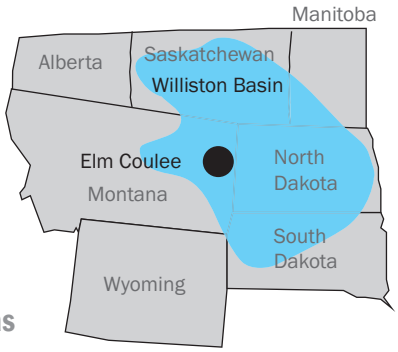


Montana's New Energy Frontier

What are the Prospects?

Tom Richmond, Administrator and Petroleum Engineer, Montana Board of Oil and Gas

Ranchers in Sidney, Montana, are receiving $1 million royalty checks. Homeowners are renting unheated garages to oil workers for $600 a month. And new technology has opened up billions of barrels of oil in the Bakken, arguably the largest inland oil find in the U.S. in the past 50 years. From 2000 to 2006, Montana's oil production more than doubled (Figure 1) as the oil industry developed and implemented a number of variations of the horizontal drilling technique in the development of the Elm Coulee Field in Richland County.

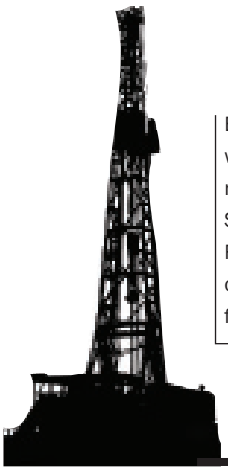
Science and technology have had a long history of influencing the development of Montana's oil and gas resources. The extraordinary and continuing interest in development of the Bakken formation in Montana and North Dakota is the product of two technologies, horizontal drilling and hydraulic fracturing. Both technologies have been in use in Montana for several years, horizontal drilling since 1989 and hydraulic fracturing at least since the 1950s. Neither by itself would have made the long known, but marginally productive oil-bearing Bakken formation the target of so many drilling rigs and oil and gas developers.

Just east of the Montana border, North Dakota has become a magnet for investment dollars, creating new jobs and bringing revenues into the state. Energy development is going strong in eastern Montana, but does it have the potential of our North Dakota neighbors?

Science, Technology, and Exploration

Montana's complex and diverse geologic setting has long provided opportunities for successful exploration and development activities aided by science and technology advancements.

The oil and gas industry has explored virtually every geologic basin in state over the last century, albeit some have been only lightly explored. The traditional producing areas include the Montana portions of the Williston, Powder River in southeastern part of the state, and Big Horn Basins in the south central Montana. The Sweet Grass Arch and other central Montana areas contribute to the state's production. Figure 2 shows oil production trends throughout the state.

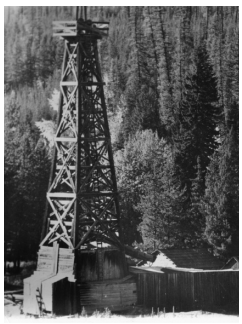


Montana's Oil & Natural Gas Development

Photos courtesy of UM's Maureen and Mike Mansfield Library Archives.

1890 — Eight dry holes were drilled near the Cruse Seeps outside Roscoe, where oil would "seep" from the ground.

1900 — The first producing wells were drilled in what would become Glacier National Park, including one near Kintla Lake (at right) and the first "oilfield" in the Swiftcurrent Creek Valley.



1910 — The creation of Glacier National Park ended drilling. The few remaining wells were abandoned and flooded with the waters rising behind Sherburne Lake Dam.

1920 — Montana's first truly commercial oil production started in 1915 in Carbon County's Elk Basin Field, a feature which continues to produce. Natural gas drilling began the next year in Fallon County.

1930 — Oil was found in the Kevin Sunburst Field in the 1920s, Cat Creek Field in the '30s and Cut Bank Field in the '40s.

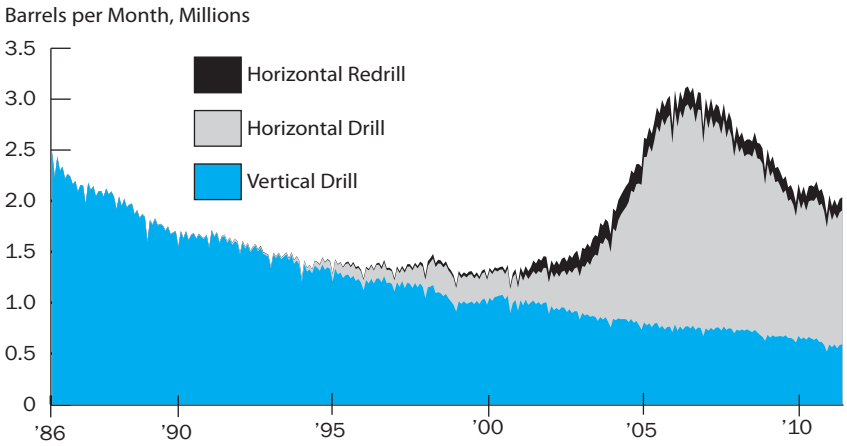
1940

The original oil-finding technology was applied in Montana as it was in many other places. In the late 1880s and early 1900s, oil developers looked for natural oil seeps as evidence of potential commercial production.

The science of oil finding progressed as geologists found and explored anticlines and domes throughout the state. Montana's first commercial oil production occurred in 1915 (see timeline). From that time through the 1960s, advances in geologic exploration methods, along with the occasional success of random drilling, increased success rates.

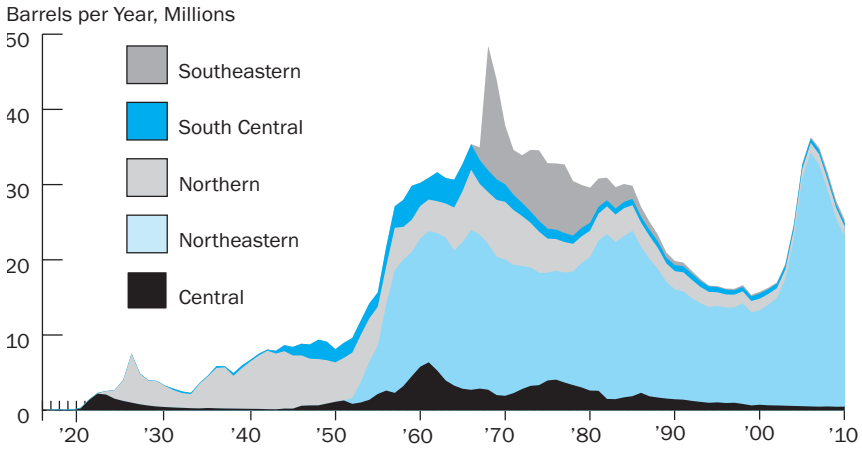
By the 1970s, seismic exploration and the ability to use electronic processing to analyze great quantities of data, produced a rush to explore the deep geological features that trapped oil in the Red River formation in the Williston Basin. In the process of exploring for Red River oil, other oil-bearing formations were penetrated and successful wells developed. The recent development of three-dimensional seismic techniques and data processing advancements continues to improve the ability of geologists and geophysicists

Figure 1
Monthly Oil Production, Vertical vs. Horizontal Wells, Jan. 1986 - Aug. 2011



Source: Montana Board of Oil and Gas Conservation.

Figure 2
Statewide Oil Production History, 1916-2010



Source: Montana Board of Oil and Gas Conservation.

The "Montana Gusher" journal was created in 1920 in Lewistown to follow the booming industry.

The technique of hydraulic fracturing, nicknamed "fracking" today, was developed by the 1950s. At the same time, oil was discovered on the Cedar Creek Anticline, deep beneath the formations drilled for natural gas the previous 40 years.

The technique of horizontal drilling began.

From 2000 to 2006, Montana's oil production more than doubled as the oil industry developed and implemented variations of the horizontal drilling technique in Richland County's Elm Coulee Field.

1950 1960 1970 1980 1990 2000 2010

Bell Creek Field in Powder River County was discovered.

There was a rush to explore the deep geological features that trapped oil in the Red River formation in Eastern Montana's Williston Basin, which is still a hot spot today.

to successfully tap oil resources from features that would otherwise escape detection.

The Bakken: Promise and Reality

The Bakken development currently drawing so much attention honors a much more recently developed exploration model, that of the "continuous resource" or "resource play." This concept suggests that organic rich shale formations like the Bakken or the Marcelleus of the eastern U.S. and the Barnett of Texas are continuously productive over large areas. While the concept admits to significant variations in well-to-well productivity, the risk of dry holes is largely eliminated. Montana's Elm Coulee field has currently about 750 producing Bakken oil wells; during the process of development, only two dry holes were drilled. It is this level of success that the continuous resource model predicts and delivers.

Bakken may be the magic name for oil resource plays in the northern plains, but the Bakken is not the same in all areas. Due in large part to the wide variation in reservoir properties, the technology used successfully in Montana's initial Bakken development was altered significantly in the North Dakota development.

The North Dakota Bakken development has been dependent on technology changes that improved the efficiency of the drilling and completion practices to match the Bakken realties in that state. Those same technologies have returned to the Elm Coulee Field, bringing more effective completion techniques for in-fill and step out wells and the recovery of additional oil. Application of this "customized" technology to Bakken development in Richland, Roosevelt, and Sheridan Counties holds great promise for migration of the very active development in North Dakota to this portion of eastern Montana.

However, the Williston Basin is asymmetrical and the center of Bakken deposition occurred in an area east of the Nesson anticline, well beyond the border into western North Dakota. The much thicker Bakken formation in this area and the additional pay zones found in the Sanish Sand and Three Forks formation have attracted many investors. This intense level of North Dakota activity changes the timing, but not the potential for significant Bakken development in Eastern Montana.

Montana's Energy Future

Although the Bakken formation is present in other areas of the state, the dispositional environment and subsequent geologic history may not be identical to that of the Williston Basin. Recent exploration indicates that oil is present in the Bakken as far west as Glacier County. It remains to be determined if technology developed in the Williston Basin will be effective in the shallower, less pressured areas of Bakken occurrence. However, exploratory interest in other areas remains high. (12)

Terms and Definitions

The **Bakken** is a subsurface rock formation with three layers: shale for the upper and lower with a varied composition in the middle. The Bakken lies between the overlying Lodgepole Formation and the underlying Three Forks Formation and occupies about 200,000 square miles of the subsurface of the Williston Basin. The formation was deposited approximately 360 million years ago.

Elm Coulee is an oilfield in Richland County, Montana, that is productive from the middle layer of the Bakken Formation. It was named shortly after the original Bakken horizontal well development started in 2000. The field currently produces about half of Montana's total oil production.

Williston Basin is an elliptical-shaped, sedimentary basin that extends from the northern Great Plains of the U.S. into Canada. The basin occupies most of North Dakota, northwestern South Dakota, eastern Montana, and a part of southern Manitoba and Saskatchewan in Canada. The U.S. part of the basin is a maximum sediment thickness of about 16,000 feet near Williston, North Dakota.

The **Nesson Anticline** in North Dakota and the **Cedar Creek Anticline** in Montana are the two prominent structural features in the Williston Basin. Oil production was discovered in both features in the early 1950s. An anticline is a convex upward fold in the earth's strata, or layers.

The term **Pay Zone** was probably borrowed from gold mining nomenclature. It is a permeable rock that contains oil or gas in sufficient quantity to produce and through which petroleum may migrate. It's also called the reservoir or reservoir rock.

Hydraulic Fracturing is stimulation treatment typically performed on low-permeability oil or gas reservoirs.Engineered fluids are pumped at high pressure, causing a fracture to open along the natural stresses in a formation. Proppant, such as grains of sand, is mixed with the fluid to keep the fracture open when the treatment is complete.

Horizontal Drilling is a subset of the more general term "directional drilling," used where the angle of the wellbore approaches 90 degrees away from vertical. Because a horizontal well typically penetrates a greater length of the reservoir, it can offer significant production improvement over a vertical well.

Play is a term used to refer to potential drilling areas whose boundaries are defined by their characteristics, such as varying degrees of hydrocarbon accumulation and other formation factors. A play (or a group of interrelated plays) generally occurs in a single petroleum system. They are used to model a region's prospects or plan for development.