NDGS NEWSLETTER

John P. Bluemle, Editor

A publication of the
North Dakota Geological Survey
University Station
Grand Forks, North Dakota 58202
Phone: (701)777-2231

DECEMBER 1985

COVER PHOTO

In the distance is Black Butte in Slope County, North Dakota (Township 134 North, Range 102 West, Sections 23, 24, and 25). Tepee Butte is the small butte to the left of Black Butte. Slide Butte, the site of the 1930s "volcanic eruption" controversy (see article, this newsletter), is just off of the left edge of the photo.

Photo by Ed Murphy (view toward the southwest).

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SEARCH FOR A NEW STATE GEOLOGIST

--John Bluemle

The North Dakota Geological Survey is now in the process of searching for a replacement for Dr. Don L. Halvorson, who resigned as State Geologist and Chairman of the University of North Dakota geology department this past summer. Sidney B. Anderson is currently the Acting State Geologist.

We hope to be able to name a full-time State Geologist no later than July 1, 1986. Until now, every State Geologist has also served as UND Geology Department chairman, a situation that was never ideal as both jobs are demanding and, certainly, each is more than a half-time position. A copy of our advertisement, which has been placed in several national journals, is reprinted below.

STATE GEOLOGIST AND DIRECTOR
NORTH DAKOTA GEOLOGICAL SURVEY

The Search Committee invites applications and nominations for the position of State Geologist of the North Dakota Geological Survey (NDGS). Located in Grand Forks on the University of North Dakota campus, the Survey was established in 1895 as a state agency conducting research on the geology of North Dakota. The NDGS staff includes 11 geologists and engineers with a total full-time staff of 25. The Survey conducts geologic and engineering investigations, disseminates information related to North Dakota's geology, oil and gas, minerals and groundwater resources, and regulates certain mineral-related activities. It also acts as an advisor to various other state agencies in matters pertaining to geology, oil and gas, and other geologic problems.

The State Geologist is responsible for continuing development of the NDGS and for the accomplishment of its missions and goals, including research, public information, and regulatory duties. The position requires a Ph.D. degree and will involve a professorship in the University of North Dakota Geology Department. The State Geologist will be expected to coordinate research activities being conducted jointly by the NDGS and the Geology Department and to encourage and support research interaction between the NDGS and other state and federal agencies and institutions.

A background in industry is desirable, preferably in petroleum geology or another mineral-related field. Experience with the geology of North Dakota and the Williston Basin is also desirable. The State Geologist must be a skillful and vigorous manager and must be able to deal effectively, in public and private, with industry representatives, the citizens of North Dakota, and legislators. Because of the broad scope of Survey responsibilities, it is important that the State Geologist have a broad perspective and background in geology. The position requires numerous public appearances, testimony, and talks before service groups and others. Duties include the preparation of a budget and the presentation of that budget to the State Legislature every two years.

Nomination deadline: April 1, 1986

Application deadline: April 30, 1986

Anticipated starting date: July 1, 1986, or negotiable

Salary: Negotiable, depending upon qualifications

Applicants must include a letter of application, a complete resume, five references with phone number, and any other supporting data. All inquiries and applications will be held in confidence.

Applicants need not be nominated, but individuals may be nominated by others. Nominations should include a brief outline of the nominee's qualifications, along with his or her current address and telephone number. Address communications to:

Mr. Sidney Anderson
Chairman, Search Committee
North Dakota Geological Survey
University Station
Grand Forks, ND 58202-8156

Phone: 701/777-2231

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BRUNO HANSON AND ANDY ALPHA HONORED

--John Bluemle

Andrew G. (Andy) Alpha, in Grand Forks to receive a Sioux Award, the University of North Dakota's highest honor, joined Bruno Hanson during the UND Homecoming celebration on October 11 at a reception in Leonard Hall. Both men are graduates of the University of North Dakota and both worked briefly for the North Dakota Geological Survey early in their careers.

Mr. Alpha received his B.S. and M.S. degrees in Geology from UND in 1934 and 1935, respectively. He has done research in the fields of soils geology, groundwater, petroleum exploration, and environmental geology in various locations in the Rocky Mountains, the West Coast states and Alaska, and Canada, including the Canadian and Alaska Arctic. While with Signal Oil and Gas, Andy was involved with the siting of the Solar L.P. Gas storage cavern, located near Mentor, Minnesota, about 40 miles east of Grand Forks. This is one of the largest such underground storage facilities in the world.

Andy has a broad spectrum of geological interests and proficiency and has long been active in the American Association of Petroleum Geologists (AAPG), American Institute of Professional Geologists (AIPG), Geological Society of America (GSA), and Sigma Xi. He is Past President of the Rocky Mountain Association of Geologists, served on the Advisory Board of AIPG, on the Advisory Committee to the Department of Geological Science at the University of Southern California, and the Department of Geology at the University of Oregon.

Andy has served as chairman of numerous field trips in the Rocky Mountains, California, and Nevada. His publications include guidebook papers and a study of the petroleum potential of the Sierra Nevada and Eastern Desert, California. His sketches appear in at least 40 guidebooks and other publications. Mr. Alpha has made several generous donations of books and other materials to the UND Geology Library.

Bernold M. (Bruno) Hanson is currently President-Elect of the American Association of Petroleum Geologists. He received his B.S. degree in Engineering Geology from the University of North Dakota in 1951 and his M.A. degree in Geology from the University of Wyoming in 1954. A job with Humble Oil and Refining Company took him to New Orleans, then to Alaska where he was geologist in charge of the Alaska Project. In 1957, Bruno became District Geologist for Humble in Midland, Texas. His enthusiastic and energetic nature resulted in rapid advancement within the company and brought him assignments from the SEPM Permian Basin Section, the West Texas Geological Society, and the AAPG. He has served on eight different AAPG committees, holding chairmanships of the Professional Standards Committee and Public Information Committee. He also served on the Business Committee and the House of Delegates. He was appointed secretary-treasurer for the Division of Professional Affairs and was elected Association secretary in 1973. And, as I noted earlier, Bruno is currently President-Elect of the AAPG.

Bruno left Humble in 1960 and became a consulting geologist and independent oil operator. He has carried on a successful business of finding and producing oil and gas, serving as president of Hanson and Allen, Inc., Hanson Exploration, Inc. and, currently, Hanson Corporation. Bruno has consulted widely, from Ecuador to Nigeria, from Norway to Alaska, and from Indonesia to Sudan. He is active in numerous professional organizations, including the American Institute of Mining Engineers (AIME-Petroleum Section), the American Institute of Professional Geologists (AIPG), Society of Economic Paleontologists and Mineralogists (SEPM), Sigma Xi, Sigma Gamma Epsilon, and numerous regional geology societies.

Bruno has been active in the Boy Scouts of America; he is an Eagle Scout with three palms, and he has received the Order of the Arrow. He has worked in many of the regional and world jamborees of scouting. Bruno has been honored with various Scouting awards, including the Silver Beaver and Silver Antelope Awards.

Bruno Hanson received the UND Foundation Sioux Award in 1978, and he is current president of the Foundation.

NEW PUBLICATIONS

The following publications were issued recently by the Survey:

Bulletin 78, Part 1 (also designated County Groundwater Study 35, Part 1) -- "Geology of Bottineau County, North Dakota," was written by John P. Bluemle. With the publication of this report, all of the planned parts of the Groundwater Studies for Bottineau and Rolette Counties are now complete. The other parts are Part II, which describes the groundwater basic data of Bottineau and Rolette Counties, Part III, which is a report on the hydrology of the two counties, and NDGS Bulletin 58, which describes the geology of Rolette County.

Bulletin 78, Part 1 describes the subsurface and surface geology, the geologic history, and the economic geology of Bottineau County although it does not treat the occurrence of oil and gas in detail. It emphasizes the stratigraphy of the near-surface glacial deposits in the county, and it includes descriptions of the landforms found in the area and explains how they formed.

The report is 57 pages long and includes a colored geologic map at a scale of ½-inch to a mile. Bulletin 78, Part 1 is available without charge from the North Dakota Geological Survey.

Bulletin 80, Part 1 (also designated County Groundwater Study 37, Part 1) -- "Geology of McKenzie County, North Dakota," was written by Clarence G. Carlson of the North Dakota Oil and Gas Division of the State Industrial Commission. All three parts of the McKenzie County Groundwater Study are now available (see the description of Bulletin 80, Part III, below).

Bulletin 80, Part 1 describes the subsurface and surface geology, and the geologic history of McKenzie County. The economic geology of the county, including the stratigraphy and occurrence of lignite in the county, is discussed in the report. However, no detailed report on the hydrocarbons is included.

The 48-page report includes a colored geologic map of the county at a scale of ½-inch to a mile. Cross sections of the Dakota Group, the post-Pierre Formation, and the Fort Union strata are also included as plates. The report is available without charge.

County Groundwater Study 37, Part II (also designated Bulletin 80, Part II) -- Ground-Water Data for McKenzie County, North Dakota," was written by M. G. Croft of the U.S. Geological Survey. The 455-page report includes data on wells and test holes in McKenzie County, water-level measurements in observation wells, chemical analyses of groundwater and water from streams and other data. The data presented in the report are useful for evaluating geologic and groundwater conditions in McKenzie County. The report includes a map at a ½-inch-to-a-mile scale showing the locations of test holes in the county. There is no charge for the report.

County Groundwater Study 37, Part III (also designated Bulletin 80, Part III) -- "Ground-Water Resources of McKenzie County, North Dakota," was written by M. G. Croft of the U.S. Geological Survey. This report provides detailed geologic and hydrologic information needed for the orderly development of water supplies for municipal, domestic, livestock, irrigation, industrial, and similar occurrences.

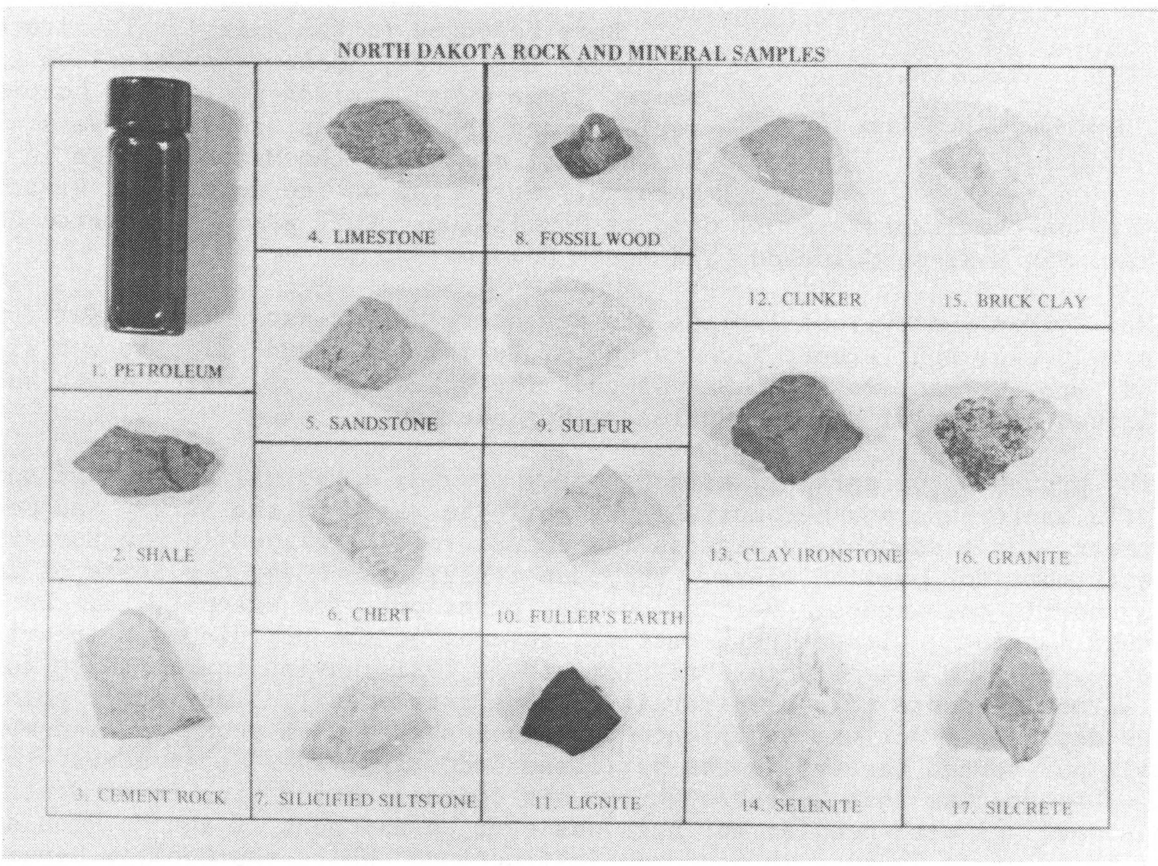
The report includes information on the location, extent, and characteristics of the major aquifers; it evaluates the occurrence, movement, recharge, and discharge of groundwater; it estimates the quantities of water stored in the major aquifers; it estimates the potential yields to wells penetrating the major aquifers; and it describes the chemical quality of the groundwater.

County Groundwater Study 37 includes a colored map showing the availability of water in the glacial drift and alluvial aquifers in the county and a geohydrologic cross section through the county. The report is 57 pages long. It is available without charge.

The Oil and Gas Division of the North Dakota Industrial Commission recently released reports listing oil and gas production statistics for North Dakota wells for the years 1983 and 1984. These publications, "Oil in North Dakota--1983 Production Statistics" and "Oil in North Dakota--1984 Production Statistics," are available from the Oil and Gas Division, 900 East Boulevard, Bismarck, North Dakota 58505. The cost is $15.00 each.

List of Publications -- We now have a new listing of publications available. Write or call us for a free copy.

North Dakota Rock and Mineral Sets -- Finally, although it probably doesn't qualify as a new "publication," the Survey has just finished compiling $6\frac{1}{2}$" by $8\frac{1}{2}$" cards on which we have mounted North Dakota rocks and minerals (see photo, below). Each card has 17 typical rocks and minerals, including petroleum, mounted on one side. The back of the card provides a description of each of the 17 samples. We expect that the rock sets should be useful to school students studying North Dakota earth science or, for that matter, to anyone who wants to learn more about some of North Dakota's typical earth materials. The Rock and Mineral Sample cards can be obtained from the North Dakota Geological Survey for $1.00 each.



CLARENCE BURTON FOLSOM, JR. -- 1917 - 1985
(Tribute written by John Bluemle, NDGS, and F. D. Holland, Jr., UND Geology Department)

C. B. "Burt" Folsom, Jr., 68, died on August 14 in Grand Forks, North Dakota. Memorial services were held on August 19 with a eulogy delivered by Dr. Wilson M. Laird. Burt was born June 14, 1917, in Denver, where he grew up and attended school. He attended Colorado School of Mines and received two degrees in petroleum engineering. He was employed by Phillips Petroleum Co. in Texas before and after World War II. During the war, Burt served in the Southwest Pacific Theater as a Captain.

Professor C. B. Folsom

Burt acted as Head of the Petroleum Engineering Department at the University of New Mexico at Socorro from 1947 to 1953. In 1953, he came to the North Dakota Geological Survey as Chief Petroleum Engineer. He was also an Associate Professor of Petroleum Engineering at the University of North Dakota from 1953 until his death. Burt was involved in revising North Dakota's oil and gas rules and regulations for the State Industrial Commission in 1953. The present oil and gas law in North Dakota is little changed from that which he formulated in 1953.

Burt belonged to the American Institute of Mining Engineers, Society of Petroleum Engineers, Sigma Gamma Epsilon geological honorary society, and the Veterans of Foreign Wars. He was past master of the Masonic Lodge in Socorro. He served on the Regulatory Practices Committee of the Interstate Oil Compact Commission. Burt was a Registered Engineer in Texas, New Mexico, Colorado, and North Dakota.

Mr. Folsom's survivors include his daughter, Martha Karin (Kaye) Sullivan, Guelph, Ontario; son, Bruce, Wichita Falls, Texas; six grandchildren; and sister, Dorothy (Mrs. Herman) Rossoll, San Diego. The University of North Dakota has established a Memorial Fund in Petroleum Engineering.

The preceding paragraphs, although they provide a factual account of some of Burt's background and accomplishments while he was with the Survey and Geology Department, don't adequately express the actual role he played in the Survey and Department for over 30 years. They don't begin to convey the sense of loss felt by Burt's colleagues. Neither do they point out, for example, that Burt continued to teach, without remuneration, several of the petroleum engineering courses ever since his official "retirement" in 1981 (having taught these for years without expense to the University before retirement). They don't point out the depth of practical experience that Burt shared with young men and women on their way toward careers in the petroleum industry. They don't convey the sense of pragmatism that Burt brought to his courses, his advice to students, and his dealings with people; for Burt was ever an exponent of the "common sense," a quality so often lacking in academic instruction. While the Geology Department was forced to make adjustments in scheduling and course loads (with Marv Rygh, NDGS petroleum engineer, helping Prof. Min Chu with classes), it was students at Homecoming who expressed to us how much they valued the instruction, advice, and help that Burt had given to them so freely. Thus, we are only beginning to sense the magnitude of his loss.

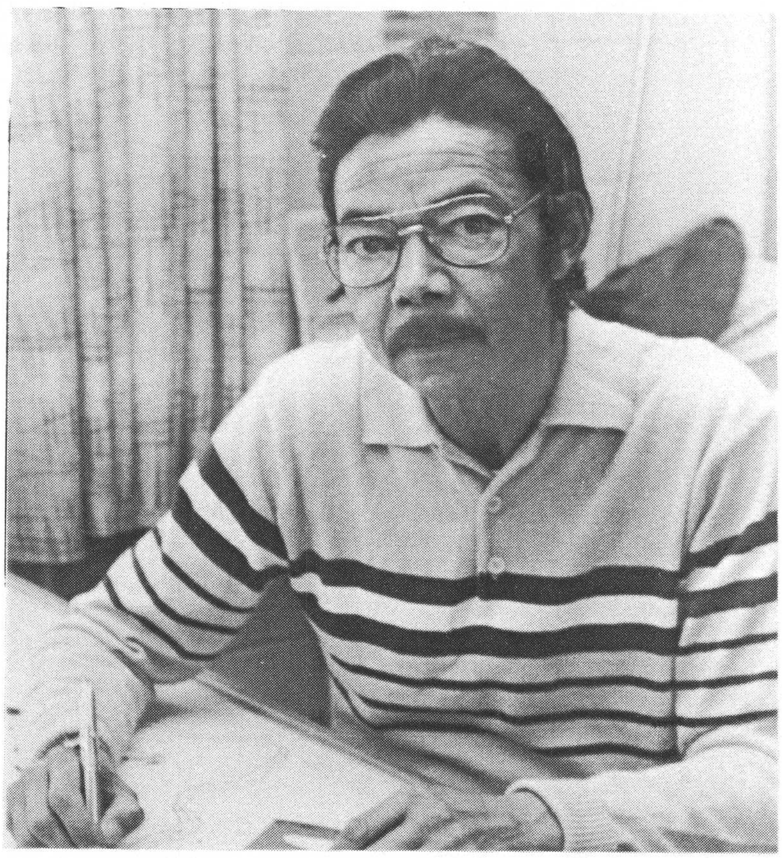
The "facts" we recounted at the beginning of this article don't tell that Burt was always the first person on the staff to arrive at his office each day, for years while he worked for the Survey and later when he was working only for the Department. Neither do our comments express the extent of his dedication to sound industrial practices and to sound education. We can only hint at the magnitude of his service to the people of the State in the early emplacement of sound regulatory practices during the early days of the development of the oil and gas industry in the State.

It is difficult to adequately convey to someone who didn't know Burt, the thread of cynical good humor that pervaded all that he did. Many of us will remember that he was one of the founders and guiding lights of the Society of the Preservation of the Memory of Outstanding Goofs; many of us can recall the wry smile, the tongue in cheek, or the quiet chuckle always present as he'd deal with daily minor crises or the bumbling good intent of students, bureaucrats, or misguided professors. Yet all who knew him realized that he could manage the same slight shrug and self-effacing smile when the prodding turned toward him as he graciously received (and prized) his citations and awards in 1968 and 1969 for ineptitudes in the lab and in golf.

The naming in 1982, of UND's student chapter of the Society of Petroleum Engineers of AIME, the C. B. Folsom Chapter and the establishment at UND by his family of the C. B. Folsum Fund in Petroleum Engineering will help to perpetuate his memory, and industry through service and his publications will continue to stand as a memorial, but the real tribute to Burt is the words of the student who said, "You can't believe how much his wisdom, advice, and teachings meant to me as I started out in the field. What a loss." We all feel it!

SURVEY PROFILES

Luke Savoy



Luke Savoy has been an NDGS drafting technician since 1979. His responsibilities include drafting various types of geologic maps and oil field maps, helping to keep them current. As the Survey's drafting supply custodian, Luke inventories, maintains, and orders the various papers, pens, pencils, and other materials used in the drafting office. Luke is originally from Washington, D.C. and he came to Grand Forks via the U.S. Air Force in 1971. Luke liked the Grand Forks area and, after serving for 22 years in the USAF, Luke retired and stayed in the area. His hobbies include camping, fishing, and other outdoor-related activities. He also collects knives and other edged weapons.

John Bluemle

John Bluemle started working for the North Dakota Geological Survey in 1962. During the past 23 years he has worked for five different state geologists and authored or co-authored an average of three or four geologic reports or maps a year dealing with various aspects of the geology of North Dakota. The subjects addressed in these reports include glacial geology, glacial tectonics, geologic history, environmental geology, educational geology, and various aspects of petroleum geology. This partial listing of topics illustrates the broad range of John's professional interests.

John was born in New Hampton in northeastern Iowa. He graduated from high school in LaPorte City, Iowa, and went on to receive his BS degree from Iowa State University in 1960. His graduate work in geology was done at Montana State University (MS, 1962) and at the University of North Dakota (PhD, 1972).

Currently, John divides his time between his research interests and his administrative duties. He is the Chief of the Surface Geology Section of the NDGS. This means he is responsible for directing the activities of the surface section and giving advice and counsel to those in this section. John also is the editor for the Survey. This requires his overseeing the printing and bidding of all Survey publications; he compiles and edits the Survey Newsletter.

John's research interests center around Quaternary geology, but include many aspects of Williston Basin geology including current oil and gas activity. Most of John's work has involved surface geologic mapping and studies of the glacial history of the upper midwest. He has published the results of his research on glacial tectonics in international journals and is recognized as an authority on the subject.

The Survey's educational publications are largely the result of John's work. He has published a nontechnical geologic book on North Dakota, field trip guides for many parts of the state, and he has compiled numerous taped slide presentations, talks, and nontechnical articles.

John and his wife, Mary, have three children, Bill (17 yrs.), Irene (15 yrs.), and Paul (13 yrs.). Mary owns and operates MINERALS DIVERSIFIED SERVICES, an information service company serving the mineral exploration industry. The whole family is active in a variety of outdoor activities including boy scouts, camping, canoeing, cross-country skiing, and travel.

ENVIRONMENTAL GEOLOGY AT THE NDGS --John Bluemle

Part of the mission of the North Dakota Geological Survey includes studies of the environment and various reclamation projects concerning the natural resources of the state. We have certain state-wide environmental responsibilities that don't change much from year to year as well as several specific projects on which we are currently working.

Our state-wide responsibilities include reviewing, as a technical advisor, 1) proposed sanitary landfill sites; 2) sites for special use disposal; 3) hazardous waste permits; and 4) surface mine permits and applications. We generally review these from the standpoint of geological and hydro-geological considerations, but we don't actually issue the permits for the facilities; that's done by the State Health Department and the Public Service Commission. Survey geologists review permit applications and issue permits for salt solution mines as part of the state Underground Injection Control Program--Class III wells. We also issue permits for the drilling of coal exploration test holes and we supervise the reclamation of the drill holes.

In addition to the ongoing duties just mentioned, we have several specific projects underway in cooperation with other state agencies. One of these involves a study of the effects that oil and gas exploration and production have on shallow groundwater resources in North Dakota. We are specifically concerned about buried drilling fluid, abandoned brine evaporation pits, and brine injection wells. This particular project has been in progress for about five years. The initial phase of the study included a detailed monitoring investigation of four buried drilling-fluid pits of differing ages, geological settings, and methods of reclamation. The second phase of the project, now nearing completion, has involved the monitoring of two additional drilling-fluid pits sited in glacial sediments, a brine evaporation pit, and a brine injection well from which brine reportedly migrated in the subsurface to a nearby abandoned seismic shot hole, where it began to flow at the land surface.

We have been conducting a detailed monitoring of the groundwater flow system around a municipal waste-stabilization lagoon in cooperation with the State Health Department. Twenty-nine wells were installed at the site near McVille, and groundwater samples are being analyzed for major ions, nutrients, trace elements, dissolved organic carbon, and volatile organics. Another cooperative project with North Dakota State University and the MMRRI involves the study of the geochemistry of groundwater and pore water within and adjacent to abandoned lignite strip mines with emphasis on whether they should be reclaimed or left alone. We also have been conducting a detailed monitoring of the groundwater flow system around a city landfill (Grand Forks) located in glacial lake sediments with the intent of assessing the environmental impacts. This project is also a joint study with the State Health Department.

We began a study this past summer of the Cretaceous shale formations in eastern North Dakota, looking particularly at the concentrations of certain trace elements such as arsenic and selenium (see the following article).

Two recent publications resulting from our environmental studies are the following:

Report of Investigation 80, Effect of Seepage from Unlined Municipal Waste Stabilization Lagoons on Chemical Quality of Groundwater in Shallow Aquifers, by Alan E. Kehew, Francis J. Schwindt, and David J. Brown. This 140-page report presents the results of an investigation of six unlined municipal waste stabilization lagoons constructed in permeable sediments directly over shallow, unconfined aquifers.

Report of Investigation 82, The Effect of Oil and Gas Well Drilling Fluids on Shallow Groundwater in Western North Dakota, by Edward C. Murphy and Alan E. Kehew. This 156-page report presents the results of water analyses and resistivity surveys of four reclaimed oil and gas well drilling sites in western North Dakota. It examines the geologic and geohydrologic variables affecting leachate migration.

Three additional (unpublished) reports to the Water Resources Research Institute:

Movement of leachate from a buried oil and gas brine-disposal pond in the Wylie Field, Bottineau County, North Dakota; a 105-page report issued in December 1985: Murphy, E. C., Kehew, A. E., Groenewold, G. H., and Beal, W. A.

Investigation of a surface brine flow from an abandoned seismic shot hole in the Black Slough Oil Field, Burke County, North Dakota; a 106-page report issued in December 1985: Murphy, E. C., Kehew, A. E., Groenewold, G. H., and Beal, W. A.

Contaminant migration of oil-and-gas drilling fluids within the glaciated sediments of north-central North Dakota; January 1986: Beal, William A., Murphy, Edward C., and Kehew, Alan E.

GEOCHEMISTRY OF SHALES

--David Brekke

The North Dakota Geological Survey has undertaken a study to determine the geochemistry of the Cretaceous-age shale formations in eastern North Dakota. Our study was prompted by the State Department of Health's interest in arsenic levels in groundwater from the southeastern part of the state. Our study will utilize rock cores, stored in our core library, and, whenever possible, samples taken from outcrops. We plan to analyze for many of the major elements in the shales (aluminum, iron, etc.) as well as for some of the heavy metals such as arsenic, selenium, cadmium, mercury, and lead. Some of these naturally occurring elements have caused health problems to livestock in other parts of the world. This article is primarily a general discussion of the geochemistry of shales.

Shale is a fine-grained detrital sedimentary rock. It is formed by the consolidation of mud--clay and silt--the particles of which are the result of erosion and chemical weathering of other rocks generally at some distance from the site of deposition. One might expect that the relative amounts of the various elements in a shale should be similar to the proportions in which these elements occur in rocks from which they were derived, but this isn't necessarily true. The proportions of major, or common elements, are generally the same on average, in shale as in the earth's crust as a whole, but the abundances of the minor elements can be considerably different, even between shales and other sedimentary rocks (see table 1). Although Table 1 is an abbreviated list of elements, it is readily apparent that minor elements tend to be concentrated in the fine-grained sediments such as shale. There are at least three reasons for this anomaly. One reason is the ionic substitution of minor elements in the structure of clay minerals. That is, if an element is similar enough in size and ionic charge to another element, the two can substitute for one another. This can lead to a concentration of certain minor elements in shales. For example, manganese and zirconium can substitute for the magnesium in montmorillonite. A second reason is that some minor elements react readily with organic matter. Since shales contain more organic matter than other rocks, this can lead to a concentration of certain elements. The third and probably the most important process that leads to an enrichment of minor elements in shales is adsorption. Fine-grained sediments have a large number of small particles of various types, mostly clay minerals, and generally have been through a variety of environmental changes over time. This presents many opportunities for minor elements to be adsorbed on the clay surfaces. Also, the small particles that make up shale have a much larger total surface area for adsorption to take place than do, for example, the surfaces of the grains in a sandstone.

TABLE 1. Average Abundance of Some Major and Minor Elements in Selected Rocks

Element	Earth's Crust	Shale
O	46.4 %	49.5 %
Si	28.2	23.8
Al	8.1	9.2
Fe	5.4	4.7
Ca	4.1	2.5
Na	2.4	0.9
Mg	2.3	1.4
K	2.1	2.5
Ti	0.50	0.45
S	0.03	0.25
C	0.02	0.10

Element	Shale	Sandstone	Carbonates
Cr	100 ppm	35 ppm	11 ppm
Cu	50	1-10	4
Zn	90	16	20
As	10	1	1
Se	0.6	0.05	0.08
Mo	2	0.2	0.4
Cd	0.2	?	0.1
Hg	0.5	0.03	0.05
Pb	20	7	9
Th	12	1.7	1.7
U	3.5	0.45	2.2

--data from numerous sources

Some of the minor, or trace element, concentrations in shales are much higher than the concentrations in other rocks. For example, about 10 times more arsenic (As), selenium (Se), mercury (Hg), copper (Cu), and molybdenum (Mo) are found in the average shale than in the average sandstone or limestone. The average shale has about twice as much cadmium (Cd) and lead (Pb) as other sedimentary rocks. Depending on the concentration, as well as on the particular chemical form a minor element takes, some of these elements may be of environmental concern. For example, small amounts of selenium are necessary for normal livestock health. However, too much selenium intake can lead to serious problems in livestock, including death. Usually, in areas where high selenium poisoning occurs, it can be related to a biogeochemical cycling of naturally occurring selenium in shales at the surface. For example, the plant species Astralagus, or "poisonvetch," concentrates selenium in plant matter, which is then ingested by livestock.

In part of southeastern North Dakota, the level of arsenic is raised above the normal. Here, glacial material directly overlies certain Cretaceous-age shales which themselves have high levels of naturally occurring arsenic. Since the glacial material is composed primarily of reworked shale in this area and the groundwater aquifers occur within the glacial material, some of the arsenic tends to make its way into the groundwater. We should stress, however, that no evidence of any health problems associated with this situation have arisen.

The geochemistry of shales and any environmental concern toward minor elements in the shales of North Dakota is a complex subject. Our intention is to work toward providing basic geochemical data on the Cretaceous shales of the eastern portion of the state since that is the largest area of near-surface occurrences. This information should be useful baseline data to other studies.

SOME THOUGHTS ABOUT GEOLOGIC MAPS

--Ken Harris

A geologic map is a map which displays geologic information such as the distribution, origin, and age relationships of rock units, and the occurrence of structural features, mineral deposits, and fossil localities (AGI, 1972).

Geologic maps display this information about surface or subsurface geology through the use of map units that are defined in the map legend. Map units can communicate descriptions of, or interpretations of, three basic aspects of geology: topography (location plus elevation), lithology (color, structure, mineralogy, grain-size, etc.), and stratigraphy (major and minor natural subdivisions of earth materials)(Clayton, 1977).

The interpretive elements (age and origin) of the three basic aspects of geology (topography, lithology, and stratigraphy) are subject to change with time and they vary somewhat with individual geologists involved in mapping. Interpretive models that are used by geologists change with time. A pre-Magellan map of the world would have been quite different than our contemporary, space-age concept of the globe.

Since the geology of an area consists of three basic aspects (topography, lithology, and stratigraphy) and three elements (description, origin, and age) of each of these aspects, then there are nine element-aspect combinations that can be mapped. For example, three combinations using the topography aspect would be descriptive-topography (the shape of the landform), genetic-topography (the origin of the landform), and chronologic-topography (the age of the landform). Similar combinations can be made for the lithologic and stratigraphic aspects using the three elements (description, origin, and age)(Clayton, 1977).

Geologists map different element-aspect combinations depending on differing needs. A geologic map made by a mineralogist (a geologist who studies rocks and minerals) is likely to emphasize different characteristics than a geologic map made by a geomorphologist (a geologist who studies landforms). Geologists with the North Dakota Geological Survey generally emphasize the descriptive element and stratigraphic aspect in their geologic maps. This results in an emphasis on the descriptive nature of the map units. Interpretation is largely presented in the legend. The resulting geologic map is not highly susceptible to changing interpretive models, and should enjoy a longer useful lifetime.

Geologic map-units must be presented on a base map. Two types of base maps are commonly used, planimetric and topographic (fig. 1). Planimetric maps present selected natural and/or cultural features in two dimensions; no elevation data is presented. Topographic maps include that information presented on the planimetric map plus elevation data, or a three-dimensional model of the area mapped. So, a geologic map presented on a topographic base map would include descriptive-topographic (element-aspect) information.

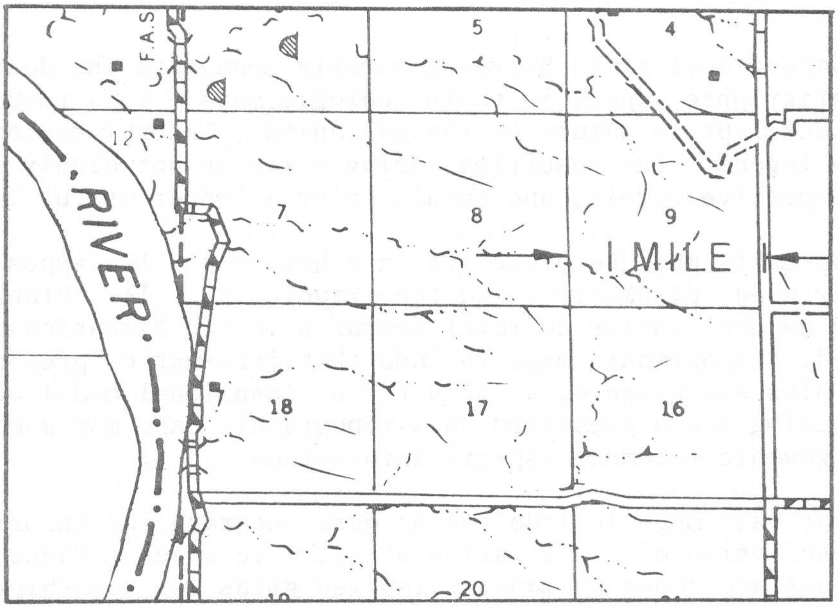
Both types of base maps include one or more geographical information systems to allow easy description of the location of specific sites. These geographical information systems are shown on maps as labeled grids for township-range-section notation, latitude and longitude, state coordinate systems, and Universal Transverse Mercator Grid System.

Base maps and, consequently, geologic maps are published at a variety of map scales. The scale of a map is the ratio of a linear distance on the map and the corresponding, actual distance on the ground. The resulting ratio can be expressed as a dimensionless ratio (1:63,360) or as a ratio of linear units of measurement (1 inch/mile or 1.58 centimeters/kilometer or 1.74 x 10^{-3} fathoms/furlong, etc.). Figure 2 illustrates this relationship for some commonly used units.

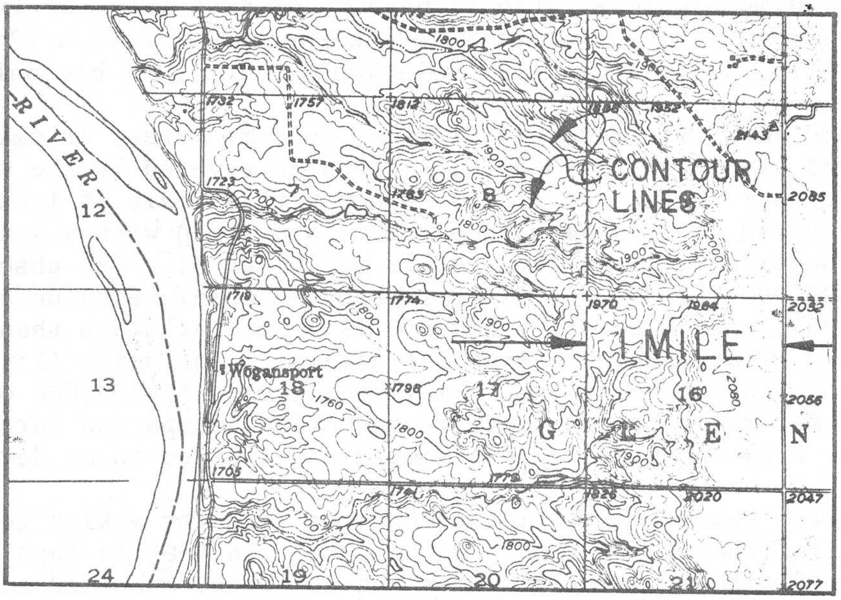
Maps are sometimes referred to as large-, intermediate-, or small-scale maps. These terms have nothing to do with the area covered by the map sheet, but instead refer only to the map scale. A map with a scale of 1:500,000 (.13 inch/mile) is referred to as a small-scale map, and a map with a scale of 1:24,000 (2.64 inches/mile) is a large-scale map (fig. 3). The absolute value of the ratio 1:500,000 (1/500,000) is less than the absolute value of the ratio 1:24,000 (1/24,000), and therefore 1:500,000 is a smaller scale than 1:24,000. Figure 4 shows the relationship between the dimensionless ratio (1:R) and selected ratios of linear dimensions. Small-scale maps (1:500,000 or .13 inch/mile) are sometimes referred to as reconnaissance maps and large-scale maps (1:24,000 or 2.64 inches/mile) are sometimes referred to as detailed maps.

Over the years, some construction techniques used for making geologic maps have changed, while others have remained the same. In the old days a geologist on horseback, armed with a geologic hammer and notebook, examined surface exposures in the area to be mapped. Today we use the same basic techniques for fieldwork, but we use a hi-tech horse (pick-up truck or 4-wheel-drive vehicle) and a drill rig, or soil probe, to eliminate our dependence on poor outcrops.

With the exception of a pair of binoculars, no remote-sensing techniques were available to our predecessors. Today, however, we have an array of remotely sensed data that may or may not be useful, depending upon the project. Some common forms of remotely sensed data are high-altitude, aerial photographs available in black and white, color, and false-color infrared; satellite images that can be displayed as selected-wave-length images or as composite-wave-length



Planimetric base map shows natural and cultural features. No indication of the Missouri River Valley is seen.



Topographic base map shows natural and cultural features plus elevation information. Contour lines connect points of equal elevation. The elevation interval between adjacent contour lines is 20 feet on this example. The Missouri River Valley is easily seen.

FIGURE 1 - BASE MAPS

$$\frac{\text{MAP DISTANCE}}{\text{GROUND DISTANCE}} = \text{MAP SCALE}$$

METRIC UNITS or ENGLISH UNITS = DIMENSIONLESS RATIO

$$\frac{(\text{cm/km})}{\text{constant 'M'}} = \frac{(\text{in/mi})}{\text{constant 'E'}} = \frac{1}{R} = 1{:}R$$

where:

$$\text{constant 'M'} = \left(\frac{1000\ \text{m}}{\text{km}}\right)\left(\frac{100\ \text{cm}}{\text{m}}\right) = 100{,}000\ \text{cm/km}$$

$$\text{constant 'E'} = \left(\frac{5280\ \text{ft}}{\text{mi}}\right)\left(\frac{12\ \text{in}}{\text{ft}}\right) = 63{,}360\ \text{in/mi}$$

Figure 2. Map distance, ground distance, ratio and map scale.

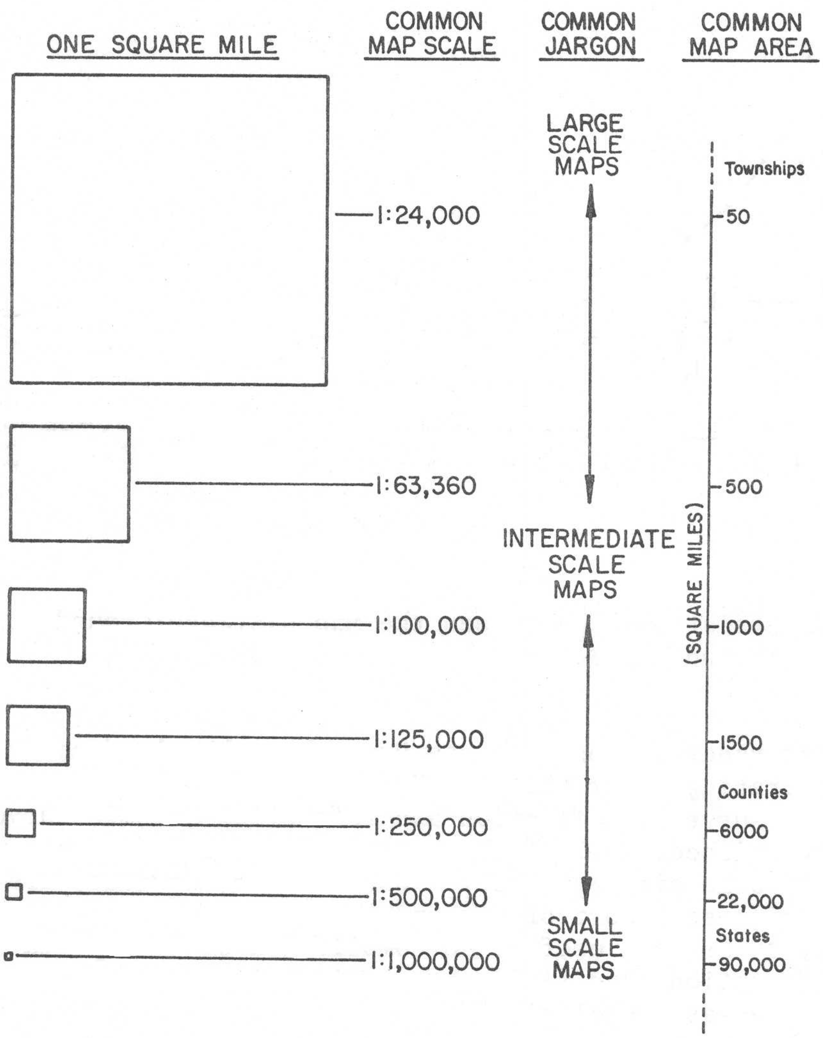


Figure 3. Comparison of common map scales.

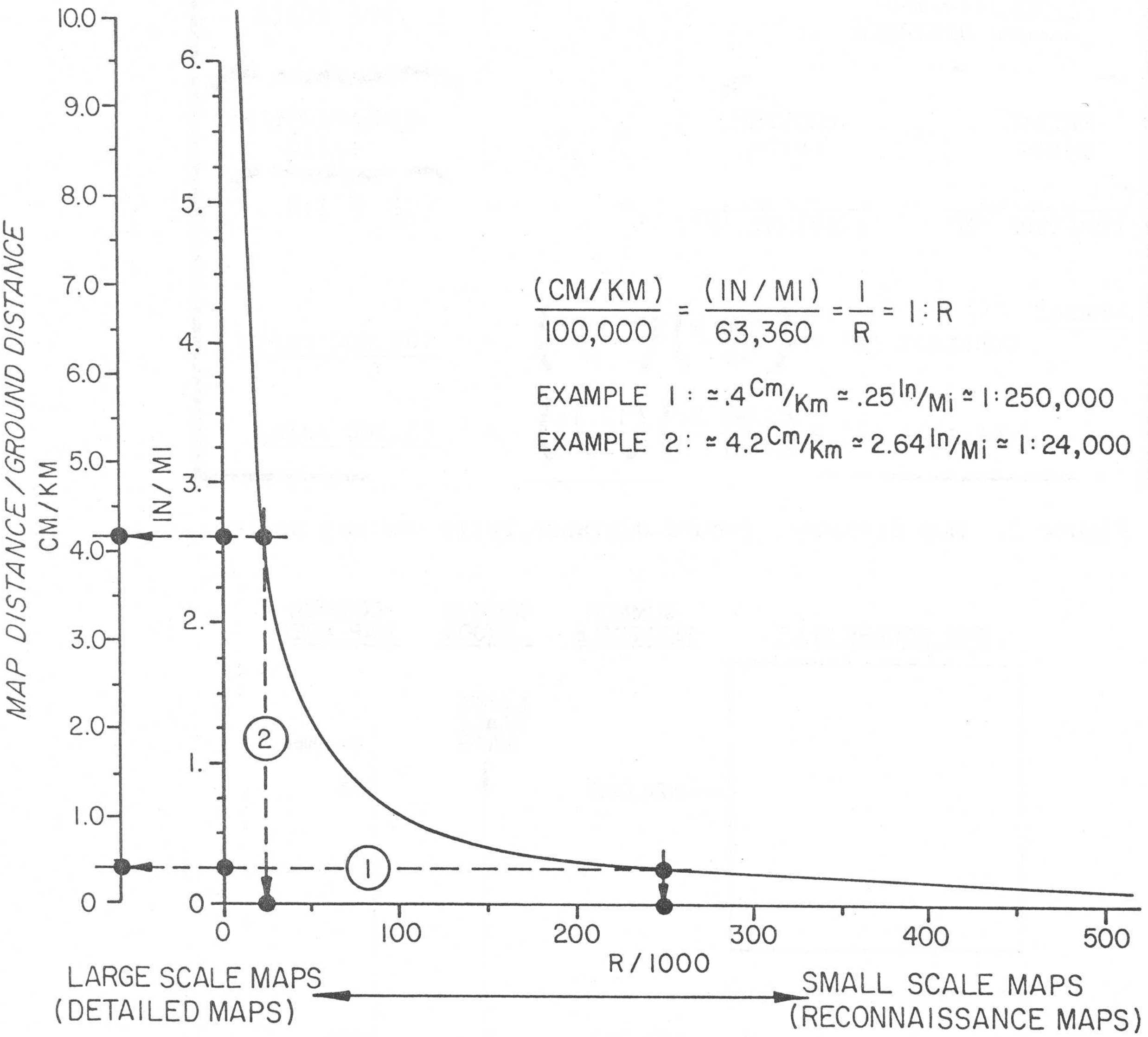


Figure 4. The relationship between the Map Distance/Ground Distance ratio and Map Scale.

images; side-looking radar images that can "see through" cloud cover and vegetation; ground penetrating radar that can "see" buried soil and rock horizons; gravity and magnetic surveys; reflection and refraction seismic surveys; and others I'm sure I've missed. All of these remotely sensed data are useful as interpretive aids in some circumstances. None of them, however, are unambiguous and all of them require some sort of "ground truthing," or calibration through field observations, to be most useful. A compilation of interpretations, remotely sensed information, and field observations is then compiled, edited, reviewed, and published as a geologic map.

Most geologic maps are produced by federal and state geological surveys, academic geologists, or geologists engaged in mineral exploration. Geologic maps are used by geologists, engineers, government agencies, private industry, and private individuals. The uses of these maps are as numerous and as varied as are the users. Basic research applications are directed mainly toward developing a better understanding of the geologic history, geologic framework, and mineral resources of the earth. Basic research generally leads to more practical applications such as the solution of problems related to the interaction of man and the environment and exploration for and exploitation of those mineral resources needed by society.

Geologic maps are a basic tool used for resource exploration and assessment. Metallic minerals such as gold and uranium have been mined in North Dakota in the past and may be mined again in the future. Construction materials like sand and gravel or cement rock are always of interest to an expanding economy. Many geologic maps have been compiled to show the distribution of oil and gas, coal, and geothermal resources in North Dakota. Surface and subsurface geologic maps will help future developers of mineral resources locate and evaluate economic deposits. These maps also aid government agencies in estimating the size of mineral and energy reserves in the state.

Environmental uses of geologic maps include providing an insight into land-use planning and evaluating the potential for natural hazards. Planners are concerned about proper waste disposal and maintaining the quality of our water resources. Geologic maps aid in choosing sites for landfills, injection wells, or toxic waste disposal sites in geologic settings that insure against pollution of potable water supplies or the degradation of other sensitive environments. The danger of natural hazards has recently become much more apparent in areas subject to landslides, volcanic activity, or areas prone to earthquakes.

North Dakota's needs for geologic maps have changed over the past twenty-five years. In the '50s and '60s there was a need for a complete set of geologic maps of the state. An intermediate scale (1:126,720 or ½ inch/mi) was selected for a series of county by county maps showing the surface geology. This statewide project is now nearing completion. There have also been two small-scale (1:500,000 or .13 inch/mile) state geologic maps made in the past twenty-five years. The first was published in 1963 by Roger B. Colton, Richard W. Lemke, and Robert M. Lindval, three U.S. Geological Survey geologists. The second was published in 1980 by Lee Clayton, then a University of North Dakota geologist. John Bluemle (1976) published a small-scale (1:1,000,000 or .06 inch/mi) geologic highway map of the state. This is a reconnaissance scale map that is useful for visualizing the overall geology of the state. In addition to these maps that show surface geology, several geologic maps showing bedrock and other buried horizons have been published.

Today our needs for geologic maps emphasize research, exploration, and exploitation of energy-related mineral resources and research related to the resulting environmental concerns. In order to satisfy these needs and incorporate new data not on the older maps the Survey is undertaking an atlas approach to the geology of the state. We have divided North Dakota into twenty-one areas, each covering about 1 degree of latitude by 1 degree of longitude. The surface and subsurface geology of the state will be plotted on these map sheets at a scale of 1:250,000 (.25 inch/mi). This is an intermediate map scale that will allow a synthesis of the various county and statewide geologic maps, and yet retain a useful level of detail. Map sheets showing surface geology, near-surface stratigraphy, bedrock geology, and mineral resources can be compiled for the twenty-one areas. Many other possibilities for special geologic maps exist and these can be generated as needed. We are now working on surface geology maps for five of the 1° x 1° areas. One of them should be finished in the summer of 1986. In addition, subsurface geology is being compiled in several of the 1° x 1° map areas in conjunction with ongoing subsurface studies.

We are enthusiastic about this new mapping atlas approach to the geology of the state and we believe that it will result in a useful compilation of geologic data at a useful map scale. Any large-scale mapping that is done in the state will likely be done in local areas for special purposes. The basic geologic data presented in the 1° x 1° series will support any such large-scale mapping efforts.

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NORTH DAKOTA OIL PRODUCTION HISTORY--SUGGESTIONS FOR FUTURE EXPLORATION

--Sid Anderson

(Editor's note: This article is essentially the text of a talk given by Sid Anderson at the North Dakota Industrial Development Association Annual Meeting in Williston on December 3, 1985.)

January 3rd, 1986, was the 35th anniversary of the recovery of the historic first pint of oil from Amerada's Clarence Iverson #1 Well. This recovery was from Devonian rocks. The official discovery date of April 4, 1951, records the date when economically producible oil was first recovered. This production was from the Silurian, not the Devonian.

The discovery period was a time of great excitement, not only in this area and across the state, but in oil circles across the country. I was a student at the University of North Dakota at that time and I recall State Geologist Wilson M. Laird's phone ringing almost constantly following the report of the discovery. A little later that April, several students, myself included, accompanied Dr. 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 in our minds as to the excitement that the Clarence Iverson discovery had generated. Dr. Laird was paged constantly and I doubt that anyone who attended the meeting left without knowing who he was. This excitement continued as Amerada followed the Iverson discovery with more discoveries on the Nesson trend, 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. There was no shortage of oil in the country in the 1950s; 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 at Mandan, 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 the other producing states, was prorated, thereby insuring that all producers received an equitable share of the market.

Producers in the early 1950s also faced another problem that may sound familiar today and about which they were often quite vocal--foreign oil. Foreign oil was slightly cheaper and it displaced domestic production.

From its beginnings in 1951, North Dakota progressed to the point where there is now, or has been, production of oil and/or gas from 649 separate pools which include 21 formations and some 30 producing horizons. Daily production exceeds 50,000 barrels of oil a day, and it is produced from formations ranging in age from the Precambrian to the Cretaceous. Oil and/or gas is currently produced in 17 of the state's 53 counties, and this production activity provides jobs as well as income for the state and the producing counties.

The Energy Information Administration, in its latest (1983) report, placed North Dakota 9th in oil production and 10th in oil reserves; 17th in gas production and 19th in gas reserves. The same EIA report credits North Dakota with a reserve of 272 million barrels of oil, about 5½ years production at the current level. Since these figures are now two years old, it would seem the state would now be credited with a reserve of 3½ years, but it is now obvious that the 273-million barrel figure is much too low; we certainly have a considerably larger reserve. Since 1951, North Dakota has produced 793 million barrels of oil. Assuming a relatively high recovery factor of 20 percent, we can calculate that approximately 4 billion barrels of oil have been discovered to date in the state. Considering all the unexplored and sparsely explored areas, an accurate resource figure would certainly be much higher. Depending on economics, a larger percentage of resources can become reserves, that is, as the economics become more favorable to the producer.

Possibilities for Future Productive Areas

Apart from the economics, which ultimately dictate whether oil companies will go to the effort of looking for oil, we can examine some parts of North Dakota's Williston Basin from a purely geologic perspective and see that many possibilities exist for significant future production. We will look at only a few of them here.

The Mississippian Madison Group accounts for the largest share of North Dakota's oil and gas production. However, Pre-Mississippian production is well established on and to the south and west of the Nesson Anticline, and in this area oil has been produced from Cambrian, Ordovician, Silurian, and Devonian reservoirs. Many more fields will be found from these horizons as well as from the Mississippian rocks.

In the area northeast of the Nesson Anticline, only one small field, the Newporte Field, plus a single well (the Shell-Golden Well, which never received field status) have produced from Pre-Mississippian rocks. The Newporte Field had wells completed in the Pre-Cambrian, the Cambrian Deadwood Formation, and the Ordovician Winnipeg Formation. The Shell-Golden Well, which was located some miles south of Newporte, was completed in the Devonian Winnipegosis Formation.

It is difficult to believe that all of the Pre-Mississippian oil and gas in North Dakota is located on the Nesson Anticline or to the southwest of it. It is quite likely that deeper production will eventually become significant in the area north and east of the Nesson as well and that more Mississippian production will also be established in that area.

Another area where exploration will almost surely prove fruitful is north-central North Dakota. A study of a Pre-Mesozoic subcrop map (a map showing what the geology would look like if all the sediments from the Triassic Spearfish to the surface were stripped off) will show that the strike of the beds has been interrupted in the center of Bottineau County and also some distance to the south. This is in the area where two Pre-Cambrian Provinces, the Churchill and the Superior come together and it is also an area of Devonian salt dissolution. When the buried salt was dissolved, the overlying beds collapsed, thus creating the interruption of the strike of the beds and possibly creating structural traps that may contain oil and gas. This collapse appears to have been multistage affecting primarily Devonian and Mississippian beds.

Basement movement may also have occurred along the Pre-Cambrian Province boundary initiating the salt dissolution and this movement could have created structural traps in the Pre-Devonian rocks. The question is: Did oil and gas migrate into them? Only drilling will tell.

In addition, the Spearfish production in north-central North Dakota will continue to grow. As the current play continues in the area, more will be learned about completion techniques and about the nature of the reservoirs.

To the north and east of this area in Manitoba, the Mississippian Lodgepole Formation accounts for most of that province's production. Thus, it seems reasonable to assume that the Lodgepole may be productive in some of the adjacent areas in North Dakota.

Returning to the deeper part of the basin, it is interesting to consider some statistics on deep drilling.

During the period from 1975-1983 (9 years), 763 wells were drilled to, or deeper than, the Ordovician Red River Formation. Of these, 243 produce from the Red River or deeper horizons. Eighty-three of these wells have up-hole potential (produce from or may be capable of producing from shallower horizons). Another 190 up-hole discoveries were made; these wells have no Red River production. Thus, 25 percent of the wells produce from zones other than the Red River Formation and, of the 763 tests drilled to the Red River, 57 percent produce somewhere in the section.

Summary

One of the challenges we face today is to determine how much of the state's oil and gas resources can be converted to reserves and ultimately to production. Another challenge is to attempt to stabilize the oil and gas industry in the state in order to minimize, as much as possible, the boom and bust cycles that have characterized the industry. Of course, many of the factors involved in these cycles are beyond the control of the state or federal government or any regulatory agency.

Recently, a long-time friend of mine, Bruno Hanson, who is currently President-elect of the American Association of Petroleum Geologists and a native North Dakotan, quoted some disturbing statistics about the number of barrels of oil discovered per foot of drilling nationally.

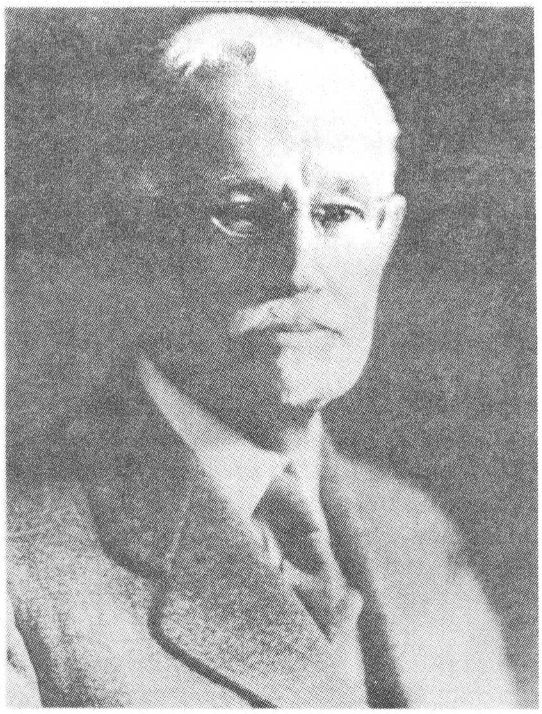
In 1950, 300 barrels of oil were discovered for each foot of drilling.

In 1970, the figure was 80 barrels per foot.

In 1980, the figure was only 40 barrels per foot.

This shows that, even with better information and more sophisticated techniques, oil is becoming increasingly more difficult and costly to find. Even so, when wildcat drilling increases, so do the discoveries. Therefore, anything that can be done to encourage the oil and gas industry to explore in North Dakota will be reflected in increased production, which will certainly be a boost to the state's economy. The industry should also be encouraged in its attempts to implement secondary, tertiary, and enhanced recovery programs.

One of the more promising methods we have seen recently for encouraging exploration for oil and gas is a program initiated by the Saskatchewan government. Saskatchewan's situation is somewhat different than North Dakota's in that there is much crown acreage (meaning that a large share of the minerals are owned by the province). The fact that it controls such large areas of minerals enabled Saskatchewan to institute a royalty holiday on new wells. In North Dakota, generally only sections 16 and 36 in each township are owned by the state. In North Dakota a royalty holiday would not be as effective as it was in Saskatchewan, but a tax holiday could be granted on new wells. This could possibly be accomplished by rescinding the 6.5% extraction tax for a specified number of months. Taxes on existing wells would not be affected. After a specified number of months had elapsed, the tax would be placed on the new wells. Producers would then be able to recover some of their costs faster, encouraging more drilling--and, in particular, wildcat drilling.



"ERUPTIONS" ON BLACK BUTTE (SLIDE BUTTE) --Ed Murphy

AUTHOR'S NOTE: Dr. Arthur Gray Leonard, North Dakota State Geologist and Chairman of the Geology Department at the University of North Dakota, died on December 17, 1932. This fall, I was going through some of his field notes and came across the last article that he wrote before his death. It was published by the University of North Dakota Quarterly Journal and is entitled Black Butte and its "Eruption" (Nos. 3 & 4, Vol. 23, p. 160-162). The article aroused my curiosity and I traveled to Black Butte this fall to study the area and try to determine what actually happened there over fifty years ago. I was fortunate to find an eyewitness and one of the central personalities in the controversy, Mrs. Ellen Roberts Pope (Mrs. Ted Pope). She graciously provided me with both information and personal insight into the event. In addition, I researched several articles covering this story from a number of North Dakota newspapers. The articles are stored on microfilm at the North Dakota Heritage Center.

I thank Mrs. Ted Pope for her valuable assistance with this article and Mr. Stanley Pope for allowing me access to Black and Slide Buttes.

Black Butte is located in east-central Slope County in southwestern North Dakota (fig. 1). It is labeled H. T. Butte on some earlier maps and for a long time it was mistakenly identified as the highest point in North Dakota (the highest point is now known to be White Butte [3506 feet above sea level] located 6 miles to the east--Black Butte reaches a height of 3465 feet above sea level).

Two smaller buttes are located to the southeast of Black Butte. In recent years, they have come to be known as Tepee Butte and Slide Butte (fig. 2). However, in the early 1930s, all three features were jointly referred to as "Black Butte." It is Slide Butte that was the site of the controversial "eruptions."

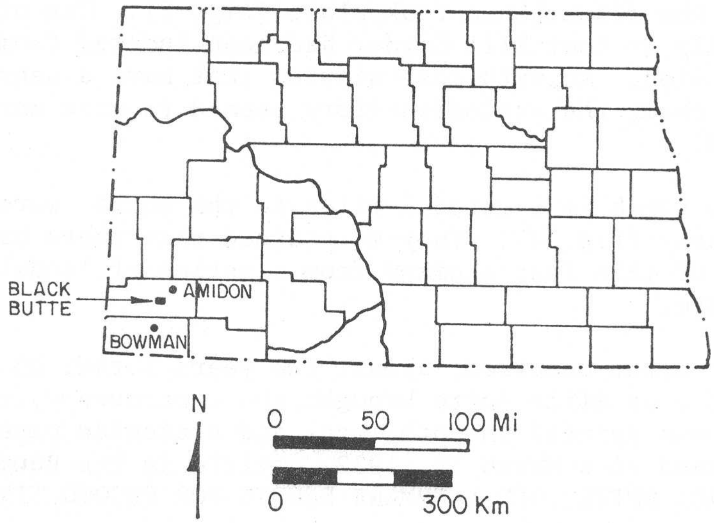


Figure 1. Location of Black Butte in southwestern North Dakota.

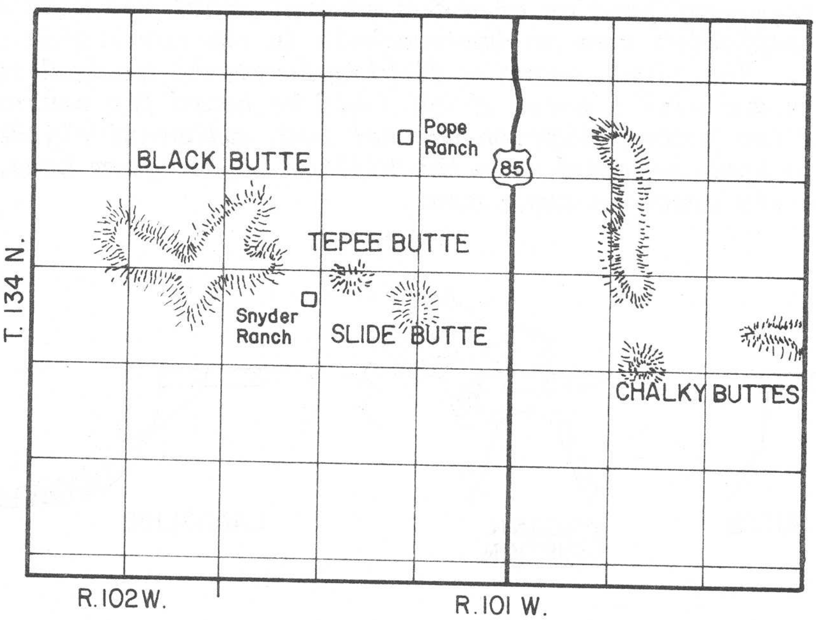


Figure 2. The locations of Black Butte, Tepee Butte, and Slide Butte in southwestern North Dakota.

The peaceful calm of an autumn morning in 1930 was suddenly broken by the crash of rock and sediment, as a cloud of dust rose and hung over a small butte just east of Black Butte. The cause of the crash became a local controversy. Was Black Butte a long dormant volcano erupting now for the first time in ages? Or was the crash simply a rockslide? The disturbance resulted in a local controversy and split area ranchers into opposing factions; those who favored a volcanism explanation and those who thought it had been a landslide (fig. 3). Both sides of the argument had strong believers and the controversy served to alienate neighbors for years.

William Snyder's homestead, situated on the southeast edge of Black Butte, was closest to where the disturbance took place (fig. 2). One of the stories that had spread locally is that Bill Snyder had been knocked from his bed by the force of an explosion. As with most stories that have a sense of adventure or controversy about them, the explosion story seemed to grow more sensational each time it was told.

The Popes, whose ranch is located 2 miles to the north, were on the other side of this controversy (fig. 2). They maintained that there had not been an explosion and all of this fuss stemmed from a series of landslides that occurred on Slide Butte.

A second similar event occurred, almost two years later, on March 26, 1932. This second disturbance on Slide Butte brought the controversy to a head and the explosion theory was printed in both local and statewide papers. The first written account appeared in a March 31, 1932, article in the Bowman County Pioneer entitled "BLACK BUTTE, OLD LANDMARK ERUPTS FOR SECOND TIME":

> *Another eruption on the sides of Black Butte....is reported to have occurred Saturday, March 26.*
>
> *Black Butte----suffered an eruption several years ago when an inexplicable explosion tore an immense hole in the north side of the historic hill. The first eruption displaced several hundred tons of dirt and rocks and with a noise which could be heard for several miles. The extent of the latest eruption has not been authoratively determined but is said to have occurred near the William Snyder farm home, at the same place as the previous explosion.*

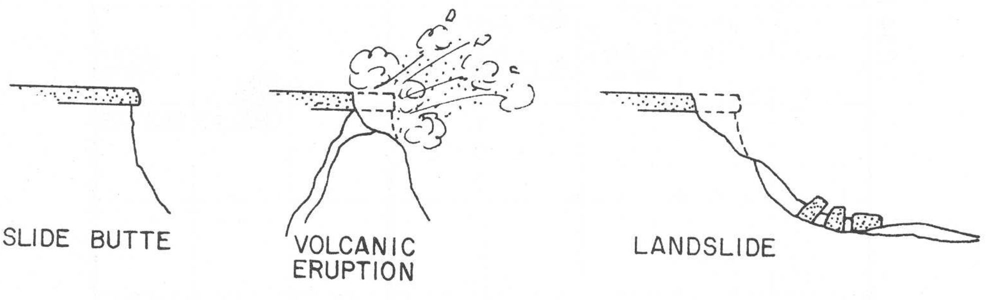


Figure 3. The controversy surrounding the "disturbances" of Black Butte (Slide Butte) centered around these two explanations.

The strange eruptions of the butte have caused much speculation among residents of this part of the state and others who have viewed the crater left by the original explosion. Geologists who visited the crater were unable to provide a definite explanation and the theory that the eruptions are due to gas pockets in underground recesses of the vast hill is said to be discredited by other geological signs. Interest in the strange antics of the butte is bound to be revived as a result of the latest eruption and while many persons were inclined to regard the first eruption as a "freak" the recent occurrence may mean that forces are at work within the great hill which are blowing it to pieces in a series of mysterious explosions....

This account was further sensationalized in an April 5, 1932, Mandan Pioneer front-page article under the headings "GAS POCKET MIGHT HAVE CAUSED BUTTE ERUPTION--TONS OF ROCKS, DIRT BLOWN OUT OF CRATER--SIMILAR BLAST OCCURRED SEVERAL YEARS AGO--INVESTIGATED AT THE TIME":

Black Butte, the bad boy of North Dakota buttes, has erupted again.

Several tons of rock, emitted from the immense hill, lay at the bottom of the butte today after an explosion which was heard for many miles.

Geologists were unable to definitely explain the phenomenon but advanced the theory the eruption was caused by gas pockets in underground recesses of the butte.

The eruption was similar to one of several years ago, when tons of rock and dirt shot out of the north side of the butte and left a huge crater. The latest eruption was from this crater....

The latest eruption lasted only a few minutes, ending before nearby farmers arrived to investigate the cause of the explosion.

On April 21, 1932, the Slope County Post printed a front-page story disclaiming the explosion theory. The article was headlined "SECRET OF BLACK BUTTE'S ANTICS IS NOW DISCLOSED." It reprinted the March 31 Bowman Pioneer article along with a rebuttal letter that Mrs. Ellen Pope had sent to the Minneapolis Journal.

Doubtless the publicity given the recent so-called eruption of Black Butte may be the means of stimulating tourist trade in this section....

Interest throughout the state has been aroused by the headlines of an article in the Mandan Pioneer of April 1. The account also appeared in the Fargo Forum and Minneapolis Journal. The Post did not make any comment on the account earlier, as residents in the immediate vicinity seemed inclined to regard the matter lightly. Inquiries from people who have visited this section lately from other parts of the state indicate that it received considerable attention.

The April 12 issue of the Minneapolis Journal under the heading of "Correction! Correction!" printed a letter from Mrs. Ted Pope. The Pope home is located approximately two miles north of the butte and the slide is plainly visible from the house.

The article in the Journal of April 5, headed "Butte in North Dakota Erupts Again," published no doubt in good faith, is just plain bunk. This disturbance is nothing more nor less than a rock slide which has been moving slowly for about twenty months. Nor is this the first time that rock slides have occurred on this little butte, which is about two miles east of Black Butte. They have been occurring for hundreds of years. We who have lived here for more than forty years and have seen slides here before, regard it as just a plain slide, and like others who live near this little butte and see it 365 days in the year, are not puzzled, have heard no explosions, have found no hot or even warm rocks, gas, or anything else out of the ordinary.

This is no puzzle to geologists who have been to our place several times, though not in the interest of the slide....

The cause of this slide is a rotten, crumbly sandstone cap rock underlain by a very slick, water-bearing gumbo. When enough of this broken stone falls into the little basin which is some 200 feet across and about 25 feet deep, it just naturally slides out and down the side of the butte, very slowly and along with the wet gumbo and water....

Dr. Leonard did some geologic field work during the 1910s and '20s around the Black Butte and Chalky Butte areas and so he was familiar with the geology of this area.

Dr. Leonard released a statement about the disturbance on April 5. It was printed in the April 28, 1932, issue of the Bowman County Pioneer under the heading "STATE GEOLOGIST SAYS GAS POCKETS CAUSE BLACK BUTTE QUAKES":

The so-called eruption of Black Butte in the western part of the state could only have been caused by the explosion of a gas pocket, Dr. A. G. Leonard, head of the University of North Dakota geology department and state geologist, said. He has visited the scene of the eruption many times. "Residents of the state have nothing to fear that there is a volcano in their midst, for the explosion could have nothing to do with volcanic tendencies," he stated. "The formation and ignition of a gas pocket is the only cause." Dr. Leonard pointed out that the butte is....capped with a thick layer of sandstone.... An underground explosion naturally would break off great masses of rock, he said.

Dr. Leonard returned to the Black Butte area to investigate during the summer of 1932. Slide Butte was plainly visible from the front yard of the Roberts' homestead. Mrs. Pope remembers that Dr. Leonard stood in the yard and told her parents that he could plainly see from there that all of this excitement was over a simple landslide.

Dr. Leonard's article on this investigation is entitled BLACK BUTTE AND ITS "ERUPTION" and was published by the University of North Dakota Quarterly shortly after his death (Vol. 23, Nos. 2 & 3, p. 160-162):

The reported recent "eruption" on Black Butte, the second which has occurred of late years, has aroused considerable interest in the state and has called attention to one of the most prominent buttes in western North Dakota....

Black Butte is grassy and flat topped, about two miles long east and west and one-quarter to three-quarters of a mile wide. It is capped by a thick sandstone which in most places forms a cliff extending almost around the butte....

....Near its base is a bed of coal five to six feet thick.

It is true that large numbers of conical buttes are found in the western part of the state, and many of these are capped with scoria or clinker, some of this material having been fused and looking like slag. The clinker, however, is not a volcanic rock but is a clay which has been burned by the heat of the burning lignite beds. The clays over the lignite are changed by the heat, the iron in them is oxidized, and they are affected much as bricks in a kiln. If they contain substances which render them readily fusible the clay will actually fuse and produce a slag-like material. It is the presence of this clinker, or scoria, capping the conical buttes which has doubtless given rise to the belief that these buttes are of volcanic origin.

The lignite beds have burned out extensively, doubtless ignited by spontaneous combustion in most cases, and have given rise to vast quantities of this pink clinker. The "eruption" might possibly have been caused by an explosion of gas which had accumulated in rocks below the surface though it is difficult to explain why the gas should have exploded. It might be that the lignite bed near the base of the butte became ignited by spontaneous combustion and the heat of the burning coal in turn ignited the gas.

Regarding the reported "explosions" on Black Butte, it may be said that they could not be of volcanic origin. There is no evidence that there have ever been any volcanoes in North Dakota, and it is certain there are none today.

When I first read Dr. Leonard's article, I considered the time period and speculated that the "eruptions" may actually have been moonshine stills exploding. Prohibition was repealed in North Dakota in 1934.

When I measured the geologic section at Black Butte and Slide Butte this fall, I also noted the lignite at the base of the butte that Dr. Leonard discusses (fig. 4). Methane gas has long been known to be present in some lignites in North Dakota. Although it is not impossible, it seems highly unlikely that methane gas from this sequence of lignites could have migrated vertically through 240 feet of sediment and collected in the sandstone cap of these buttes.

Water is commonly the catalyst behind a landslide or slump. The precipitation records for 1930 show that unusually high rainfall occurred during the month of August when the disturbance took place (fig. 5).

Precipitation amounts were not unusually high in March of 1932 when the second "disturbance" occurred (fig. 5). However, the following March 3 article from the Slope County Post reveals that a large quantity of water was available because of rapid snow melt:

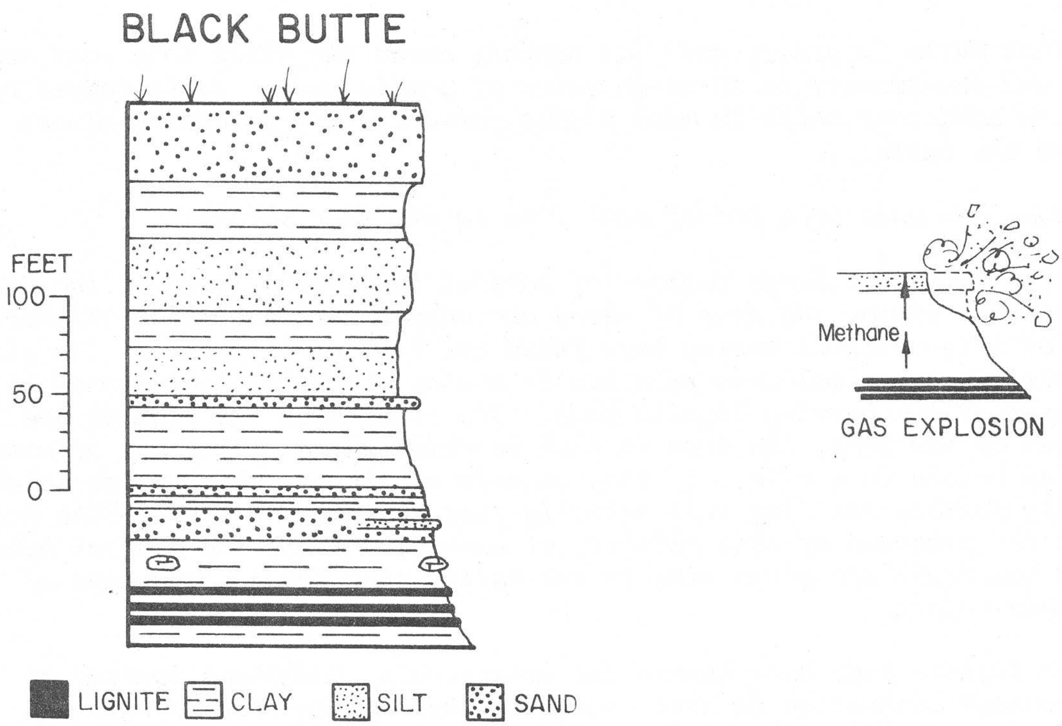
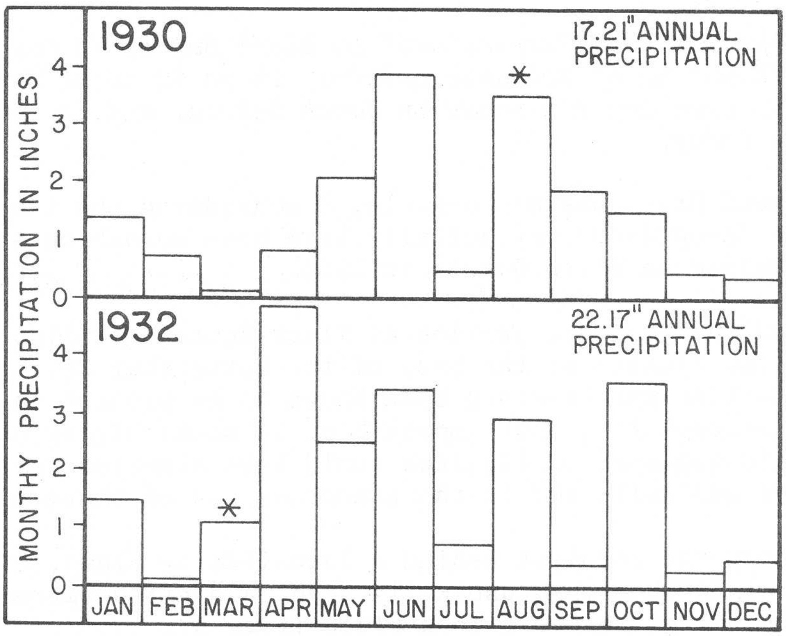


Figure 4. The geologic section of Black Butte and Slide Butte and Dr. Leonard's explanation for the "eruption."



*Month "Disturbance" Occurred

Figure 5. The 1930 "disturbance" was preceded by heavy amounts of precipitation. The 1932 "disturbance" was not preceded by heavy precipitation but occurred after a rapid snow melt (see text).

Warm weather from Wednesday morning until Saturday of last week coupled with gentle Chinook winds from the southwest gently removed most of the snow of winter from the landscape in southwestern North Dakota.

Many local people declared they had never seen the snow go so quickly following a cold winter when there was a plentiful supply of snow....

Four days from winter there was spring with water running freely in the fields to the river where bottom ice raised and slipped down stream....

Aerial photographs of Black, Tepee, and Slide Buttes taken in 1951, 1957, and 1980 show that slumps, flows, and rockfalls are quite prevalent and have occurred along most of the edges of these buttes. These photographs clearly show a large area of mass movement on the north face of Slide Butte. This particular type of movement would be classified as a debris flow because flow characteristics are evident in these photographs. The large bowl-shaped depression along the edge of the butte, referred to as the "crater" in the newspaper articles, has resulted from the removal of sediment from the head of the flow and not from an explosion.

The geologic data that I collected in the Black Butte area has led me to conclude that these "disturbances" were a series of large debris flows. This concurs with the eyewitness account of Mrs. Ellen Pope.

What has puzzled me is why Dr. Leonard did not simply point out that this incident could have been explained by a series of landslides. He did not mention this explanation in either his press release or his article. The Black Butte (Slide Butte) incident received widespread attention as demonstrated by the newspaper articles. It was also the source of a heated local argument, one that Mrs. Pope remembers resulted in some neighbors, on opposite sides of the argument, not speaking to one another for many years. Dr. Leonard was certainly aware of all of this. His press release and article did point out, unequivocally, that these disturbances could not have been caused by volcanic activity. This revelation, no doubt, did serve to calm some of the people. However, he may have felt that to publicly denounce the idea that any explosions occurred would have needlessly discredited and ridiculed those who believed they had taken place. (This concurs with his reputation around campus of being first and foremost a gentleman.) Therefore, he proposed the methane gas theory to explain how any explosions could have occurred.

Of course, we will never know whether this explanation is right or not, but it is substantiated by Mrs. Pope's recollections of Dr. Leonard telling her and her parents that the "disturbance" was nothing more than an obvious landslide.

The fifty-four scientific articles that were authored by Dr. Leonard during his lifetime are testament to his geologic knowledge and abilities. Perhaps this incident demonstrates that he also had a deep concern for human feelings and a sense of diplomacy.

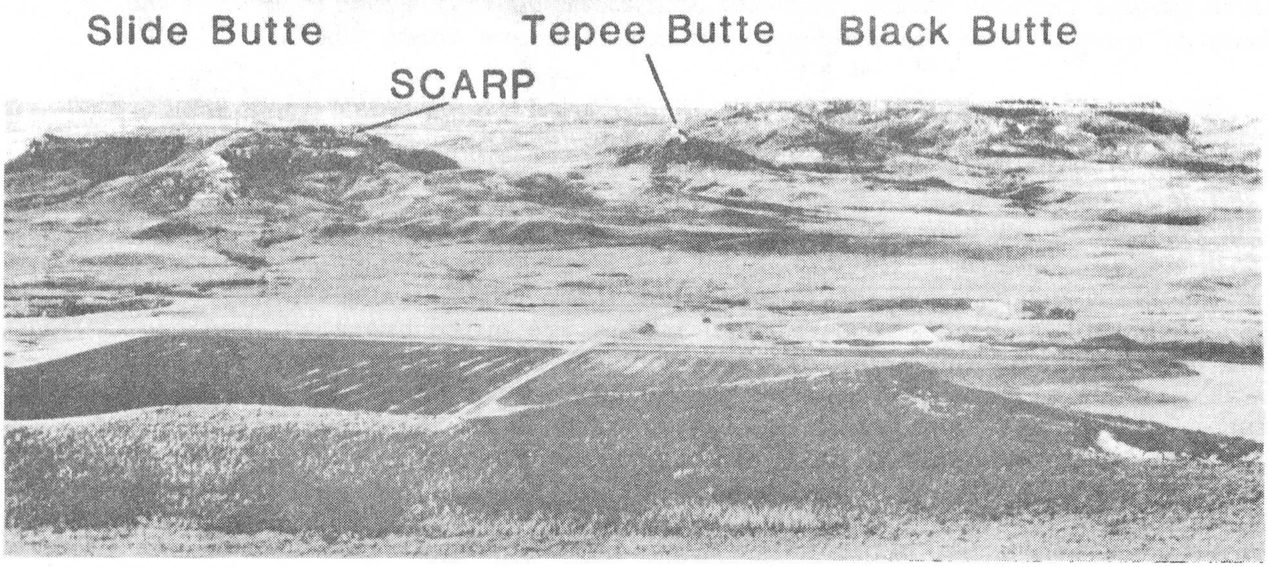


Figure 6. View to the west over Slide Butte, Tepee Butte, and Black Butte. Photo was taken from the top of Chalky Buttes. A portion of the west edge of the scarp (the "crater"), that was created by the early 1930's debris flow, is clearly visible.

OIL & GAS ACTIVITY

--John Bluemle

For the past several years, we have provided a rundown of the previous year's oil and gas activities in the June Newsletter. This has included a listing of discovery wells along with data on the wildcat and development wells drilled, success ratios, production figures, numbers of rigs operating, and other pertinent information. We expect to continue to provide this information in the June Newsletter, but I'm going to include some preliminary 1985 data on discovery wells and permitting in this issue, even though all the information is not yet available.

Table 1 lists the discovery wells drilled in North Dakota through the first 11 months of 1985 along with some completion data. Please let me know if you note any errors or omissions in the list. I realize some changes will be necessary as additional 1985 discoveries are reported and spaced early in 1986. During 1985, the Oil and Gas Division of the Industrial Commission issued a total of 550 permits to drill oil or gas wells (all types; exploratory, development, outpost, and extension). These can be categorized as follows: 135 for exploratory (wildcat) wells, 420 for development, outpost, and extension wells. In 1984, a total of 724 drilling permits were issued (183 for wildcat wells, 541 for development, outpost, and extension wells).

It now appears that North Dakota's oil production in 1985 will be down more than a million barrels from the 52.6 million barrels produced in 1984, our highest production year. Production in 1985 should be about 51.4 million barrels, still the second highest annual figure and ahead of the 1983 figure of 50.7 million barrels. Daily production figures in 1985 have tended to drop during the year, averaging about 141,800 bopd during the first six months and about 139,600 bopd during the second half of 1985.

During 1985, a total of 480 industry representatives, consultants, and others utilized our core library facilities here in Grand Forks, examining 23,455 feet of oil well core and thousands of feet of well cuttings.

Currently (late December), 45 oil rigs are drilling in North Dakota. A year ago at this time, 50 rigs were operating. The average number of oil rigs operating in North Dakota during 1985 was about 38, with a low of about 25 in March and April, and a high over 50 in November. Last year (1984) we had an average of 51 rigs operating in North Dakota.

We will try to provide a more complete summary of oil and gas production, drilling, and other statistics in the June Newsletter.

COUNTY FILE NO. ORDER NO.	COMP. DATE	OPERATOR, WELL NAME, LOCATION	FIELD -POOL (NUMBER OF WELLS CURRENTLY IN POOL)	SPACING	TOTAL DEPTH	INTERVAL PERFORATED	INIT. PROD. (CURRENT DAILY PROD. -BBLS. OIL)	GRAV.	GOR	WATER
BILLINGS 11344 3957	02MAR85	CANTERRA PETROLEUM, INC. BN #6-31 SENW SEC. 31-140-101	MARQUIS -DD (1)	160	12175	10616-10634	211 (52)	40.9	844.00	7.00 B
BILLINGS 11501 4071	09JUL85	CANTERRA PETROLEUM, INC. US 12-30 NWSW SEC. 30-140-101	MARQUIS -MMFB (1)	160	10980	9306- 9320	85 (32)	40.0	600.00	77.00 B
BOTTINEAU 11398 4088	21JUN85	GENERAL ATLANTIC ENERGY CORP. BLUE STREAK 21-26 NENW SEC. 26-163- 81	HULSE COULEE -MMRM (1)	40	3525	3469- 3495	5 (3)	.0	.00	10.00 B
BOTTINEAU 11400 4069	02MAY85	GENERAL ATLANTIC ENERGY CORP. MAD MAX 1 SENE SEC. 21-161- 81	MAD MAX -MM (1)	40	4150	4054- 4062	16 (-)	28.0	.00	10.00 B
BOTTINEAU 11448 4022	12APR85	VALERO PRODUCING CO. TREND-SKAADEN 43-28 NESE SEC. 28-163- 77	HARAM -MMT (2)	40	4100	3017- 3021	72 (83)	32.3	.00	278.00 B
BOTTINEAU 11804 4207	0000085	GEORESOURCES, INC. ANDERSON ET AL 1-24 NWSE SEC. 24-163- 79	LEONARD -MM (1)							
BOWMAN 11454 4123	28JUN85	QUADRA OIL & GAS, INC. PALCZEWSKI 34-11 NESW SEC. 34-129-100	SOUTH GOLD -ORR (1)	320	9380	9147- 9152	105 (18)	39.5	.01	397.00 B
BURKE 11161 3945	04JAN85	TYREX OIL CO. LEICHTNAM 43-30 NESE SEC. 30-161- 89	SHOCKLEY -MMBB (2)	80	6420	6275- 6290	68 (17)	30.0	.00	78.00 B
BURKE 11616 4156	0000085	GENERAL ATLANTIC ENERGY CORP. GAEC PICKETT 34-23 SWSE SEC. 23-162- 90	PICKETT -MM (2)		6200					
BURKE 11691 4167	00AUG85	CENTURY OIL & GAS CORP. ANDERSON 24-5 SWNW SEC. 24-161- 91	CLAYTON -MM (1)	80	0	0- 0	0 (*)	.0	.00	.00 X
DIVIDE 10126 4153	13JUL85	HNG OIL CO. ANDERSON-STATE 30 #1 NESW SEC. 30-161-102	DANEVILLE -DW (1)	160	11366	10048-10057	143 (16)	39.0	.00	175.00 B
DIVIDE 10607 4178	10SEP85	TXP OPERATING COMPANY TXPOC-NORRIS #1-25 SESE SEC. 25-162-102	CLINTON -OG (1)	160	11230	10832-10854	208 (161)	38.6	817.00	.00 X
DIVIDE 10904 3943	23JAN85	FULTON PRODUCING CO. BERCO-HANISCH 1-25 SESW SEC. 25-161- 98	MORAINE -DD (1)	160	10584	9336- 9346	180 (114)	38.0	278.00	5.00 B
DIVIDE 11235 3969	15MAR85	TEXACO INC. CLARA KOSTECK NCT-1 #1 SESW SEC. 7-163- 95	KIMBERLY -DD (1)	160	10775	8151- 8162	314 (-)	39.8	223.00	45.00 B

COUNTY FILE NO. ORDER NO.	COMP. DATE	OPERATOR, WELL NAME, LOCATION	FIELD -POOL (NUMBER OF WELLS CURRENTLY IN POOL)	SPACING	TOTAL DEPTH	INTERVAL PERFORATED	INIT. PROD. (CURRENT DAILY PROD. -BBLS. OIL)	GRAV.	GOR	WATER
DIVIDE 11284 3941	05FEB85	LOUISIANA LAND & EXPLORATION CO. PEDERSON 11-18 #1 NWNW SEC. 18-163- 99	WEST AMBROSE -DD (1)	160	10983	8364- 8373	77 (28)	37.0	610.00	170.00 B
DIVIDE 11504 4230	01NOV85	CHIEFTAIN INTERNATIONAL, INC. ARCHIE S. PETERSON 1 SWNW SEC. 31-163- 97	FILLMORE -DD (*)	160	9901	8467- 8476	50 (*)	.0	832.00	188.00 B
DIVIDE 11589 4206	07SEP85	LOUISIANA LAND & EXPLORATION CO. HEUER 41-20 NENE SEC. 20-161- 95	SADLER -MMR (1)	160	10632	7428- 7514	52 (*)	35.4	1155.00	221.00 B
DUNN 11543 4182	16AUG85	SUN EXPLORATION & PRODUCTION CO. HIBL 1 NWNW SEC. 7-141- 97	BARTA -MMFB (1)	160	13160	9562- 9565	312 (124)	40.5	1000.00	44.00 B
MC KENZIE 7823 4168	03JUL85	AMOCO PROD CO FEDERAL "C" #1 NENE SEC. 4-146-100	TRAILSIDE -MMCN (1)	160	11430	9362- 9370	115 (109)	.0	.00	30.00 B
MC KENZIE 8439 4035	21MAR85	TRAVERSE OIL COMPANY NYGAARD #1-19 SESW SEC. 19-151-100	PATENT GATE -MMCN (1)	160	13956	9562- 9593	33 (19)	40.0	1515.00	72.00 B
MC KENZIE 9057 4065	05MAY85	TEXACO, INC. TEXACO-PHILLIPS ET AL RIGGS #10-31 NWSE SEC. 31-151- 95	BLUE BUTTES -SOS (1)	320	14094	13540-13549	731 (578)	52.2	2549.00	8.00 B
MC KENZIE 11093 4180	18AUG85	GETTY OIL CO. COVERED BRIDGE "A" 10-6 SENW SEC. 10-146-102	COVERED BRIDGE -MBK (1)	160	11266	10632-10655	36 (26)	41.1	1250.00	4.00 B
MC KENZIE 11110 4100	17JAN85	AMERADA HESS CORP. SWENSON 20-22 SENW SEC. 20-152- 95	HAWKEYE -ORR (1)	160	14900	13869-13934	148 (74)	57.2	6615.00	30.00 B
MC KENZIE 11198 3922	30JAN85	TEXACO INC. OSCAR JONSRUD 1 NENW SEC. 5-151- 96	EDGE -SI (1)	320	14025	12291-12322	1082 (140)	49.2	2218.00	243.00 B
MC KENZIE 6532 4233	14NOV85	PENNZOIL COMPANY DEPCO #1-15BN SWSE SEC. 15-147-101	BULL MOOSE -DD (1)	320	13225	11187-11194	280 (-)	42.7	69511.00	.00 X
MC KENZIE 11204 3923	05JAN85	TEXACO INC. TEXACO EXCHANGE OIL & GAS 1 SENW SEC. 17-151- 96	DIMMICK LAKE -SI (2)	320	14100	12382-12431	912 (56)	46.1	1644.00	48.00 B
MC KENZIE 11214 3944	05FEB85	DEPCO, INC. NORTH BRANCH 22-35 SENW SEC. 35-148-102	NORTH BRANCH -DD (2)	320	13435	11387-11394	212 (241)	41.0	840.00	.00 X
MC KENZIE 11313 4155	16MAY85	MILESTONE PETROLEUM, INC. FEDERAL HEART 12-6 NWSW SEC. 6-146- 99	WEST BUTTE -ORR (*)	320	13852	13578-13587	31 (*)	54.6	32490.00	110.00 B
MC KENZIE 11313 4155	22JUL85	MILESTONE PETROLEUM, INC. FEDERAL HEART 12-6 NWSW SEC. 6-146- 99	WEST BUTTE -MMCN (1)	160	13852	9654- 9664	239 (67)	43.1	836.00	232.00 B
MC KENZIE 11401 4126	18JUN85	TEXACO INC. HARLEY OLSON #1 NESW SEC. 5-151- 96	EDGE -MMCN (1)	320	12450	9136- 9172	19 (68)	44.0	1157.00	70.00 B
MC KENZIE 11549 4181	21SEP85	BASIC EARTH SCIENCE SYSTEMS, INC. ROSEBUD 22-11 SENW SEC. 11-153-101	BAKER -ORR (1)	320	13525	13253-13269	325 (192)	46.0	2.00	.00 X
STARK 11298 3940	22JAN85	HRUBERTZ OIL CO. DECKER 1-31 NENW SEC. 31-140- 95	DAVIS BUTTES -PNT (2)	160	7925	7808- 7814	122 (38)	31.3	.00	9.00 B
WILLIAMS 8441 4017	03MAR85	MAPCO PRODUCTION COMPANY TOFTE #1-1 NENE SEC. 1-153-100	CRAZY MAN CREEK -MMCN (3)	160	14377	9760- 9788	134 (22)	38.1	784.00	7.00 B

COUNTY FILE NO. ORDER NO.	COMP. DATE	OPERATOR, WELL NAME, LOCATION	FIELD -POOL (NUMBER OF WELLS CURRENTLY IN POOL)	SPACING	TOTAL DEPTH	INTERVAL PERFORATED	INIT. PROD. (CURRENT DAILY PROD. -BBLS. OIL)	GRAV.	GOR	WATER
WILLIAMS 8861 (*)	10SEP85	AL-AQUITAINE EXPL. LTD. STONEY CREEK AL-AQUITAINE 31-156-99 HIEPLER 1-31 SENW SEC. 31-156- 99	WILDCAT -MMFAR (*)	(*)	14182	9420- 9440	515 (623)	37.0	.00	.00 X
WILLIAMS 10676 4054	17MAY85	FULTON PRODUCING COMPANY UNION-MCGINNITY #1-6 SENW SEC. 6-158- 95	TEMPLE -DD (2)	160	12250	10053-10287	110 (8)	38.8	455.00	157.00 B
WILLIAMS 11137 4133	01JUL85	GULF OIL CORP. PEDERSON 5-24-4C NWSW SEC. 24-153-102	HARDSCRABBLE -DD (3)	(*)	11200	11032-11050	191 (391)	38.0	746.00	.00 X
WILLIAMS 11346 4056	25MAR85	SUPERIOR OIL COMPANY PETERSON FLB #24-33 NWSE SEC. 24-155-101	TANDY -ORR (1)	160	13720	13493-13552	60 (56)	47.2	633.00	61.00 B
WILLIAMS 11420 4031	16APR85	HARPER OIL CO. HANSEN 4-2 NWNW SEC. 2-153-102	ROSEBUD -MMNS (3)	160	9530	9348- 9368	202 (161)	36.5	713.00	36.00 B
WILLIAMS 11517 4232	0000085	BWAB, INC. C. MORTENSON 3-44 SWSW SEC. 33-155- 96	WEST CAPA -ORR (1)		12950					

(-) – no current production
(*) – no information

FORMATION KEY

DD – Duperow	MMCN – Mission Canyon	MMR – Ratcliffe	ORR – Red River	
DW – Winnipegosis	MMFAR – Rival	MMRM – Midale	PNT – Tyler	
MBK – Bakken	MMFB – Fryburg	MMT – Tilston	SI – Interlake	
MM – Madison	MMNS – Nesson	OG – Gunton	SOS – Stonewall	
MMBB – Bluell				

TAX INCENTIVES FOR DRILLING?

--David Fischer

Oil and gas extraction and severance taxes are important sources of revenue for North Dakota. The amounts of revenue provided by oil and gas taxes over the past five fiscal years rose from 9 percent in 1980 to become the major source of revenue at 35 percent in 1982 and 1983 (fig. 1). During the 1984 fiscal year, however, oil and gas taxes fell to the extent that they supplied only 24 percent of the state's revenues, less than income taxes at 27 percent and sales taxes at 26 percent. With the current trend of decreasing monthly production, the drop in the rig count, and continued declining oil prices, it seems likely that the total contribution to the state's revenue from oil and gas taxes will continue to decrease unless the factors controlling oil and gas production somehow change.

TAX	1980	1981	1982	1983	1984	1985
Oil and Gas	9	22	35	35	28	24
Sales	33	29	27	27	29	26
Income	27	25	17	16	20	27
Motor Vehicle	14	11	10	10	11	11
Coal Severance	4	4	4	4	4	4
Cigarette	3	2	2	2	2	2
Other	10	7	5	6	6	6

Figure 1. Percentage of tax income to the state of North Dakota from various sources (figures given as a percent of total revenues). Figures are given for fiscal years.

What factors affect oil and gas production and what can be done to stabilize the tax revenue base? This is a difficult question to answer, but we need to ask it in order to begin to understand the problem. Destabilization of the price of oil due to over-production, conversion of many industrial complexes to coal, and the erosion of the oil cartel (OPEC), seem to be among the factors most commonly called upon to explain the state of oil and gas production and pricing, and as a result, falling tax revenues for North Dakota over the last two years. Unfortunately, little can be done to change most of these factors. It stands to reason that any manipulative attempts to affect oil and gas revenues are quite speculative; furthermore, any projections of likely changes in the basic formulas of these factors are probably questionable. Let's examine some of the factors that have had an effect in North Dakota and the surrounding states and provinces.

North Dakota

In January of 1981, North Dakota initiated a 6½ percent extraction tax on crude oil. The implementation of this tax coincided with and certainly was a major reason for the large increase in total oil and gas tax revenues to the state (fig. 1). It is also significant that, in 1981, the price of oil (fig. 2) the number of wells drilled (fig. 3), and the total number of discoveries (fig. 4) all reached their maximums in North Dakota. The net result of these positive factors was an increase in production of nearly 6,000,000 barrels of oil in North Dakota in 1981 over 1980 (fig. 5). Another question also needs to be asked: What effect would the 1981 extraction tax have had had it been enacted during a time of a weakening oil market, like we have today? We don't really know what would have happened had this been the case.

YEAR	AVERAGE PRICE PER BARREL
1984	$28.39
1983	29.20
1982	31.89
1981	35.63
1980	26.42
1979	13.64
1978	9.75
1977	8.00
1976	7.84
1975	7.32
1974	6.04
1973	3.90
1972	3.23

Figure 2. Average yearly price of North Dakota crude (from IPAA).

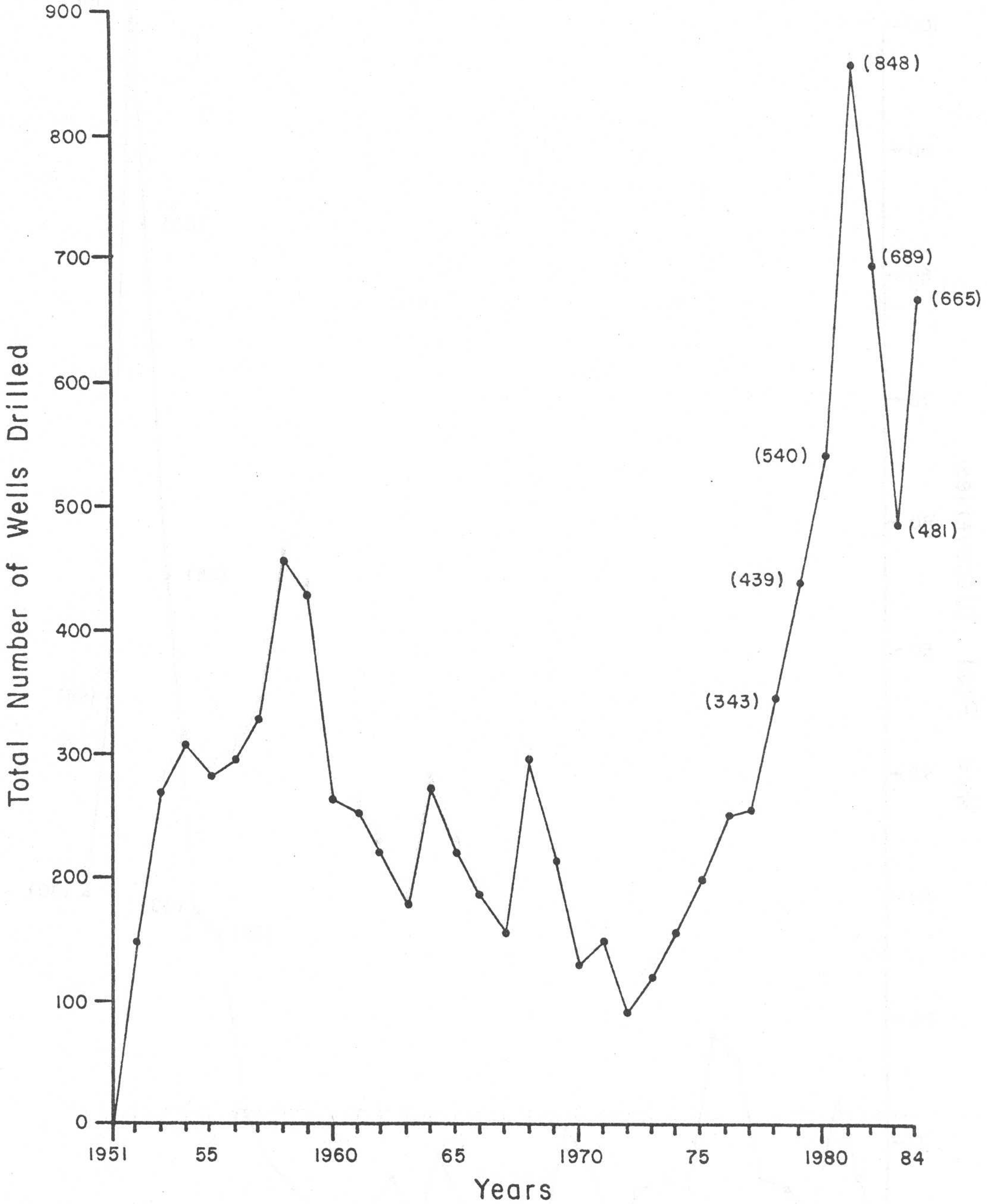


Figure 3. Graph showing the number of wells drilled each year in North Dakota since oil was discovered in 1951. The totals include both exploratory and development wells.

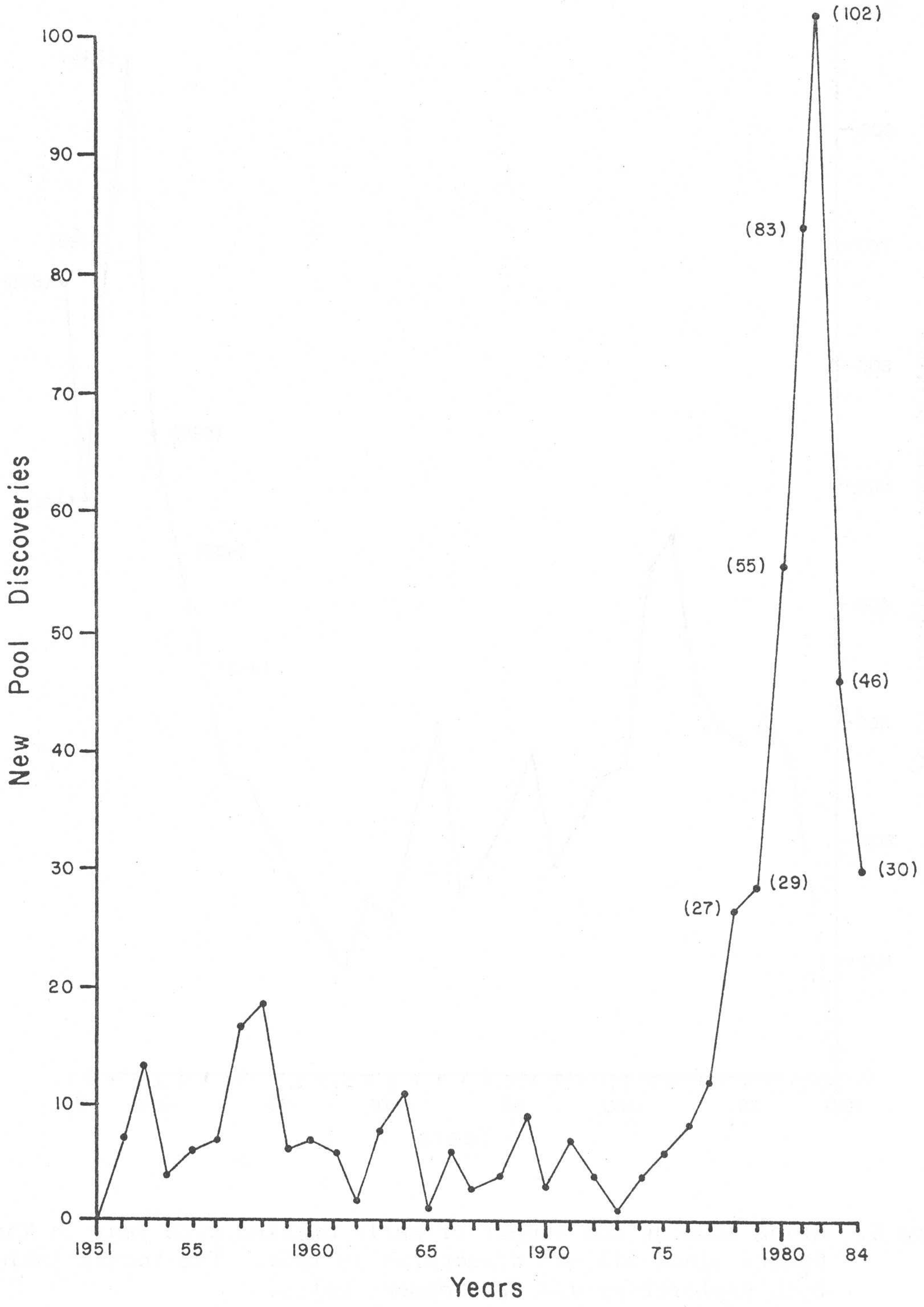


Figure 4. Graph showing the number of new pools discovered each year in North Dakota.

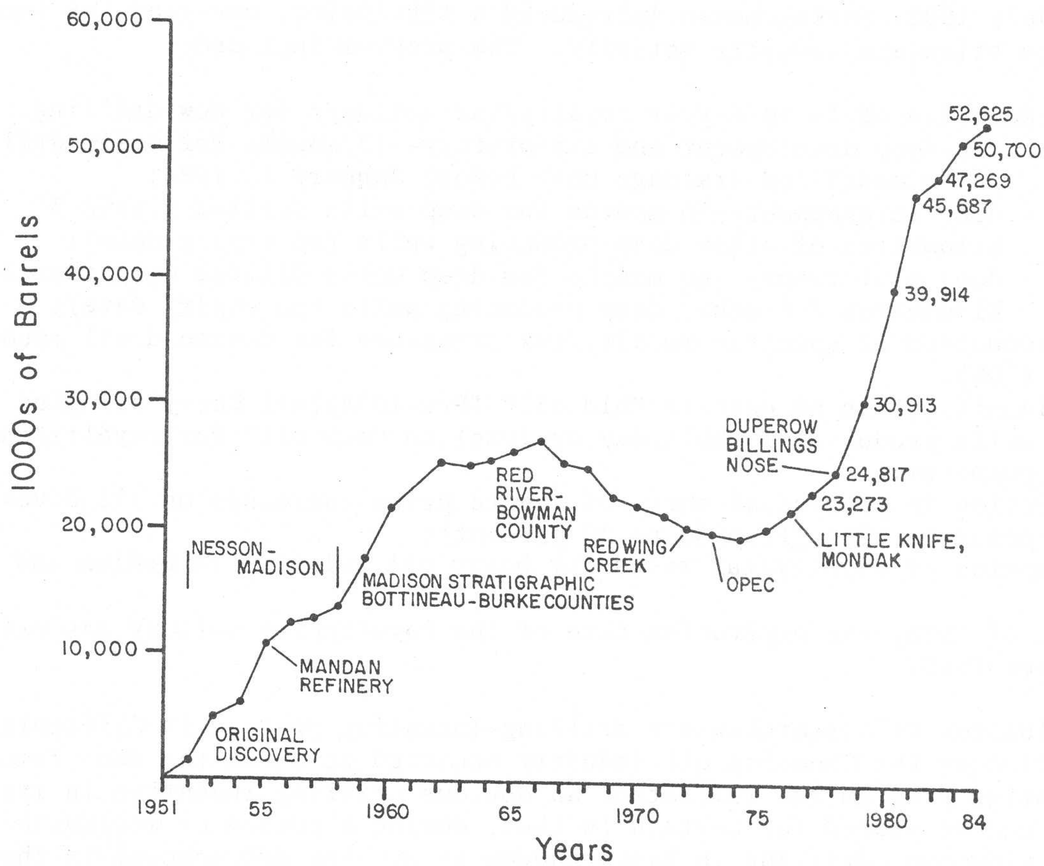


Figure 5. Annual crude oil production in North Dakota. Figures since 1977 are given in thousands of barrels; thus, production in 1984 was 52,625,000 barrels. Major events affecting oil production are noted on the graph. Production in 1985 is not yet official, but will be down slightly.

Manitoba

In 1979, Manitoba initiated a drilling incentive program in the form of tax relief for wells drilled after January 1, 1979, and prior to January 1, 1987. The incentive program in Manitoba is basically a percentage reduction in royalty rates for a given period of time. The incentive time period is calculated based on total well depth, plus any "unused qualifying footage from unsuccessful incentive wildcat wells drilled and abandoned since the last successful new well placed on production by the operator." The petroleum incentive program appears to have had a positive effect on the level of exploration, but no definite statistics are available to verify this (personal communication, Hugh R. McCabe (Geological Services Branch, Manitoba Department of Energy and Mines).

Saskatchewan

In July 1982, Saskatchewan introduced a five-point, one-year tax incentive program to stimulate industry activity. The program included:

Introduction of 1- to 6-year royalty/tax holidays for new drilling.
- non-deep development and exploratory--12 months for wells drilled on an undrilled drainage unit before January 1, 1984;
- deep development--36 months for deep wells drilled within 3 kilometres of other deep producing wells (no expiry date);
- deep exploratory--60 months for deep wells drilled more than 3 kilometres for other deep producing wells (no expiry date);

Introduction of specific royalty/tax structure for enhanced oil recovery (EOR);

Reclassification of certain "old oil" (Pre-1974)(all heavy oil plus wells producing 10 bbls/day or less) to "new oil" for royalty/tax purposes;

Reduction in provincial share of future price increases on oil developed prior to 1981 (from 50 to 40 percent);

Reduction of royalty/tax rates for heavy oil relative to medium and light.

In August of 1983, the expiration date of the royalty/tax holiday was extended to December 1985.

Evaluation of Saskatchewan's drilling-incentive program is difficult. Deregulation of the Canadian oil industry occurred at about the same time the tax incentive program was initiated, an obvious drilling incentive in itself. All that can be stated for certain is that, during a period of worldwide industry slowdown, drilling in Saskatchewan is up over 400 percent in the last three years (fig. 6), production is steadily increasing (fig. 7), and Provincial revenue from oil and gas is up by 53 percent.

Montana

In 1985, Montana moved to standardize the net proceeds tax on new oil and gas at 7 percent. The net proceeds tax is a property tax, administered locally. This tax had varied, from county to county, from between 0 percent to 16 percent. An understanding of how tax incentives might affect activity in North Dakota might be drawn by comparing drilling activity in Montana counties that now have decreased net proceeds tax with those that now have increased rates. However, since the new tax structure was emplaced late in 1985, we do not yet have any record to make valid comparisons.

Conclusions

North Dakota is currently experiencing a revenue "crisis," due in part to sliding oil prices and decreasing production. With relatively large areas still undrilled and deeper horizons yet to be adequately evaluated in many areas, the Williston Basin still remains an attractive exploration province. However, several inherent problems are associated with drilling in the Williston Basin.

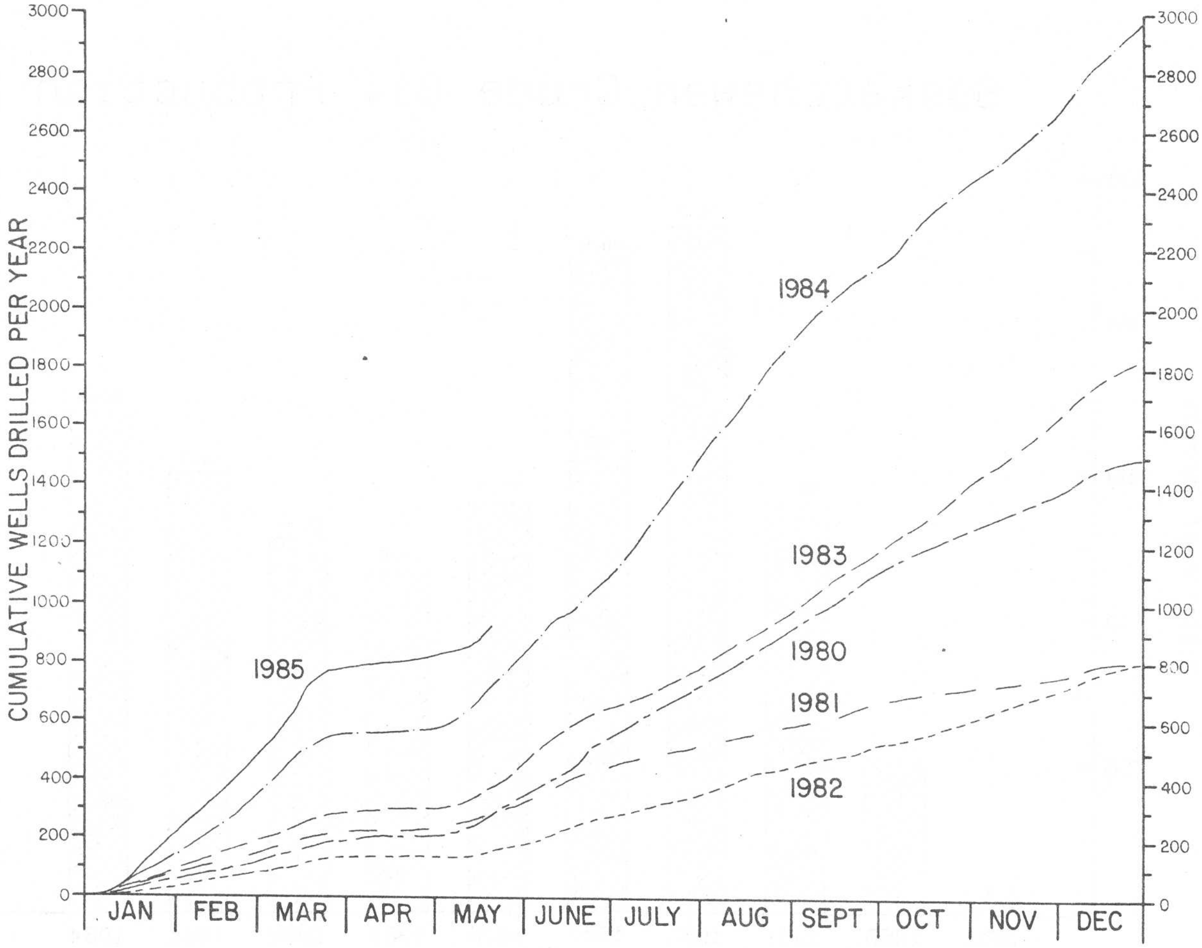


Figure 6. Saskatchewan drilling summary of total oil and gas wells. Information taken from the Petroleum and Natural Gas Division of the Saskatchewan Division of Energy and Mines.

They include:

1) relatively deep reservoirs compared to other Rocky Mountain provinces;
2) the presence of hydrogen sulfide gas;
3) salt; horizons which complicate drilling and are a major cause of collapsed casing;
4) a rigorous climate.

These problems, along with the falling price of oil, have to be dealt with in any attempt to increase exploration and stabilize oil-tax revenues in the North Dakota portion of the Williston Basin. A possible way to do this may be through some kind of tax incentive program. The tax holiday experience in Saskatchewan suggests that tax incentives might have the desired effect of tending to increase exploratory activity in North Dakota.

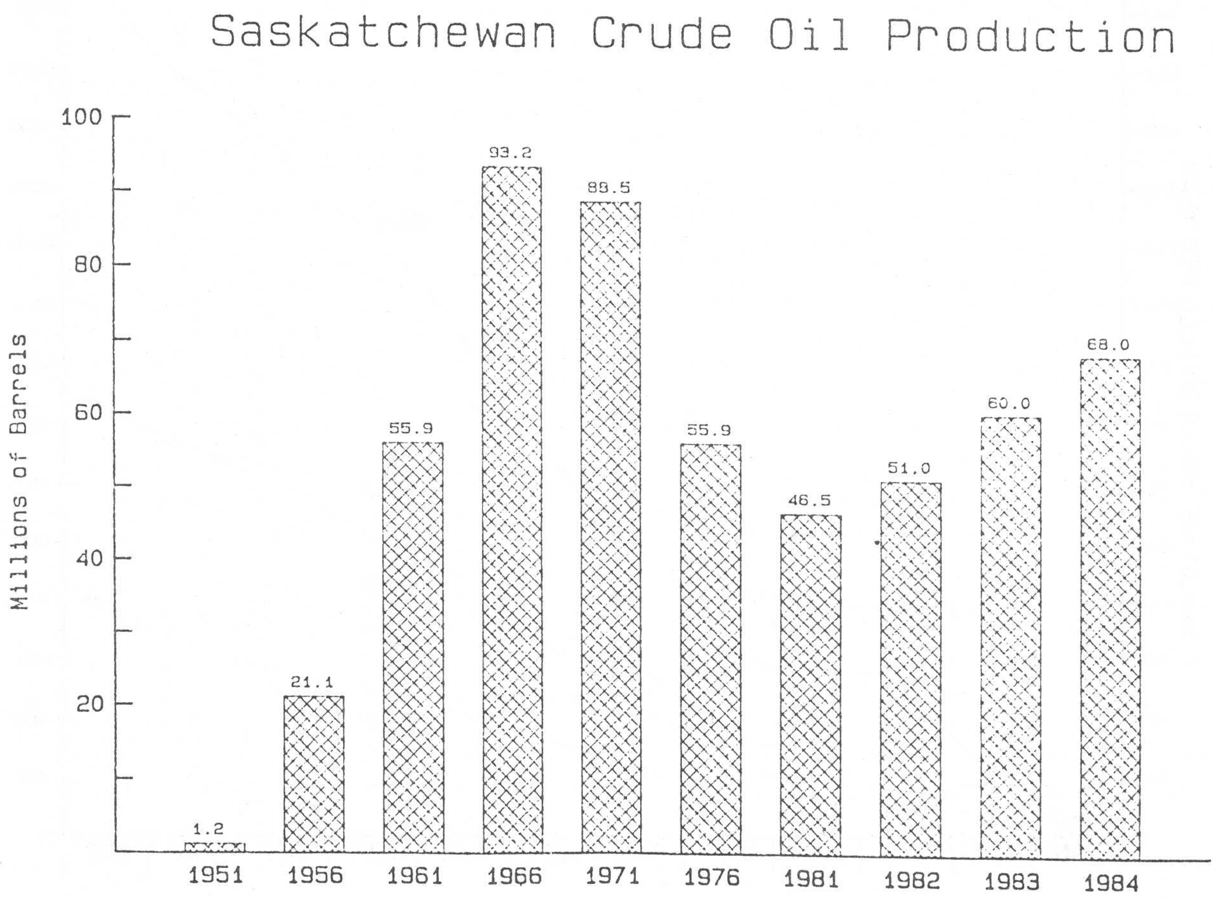


Figure 7. Crude oil production in Saskatchewan since 1951 in millions of barrels. Production at 5-year intervals until 1981; then annually.

COMMENTS

Do you have questions, comments, or suggestions regarding the newsletter or North Dakota Geological Survey services? For additional information on any of the items mentioned in the Newsletter, please contact John Bluemle, NDGS Newsletter Editor, North Dakota Geological Survey, University Station, Grand Forks, ND 58202-8156.

ADDRESS CORRECTION

( ) Please correct the address to read as follows:

Name ____

Address ____

____________________________________ Zip Code ________

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