# Black Gold:

The Role of the Geologic Survey in the Exploration, Discovery, and Development of Oil Prospects and their Economic Implications to North Dakota

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The North Dakota Geological Survey was commissioned in 1895 by an act of the North Dakota Legislature. The Survey is responsible for the study of the State's geology, including its mineral and fossil fuel resources.

In 1951, the first economic oil-producing well was completed in North Dakota. The North Dakota Geological Survey was the State agency responsible for regulation of the oil industry until 1981. In 1981, a separate Oil and Gas Division was created with the responsibility of regulating the oil and gas industry, thereby allowing the Survey to continue with it's mission to locate, study, and characterize the subsurface geology and the oil potential of geologic formations in a scientific and unbiased fashion, free from regulatory constraints or conflicts.

The Survey remains today as the lead State agency in the scientific study of oil and gas reservoirs, traps, and source rocks.



The Survey has cooperated with the petroleum industry to develop an enterprise that is now more than 50 years old in the State. More than 14,000 oil and gas wells have been drilled since 1951. These wells have produced more than 1.3 billion barrels of oil, valued at more than 20 billion dollars.

North Dakota has reaped enormous benefits from the oil industry in several ways, including:

- Revenues related to sale of oil leases on State lands
- Revenues from the sale of oil leases on Federal lands that are partially returned to the State and counties which in 2001 amounted to <u>10.4 million dollars</u>
- Tax revenues from oil production and extraction
- Income tax on royalties and bonuses to owners of mineral rights
- Sales taxes on materials for construction of new wells that average about 25,000 dollars per well
- And also jobs and income taxes related to employment in the oil patch

•Each drilling rig accounts for approximately 120 direct and indirect jobs that in 2001 amounted to 2,200 high paying jobs in the oil patch

•In the mining industry in 2000, the annual average wage was 44,305 dollars, or 80% **above** the statewide average wage of 24,683 dollars



In the past 50 years, the oil and gas industry generated more than 510 million dollars from leases, bonuses, royalties, and rentals on State lands alone.

In 1980, the State received 68.5 million dollars from leases on State lands. More recently, in 1995, oil companies paid nearly 13 million dollars for leases on State lands associated with exploration and development of the Lodgepole play. More will be said about the Survey's role in the Lodgepole play later in this presentation.



The State's general fund is enriched greatly by oil-extraction and oil-production taxes. In the past 50 years, oil has generated more than 1.9 billion dollars in oil-tax revenues.

In the early 1980s, when the international oil market was especially strong, oil-tax revenues exceeded 150 million dollars four years in a row, peaking at 176.6 million dollars in 1984.

In 2001, the most recent statistics available at the time of this presentation, the State received 70.8 million dollars from oil-tax revenues.



Oil-tax revenues have been vital to providing funds to operate the State government. In 1982 and 1983, oil-tax revenues constituted more than 30% of all State tax revenues.

In the 2001 - 2002 biennium, oil-tax revenues constituted more than 8% of the total State tax revenues.

The combined taxes from all fossil fuels (oil-, gas-, and coal-tax revenues) have ranged from 9% to more than 40% of the State's tax revenues in the past 23 years. Currently in 2003 they are generating slightly more than 12% of the State's tax revenues.



Survey geologists study the subsurface geology of the Williston Basin to identify and characterize oil and gas reservoir rocks, traps, and source rocks for many purposes including, locating potential new oil and gas resources, and providing the information necessary to recover additional oil from known fields.

Survey geologists have worked with the oil industry to develop the oil and gas resources of the Williston Basin. Discoveries by the oil industry are examined by the Survey for many reasons. One reason is to provide advice to other state agencies, such as the Land Department, the Tax Commission, the Industrial Commission, the Oil and Gas Division, the Environmental Health Division of the Health Department, and the State Water Commission. Another reason is to find other areas with rocks with similar characteristics to proven oil fields. These analogues are a primary tool in oil exploration. In other cases, Survey geologists have identified structures, rock types, and locations where there is a high probability of finding economically valuable quantities of oil and gas.

Some of the major contributions to oil development in North Dakota made by the Geologic Survey include:

- In 1966 Sid Anderson delineated and mapped the Billings Nose
- In 1978 Lee Gerhard encouraged infill drilling in Glenburn Field
- Beginning in 1993 Randy Burke and Paul Diehl encouraged Lodgepole oil development with maps, presentations, and papers on the Lodgepole Formation
- In 1994 Bill McClellan determined the oil potential of the Red River B zone in the Cedar Creek Anticline in Bowman County
- And, in 2001 Paul Diehl presented information at industry meetings on production of the Cedar Hills Red River "B" horizontal well field, the most recent giant oil field discovered in the continental United States.



The North Dakota Geological Survey maintains the Wilson M. Laird Core and Sample Library. The facility is housed on the campus of the University of North Dakota in Grand Forks.

The Wilson M. Laird Core and Sample Library is one of the premier facilities of its kind and has the most complete collection of rocks from any oil-producing basin in the United States. The facility houses more than

- •80 miles of core which is stored in more than 140,000 boxes,
- •40,000 boxes of drill cuttings
- and 170,000 thin sections made from these samples and an even greater number of photomicrographs

Companies are required by law to submit cores and samples collected from oil and gas wells in the state. Assuming an average cost for an oil well in the Williston Basin of 1 million dollars, the core stored in the Geological Survey facility represents a collection that cost more than 14 billion dollars to obtain over a period of 50 years.

Thousands of geologists from the oil and gas industry, government, and academia have studied and continue to study the cores and well cutting samples in an attempt to find more oil in the Williston Basin. This facility is invaluable to the petroleum industry interested in North Dakota.

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Industry's interest in the Williston Basin declined sharply after the oil boom of the early 1980s. Companies retreated from North Dakota in the face of a more challenging oil market, where cheap foreign oil made domestic prospecting less profitable.

In an effort to generate greater interest in the oil fields of North Dakota, the Survey began in 1993 to host an annual conference intended to bring new technologies for horizontal drilling and production to North Dakota. Many of these new technologies can be used to revitalize old, nearly abandoned fields to make them economic again.

These meetings are important in providing a forum for geologists, petroleum engineers, oil operators, drillers, and oil-field support teams to learn of new oil plays, the latest developments in drilling technologies, and the latest developments in enhanced oil-recovery technologies. From 300 to over 600 people employed in the oil industry have found these three-day-long conferences vitally important to network with other companies and to gain business contacts.

Attendees of these conferences consistently remark that each conference is better than the past and all of the Survey's conferences are not only unique but among the best in the industry.



Survey geologists promote oil activities in the state in other ways too.

Some include:

- Publication of Mineral Resource Maps, Geologic Investigations, maps for the North Dakota Geologic Atlas Series, County Groundwater Studies, Bulletins, an Educational Series, and many additional types of geological information.
- Publication of short articles in the *North Dakota Geological Survey Newsletter* a semiannual publication of the Survey.
- Oral presentation of research to industry, to other professional forums, and to scientific conferences
- Submission of peer-reviewed science papers in national and international journals
- And phone calls, letters, e-mails, and other personal communications with industry officials, companies, and North Dakota's citizens on a one-on-one basis.



The North Dakota Geological Survey's activities have been crucial to maintaining and promoting oil activity in North Dakota. Although there are many examples of fields and prospects that were identified or further studied by the Survey, one recent example, the Lodgepole play, serves to illustrate the direct economic benefits to the State that can be directly attributed to Survey activities.



The Lodgepole oil play was initiated by accident when Conoco drilled a wildcat to test the Ordovician rocks in Stark County. Finding the Ordovician rocks unproductive, the well was completed in a rock type previously unseen in the Lodgepole Formation in North Dakota. This Lodgepole discovery well initially produced over 4000 barrels of oil per day and began a frantic lease and exploration play for the Lodgepole in North Dakota.

Survey geologists, Randy Burke and Paul Diehl, began investigations of the geologic framework of this oil-producing strata in the Lodgepole Formation. Their work involved detailed study of new cores taken as the play unfolded, old cores and samples stored in the Wilson M. Laird Core Library, analysis of thin sections, and field study of the Lodgepole Formation in remote outcrops in rugged areas accessible only by foot. Burke and Diehl began to publish their results in 1993 within 3 months of the discovery. The publications were accompanied by a number of oral presentations at various meetings, including the second Horizontal Well Workshop, the Houston Geological Society, the Denver Landman's Association annual meeting, the International Williston Basin Symposium in Billings, Shell Oil Company in Houston, Society of Engineering Geologists, and many other professional venues.



The oil industry was greatly impressed by their work, which then created a "stampede" for new land lease sales. In 1995, the State received nearly 13 million dollars in oil-lease revenues on State lands alone. This is conservatively estimated to be only about one tenth of the total leases taken on private lands. The State received millions more from oil-revenues on federal lands. Revenues from federal lands are returned in part to the State and the counties.

Note that the lands leased are indicated by colored spots and that the majority fall within the paleyellow arc mapped by Burke and Diehl as the zone of geologic similarity with the Dickinson discovery.



The revenue from this study is still pouring into the State's coffers. In addition to the 12.7 million dollars received from oil-lease sales on State lands, the study has been partly responsible for the construction of 44 producing wells in Lodgepole strata. These wells have brought in an estimated 44 million dollars in construction costs and 1.1 million dollars in sales taxes on materials. Additional millions of dollars have been spent in the State to install the Lodgepole pools enhanced recovery units.

Oil-tax revenue from Lodgepole production alone has now exceeded 61 million dollars and gas-tax revenue from the Lodgepole Formation is 840 thousand dollars. This is a field that has been developed in just the past 9 years and will likely produce for an additional 15 to 25 years, all the while adding oil-tax revenue to the State.

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Development of Lodgepole oil is one of many oil opportunities NDGS geologists have aided and encouraged. Other major contributions by the NDGS geologists include:

The Billings Nose identified by Sid Anderson in 1966
The Glenburn Field, work by L.C. Gerhard in 1978
The Red River B zone on the flank of Cedar Creek Anticline, promoted by Bill McClellan in 1994

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The Lodgepole oil play is just one of many that Survey geologists have helped develop.

The Survey also contributed to the recent development of the Red River B zone Cedar Hills Field in Bowman County on the flank of the Cedar Creek Anticline. Prior to 1994, there were only four producing wells in the area now comprising the Cedar Hills Field in North Dakota. In April of that year at the Second Annual Horizontal Well Workshop held in Minot, Survey geologist, Bill McClellan, gave a presentation emphasizing the good potential for economic oil production by horizontal drilling in the Red River B zone in western Bowman County. That talk caught the attention of the oil industry and encouraged immediate activity. The discovery well for Cedar Hills Red River B Field was completed in October 1994.

Today, thanks in large part to the work of the Survey, there are more than 300 producing wells in the Cedar Creek Anticline. These wells have thus far produced more than 30 million barrels of oil, valued at an estimated 690 million dollars. New wells continue to be drilled to increase oil recovery.

The State has received more than 44 million dollars in oil taxes and 470,000 dollars in gas taxes from this field. These wells cost an average of 1.2 to 1.5 million dollars to complete and represent more than 400 million dollars of investments and construction in North Dakota. The sales taxes alone on just the well materials is more than 10 million dollars.

The Cedar Hills Field is classified as a "giant" U.S. oil field, that is a field that will produce more than 100 million barrels of oil. This is the only giant oil field discovered on-shore in the contiguous United States in the past five years. It will likely continue to produce oil for another 20-30 years.

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#### Conclusion

A recent Survey report has calculated that there are still 700 million barrels of proven reserves and an additional 800 million barrels of undiscovered oil in western North Dakota.

On-going Survey studies of new technologies, particular CO2 injection, are likely to enhance recovery of oil from aging fields, increasing economic return for producers and tax revenues for the State.

Although the North Dakota Geological Survey is a small agency, it is one of the largest revenue-generating agencies in the state. We more than pay our own way!

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A recent Survey report by LeFever and Heck in 1995 has calculated that there are still 700 million barrels of proven reserves and an additional 800 million barrels of undiscovered oil in western North Dakota.

On-going investigations by Survey geologists are examining the economic potential of injecting CO2 into maturing oil fields with the prospect to increase recovery of oil from aging fields. Typically, only 10 to 20% of the oil is extracted from an oil field, therefore a great amount of oil remains in North Dakota's oil fields. Increased understanding of the detailed geology related to flow parameters of the reservoirs along with new technologies will allow by-passed oil to be economically recovered. Part of the mission of the Survey is to make North Dakota oil and gas operators and producers aware of the new technologies and what the technologies can do. Modern technologies are increasing the economic return and total oil extraction from old, declining fields.

The Survey is staffed by scientists. Much of what we do is highly technical and is generally unknown to the citizens of North Dakota. However, the oil industry pays attention to our work and much of what the oil industry does is influenced by the investigations conducted by the Survey. Whereas industry's presence and interest in North Dakota wanes and ebbs with the flow of the international oil market, Survey geologists' objective is to keep oil and gas activities a vital part of North Dakota's economy by expanding our knowledge of new technology and details of the geology of the Williston Basin.

Through the promotion of horizontal drilling methods and technologies the Survey has played a significant role in increasing North Dakota's annual production while the production of most states continues to decline. From the standpoint of State budgets, the North Dakota Geological Survey is a small agency with a small budget, yet it is one of the largest revenue-producing agencies in the state.



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For more details about the economic benefits of Survey oil and gas activities the following reprints of NDGS Newsletter articles are included. Click on the article you choose to read.	
1. <u>NDGS Provides Part of Geologic Framework for Weyburn Project: An</u> <u>International Research Project with Significant Economic Implications</u> <u>to North Dakota and the World by Randy Burke.</u>	
2. <u>Small-scale Geologic Structures within Cedar Hills Red River B Field,</u> <u>Bowman and Slope Counties, North Dakota by Paul Diehl</u>	
3. <u>The Lodgepole Formation Carbonate Buildup Play and Waulsortian</u> <u>Mounds in North Dakota by R. Burke and P. Diehl</u>	
<ol> <li>Oil Exploration and Development in the North Dakota Williston Basin: 2000-2001 Update by Thomas J. Heck</li> </ol>	
5. Black Gold: The Economics of Oil in North Dakota by Mark Gonzalez	

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