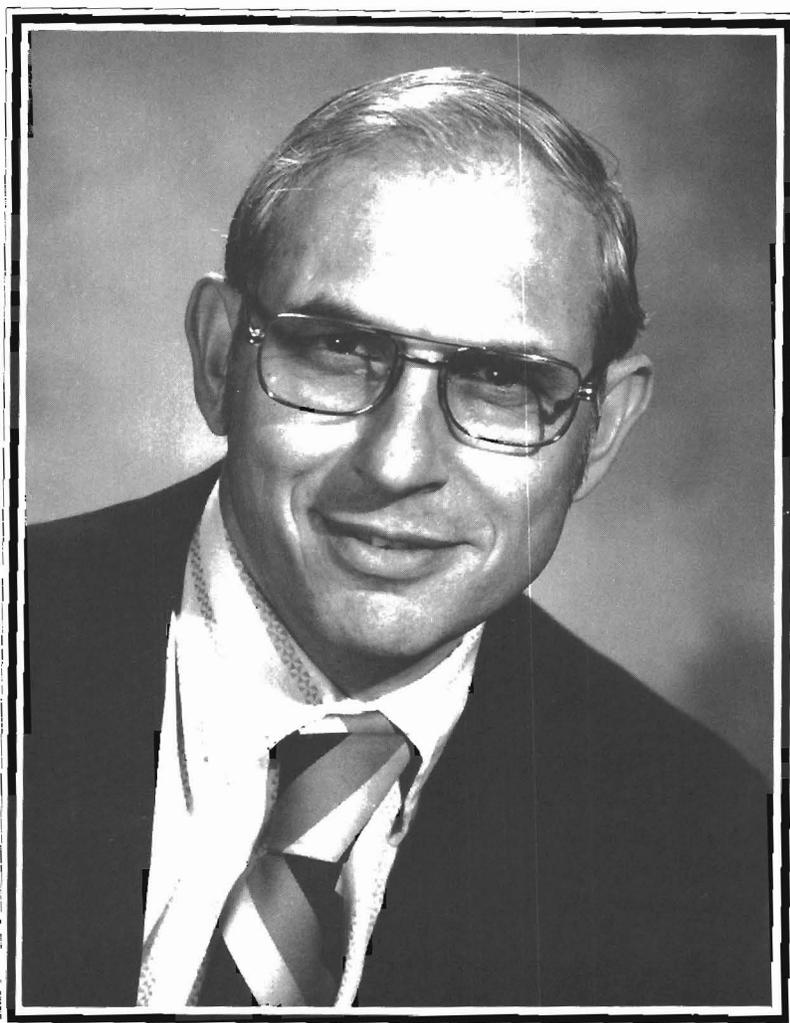


Figure 43. Lee C. Gerhard, State Geologist, 1978-1981. Lee Gerhard was born in 1937, in Albion, New York. He received a B.S. in Geology from Syracuse University (1958), a M.S. in Geology from the University of Kansas (1961), and a Ph.D. from the University of Kansas (1964). Gerhard worked for Amerada Petroleum Corp. in the Powder River and Williston Basins after receiving his master's degree. He worked as an exploration geologist and regional stratigrapher for Sinclair Oil & Gas in the Permian Basin after he received his Ph.D. After service in the U.S. Army Signal Corps, Gerhard served as an instructor of geology at the University of Kansas from 1960-64 and as an Associate Professor of Geology at the University of Southern Colorado from 1966-72. Gerhard was Assistant Director of the West Indies Laboratory and Associate Professor of Geology at Fairleigh Dickinson University from 1972-75.

Primarily trained as a structural geologist, paleontologist, and stratigrapher, Gerhard developed an interest in carbonate sediments and rocks while exploring for oil in West Texas and New Mexico. He came to the North Dakota Geological Survey as Assistant State Geologist and Associate Professor of Geology at the University of North Dakota in 1975. He was named Acting Chairman of the Geology Department and Acting State Geologist in September, 1977, and State Geologist in July, 1978.

Gerhard resigned as State Geologist on August 1, 1981, for a job with Supron Energy Corporation in Denver. He is currently (1995) State Geologist for the Kansas Geological Survey.

Minot area. In 1980, Kehew took a professorial position with the University of North Dakota geology department and also continued to do projects during the summer with the Survey until 1985, when he left for Western Michigan University. Kehew wrote reports on the effects of seepage from municipal waste lagoons on groundwater in shallow aquifers and (with Ed Murphy) on the effects of oil and gas well drilling fluids on shallow groundwater in western North Dakota.

Dr. Kenneth L. Harris was hired as a Quaternary geologist in 1977. Harris had worked for Schlumberger Well Services in Montana and as an exploration geologist for Cities Service Oil Company in Tulsa, Oklahoma, and Jackson, Mississippi. He had M.S. and Ph.D. degrees in geology from the University of North Dakota and a B.S. degree in electrical engineering from North Dakota State University. His early work with the North Dakota Geological Survey, evaluating the hydrothermal resources of the state, resulted in the publication of a Geothermal Resources Map of North Dakota in 1981. Most of his work, during the 1980's, was on North Dakota's glacial stratigraphy.

Noble took a one-year leave of absence in September, 1977, to take a position as Deputy Director for Uranium-Thorium, Office of Energy Resources, U.S. Geological Survey. Gerhard took over Noble's duties as Acting State Geologist and Acting Chairman of the Geology Department.

The 1979 Legislature provided the regulation of the subsurface storage of petroleum and other materials and the underground disposal of industrial and municipal wastes, including nuclear wastes. This authority was placed with the Industrial Commission, acting through the Office of State Geologist.

The Geological Survey was active during the late 1970's, in assessing the lignite potential of North Dakota. As part of a 1975-79 cooperative

coal drilling program with the Conservation Branch of the U.S. Geological Survey, Survey geologists, led by Clarence Carlson, were involved in exploration drilling, geophysical logging and the interpretation of acquired data. The project was designed to obtain information over as wide an area as possible, make it available to the public, and get maximum stratigraphic information. The studies consisted of drilling two or three test holes per township in the areas of study with depths ranging from about 100-800 feet. The intent was to assess the lignite resources of the state rather than to define strippable reserves. A total of 224,000 feet of drilling at 667 sites throughout the area of lignite resources helped the Survey to gain a good general knowledge of the state's lignite resources.

At about the same time (mid-1970's) North Dakota Geological Survey geologist Gerald Groenewold conducted a study of the coal stratigraphy in the Knife River Basin in west-central North Dakota. Using the new stratigraphic framework resulting from Groenewold's and other's work, it became possible to correlate the various coal beds in much of western and southwestern North Dakota and to develop much more accurate estimates of total strippable lignite reserves. Groenewold's work led to a more detailed understanding of the hydrology of the coal-producing areas, enabling Survey geologists to accurately predict the effect on water supplies due to mining in the area.

Other environmental issues were important during this time. Survey geologists were involved in a series of studies to develop data to enable the Legislature, as well as involved governmental agencies and industry, to formulate sound legislation and decisions in mine planning and reclamation programs. The reclamation studies included work on the Dunn Center and Falkirk areas and the Knife River Basin.

Studies of Quaternary (mainly glacial) stratigraphy were also important during the late

1970's. The Survey's cooperative surface mapping of the state was almost complete by the end of the decade, although some of the reports resulting from the study took several more years to complete. In 1980, the U.S. Geological Survey published the *Geologic Map of North Dakota*. The map was compiled by Lee Clayton of the UND Geology Department, with assistance from North Dakota Geological Survey Geologists Stephen Moran, John Bluemle, and Clarence Carlson. Clayton's compilation was based largely on information gained through the Survey's mapping program. The Survey also contributed a geologic map of the Dakotas Quadrangle (1:1,000,000) to the U.S. Geological Survey for compilation into a new Quaternary map of the United States.

The Survey continued to cooperate with the State Health Department in evaluating existing and potential sites for municipal and industrial solid waste disposal. The evaluations were aimed mainly at protecting surface water and groundwater resources from pollution. During the early 1980's, these studies were expanded to include lagoons.

Dr. Gerhard was appointed State Geologist and Chairman of the Geology Department on July 1, 1978. Because an oil boom was in progress

at the time, it was apparent that the core library facilities were being overtaxed due to the large influx of new oil-well cores. A new and much larger core and sample library was designed and built in 1980, on the University of North Dakota campus during Gerhard's tenure as State Geologist.

The new core and sample facility, which was named the Wilson M. Laird Core and Sample Library, was dedicated on October 3, 1980 (Figures 44 and 45). It includes 20,482 square feet of total floor space; of this, 18,432 square feet are devoted to core and sample storage and the remainder is office and laboratory space for the preparation and analysis of cores. The facility can hold about 200,000 boxes of core. Rod Stoa, who was hired by the Survey in 1980, became the first Core and Sample Technician at the new core library.

Gerhard's interest and expertise in carbonate geology led him to conduct a series of in-depth studies of Williston Basin carbonate rocks and of various modern sedimentological analogs. His interests were also reflected in his efforts toward establishing the Williston Basin Carbonate Core and Sample Laboratory, which was set up in conjunction with the new Core and Sample



Figure 44. E.A. Noble, Wilson M. Laird, and Lee C. Gerhard at the dedication of the Wilson M. Laird Core and Sample Library on October 3, 1980.



Figure 45. Wilson M. Laird Core and Sample Library on the University of North Dakota campus, Grand Forks.

Library. Survey geologists and Geology Department students undertook a number of stratigraphic studies of core designed to better understand Williston Basin geology. The results of several of the studies were published in the 1978 Williston Basin Symposium volume. The main goal of the Survey in doing these and other studies relating to the occurrence of oil and gas was, and still is, to learn more about Williston Basin rocks and geologic processes, not to develop specific drilling prospects.

Randolph B. Burke was hired in 1979, to study carbonate rocks. Burke came to the North Dakota Geological Survey with a B.S. in geology from the University of Southern Colorado and a M.S. in oceanography from the University of South Florida. He had experience with modern carbonate environments and, prior to coming to the Survey, he was employed by the Smithsonian Institution where he had been involved in research on Caribbean reef geology and ecology. He studied coralline algae and reef structures in the Caribbean. His knowledge of carbonates was applicable to North Dakota's oil-producing carbonate formations. Burke received his Ph.D. in geology from the University of North Dakota in 1988.

Also in 1979, Erling A. Brostuen was appointed to the position of Assistant State Geologist. Brostuen had been involved with oil and gas regulation and conservation when he had

been stationed in the Survey's Williston office. Also, he had been involved with subsurface mineral regulation and uranium exploration/development after he moved to Grand Forks in 1974. At the same time, Wesley D. Norton was named Chief of Field Engineering; he had been stationed at the Survey's Bismarck office since 1968. Norton had been with the Survey since 1960, first as a field inspector in the Williston office, and then as a petroleum engineer in Grand Forks. Norton's staff included eight field inspectors, one engineer, one geologist, a secretary, and a clerk. He was also named principal advisor to the State Geologist for field implementation and regulatory decisions.

Dramatically increased oil and gas drilling and production activity in 1980, along with continued work in coal, uranium, and other resources, necessitated increased staffing and organizational changes within the Survey. The Survey's staff increased by 12, to a total of 43 full-time employees. Most of the new staff positions were dedicated to the increased workload of oil and gas exploration and development and the accompanying administrative support. The new positions included four new field inspectors and two petroleum engineers.

Studies of North Dakota's Tertiary stratigraphy continued during the early 1980's, (Figure 46). Survey geologists conducted an

exhaustive, integrated regional study of the Cenozoic rocks in the Williston and Powder River Basins, dealing with the potential for coal mining, uranium occurrences, and related groundwater problems. Study of the State's hydrothermal resources provided information on variations in geothermal gradients as well as depth, thickness, temperature, and water quality of deep, principally Paleozoic, aquifers.

Edward C. Murphy assumed a half-time position as a coal geologist with the Survey in 1980, while finishing his M.S. degree in geology at the University of North Dakota. He soon became involved in environmental geologic work and studies of Tertiary stratigraphy. Murphy became a full-time Survey employee in 1981.

Also in 1981, John W. Hoganson, who had been a part-time Survey employee, was hired into

a full-time position. Hoganson was a paleontologist who had a B.A. in geology from North Dakota State University and a M.S. from the University of Florida. He had also worked as a micropaleontologist with Union Oil Company of California in the Gulf region. Hoganson received a Ph.D. in geology from the University of North Dakota in 1985.

During field work in 1980, the North Dakota Geological Survey was contacted by a Corps of Engineers geologist about an outcrop of shale in the Pembina River Valley (SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 31, T. 163 N., R. 56 W.). The shale was identified as Cretaceous Greenhorn Formation by Survey geologists. It occurs at the site of a proposed dam that was intended to dam the Pembina River. This is the geologically oldest known in-place exposure of rock in the state.

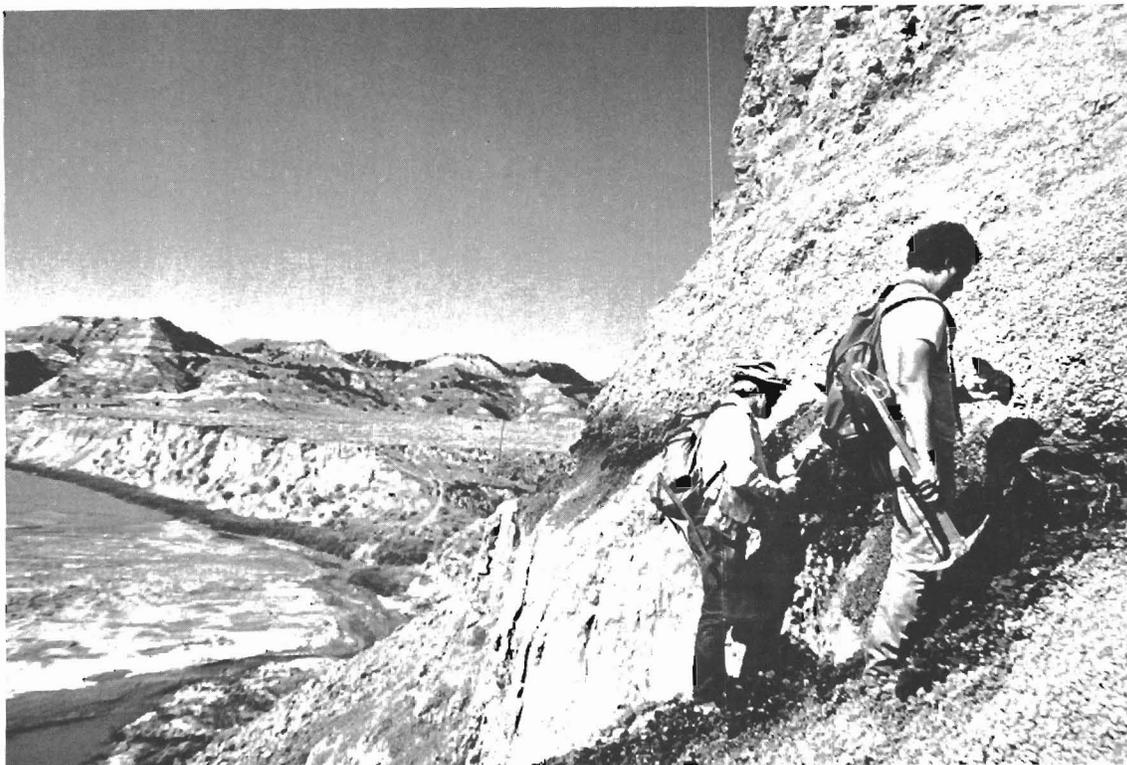


Figure 46. Survey geologist John Hoganson (right) working on Tertiary stratigraphy along the Little Missouri River, Billings County. Geologist on the left is Doug Nichols, USGS.

The Split

The North Dakota Geological Survey's role in regulating oil and gas exploration and production ended in 1981, when the 47th Session of the North Dakota Legislature passed House Bill 1536, amending Chapter 38-08 of the North Dakota Century Code relating to the powers and duties of the North Dakota Industrial Commission and the State Geologist. The Survey's regulatory role was transferred directly to the Industrial Commission. The new arrangement was actually not quite what Governor Olson had wanted. He had pushed for establishing a Department of Natural Resources (DNR), but the Legislature was unwilling to do this. Consequently, the splitting off of the Survey's oil and gas regulatory authority was somewhat of a compromise. The arrangement addressed the concern of some people in government who felt that the regulation of oil and gas should be closer to the center of state government, particularly in view of the fact that the oil and gas industry at that time was enjoying a series of "boom" years.

As a result of the new legislation, all Survey personnel who were involved with oil and gas regulation were transferred to a newly created Industrial Commission Oil and Gas Division. The change involved about 25 Survey employees, including all of the Bismarck and Williston personnel, as well as six Grand Forks positions. As a result, except for its operation of the core and sample library, the North Dakota Geological Survey no longer had any official role in oil and gas regulation, although NDGS geologists continued to study the geology of the oil and gas producing formations in the Williston Basin. The 1981 Legislature also provided for the regulation of geothermal energy development by the Industrial Commission acting through the Office of the State Geologist.

In August, 1981, Gerhard left the Survey for a job with Supron Energy Corporation in Denver. He was temporarily succeeded by Erling Brostuen as Acting State Geologist. However, Brostuen left after three months to become manager of Resources Engineering Management International, Inc., also in Denver. Dr. Donald L. Halvorson, who had been half-time with the Survey since July 1, 1980, was then named Acting State Geologist and, on February 1, 1982, Halvorson was named State Geologist and Chairman of the University of North Dakota Geology Department.

Also, in 1981, Roger Borchert, a field inspector for the Survey's Oil and Gas Division, resigned to accept a position with a group of independent consulting geologists. James C. Dufty was hired as a new field inspector.

During Halvorson's tenure, the NDGS obtained the use of and eventually acquired its own computer system for the purpose of well-record management and geologic research. The Survey issued two particularly valuable reference publications in 1981 and 1982. The *Lexicon of Stratigraphic Names of North Dakota* was compiled by Joanne V. Lerud, who had been the Survey's librarian. The lexicon, which remains an extremely valuable reference to North Dakota geology, is as complete as possible a listing of all terms that have been applied to the various stratigraphic units recognized in North Dakota. The listing includes a history of the terminology applied to each unit, its age, area of extent, lithology, thickness, relationships to other units, and references to type sections. Also in 1981, the Survey published Mary Woods Scott's *Annotated Bibliography of the Geology of North Dakota, 1960-1979*. This was a companion volume to her earlier bibliography of geologic literature on North Dakota (1906-59) published in 1972.

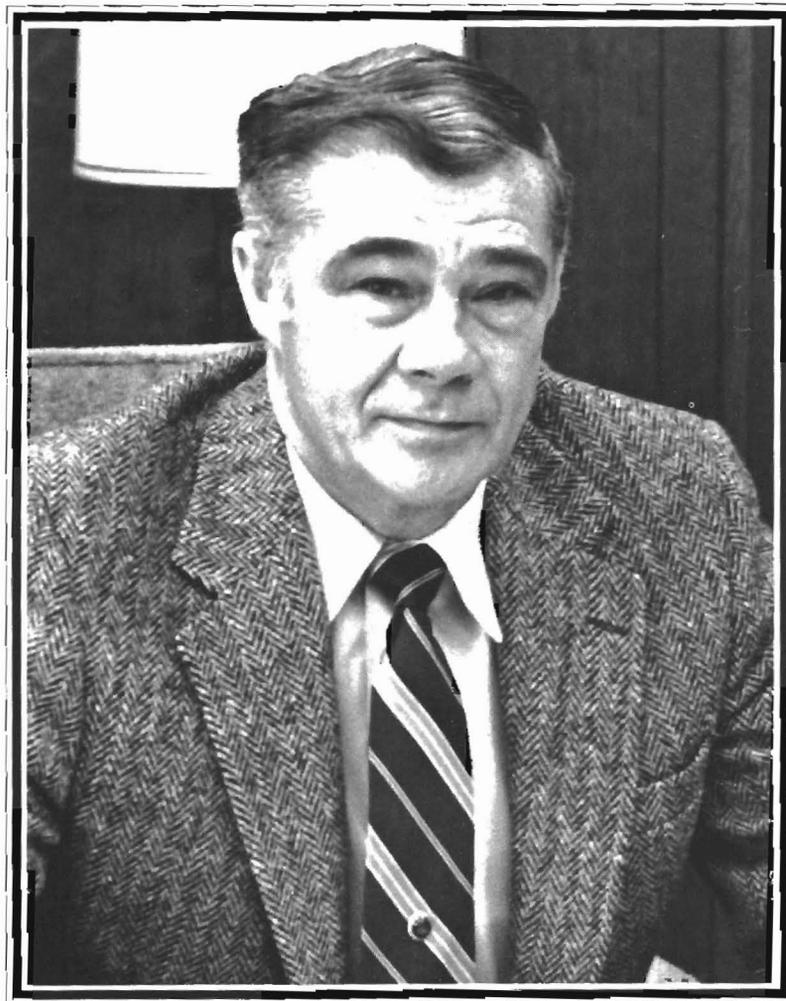


Figure 47. Donald L. Halvorson, State Geologist, 1982-1985. Don Halvorson began working part-time for the North Dakota Geological Survey in 1977, while also teaching in the Geology Department at the University of North Dakota. He was employed full-time in July, 1980, and was named State Geologist and Chairman of the University of North Dakota Geology Department on February 1, 1982. Halvorson is a native North Dakotan, born in Wildrose in 1934. He received his B.S. in earth science from the University of Colorado (1965), an M.S.T. (Master of Science in Teaching) in geology from the University of North Dakota (1971), and a Ph.D. (also from the University of North Dakota) in geology (1979). His specialty was mineralogy and geochemistry and he had done extensive work in the Black Hills, South Dakota and Wyoming, particularly on Devils Tower, prior to joining the Geological Survey. He had also done geologic research in Africa as well as volcanism research in the Canary Islands, Hawaiian Islands, and Baja, California.



Figure 48. Excavation of a mosasaur in the Cooperstown area, 1995.

Julie A. LeFever, a structural geologist, David W. Brekke, a clay mineralogist-sedimentary petrologist, and Marvin E. Rygh, a petroleum engineer, were added to the Survey staff as full-time employees in 1982. Robert E. Seidel was named Deputy State Geologist and the Geological Survey was reorganized into a Subsurface Section, headed by Sid Anderson, and a Surface Section, headed by John Bluemle. In addition, an advisory board was established consisting of the Section Chiefs, Administrative Officer, the Deputy, and the State Geologist.

Through the 1980's, the Geological Survey continued to produce numerous publications relating to a variety of ongoing activities. In 1982, a new bedrock geologic map was published at a scale of 1:1,000,000 and in 1986, a depth-to-bedrock map was published. Survey geologists continued their reconnaissance mapping of the surface geology of North Dakota counties, although this was winding down. Ed Murphy published a series of environmental and educational reports. The Survey issued a number of publications dealing with the geology of the oil and gas producing formations. In 1983, Kenneth Harris initiated a study of 1° x 1° areas to take up where the county groundwater studies left off.

The Survey also began research on North Dakota's vertebrate paleontology about this time, focusing on the study of some of the fossiliferous Tertiary formations in the southwestern part of the state. John Hoganson led this effort, cooperating with vertebrate paleontologists from the Manitoba Museum of Man and Nature in Winnipeg, excavating an Oligocene mammal site near Dickinson. The North Dakota Geological Survey Fossil Resource Management Program was inaugurated in 1983, by Hoganson, who was designated as the Survey's paleontologist (Figure 48).

In 1984, two paleoclimatic studies were underway. John Hoganson studied the fossil insects found in excavations in the McClusky Canal as proxy indicators of past environments and Robert Seidel worked on a paleoclimatic investigation of southwestern North Dakota, using deflation basin stratigraphy.

In 1986, the Survey produced a set of slides on the geology of the state intended mainly for earth science teachers. This slide set was loaned out on demand and was later (1991) converted to a video format.

In 1987, the Survey began a several-year cooperative geologic mapping program (COGEOMAP) in southwestern North Dakota with the U.S. Geological Survey, mapping and dating Eocene, Oligocene, and Miocene sediments. Initially the purpose of the first three-year COGEOMAP project was to determine the ages of the rocks capping many of the buttes in the western part of the state (*Figure 49*). The project was conducted with input from Dr. Nels Forsman (UND Geology Department), using geochemical and fission-track methods to date the volcanic materials contained in the caprock on the Killdeer Mountains. The COGEOMAP mapping project expanded as Ed Murphy and John Hoganson mapped virtually all of the Eocene, Oligocene, and Miocene deposits in the state, and thoroughly described the stratigraphy of these units. The project included considerable drilling, with coring of the sedimentary units being studied. Murphy and Hoganson also studied the Cretaceous-Tertiary boundary in detail, completing that project in 1995.

Survey geologists studied the precipitation of evaporites in East Stump Lake in Nelson County

in 1987-88, coring the bottom of the lake during the winter when it was frozen over. They determined that the highly mineralized water precipitates sodium sulphate in the form of mirabilite, which can be converted to thenardite by the application of heat. The bottom sediments in the lake contain a large resource of sodium sulphate.

During the 1980's, the Survey worked on a number of environmental problems. Survey geologist Ed Murphy worked with the State Health Department on a study of organic and inorganic leachate migration from municipal landfills and industrial dump sites in the state. Survey geologists were also involved with a number of other studies with the Health Department. These included studies of the occurrence of radon in North Dakota, the occurrence of arsenic and other trace elements in Cretaceous shales in the eastern part of the state, and a study of water quality in Devils and Stump Lakes. Murphy also worked with the Bureau of Land Management on a study of migration of herbicides to and through the groundwater system.



Figure 49. View to the northwest over the Chalky Buttes. Photo was taken from the top of White Butte, Slope County, the highest point in North Dakota at 3,506 feet (also see *Figure 22*). The NDGS completed a study of the major buttes of western North Dakota in 1995.

Turmoil in the 80's

The continued productivity of the Survey through the 1980's is somewhat surprising in view of a dispute which began in 1981, during which the university attempted to exercise authority over the Geological Survey. This position was stated in a memo from Dean Alan Fletcher of the School of Engineering and Mines to Halvorson dated June 6, 1983. In his memo, Fletcher clarified his interpretation of the reporting responsibilities of the State Geologist to the Dean of Engineering:

"This reporting responsibility arises from the fact that this particular state agency has as its chief officer, the 'Professor (Chairperson) of the Geology Department,' as specified in the State Century Code. This requires that the Survey be administratively part of the School of Engineering and Mines; and, consequently, the Survey has been responsible to the President through the Dean of the School of Engineering and Mines. In other words, its lines of administrative responsibility are identical to those of the EERC, EES, and MMRRI, as they have always been."

The Dean went on to write:

"The Survey's administrative responsibilities within the University have no bearing or effect on the fact that its professional and technical responsibilities include advising the North Dakota Industrial Commission or providing consultation and advice to the State Administration or other state agencies. Nor does the fact that the Survey has a separate state budget make any difference to its reporting responsibilities."

"The . . . State Geologist, as chief officer of the Survey reports to the Dean on any and all matters of concern to the Survey, just as he

does with respect to the office of Chairperson of the Department of Geology, which is the position that makes him State Geologist."

After nearly two more years of controversy, Dean Fletcher requested Halvorson's resignation as Department Chairman. Halvorson's dismissal needs to be placed in the context of events taking place at that time.

Early in 1985, the UND Energy Research Center was experiencing financial problems so that it appeared that it might not be able to continue its operation. The Research Center (which had formerly been operated by the U.S. Bureau of Mines) had been established at UND as a part of the university's Engineering School, under the Dean of Engineering. It had been granted an initial budget of federal funding, a decreasing fund that was to be replaced by grant and other moneys they were to raise through private contracts. The amount of money being raised at that time was insufficient and the Center was forced to enact staff cuts.

The response of the Dean of the Engineering School, as clearly stated in his June 6 memo, was to move to take direct charge of the North Dakota Geological Survey, and its separate budget. His intent, stated in a series of memos on file at the NDGS, was to use the Survey's funding to help resolve some of the Energy Research Center's financial problems, both by directly tapping the funds and to provide state match for federal grants. The State Geologist, Don Halvorson, objected to this course of action. However, university officials, including the Dean and later the President of the university, maintained that, since the Geology Department was part of the School of Engineering and Mines, and the Department Chairman was subject to the Dean of Engineering, then the State Geologist (who was

also Department Chairman) must also answer to, and be subject to, the Dean of Engineering.

It is true that, from its beginning in 1895, the Professor of Geology at the university had been designated, ex-officio, State Geologist. However, most Geological Survey personnel and industry people maintained that, since the State Geologist was also directly under the State Industrial Commission, and the Geological Survey's regulatory authority was based on that relationship, the State Geologist's regulatory decisions could not be subject to university approval. Fletcher disagreed and maintained that Survey regulatory decisions were also subject to his approval.

Dean Fletcher maintained that the Geological Survey, under Halvorson, was tending to concentrate its research more on geologic problems that were leading it away from the

university's goals. At one point, Fletcher stated in a memo to Halvorson that the Survey's main duties revolved around the problem of reclaiming mined lands. This statement by the Dean convinced industry representatives that the university was trying to change the agenda of the Geological Survey, changing the emphasis from oil and other mineral resource studies to environmental issues.

With Halvorson's departure, the decision was made at the university that the dual position - State Geologist/Department Chairman - should be separated into two full-time positions. In August, 1985, Sid Anderson was designated Acting State Geologist, and a Search Committee for a new, full-time State Geologist was named (Figure 51). However, during the summer of 1986, budget cuts of four percent were enacted for all state agencies, with the prospect for additional cuts of up to ten percent. The budget



Figure 50. North Dakota Geological Survey support staff on a field trip to Sully's Hill near Devils Lake in the late 1980's. People shown standing on the overlook above Devils Lake are (left to right) Clara Laughlin, Marilyn Rood, Connie Borboa, Kent Hollands, Debra Kroese, Linda Carlson, Marvelyn Bohack, Eula Mailloux, and John Bluemle.

problems made it necessary to put the search for a State Geologist on hold.

The uncertainty and unrest continued in the Survey through 1987. In June, 1987, Fletcher issued a memo detailing his ideas for a reorganized School of Engineering and Mines, which included a new Center for Geosciences. He reiterated his plans to utilize the Geological Survey's Legislative appropriation to provide a more stable basis for operating the mining institute and the university's mechanism for obtaining research grants in energy and mineral-related fields.

In September of 1987, several alumni contacted members of the North Dakota Board of Higher Education, expressing their concerns. They pointed out that the research of the Geological Survey has to be funded directly by state, not by private or federal interests. Quoting from a September 8, 1987, letter from Bruno Hanson to Jack Pfister, President of the North Dakota Board of Higher Education:

"Long-term research, leading to wise management and use of the state's resources, are not those topics that industry, or even the federal government are willing to pay for. No one, except the State, can be expected to pay for programs that will be in the long-term interest of the State."

He went on to say:

"Industry, rightfully, has the profit motive as its primary goal in funding research. It therefore wants rapid results for timely application in the marketplace. The goal of a University in research reflects two needs: stature in the research community, and the need for overhead funding . . . The Geological Survey's purpose in conducting research is completely different from that of the University. The Geological Survey is mandated for the on-going, long-term research

necessary for the wise management and use of the State's mineral resources."

In a letter to Governor George Sinner, dated October 26, 1987, Roger Borchert, a geologic consultant in Bismarck, urged the following:

". . . 1) that you, as Governor of North Dakota, stop any absorption of the Geological Survey into the UND Department of Geology; 2) that a status-quo be maintained as to the organization and posture of the Geological Survey until the 1989 Legislative Session; 3) that legislation be introduced in the 1989 Legislative Session to remove the Geological Survey from the control of the Department of Higher Education and that it be placed separately under the control of the North Dakota Industrial Commission."

In his response to Borchert, Governor Sinner wrote (November 17, 1987):

"Concerning your recommended actions, the North Dakota Constitution establishes the Board of Higher Education and states, 'said board of higher education shall have full authority over the institutions under its control . . . ' Consequently, I as Governor do not have the authority to respond to your first two suggestions. Your last suggestion is a concept that deserves consideration, and has been referred to my staff for their review. However, as you indicate, integration of the Survey into the Industrial Commission would require an act of the Legislature."

By April of 1988, independent geologists throughout the state (as well as alumni from elsewhere) were suggesting that a study group be formed to determine the best solution to the problem. In August, 1988, Governor Sinner, acting as a result of the concerns that were being brought to his attention regarding the status of the Survey, named a task force to:

" . . . examine the role of the North Dakota Geological Survey, its regulatory functions and whether or not it should be a separate agency."

The Task Force was instructed to deal with two issues:

1. Should the North Dakota Geological Survey continue its association with the University of North Dakota, should it become a separate, independent state agency, or should it become more closely associated with the Industrial Commission?
2. Should the North Dakota Geological Survey retain its regulatory functions or should these functions be transferred to other agencies?

The task force was also instructed to address the following issues:

1. Should an entity with regulatory functions be associated with a university?
2. Should the Geological Survey continue to be closely associated with the University of North Dakota, or would it better satisfy its goals by being separated from the university?
3. What role is the Geological Survey to play in North Dakota?
4. What amount of the Survey's time and resources are spent carrying out its regulatory function?
5. Should the State Geologist also be head of UND's Geology Department?
6. What should be the long-term goals of the Geological Survey and once such goals are defined, how can the Survey maintain a committed focus upon the goals?
7. Are any statutory responsibilities of the Geological Survey being carried out by other

institutions and, if so, should such responsibilities be formally transferred to such institutions?

Following the Task Force meeting in September, 1988, Senate Bill 2261 was drafted as *" . . . an Act to provide for a geological survey and a State Geologist and their duties and powers . . ."* It called for the Industrial Commission to decide the location of the Geological Survey and to hire a State Geologist. The bill was approved on April 28, 1989. The Commission moved immediately to move the Survey to Bismarck.

With the adoption of Legislation separating the Office of State Geologist from the Board of Higher Education during the 1989 Legislative Session, Sid Anderson once again took over as Acting State Geologist (Frank Karner, Professor of Geology at the university, had served as State Geologist from July, 1988, until the Legislature met in 1989).

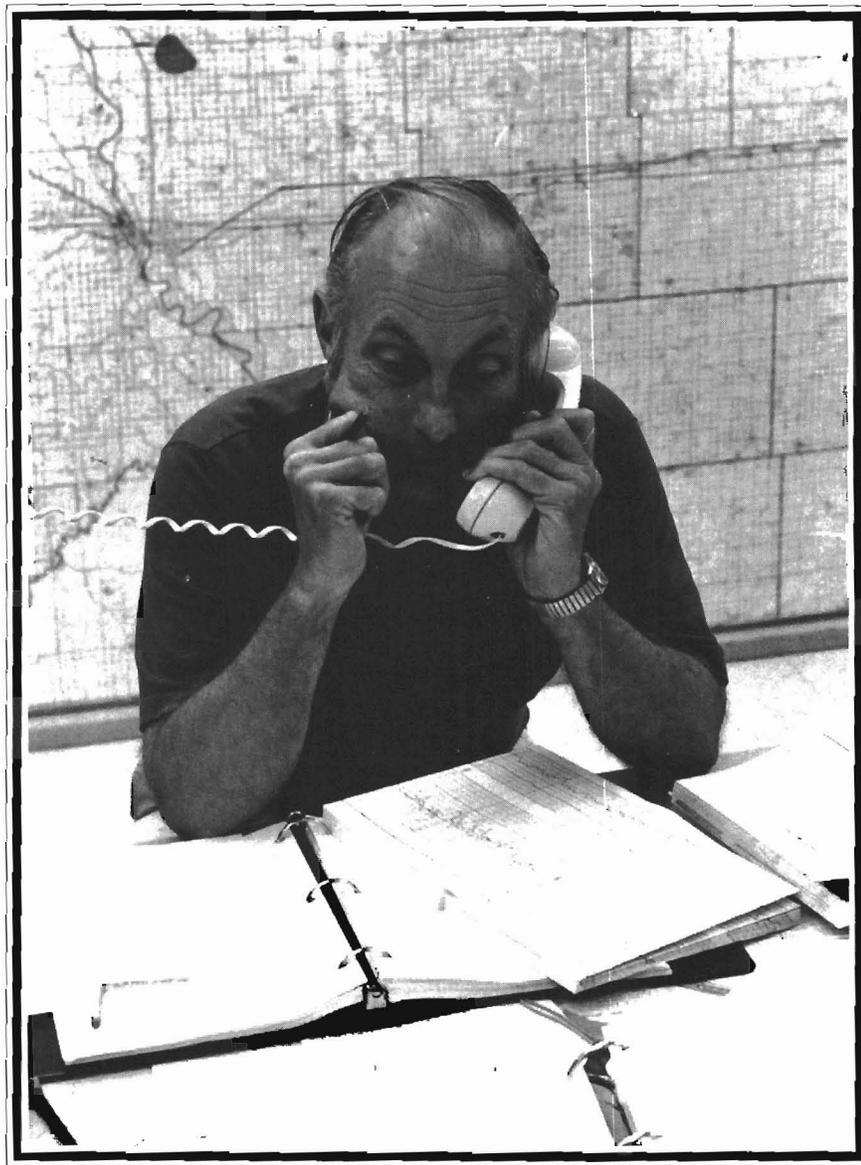


Figure 51. Sidney Bakken Anderson, Acting State Geologist, 1985-1990. Sid Anderson was born in 1927, in Northwood, North Dakota, and attended school in Finley. He attended the University of Wyoming for a year and received a Ph.B. in Geology from the University of North Dakota (1951) after serving in the Navy. After working for a year for the U.S. Geological Survey in Grand Forks, Anderson joined the North Dakota Geological Survey on January 15, 1952. He was Chief of the Subsurface Division of the NDGS for nearly 39 years, and Acting State Geologist from 1985, until his retirement in 1990.

Anderson's 39 years with the North Dakota Geological Survey is the longest anyone has worked for the agency. During his years with the Survey, Anderson worked mainly on the stratigraphy and geologic history of North Dakota's oil-producing formations. He worked with large numbers of students at the university, helping them with their reports. He served on and chaired numerous committees for the American Association of Petroleum Geologists and other professional organizations. Anderson currently serves on the Core and Sample Preservation Committee.

The Move

As noted above, in 1989, the State Legislature decided to remove the Geological Survey from the jurisdiction of the Board of Higher Education and place it entirely under the Industrial Commission (the Industrial Commission already had jurisdiction over the Survey's regulatory functions). Following this legislation, the Survey was moved to Bismarck, although the Core and Sample Library remains on the University of North Dakota campus in Grand Forks. Also in 1989, the Geological Survey was designated enforcer of regulations relating to paleontological resources.

The position of State Geologist was transferred to Bismarck, effective at the end of the 1989 Legislative Session. Sid Anderson, who was Acting State Geologist, continued in the position until August 21, 1990, when he retired after 39 years with the Survey. Anderson commuted to Bismarck from Grand Forks for about a year prior to his retirement.

Along with the State Geologist, ten full-time Geological Survey positions were transferred to Bismarck in 1989. Five people actually moved to Bismarck: John Bluemle, Assistant State Geologist; Randolph Burke, carbonate geologist; John Hoganson, paleontologist; Ed Murphy, environmental geologist; and Eula Mailloux, publications clerk. In addition, Marv Rygh, petroleum engineer with the Geological Survey in Grand Forks, was transferred to the Oil and Gas Division and moved to Bismarck.

Geologists David Brekke, David Fischer, and Ken Harris resigned their positions with the Geological Survey when it was moved to Bismarck. Other Geological Survey staff in Grand Forks who resigned included Connie Borboa, the Survey's Administrative Officer (Clara Laughlin, the Survey's Administrative

Officer since 1965, had retired in 1988), Marilyn Rood, account technician, Ken Dorsher, draftsman, and David Lechner, lab technician. Palmer Roos, technician, retired from his position with the Survey.

With the move of the Geological Survey to Bismarck, a partial re-combination of the Survey and Oil and Gas Division was accomplished. The two agencies share office space in the Manhattan Building at 1022 East Divide Avenue, just northeast of the State Capitol building (*Figure 52*). Some support staff is shared by the Geological Survey and Oil and Gas Division. Shared staff (as of late 1995) include Karen Gutenkunst, Business Manager, Jim Lindholm, Annette Materi, and Evie Roberson. The Survey has one full-time secretary, LaRae Fey, a publications clerk, Sheila Senger, and a technician, Russ Prange.

Two new geologists, Thomas J. Heck and Mark R. Luther, were added to the North Dakota Geological Survey staff in 1989. Tom is a petroleum geologist with a B.S. from the University of Wisconsin-Milwaukee and a M.S. from the University of North Dakota. He worked at Conoco from 1979-87, in Louisiana, the Texas Gulf Coast, and in the Powder River and Williston Basins. He had also worked as a mudlogger with Tooke Engineering and as a consulting geologist with Sunburst Consulting, as well as working as a private consultant.

Mark Luther had earned a B.S. in geology, with an archeology minor from Idaho State University and a M.S. in petroleum geology from the University of North Dakota. He worked for the North Dakota Health Department as an environmental scientist prior to coming to the Survey. Luther quickly became involved in surface mapping and directing the Survey's new Geographic Information System Laboratory



Figure 52. The North Dakota Geological Survey moved to Bismarck in 1989, into this building at 1022 East Divide Avenue. The building is known as the "Manhattan Building".

shortly after arriving at the Survey. The Survey also hired Rich Baker in 1989, a draftsman shared with the Oil and Gas Division.

John P. Bluemle was appointed Acting State Geologist in 1990, and State Geologist in 1991, a position he continues to hold (Figure 53). Following his appointment, the 1991 Legislative Session increased the Survey's budget by about 20 percent, granting an additional six employees. New geologists included Robert F. Biek, William A. McClellan, Paul E. Diehl, and Phillip L. Greer. In addition to these four geologists, LaRae Fey was hired as the Survey's secretary and Kent E. Hollands became the Laboratory Technician at the Wilson M. Laird Core and Sample Library in Grand Forks.

Solid waste issues continued to be a major concern to North Dakotans and to the Geological Survey (Figure 54) during the 1990's. During a 20-year period beginning in the mid-1970's, the Survey had conducted a number of environmental studies in the state, including the impact of surface coal mining, oil and gas exploration/development, landfills, municipal wastewater impoundments, and pesticides.

In 1991, Survey geologists evaluated the geology of a proposed municipal waste site near Minot. Also in 1991, the Legislature assigned the Survey the four-year task of evaluating the 62 active landfills in North Dakota with the evaluations to be provided to the State Health Department, which is the agency in charge of regulating landfills. Phillip L. Greer, an environmental geologist, was hired to conduct the project. A Wyoming native, Greer came to the Survey from the Wyoming Geological Survey where he had mapped several 7.5 minute quadrangles and also been involved in a variety of subsurface studies. Greer had a B.A. degree from Macalester College in Minneapolis and a M.S. degree in geology from the University of Wyoming. He also had been a geology instructor at the University of Wyoming. Greer remained with the North Dakota Geological Survey for four years, until the landfill-evaluation project was completed in 1995.

Dr. William A. McClellan, a petroleum geologist who came to the Survey from Columbia Gas Development Corporation in Houston, where he had been for the previous four years, had a total of 23 years of oil-industry experience.

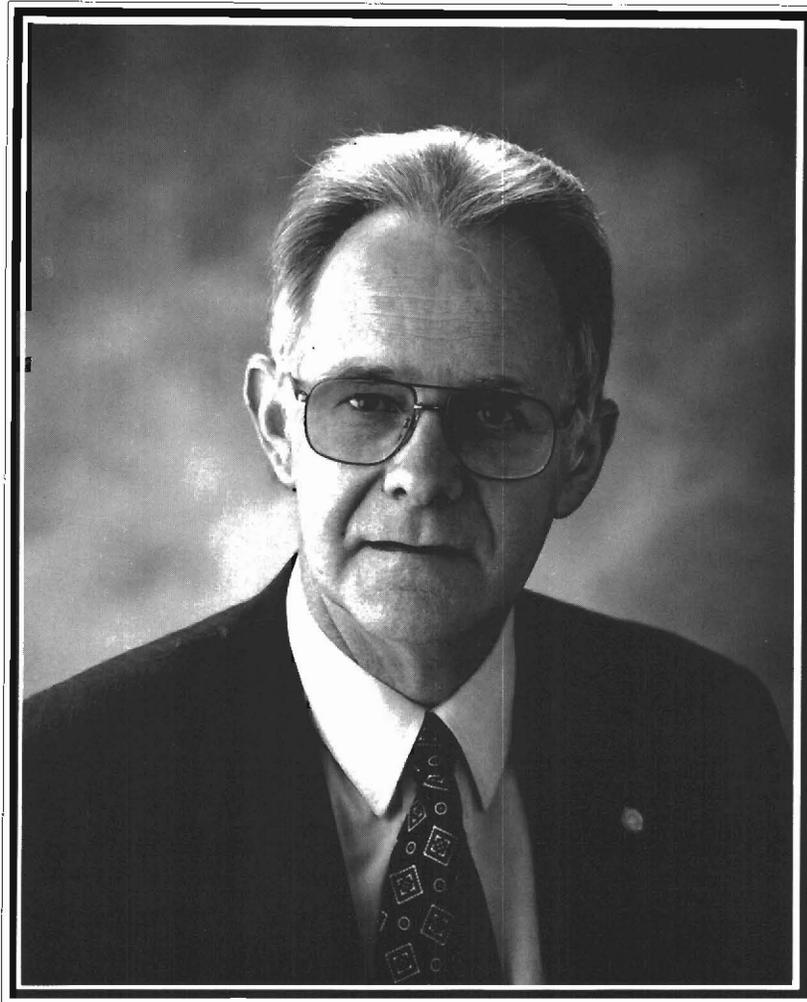


Figure 53. John P. Bluemle, State Geologist, 1990-Present. Bluemle was born in New Hampton, Iowa, in 1938, and grew up in LaPorte City, Iowa. He received a B.S. in geology from Iowa State University (1960), a M.S. from Montana State University (1962), and a Ph.D. from the University of North Dakota (1972) - seven years after coming to the North Dakota Geological Survey. Bluemle served as editor for the Survey for many years and was Assistant State Geologist from 1987-90. He was named Acting State Geologist on June 28, 1990, and State Geologist on May 13, 1991.

Bluemle spent most of his career at the North Dakota Geological Survey as a surface geologist mapping the geology of 23 counties, all in the glaciated part of the state. He specialized in glacial landforms and geomorphology, working on a variety of features related to ice-thrusting and other glaciotectonic processes. During his career with the North Dakota Geological Survey, Bluemle has published well over 100 technical papers as Survey reports in various journals as well as numerous general-interest articles in NDGS publications and elsewhere. Bluemle directed activities of the Geological Survey's Surface Section and served as an Adjunct Associate Professor of Geology at the University of North Dakota for many years supervising students in projects done with the Survey's support.



Figure 54. Aerial photograph of the Devils Lake landfill in 1987. The survey provides geologic evaluations to the Health Department to aid them in their siting responsibilities. Photo by Ed Murphy.

Prior to working with Columbia, he had been employed by Transco Exploration Company, MGF Oil Corporation, Odessa Natural Corporation, and Amerada Hess Corporation, all in Denver. He also had worked with Atlantic Richfield in Calgary for four years. McClellan had degrees from the University of Arizona (B.S.), the University of Cincinnati (M.S.), and the University of Washington (Ph.D.). He was appointed to the position of Assistant State Geologist for the North Dakota Geological Survey in April, 1991. McClellan remained with the Survey until May, 1995, when he was the victim of a reduction in force mandated during the 1995 Legislative session.

Robert F. Biek, who was hired primarily for surface mapping, came to the North Dakota Geological Survey in 1992, from Connecticut, where he had been a Staff Geologist for Applied Earth Technologies, Inc. and also a consulting geologist for the Litchfield Hills Council of Elected Officials and for the Northwestern Connecticut Council of Governments. He had a B.A. degree in geology from the University of California, Berkeley and a M.S. degree from Northern Illinois University. In addition to his mapping duties, Biek also took charge of the Survey's geothermal regulation program and he was appointed editor for the Survey in 1992.

Dr. Paul E. Diehl had been employed by Holden Oil in Oklahoma City prior to coming to the Survey in 1992. His 17 years of industry experience also included work for ANSON Corporation in Oklahoma and for Conoco as an exploration and production geologist in international exploration. In addition to his petroleum industry experience, Diehl had taught at the University of Oklahoma. He had also served as an officer in the U.S. Air Force 1st Geodetic Survey Squadron. Diehl had B.S. and Ph.D. degrees in geology from Penn State, and a M.S. in structural geology from Franklin and Marshall College.

Personnel were also hired to help Mark Luther develop the Survey's new Geographic Information System (GIS). Sharon Murfield-Tyler was hired in 1992, and left in 1993. In 1994, Rod E. Bassler was hired as the Survey's GIS Analyst. Bassler came to the Survey with a B.S. from the University of Wisconsin and an anticipated M.A. from the University of Kansas. Bassler moved quickly to establish the Survey's GIS Laboratory as a vital part of NDGS operations.

In 1990, the Geological Survey had begun a cooperative arrangement with the Historical Society and established a State Fossil Collection,

which is housed in the Heritage Center (later, in 1994, a State Rock, Mineral, and Gemstone Collection was added). The first large display of North Dakota fossils at the Heritage Center opened in February, 1991 (Figures 55 and 56).

Survey geologist John Hoganson continued to work closely with the staff in the Heritage Center, helping with exhibits, tours, and educational materials. The first fossil skeleton of any large prehistoric animal ever displayed in North Dakota was prepared as part of a memorandum of agreement with the Historical Society. The Highgate Mastodon is on permanent display in the Heritage Center (Figure 55). The restoration was accomplished by Hoganson, assisted by George Lammers, Curator of Geology at the Manitoba Museum of Man and

Nature in Winnipeg, with help from several volunteers and specialists. The restoration of the Highgate Mastodon was made possible by a grant from the North Dakota Heritage Foundation. Numerous other fossil exhibits in the Heritage Center have resulted from the Survey's association with the Historical Society; Hoganson is currently helping with additional exhibits for the Heritage Center and also for a new museum in Pembina.

In 1995, the National Park Service allocated funds for paleontological investigations in western North Dakota. The NDGS received a Park Service grant to identify, map, and assess the significance of Paleocene fossil sites and fossils within the boundaries of the park. Areas near the park have produced large numbers of Paleocene

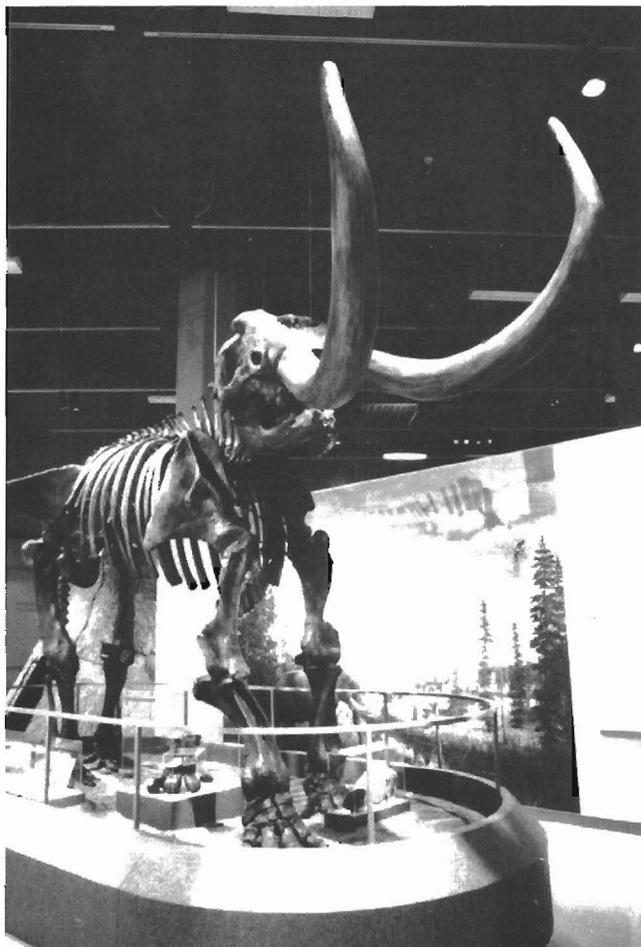


Figure 55. Restored skeleton of the Highgate Mastodon, on display at the North Dakota Heritage Center, Bismarck. The specimen, a male, is over 20 feet long and stands 10 feet high at the shoulder. The restoration was accomplished by John H. Hoganson (NDGS) assisted by George Lammers (Curator of Geology at the Manitoba Museum of Man and Nature in Winnipeg) with the help of several volunteers and specialists. Photo by Todd Strand.

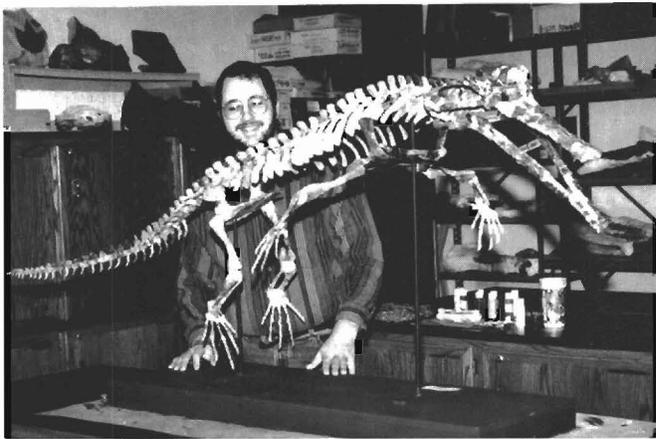


Figure 56. Johnathan Campbell with restored champsosaur skeleton in the NDGS Paleontology Lab. The Champsosaur was a crocodile-like reptile that inhabited swamps in western North Dakota about 55 million years ago.

fossils, including crocodiles, alligators, turtles, fish, mammals, clams, snails, and exotic plants and park officials wanted to know what fossil resources exist within the park.

In May, 1995, the Survey signed a memorandum of agreement with the USFS-Custer National Forest to establish a cooperative effort with respect to management and protection of significant paleontological resources on National Forest Lands in North Dakota. The MOA revised and updated a similar agreement that was established between NDGS and USFS in 1987. The 1987 MOA had been the first of its kind between the USFS and any state regarding management of fossil resources.

In August of 1990, the Survey, working with the Central Dakota Gem and Mineral Society and with help from the Washburn detachment of the Army National Guard, moved an 80-foot-long fossil tree (a Paleocene dawn redwood tree - "*Metasequoia*") from the shore of Lake Sakakawea to the North Dakota State Capitol grounds (Figure 57). The tree is located in the Centennial Grove, on the west side of the Capitol grounds. The project, which is consistent with the Survey's directive to promote public awareness of North Dakota's paleontological resources, was done in conjunction with North Dakota's Centennial observance.

In the late 1980's, and early 1990's, Survey geologists investigated the geochemistry of Cretaceous shales in North Dakota. This project, done with the cooperation of the U.S. Geological Survey, was an outgrowth of the discovery of high arsenic levels in the groundwater in southeastern North Dakota. Other projects at the time included studies of the occurrence of gas in the Winnipeg/Deadwood Formations and a study of the potential of the Mississippian/Devonian Bakken Formation, which had attracted considerable interest in the 1980's, as a target for horizontal drilling for petroleum resources.

The North Dakota Geological Survey became an Earth Science Information Center (ESIC) in 1990, taking over responsibility from the USGS for sales of topographic maps for the state. The Survey is constantly expanding its acquisition and sales of both paper and digital federal map products. A variety of topographic, natural resource maps, and other kinds of earth science information are provided to the public. The Survey acts as a clearing house for the sale of airphotos, topographic maps, and other kinds of maps.

The North Dakota Geological Survey and several other state and federal agencies operating in the state cooperated to acquire and install a high-accuracy Global Positioning System (GPS)

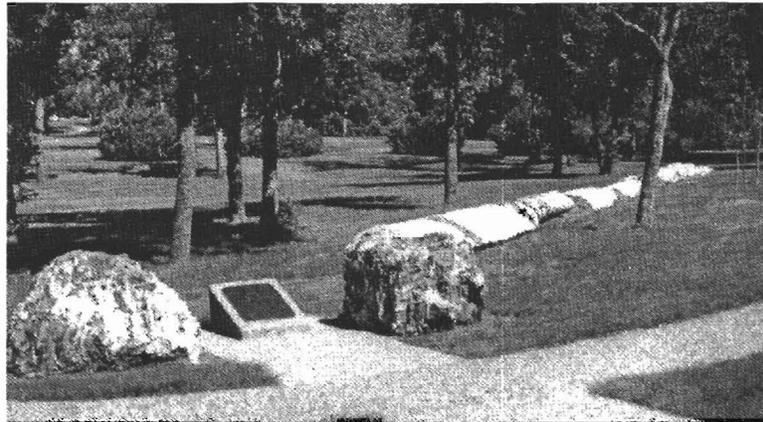


Figure 57. Three photos of a tree trunk in the Centennial Grove on the State Capitol grounds. Top left photo shows Army National Guard crew unloading parts of the tree trunk. Top right photo shows tree trunk in place, with the State Capitol in the distance, and bottom center photo gives an overall view.

community-base station in Bismarck in 1994. Equipment at the base station includes a Trimble 4000 System SSE geodetic-grade receiver, antenna, Trimble Universal Reference Station (URS) software, and a personal computer with modem. The geodetic-grade receiver is capable of determining positions in 3-D with accuracies in the sub-centimeter range. The installation of the URS software in Bismarck is the fourth of its kind in the United States. Because of its central location in Bismarck, the community-base station provides a means for correcting data gathered throughout North Dakota and parts of adjacent states. NDGS geologist Mark Luther directs operations of the base station (*Figure 58*).

In 1993, the Survey began a new, detailed surface-mapping program, initially concentrating in the Jamestown area. The first work in the mapping program was done by Bob Biek, with Ed Murphy becoming involved in a study of the Dickinson area in 1994. The detailed mapping was partially supported by federal funds from the STATEMAP component of the National Geologic Mapping Act. In 1995, Biek mapped

the geology of Theodore Roosevelt National Park at a scale of 1:24,000 as part of a project partially funded by the STATEMAP program.

During the early 1990's, the Survey began becoming more involved in efforts to point out potential oil-exploration plays in North Dakota. As a result of a series of workshops, co-sponsored with the Saskatchewan Energy and Mines, the Survey encouraged development of horizontal drilling in the state. These workshops were highly successful, and resulted in greatly increased oil-exploratory activity. During 1994-95, the Survey became more involved in a developing oil-exploration play in the Dickinson area. The Survey's role, as always, was and is to provide accurate information to interested companies and others.

In 1994, State Geologist John Bluemle signed two memoranda of understanding for cooperative studies and sharing of information on natural resources development in the Williston Basin. The first was with Phil Reeves, Executive Director of the Saskatchewan Energy and Mines



Figure 58. NDGS geologist Mark Luther using a Global Positioning System (GPS) receiver to locate the geographic center of North Dakota. The geographic center of the state lies in this prairie pothole, 2.8 miles southwest of McClusky, in Sheridan County. This area is characterized by hummocky, collapsed glacial topography with numerous lakes and sloughs.

and the second was with Gary Barnes, Deputy Minister for the Manitoba Energy and Mines Petroleum Branch. The Manitoba agreement, signed in Winnipeg, calls for cooperative studies and recognizes the importance of the mineral industry to the economies of North Dakota and Manitoba. The purpose of the Saskatchewan agreement, signed in Minot, North Dakota, is to insure cooperation among the agencies, and to encourage cooperation between Saskatchewan and North Dakota oil producers. In addition to joint studies already underway, both agencies expect to enhance their sharing of information to industry through workshops and other means.

The agreement signed with the Saskatchewan Energy and Mines formalized a series of

horizontal-drilling workshops the two agencies have co-sponsored. The first two workshops, held in 1993 and 1994, were in Minot, North Dakota and the Third workshop was held in Regina, Saskatchewan. The workshops consisted of talks and poster sessions emphasizing geologic topics and engineering topics. Response to the workshops was overwhelmingly enthusiastic. One of the reasons for the nearly unique success of the workshops is that, prior to their initiation, there was insufficient communication across the United States-Canada border about Williston Basin geology and horizontal drilling techniques. A fourth workshop is planned for Bismarck for May, 1996.



Figure 59. John Bluemle, State Geologist, and Arthur Link, former Governor of North Dakota, plant a tree on the North Dakota State Capitol grounds on June 23, 1995, as part of the observance of the Geological Survey's and Historical Society's Centennial Year. Photo by Todd Strand.

The Present and Future

North Dakota Geological Survey's centennial year is 1995. As part of our 100th anniversary, we sponsored a number of special activities, including hosting the annual meeting of the North Dakota Academy of Science in April, 1995. The Academy meetings were highlighted by a symposium on North Dakota geology. We "officially" observed our 100th birthday, along with the 100th birthday of the Historical Society, at a party on June 23, at the State Heritage Center (*Figures 59 and 60*). As part of the observance of our Centennial, we planned to issue several special publications to commemorate the event, including a new Bibliography of North Dakota Geology and a Centennial Volume consisting of a collection of essays on North Dakota geology, as well as this report on the History of the North Dakota Geological Survey.

As matters currently stand (in late 1995, as I write), geologists with the North Dakota Geological Survey are working on a variety of geological investigations, many of them in cooperation with other state and federal agencies. A sampling of these include: investigating the petroleum resources and hydrocarbon-bearing rocks of western North Dakota; unraveling the remarkably complex glacial history of the State (*Figure 61*); mapping the Cretaceous/Tertiary boundary, a time when many plants and animals became extinct; and working to understand the impact of waste disposal on groundwater resources. These and many other investigations are currently underway by Survey geologists.

Through the 1970's, and into the 1990's, Survey geologists were periodically involved in studies of the fluctuating level of Devils Lake (*Figures 62 and 63*). They pointed out that the level of Devils Lake fluctuates entirely in response to climatic cycles and that the changing lake levels are not significantly influenced by wetlands

drainage, farming practices, etc., although they may be influenced by the underlying aquifer. The NDGS has studied Devils and Stump Lakes for many years, beginning in the early 1900's, when Howard Simpson published a report on it. In the early 1990's, the rapidly rising level of Devils Lake caused great concern to residents of the area and Survey geologists suggested several possible solutions for dealing with the problems.

North Dakota is currently (late 1995) experiencing an oil-exploration boom as discoveries in the Lodgepole Formation in the Dickinson area continue. In February of 1993, Conoco announced its discovery of oil in the Lodgepole Formation. The oil occurs in carbonate buildups and, after Conoco's discovery, two NDGS geologists, Randolph Burke and Paul Diehl, extensively studied the petroleum geology of the Lodgepole. Burke and Diehl responded to a great number of requests for information about the play and provided about 30 technical papers, talks, seminars, etc., as well as publishing reports in the Survey's newsletter, industry trade journals, and elsewhere. They responded to numerous industry organizations requesting them to speak in various industry centers to groups of geologists, landmen, oil company engineers, and others. Burke and Diehl also compiled a series of maps showing the likely areas in North Dakota where potential for additional Lodgepole production may exist. The maps were in great demand and they were directly responsible for near-record revenues to the state during lease sales of state lands. As a result of the new Lodgepole production, North Dakota experienced an increase in total production in 1995, a turn-around from the declines the state had seen for several recent years.

The Survey's geologic mapping program remains one of our most important activities. Survey geologists Ed Murphy and John Hoganson

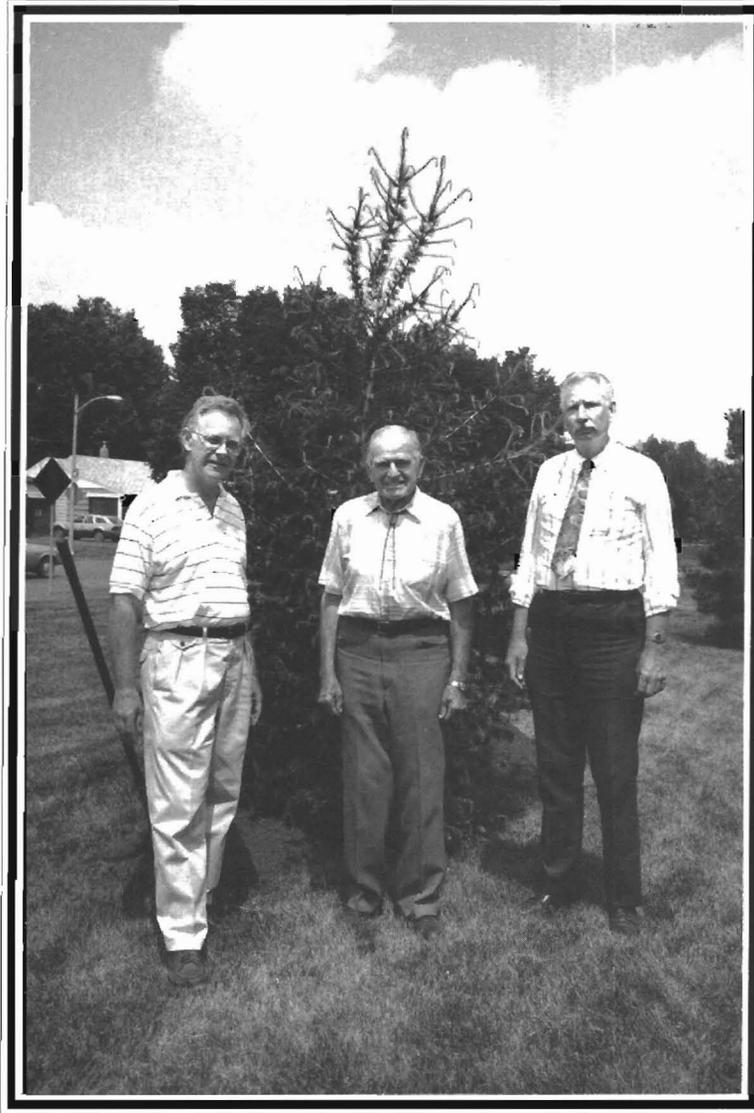


Figure 60. Pictured left to right: John Bluemle (State Geologist), Arthur Link (former Governor of North Dakota), and James Sperry (Historical Society Superintendent) at an official tree planting ceremony in observance of the Centennial for both the North Dakota Geological Survey and the North Dakota State Historical Society. The tree is a tamarack (larch). Photo by Todd Strand.



Figure 61. Bob Biek, NDGS geologist, standing at the base of an exposure of glacial till beds near Riverdale along Lake Sakakawea. Survey geologists are involved in studies of the stratigraphy of glacial sediments in various parts of the state. Photo by John Bluemle.



Figure 62. NDGS geologist, John Bluemle, sampling at Stump Lake in the winter of 1990. Stump Lake has a substantial resource of the mineral mirabilite (hydrated sodium sulphate) that has the potential to be utilized in a process that would also lower the salinity of the lake. Photo by Mark Luther.

recently completed a study of the major buttes of western North Dakota (*Figure 49*) and a study of the Cretaceous-Tertiary boundary in south-central North Dakota.

The NDGS was awarded federal STATEMAP funding to map the geology of the urban Bismarck-Mandan area in detail (1:24,000) (*Figure 64*) and also part of the Grafton Quadrangle in northeastern North Dakota (1:100,000 scale mapping). Ed Murphy and Bob Biek plan to map the Bismarck-Mandan area in 1996, stressing geologic hazards. Mark Luther will map the Grafton 1:100,000 Quadrangle, an area mainly in the Red River Valley in which glacial lake and shoreline features predominate.

The North Dakota Industrial Commission, acting through the office of the State Geologist, has several specific regulatory duties. They include:

- preservation and maintenance of oil-well core and drill samples;
- regulation of coal exploration test holes;
- use of geothermal resources;
- protection of fossil resources;
- regulation of subsurface minerals and underground fluid injection (Class III injection wells) (*Figure 65*); and
- resolution of conflicts in subsurface mineral production.

Our regulation of oil-well core and drilling samples is accomplished in conjunction with our operation of the Wilson M. Laird Core and Sample Library in Grand Forks (*Figure 45*). This is one of the finest facilities of its kind in the United States. The current Director is Julie A. LeFever, who is assisted by one technician, Kent Hollands. Approximately 90 percent of all core that has been cut in wells drilled for oil and gas in

the North Dakota portion of the Williston Basin is stored in the library and these materials are available for study. The Core and Sample Library is one of the most important "tools" the State offers for promoting oil and gas development in North Dakota. Besides the direct economic benefits to the State from drilling wells, core data is an important tool in determining the correct siting of wells in secondary and tertiary recovery projects.

In addition to our own direct regulatory authority, the Geological Survey acts as an advisor, providing geological information to other state, local, and federal agencies to assist them in their regulatory duties. We provide advice on waste disposal to the Department of Health and

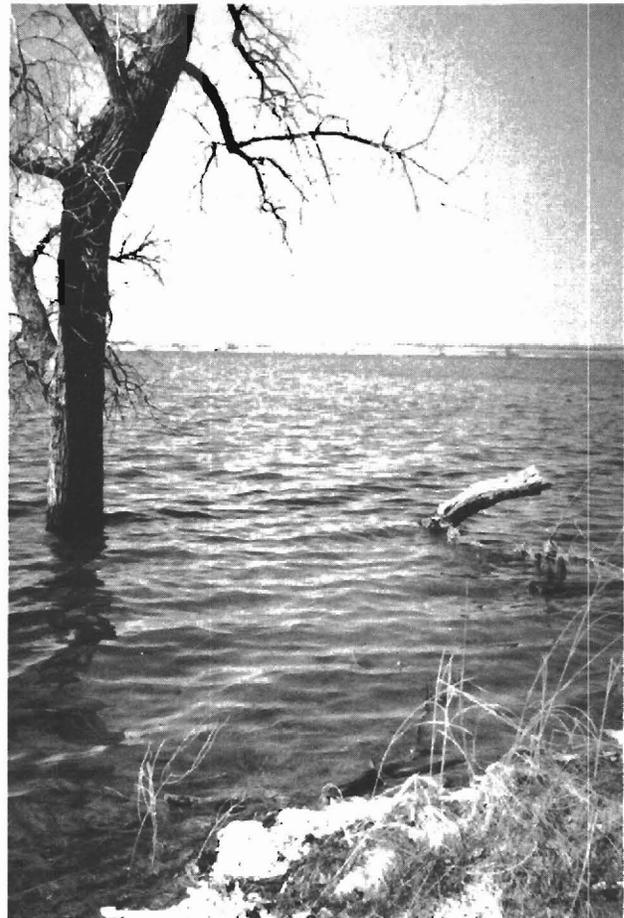


Figure 63. High water along the shore of Devils Lake. Devils Lake rose rapidly between 1992 and 1995, rising to its highest level in 120 years during the summer of 1995.

Consolidated Laboratories and on petroleum geology to the Oil and Gas Division. We evaluate oil and gas lease sale lands for the North Dakota Land Department. We also advise a number of federal agencies on issues relating to management of paleontological resources. In addition, the State Geologist serves as an advisor on a number of boards: North Dakota Lignite Council, Water Pollution Control Board, Air Pollution Control Board, and others.

The Geological Survey's studies of mineral resources in the state continue, with Ed Murphy's review of the state's clay deposits and studies of leonardite and sodium sulphate currently underway (*Figure 66*). In 1995, Murphy also began an evaluation of the state's coal resources utilizing the 20,000 electric and driller's logs that have been generated by coal company explorations in the western half of North Dakota over the past 20 years (*Figure 67*).

The Survey's paleontology programs continue to expand under John Hoganson's direction. Collection of a variety of specimens is underway in the field. They include fossil turtle sites and a mosasaur excavation near Cooperstown. Several specimens are currently being restored at the Survey's paleontology

laboratory at the North Dakota Heritage Center. The Survey continues to work closely with several federal agencies (including the U.S. Forest Service, Corps of Engineers, and Park Service), helping them to manage their fossil resources. We have signed several memoranda of understanding with these and other federal agencies.

The NDGS intends to release CD ROM's providing a variety of information, including various kinds of digital map data. Initial kinds of information that will be available on the CD ROM's are a statewide surficial geology map, along with a shaded relief map, physiographic province map, an endangered species distribution map, and some county-based maps showing coal-exploration borehole locations. Space permitting, we expect to include other digital maps or data that might be ready when the CD ROM is created. With the exception of the surficial geology map, digital maps will be provided in two formats: ARC/INFO graphics files and Postscript files. In addition to these two formats, the surficial geology map will also be provided as an ARC/INFO Export file.



Figure 64. View east over the Missouri River from Mandan. The Geological Survey will begin mapping the geology of the Bismarck-Mandan area in 1996, as part of an urban mapping program that has already seen projects completed in Jamestown and Dickinson. Photo by Ed Murphy.



Figure 65. The AKZO Salt, Inc. plant (Williston) in 1987, two years prior to its closure. This site was regulated under permits issued by the Survey. After six years of negotiations with the company following the plant's closure, the salt pile in the foreground was removed in 1995. Photo by Ed Murphy.



Figure 66. Sodium sulphate (mirabilite - commonly known as Glauber salt) has precipitated along the west shore of Miller Lake, Divide County. This salt forms on shores and lakebeds in the fall when cooling water temperatures cause the salt to precipitate. The NDGS cored 49 feet of salt-laden mud at Miller Lake during January, 1996, as part of a project to evaluate sodium sulphate resources. Photo by Ed Murphy.



Figure 67. Aerial photograph of the Coteau Freedom Mine near Beulah. This is the largest coal mine in the state, with annual production in 1994, of 15,729,271 tons. Photo by Ed Murphy.

I believe that the North Dakota Geological Survey has to continue to do what it has always done: basic research on North Dakota's mineral resources; to encourage exploration, development, and production for the economic benefit of the state's citizens; study of the geology to add to our understanding of our surroundings; and service to the public. Up-to-date knowledge of our resources is also necessary to enable us to effectively discharge our various regulatory duties.

We must continue to conduct basic and ongoing studies of all the geologic formations with potential to produce hydrocarbons and other mineral resources in North Dakota. These studies provide a broad data base that mineral exploration companies can tap as they develop their own plays. Recent examples include the current Lodgepole petroleum exploration and development play in the Dickinson area. NDGS geologists first pointed out the potential for production from the Lodgepole 15 years ago. When oil was discovered in the Lodgepole in Stark County near Dickinson in 1993, the Survey was able to provide accurate technical information to aid the oil companies developing the play. The kinds of basic studies we have always done need to continue so we can respond with geologic information when it is needed.

Similarly, the horizontal Red River play, now underway in Bowman and Slope counties, is an example of a highly successful oil play that was strongly influenced by information provided by an NDGS geologist during one of a series of horizontal well workshops the NDGS has sponsored during the 1990's, in cooperation with the Saskatchewan Energy and Mines. We will continue to provide information about the latest geologic theories and technology.

These are just two examples of new oil production resulting, in the one instance many years after the NDGS had pointed out existing potential, and in the other an immediate consequence of the our ongoing efforts to promote new technology. Both illustrate that our work makes a huge difference to the state's economy. Our geologists point the way; they "plant the seeds" that germinate when someone reads a Survey report or calls us for information. Without these seeds, the state's mineral industry, both existing and other as-yet undeveloped mineral resource industries, will not prosper.

The Geological Survey is a rarity among state agencies. It has always produced far more revenue for the state than it costs to operate the agency. But the Survey does more than simply generate new wealth for the state. It also

enhances the quality of life for North Dakotans by providing knowledge and information about our surroundings - the hills, plains, badlands, buttes, gems, minerals, and fossils. Our geologists prepare specimens like mastodons and mosasaurs for display in the North Dakota Heritage Center and other places. These are things people learn from and enjoy. They add to our quality of life and help us understand our natural heritage.

One of the most important things our geologists do is to interpret the geologic history of the state. Of course, the mapping we do provides us with detailed knowledge of mineral resources and environmental hazards, but it also adds to our overall understanding of our surroundings for the benefit of everyone. Our geologists were "environmentalists" in the truest sense long before the term became fashionable.

Our role is changing as we near the end of the 20th Century. Traditionally, the role of every geological survey has been to find, appraise, and show how to exploit the mineral resources. That's why the North Dakota Geological Survey was founded 100 years ago - it is why every state and national geological survey was founded. However, for the past 20 or 30 years, this hasn't been enough. In addition to our original charge, we are now expected to conduct basic geologic studies to enable us to provide accurate responses to questions about waste disposal, cleanup, and hazards mitigation.

We have a greatly expanded public service role. Our geologists are increasingly called upon to speak to service groups and to conduct workshops in various parts of the state. The number of requests for information is growing dramatically; visitors to our offices, phone and mail inquiries, and map and other publications sales are all increasing every year. We are currently responding to about 4,000 public inquiries a year. Questions come from industry and government personnel, legislators, teachers and students, tourists, and interested citizens -

anyone and everyone. People are demanding geologic information of all kinds whether it be identification of a rock or fossil, advice on maps available for the area they live in, a request of our geologists to lead a field trip or give a lecture (Figure 68), or perhaps to provide the basic geologic information required to site a landfill. All in all, the North Dakota Geological Survey is providing a greater variety of geologic information to a greater number of people than ever before.



Figure 68. State Geologist, John Bluemle, speaking to a group of people during a field trip northeast of Bismarck in Burleigh County.

Appendices

APPENDIX A

State Geologists and Assistant State Geologists

State Geologists

E.J. Babcock	1865-1902	1895-1902
Frank A. Wilder	1870-1930	1902-1903
A.G. Leonard	1865-1932	1903-1932
Howard E. Simpson*	1874-1938	1933-1938
Frank C. Foley	1906-1985	1938-1941
Wilson M. Laird	1915-	1941-1969
E.A. Noble	1922-	1969-1978
Lee C. Gerhard	1937-	1978-1982
Donald L. Halvorson	1934-	1982-1985
Sidney B. Anderson (Acting)	1927-	1985-1988 ♦ 1989-1990
Frank R. Karner	1934-	1988-1989 (about 6 months)
John P. Bluemle	1938-	1990-Present

Assistant State Geologists**

Charles H. Clapp	1905-1907
John C. Barry	1908-1909
Howard E. Simpson	1910-1921
Leonard P. Dove	1921-1925
Herbert H. Sand	1933-1934
Frank C. Foley	1934-1935
Irving Grossman	1947-1949
Nicholas N. Kohanowski	1949-1952
Stanley P. Fisher	1952-1953
Miller Hansen	1953-1964
E.A. Noble	1965-1969
Lee C. Gerhard	1675-1978
Erling A. Brostuen	1979-1981
Robert E. Seidel	1982-1985
John P. Bluemle	1987-1990
William A. McClellan	1992-1995

* Howard E. Simpson served, unofficially, as State Water Geologist from 1921-29, and as the Official State Water Geologist from 1929-33.

** The record is incomplete for the Assistant State Geologists; records are lacking for some of the early years and at times, no one was serving in the position. The position of Assistant State Geologist was abolished in 1995.

APPENDIX B

Legal Citations

- * S.L. 1895, ch. 66, 1 (Establishment of the North Dakota Geological Survey) *Repealed, 1981*
N.D. Laws 1911, ch. 195 (First Conservation Statute) *Repealed*
N.D. Laws 1927, ch. 249 (Reports on university and school lands) CC 15-05-16
N.D. Laws 1929, ch. 184 (Second Conservation Statute) *Repealed*
N.D. Laws 1937, ch. 135 (Repealed the 1929 measure and enacted its replacement) *Repealed*
N.D. Laws 1941, ch. 170; N.D. Rev. Code c. 38-08 (1943) (First of the Modern Oil & Gas Conservation Statutes)
- * N.D. Laws 1953, ch. 227; Revised Code of North Dakota, secs. 38-08-01 to 38-08-22 (1957 Supp.) (Update of 1941 Law; numerous revisions; jurisdiction revised in 1981)
- * S.L. 1967, ch. 289 (Subsurface minerals) CC 38-12-02; 38-12-03
S.L. 1967, ch. 479 (Water pollution control) CC 61-28-03
S.L. 1969, ch. 260 (Air pollution control) CC 23-25-02
S.L. 1971, ch. 351 (Resolution of conflicts in subsurface mineral production) CC 38-15
S.L. 1975, ch. 321 (Severance of minerals and surface damage)
- * S.L. 1975, ch. 317 (Coal exploration drilling) CC 38-12.1-01 to 38-12.1-05
S.L. 1977, ch. 318 (Mineral Exploration Permit Fees)
S.L. 1979, ch. 396 (Notice of drilling operations) Revised 1983, ch. 407; 1983, ch. 408; 1987, ch.433
CC 38-11.1-05
S.L. 1979, ch. 399 (Surface mining reclamation) CC 38-14.1-03
- * S.L. 1981, ch. 365 (Director of Oil & Gas) CC 38-08-04.2
- * S.L. 1981, ch. 377 (Geothermal resources) CC 38-19
- * S.L. 1989, ch. 645 (Paleontological resource protection) CC 54-17.3
- * S.L. 1989, ch. 656 (Geological Survey, new enabling legislation) CC 54-17.4
S.L. 1991, ch. 277 (Solid waste management: preconstruction site review and review of existing landfills) CC 23-29-07.6; 23-29-07.7
S.L. 1991, ch. 286 (Wellhead protection) CC 23-33-12

KEY: S.L. = Session Laws (year and chapter noted)
CC = Century Code citation
* = Principal Enactments

APPENDIX C

North Dakota Geological Survey Staff 1895 - 1995

Year of Entry	Name	Year of Termination
1895	Babcock, Earle J.	1910
1899	Bisbee, Marcia	1908
1899	Johnson, Edith	1899
1901	Wilder, Frank A.	1903
1901	Wood, L.H.	1904
1901	Chandler, Elwyn F.	1910
1903	Leonard, Arthur Gray	1932
1905	Clapp, Charles H.	1906
1907	Barry, John G.	1908
1909	Simpson, Howard E.	1938
1909	Ruediger, G.F.	1916
1909	Brannon, M.A.	1910
1909	Young, R.T.	1910
1909	Atkinson, T.R.	1910
1915	Heath, Fred H.	1916
1919	Dove, Leonard Percy	1924
1919	Eaton, H.N.	1922
1923	Turnbaugh, C.E.	1928
1927	Sand, Herbert H.	1936
1933	Foley, Frank C.	1941
1933	Abbott, George A.	1936
1933	Voedisch, Frederic W.	1936
1933	Lavine, Irvin	1934
1933	Budge, William E.	1934
1935	West, Philip W.	1936
1938	Tisdale, Ernest E.	1941
1938	Timm, Bert	1939
1939	Holmes, Chauncey D.	1940
1940	Laird, Wilson M.	1969
1940	Meblin, Denise	1941
1940	Garaas, Howard A.	1947
1941	Templeton, J. Stevens	1942
1941	Mitchell, Robert H.	1942
1941	Supernant, Grace	1942
1941	Kaloupek, Virginia	1943
1942	Rasmussen, William C.	1942
1943	Greenlee, Arthur L.	1944
1943	Blide, Louise	1945
1943	McLaughlin, Thad G.	1944
1944	Bosard, Geraldine	1944
1944	Ness, Norma Sue	1944

Year of Entry	Name	Year of Termination
1944	Pitsenbarger, Elsie	1945
1945	Bentley, Virginia S.	1946
1945	Nevin, Charles M.	1945
1945	Powers, William E.	1945
1946	Ball, John R.	1946
1946	Branch, John R.	1946
1946	Tetrick, Paul R.	1946
1946	Grossman, Irving G.	1949
1946	Easker, David G.	1947
1947	Stennes, Ione Monger	1950
1948	Fisher, Stanley P.	1953
1949	Jenkinson, Lewis F.	1950
1949	Riski, Bette	1950
1950	Kohanowski, Nicholas N.	1958
1950	Klipfel, Clarence	1952
1950	Neff, Juanita	1952
1951	Hansen, Miller	1964
1951	Ness, Marjorie	1953
1952	Green, Elsie	1954
1952	Anderson, Sidney B.	1990
1952	Fredrickson, Beverly Mathison	1958
1952; 1964	Weir, Patricia Livingood	1961; 1964
1952	Dallas, Dois D.	1955
1952	McCabe, William	1955
1953	Flatten, Joann	1953
1953	Cameron, Richard J.	1972
1953	Folsom, Jr., C.B. (Burt)	1981
1953	Hanson, Marcella O.	1965
1953	Smith, Carole	1954
1953	Strassberg, Morton	1954
1953	Caldwell, John	1953
1954	Carlson, Clarence G. (Kelly)	1981*
1954	Hansen, Dan E.	1967
1954	Arneson, William W.	1957
1954	Bock, Shirley Everson	1955
1954	Danielson, Ray O.	1956
1954	Larson, Louis I.	1959
1954	Miller, Louis Gamme	1956
1954	Nelson, Laverne B.	1955
1954	Nielsen, Jeannine D.	1956
1955	Sperling, Joyce Joachim	1962
1955	Hainer, John L.	1956
1955	Turner, Perry	1956
1955	Voorhees, Thomas R.	1956
1956	Bubb, Lois Skavlem	1957
1956; 1967	Keena, Jean Becker	1957; 1968
1956	Maywald, Richard H.	1957
1956	Peterson, James D.	1957

Year of Entry	Name	Year of Termination
1956	George, Robert S.	1962
1956	Recktenwald, Herbert J.	1956
1956	Johnson, David S.	1960
1956	Wilch, Lamont O.	1957
1957	Garske, Jay T.	1957
1957	Christianson, Gloria Gangelhoff	1958
1957	Madenwald, Kent A.	1963
1957	Gilbert, Rose Marie Charbonneau	1959
1957	Wilborn, Floyd E. (Jack)	1981*
1957	Hennessey, Diane A.	1959
1957	Hentges, Collette	1959
1957; 1964	Stoltman, Mary Jane	1960; 1966
1957	Guttenberg, Ronald E.	1960
1957	Eisenhard, Robert M.	1958
1957	Eastwood, William P.	1962
1958	Clayton, Lee S.	1965
1958	McKay, Judie L. Rohrer	1959
1958	Thoraldson, Sharon	1959
1958	Bergstrom, Sylvia	1959
1958	Kume, Jack	1966
1959	Berg, Larry D.	1960
1959	Machovsky, Bonnie	1960
1959	Mendoza, Herbert A.	1960
1959	Larsien, Mary Pladson	1967
1960	Anderson, Fae M.	1963
1960	Carter, Jr., Arthur D.	1962
1960	Caster, Alva M.	1961
1960	Pflaum, Mary Lou	1967
1960	Sorlien, Janet Larson	1961
1960	Pasbrig, Bonnie	1960
1960	Olsen, Ann Marie	1961
1960	Stennes, Sally	1961
1960	Norton, Wesley D.	1981*
1961	Bosh, Judy R.	1962
1961	Nybo, Patricia Rourke	1963
1961	Jackson, Jean Loveid	1962
1961	Hunt, John B.	1963
1961	Skjonsby, Barbara S.	1962
1961	Erickson, Alice A.	1962
1961	Cook, Heidi V.	1962
1961	Tuthill, Samuel J.	1964
1962	Anderson, Joyce	1963
1962	Edwards, Mary M. McGill	1964
1962	Freers, Theodore	1969
1962	Gunderson, Karlyn L.	1964
1962	Klug, Geraldine	1979
1962	Meldahl, Charles B.	1965
1962	Reiswig, Beverly	1963

Year of Entry	Name	Year of Termination
1962	Warthen, Robert	1963
1962	Wisler, Judy	1963
1962	Bluemle, John P.	Current
1962	Zoller, Alice	1963
1962	Brown, Gail P.	1962
1963	Carr, Betty Lou	1964
1963	Huizenga, Sylvia	1965
1963	Schroeder, Ethel	1974
1963	Auch, Florine	1965
1964	Bell, Myrtle	1967
1964	Jones, Audrey	1965
1964	Linder, Nicolai	1965
1964	Salwerowicz, Frank	1966
1964	Williams, Juanita	1968
1964	Nesland, Carol	1965
1965	Brostuen, Erling	1981
1965	Jeanotte, Jeanette	1966
1965	Johnson, Trudy	1966
1965	Laughlin, Clara B.	1989
1965	Noble, Edwin A.	1977 (Res. 7-1-78)
1965	Ryyth, Bonnie	1965
1965	Strehse, Cheryl O'Connell	1967
1966	Cowan, Madelyn	1966
1952; 1966	Haraldson, Harald H.	1953; 1968
1966	Nelson, Betty Ann	1967
1966	Nelson, Mavis	1967
1967	Roth, Bonita Redman	1969
1967	Thompson, Ruth	1968
1967	Winger, Edgar I.	1968
1967	Bradshaw, Robert	1970
1967	Brownell, Donna M.	1969
1967	Filipi, Susan D.	1969
1967	Giesinger, Jane	1969
1968	Barta, Cynthia	1970
1968	Kallestad, Kenneth	1981*
1968	Knight, Linda	1969
1968	Pederson, Judith	1969
1968	Arndt, B. Michael	1976
1969	Bjerklie, Linda	1972
1969	O'Shaughnessy, Sheila	1981*
1969	Haake, Ellis V.	1981*
1969	Kramer, Michele	1969
1969	Moran, Stephen R.	1976
1969	Nehring, Mary Lou	1970
1969	Rivinius, Joyce	1970
1969	Simons, Raymond A.	1973
1969	Sweeney, Helen	1970
1969	Johnson, Duane C.	1969

Year of Entry	Name	Year of Termination
1970	Ferguson, John I.	1980
1970	Lawrence, Connie	1970
1970	Johnson, Fern	1970
1970	Johnson, Deborah Lee	1970
1970	Lawrence, Lee K. Nerby	1972
1970; 1973	Miller, E. Kathleen	1972; 1989
1970	Klym, Elizabeth	1972
1970	Knudson, Karollyn	1979
1972	Sevigny, Denise	1977
1972	Adams, Linda	1973
1972	Nehring, Deborah	1978
1972	Borboa, Connie	1989
1973	Roos, Palmer	1989
1973	Lechner, David	1989
1973	Hjelmstad, Kathi	1981
1974	Rood, Marilyn	1989
1974	Groenewold, Gerald H.	1984
1975	Borchert, Roger	1980
1975	Dannewitz, Doren A.	1981*
1975	Gerhard, Lee C.	1981
1975	Novak, Paulette Schulz	1977
1975; 1989	Gutenkunst, Karen	1981*; Current
1976	Hobbs, Howard	1977
1977; 1985	Kehew, Alan	1985
1977	Harris, Kenneth L.	1989
1977	Nichols, Debra	1979
1977	Nelson, Kathy	1981
1977	Walker, Daniel	1980
1978	Ruddy, David	1981
1978	Baugh, Debbie	1978
1978	Latka, Robert	1980
1978	Tucci, Nicholas J.	1979
1979	Kroese, Debra J.	1989
1979	Stenvold, Cheryl	1980
1979	Umphrey, Howard	1981
1979	Burke, Randolph B.	Current
1979	Wollan, Glenn L.	1981*
1979	Kadrmass, Connie M.	1981*
1979	Beaudry, Donna	1980
1979	Priddy, John K.	1981
1979	Garbe, Robert K.	1981*
1979	Savoy, Luke	1987
1979	Mailloux, Eula M.	1994
1979	Schreiner, Cheryl L. Duggan	1983
1980	Brekke, David W.	1989
1980	Halvorson, Don L.	1985
1980	Hicks, Bruce E.	1981*
1980	Juenker, Bruce J.	1981*

Year of Entry	Name	Year of Termination
1980	Stoa, Rodney	1989
1980	Murphy, Edward C.	Current
1980	Dufty, James C.	1981*
1981	Behl, Anne	1987
1981	Bohack, Marvelyn A.	1989
1981	Dorsher, Kent	1989
1981	Hoganson, John W.	Current
1981	LeFever, Julie A.	Current
1982	Rygh, Marvin	1989**
1982	Seidel, Robert E.	1987
1983	Diemert, Jana G.	1984
1983	Fischer, David W.	1989
1985; 1991	Hollands, Kent E.	1989; Current
1987	Carlson, Linda M.	1989
1988	Molstad, Janna B.	1989
1989	Lindholm, James S.	Current
1989	Luther, Mark R.	Current
1989	Materi, Annette	Current
1989	Prange, Russell D.	Current
1989	Baker, Richard A.	Current
1989	Roberson, Evelyn	Current
1989	Henke, Darby	1994
1991	Greer, Phillip L.	1995
1991	Fey, LaRae	1996
1992	Biek, Robert F.	Current
1992	Diehl, Paul E.	Current
1992	McClellan, William A.	1995
1992	Murfield-Tyler, Sharon	1993
1994	Bassler, Rod E.	Current
1995	Senger, Sheila	Current

* Transferred to new Oil and Gas Division and moved to Bismarck - 1981

** Transferred to the Oil and Gas Division and moved to Bismarck - 1989

APPENDIX D

Geological Survey Appropriations

Year	State Funds	Federal Funds	Total Survey Biennial Receipts
1895-1900	<i>No appropriation except \$300/year for expenses. The first appropriation (made in 1899) was a "small appropriation".</i>		
1900	?	-0-	?
1901	?	-0-	
1902	?	-0-	?
1903	1,000	-0-	
1904	1,000	-0-	2,000
1905	1,000	-0-	
1906	1,000	-0-	2,000
1907	1,000	-0-	
1908	1,000	-0-	2,000
1909	1,000	-0-	
1910	1,000	-0-	2,000
1911	1,000	-0-	
1912	1,000	-0-	2,000
1913	1,000	-0-	
1914	1,000	-0-	2,000
1915	1,000	-0-	
1916	1,000	-0-	2,000
1917	1,000	-0-	
1918	1,000	-0-	2,000
1919-1920	3,000	-0-	21,000

The 1919 annual appropriation included \$18,000 for a special lignite investigation.

1921-1922	3,000	1,250	5,250
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Includes \$500 from Highway Department in 1921 and \$1,000 in 1922.

1923-1924	1,250	1,250	2,500
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For 1921 and 1923, \$1,250 in state matching for USGS topographic mapping.

1925-1926	-0-	-0-	-0-
1927-1928	-0-	-0-	-0-
1929-1930	-0-	-0-	-0-
1931-1932	-0-	-0-	-0-
1933-1934	-0-	100,000	100,000

Several federal relief programs began in 1934: Public Works Administration, National Resources Board, Federal Emergency Relief Administration, United States Geological Survey.

1935-1936	3,450	100,000	103,450
1937-1938	8,750	1,250	10,000
1939-1940	-0-	-0-	-0-
1941-1942	16,750	10,000	26,750

For 1941 and 1942, \$5,000 annual fund match for topographic mapping.

Year	State Funds	Federal Funds	Total Survey Biennial Receipts
1943-1945	6,934	11,454	18,388
1945-1947	15,150	2,000	17,150
1947-1949	17,025	1,875	18,900
1949-1951	21,275	- 0 -	21,275
1951-1953			36,250
			40,014

A special appropriation of \$40,014 from the State Emergency Commission used to deal with the added expense to the Geological Survey resulting from the discovery of oil in 1951.

1953-1955			310,000
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The 1953-55 appropriation included a special appropriations of \$20,000 for a core storage shed.

1955-1957			269,700
1957-1959			330,500
1959-1961			387,034
1961-1963			442,064

The 1961-63 appropriation included \$23,742 for an addition to the core shed.

1963-1965			435,292
1965-1967			461,469
1967-1969			485,818
1969-1971			575,106
1971-1973			667,818
1973-1975			741,000
1975-1977			1,225,579
1977-1979			1,419,968
1979-1980	1,625,995		

(includes \$586,765 for new core library)

1980-1981	1,185,265		2,811,260
1981-1982	1,011,525		
1982-1983	990,543		2,002,068
1983-1984	878,363		
1984-1985	885,901		1,759,562
1985-1986	985,040		
1986-1987	968,658		1,953,698
1987-1988	834,148		
1988-1989	864,057		1,698,205
1989-1990	600,413		
1990-1991	556,025		1,179,391

(plus \$47,952 federal funds)

(no clerical salaries included - this amount from a different cost center)

1991-1992	869,394		1,846,108
1992-1993	1,040,985		
	(plus \$154,250 federal funds)		
1993-1994	939,774		1,933,370
1994-1995	936,499		

Selected References

I haven't attempted to reference much of what I've included in this report on the history of the North Dakota Geological Survey. Had I done so, I would have had to reference virtually every technical report ever written by Survey geologists, as well as many others. Even so, there are a few sources I need to specifically list - these are noted below.

The reader interested in pursuing these and other topics relating to the history of the study of geology in North Dakota can refer to Mary Woods Scott's two bibliographies (Scott, 1972; 1981) and the Bibliography of North Dakota Geology from 1981 through 1993. (Greenwood, et al., in preparation). Readers interested in a generalized, topical bibliography might want to refer to Bluemle, 1991.



- Bluemle, J.P., 1991, The Face of North Dakota: North Dakota Geological Survey Educational Series 21, 177 p.
- Brekke, D. W., 1988, History of the North Dakota Geological Survey in The State Geological Surveys, A History: Socolow, A. A., Editor, American Association of State Geologists, p. 337-343.
- Budge, C.E., 1946, Bibliography of the geology and natural resources of North Dakota, 1814-1944: North Dakota Research Foundation Bulletin No. 1, Reprinted 1959: North Dakota Geological Survey, 214 pages.
- Folsom, C.B., 1980, A History of the North Dakota Geological Survey: North Dakota Geological Survey Miscellaneous Series 58, 51 pages.

- Greenwood, Larry, and others, in preparation, Annotated bibliography of the geology of North Dakota, 1980-1993: North Dakota Geological Survey Miscellaneous Series (in preparation)
- Laird, W.M., 1955, The History of the Geology Department at the University of North Dakota: Contributions to the Geology of North Dakota, The Compass of Sigma Gamma Epsilon, Vol. 32, p. 153-156.
- Lerud, Joanne, 1982, Lexicon of stratigraphic names of North Dakota: North Dakota Geological Survey Report of Investigation 71, 139 pages.
- North Dakota State Industrial Commission, 1952, Hearing on application of Amerada Petroleum Corporation and Hunt Oil Company for eighty acre spacing for Beaver Lodge Pool: North Dakota State Industrial Commission, 256 pages.
- Scott, M.W., 1972, Annotated bibliography of the geology of North Dakota, 1906-1959: North Dakota Geological Survey Miscellaneous Series 49, 132 pages.
- Scott, M.W., 1981, Annotated bibliography of the geology of North Dakota, 1960-1979: North Dakota Geological Survey Miscellaneous Series 60, 287 pages.
- Shemorry, W.E., 1991, Mud, sweat and oil - the early years of the Williston Basin: William E. Shemorry, Williston, North Dakota, 208 pages.