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Pennsylvania **GEOLOGY**



Special edition featuring the Oil Heritage Region

COMMONWEALTH OF PENNSYLVANIA

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CONTENTS

Heritages of our commonwealth	1
Why the Drake well?	2
Sur La Belle Riviere: a paeen to the once and future glory of Venango County	4
The origin of oil	9
Oil Creek's riparian wells	14
As the drill-bit churns	19
The pit and the petroleum	23
The science of drilling oil wells	27
Announcement—Survey sponsors "Geology Day" at Oil Creek State Park and releases new park guide	32

ON THE COVER

Colonel Edwin L. Drake in front of the famous Drake well near Titusville, Pa. Drawing by Lajos J. Balogh.

PENNSYLVANIA GEOLOGY

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Heritages of Our Commonwealth

With this issue of *Pennsylvania Geology*, we begin a new activity to describe and celebrate the geologically related heritages of our commonwealth. This activity is in partnership with DCNR's Bureau of Conservation and Recreation, and with local area groups that are developing and promoting heritage resources of Pennsylvania under the Pennsylvania Heritage Park Program.

Much of the heritage of early social and economic development in Pennsylvania relates to our use of the landforms and geological resources of our state. While Pennsylvania's rugged terrain impeded and channeled transportation, the geologic resources that were contained in the underlying rocks provided the wealth for its industrialization.

One such area of early industrialization is in Venango and Crawford Counties, now the new Oil Heritage Region, where oil became the focus and fuel of development. At the Drake Well Museum and in Oil Creek State Park,¹ one can learn about the rich heritage and evolution of Pennsylvania's oil industry, which led to the present national and worldwide industry. The beauty of the Oil Heritage Region today also reflects the marvelous restorative powers of our natural forest ecosystems in a region formerly blighted by uncontrolled exploitation of a geologic resource.

Development in our commonwealth was strongly affected and fueled by the effective commercial use of the bounteous oil and natural-gas resources that occur throughout much of western Pennsylvania. The series of articles herein presented are designed to provide a geological perspective for better understanding the oil-industry heritage of Venango and Crawford Counties. The geologically related heritage of the region is so abundant that not all articles prepared for this issue could be included herein; one will appear in a future issue of *Pennsylvania Geology*. We hope these articles—descriptive, fanciful, and historical—will provide you with a better understanding of the heritage of Pennsylvania's petroleum resources.

Use of Pennsylvania's geologic resources has provided us with a common wealth of heritage and history that we should understand as we plan for future use and development of our land.



Donald M. Hoskins
State Geologist

¹See page 32 for a description of the "Trail of Geology" park guide recently released for Oil Creek State Park.

Why the Drake Well?

by John A. Harper

Bureau of Topographic and Geologic Survey

Most of us learned in grade school that the petroleum industry got its start in 1859 near Titusville, Pa., when an unassuming former railroad conductor named Edwin L. Drake (front cover) drilled a well to 69½ feet and struck oil. And in the ensuing years, the industry, centered around Venango County, invented and improved upon the technologies of drilling, producing, transporting, refining, and marketing crude oil and oil products, making the region one of the richest and most influential in the world. Yet a look at world history shows that, in reality, the petroleum industry was already centuries old by the time Drake arrived at his appointment with destiny.

The ancient Sumerians, Assyrians, Persians, Egyptians, and others were dealing in oil and oil products, such as asphalt, in 4,000 B.C., and the business was old then. There were various uses for oil products, such as waterproofing boats, embalming dead pharaohs, greasing chariot axles, and mortar for masonry. The Chinese had a complete oil and gas industry in 100 B.C., from drilled wells to bamboo pipelines, and even junk “supertankers,” transporting oil and gas for light and heat (Figure 1). The Greeks, Romans, and Carthaginians used oil for a variety of purposes, including military ones. The Incas were using petroleum products for waterproofing, embalming, and medicine when Europeans “discovered” the New World.

In Europe during and after the Renaissance, many people were acutely aware of the history and worldwide occurrence of oil. European universities were experimenting with and teaching sophisticated organic chemistry and technology that would eventually become the backbone of the oil industry. Europeans settling in North America quickly learned from the natives; petroleum products became important to the colonies centuries before the country we call the United States was hewn from the forests, prairies, and mountains. In remote parts of North America, many people used rock oil as a cheap, if obnoxious, form of energy. Most early American citizens considered oil a nuisance: burning with a thick, foul-smelling smoke, creating fire hazards, contaminating fishing streams, and spoiling salt production (in the 1800’s, most of the salt in western Pennsylvania came from evaporated salt water obtained by drilling wells). But oil was readily available in numerous seeps across the continent, and the pragmatic settlers used what was at hand. Then, just prior to 1859,

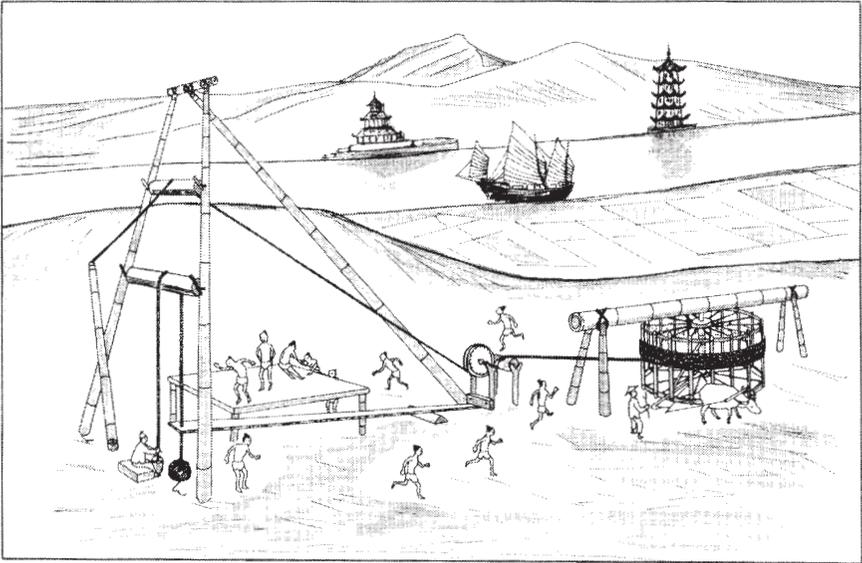


Figure 1. The Chinese had a complete petroleum industry over 2,100 years ago. Drawing by Lajos J. Balogh.

there were several deliberate attempts to drill or bore for oil in places like Germany and Canada, including the successful operations of James M. Williams in Ontario.

So, with all this history preceding it, why is the Drake well, and the man who drilled it, credited with founding the oil industry? And beyond that, why was "...one of the world's most essential industries left to grow up in the backwoods of Pennsylvania[?]" (Owen, 1975, p. 1). The answers to these questions lie in the vagaries of timing and vision. As Owen (1975, p. 1) continued, "The fact that the cumulative experience became productive at this location—and that the ancient tradition did not mature until this time (1859)—constitutes one of the great paradoxes of economic history." By 1859, the old chronicles had (as usual) been forgotten, and four factors had come together to ensure Drake's place in history.

First, the world supply of whale oil, the chief source of fuel for lighting in the "civilized world," was being rapidly depleted due to overwhaling, and the price had climbed to \$100 per barrel in the United States. Oil and gas distilled from coal, the only other readily available sources of illumination other than candles, were expensive and were produced in limited quantities in America. Second, Yale professor Benjamin Silliman, probably the best-known chemist from North America, had successfully broken down crude oil through distillation into eight distinct products, each of

which had its own potential value. For example, paraffin, the last distillation product, is still used for making candles and sealing wax among other things. Third, Samuel Kier, the successful Pittsburgh entrepreneur who sold crude oil for medicinal purposes, invented and promoted a method of refining crude oil to remove most of its impurities. He also invented an improved lamp burner that allowed the refined oil, or kerosene, to burn with a bright flame while emitting little or no foul odor. And fourth, through a series of circumstances, a sample of oil from the property of Brewer, Watson and Company, a lumber company on Oil Creek, came to the attention of George A. Bissell, a New York lawyer and promoter. This factor was perhaps the most important of all, because Bissell, whose excitement over the oil sample enticed him to co-found the Pennsylvania Rock Oil Company that hired Drake, had the foresight to understand the potential for commercial development of crude oil, and he set about realizing that potential.

So when August 27, 1859, rolled around, the stage had already been set, and the play was well into the final act. The promoters of Pennsylvania oil fields had better publicity than their competitors in Germany, Canada, and elsewhere, and the theater had standing room only. The curtain call would be what we now recognize as the modern petroleum industry. It could have happened anywhere oil is found. It could have involved any one of a large number of people with imagination and resources. But, in fact, it did not, and the rest is, as they say, history!

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Sur La Belle Riviere: A Paean to the Once and Future Glory of Venango County

by Kathy J. Flaherty and John A. Harper
Bureau of Topographic and Geologic Survey

AN EARLY VIEW. When French explorers first came to northwestern Pennsylvania, so impressed were they with the scenic landscape and waterways that they named the dominant stream, the Allegheny River, “La Belle Riviere” (the beautiful river). On its tortuous journey from its headwaters in Potter County, Pa., to its confluence with the Monongahela River in Pittsburgh, the Allegheny River passed through some of the

most picturesque country on the new continent. In what is now Venango County, the pioneers discovered breathtaking vistas of winding streams, rolling hills, and gorges, all draped with lush vegetation. Today, three or four centuries later, much of the area appears as it did when the French first observed it.

For a time, however, Venango County and adjacent areas were not so pretty. During industrial development in the nineteenth and early twentieth centuries, the hills were denuded by overlumbering, and oily, muddy hillsides sprouting a multitude of derricks replaced the greenery (Figure 1). Jams of logs, rafts, oil barrels, and other evidence of human habitation polluted the streams, and both waterways and roads became festering sewers. But that was long ago. Now, as if by magic, nature and time have cooperated to restore the region to much of its prior scenic glory.

One might ask, How did northwestern Pennsylvania get to be so picturesque? What serendipitous conjunction of time and earth process occurred to create this scenic landscape? And how did the interactions of European settlers and the land affect the development of Venango County?



Figure 1. Mather photograph of Benninghoff Run, a tributary of Oil Creek, in 1865, showing the area to be a barren wasteland crowded by oil derricks too numerous to count. Photograph courtesy of the Drake Well Museum.

THE REGION THAT CAME IN FROM THE COLD. The answers begin in the antiquity of geologic time. Hundreds of thousands of years ago, the global climate changed drastically, and great sheets of ice, miles thick, covered the north polar regions as far south as the fortieth parallel. The Ice Age had begun. Prior to the invasion of the first glacier, the dominant waterway in Venango County was the “Middle Allegheny River,” which originated northeast of Tidioute in Warren County and followed the approximate present course of the Allegheny River through Venango County, past Oil City to Franklin. At Franklin, it turned northwest along the course of what is now French Creek and flowed across Crawford and Erie Counties into an ancestral Lake Erie basin (the Great Lakes did not yet exist). As this first of four ice sheets advanced southeastward through northwestern Pennsylvania, the ice blocked the “Middle Allegheny” and other north-flowing streams, causing lakes to form along the leading edge of the glacier. Eventually, the lakes became so deep that the water flowed over the hilltops and ridges separating the streams, reversing the direction of ancient drainage in the area. Water from the melting glacier greatly increased the natural flow of the streams, generating enough energy to scour the landscape and transport large amounts of silt, sand, and gravel formerly trapped in the ice. Eventually, the river valley widened in places, and its bed became clogged with a thick blanket of glacial debris.

As the glacier melted, the earth’s crust, which had been depressed by the weight of the ice, began to rebound. The land surface rose, and the river cut down into the surrounding bedrock, sometimes creating new channel segments. Remnants of the old riverbed remain stranded like “shelves” above present stream levels. Perhaps the best example of this is the long flat area on the south side of the Allegheny River between Franklin and Oil City where Joseph Sibley built his famous River Ridge Farm. Another example is the valley on the north side of Point Hill, across French Creek from Franklin. The valley, now occupied by the borough of Rocky Grove, formerly was the channel of the “Middle Allegheny River.” These shelflike remnants eventually became the workbenches of Venango County during the 1800’s, supporting industry, roads, railroads, and towns. By the end of the Ice Age, about 10,000 years ago, the region had deep gorges, flat river terraces, till-covered hillsides ideal for the growth of lush vegetation, and south-flowing rivers and streams.

MUD ROADS AND TREACHEROUS WATERS. The banks of the principal waterways of northwestern Pennsylvania were ideal sites for towns; therefore they were settled long before petroleum was discovered. Oil City, located at the junction of Oil Creek and the Allegheny River on land once granted to Cornplanter, Chief of the Seneca Indian Nation, had a grist mill, iron furnace, store, warehouse, hotel, and steamboat landing by the mid-1800’s. Franklin, a thriving town since the late 1700’s, boasted

a rolling mill that manufactured “bar-iron” and nails, machine shops, flour mill, and foundries, and was able to accommodate the growing oil region due to its key location at the confluence of French Creek and the Allegheny River.

Heavy pine forests along the Allegheny River and its tributaries provided timber for the principal industry of lumbering. Sawmills built near the headwaters of Oil Creek, a major lumbering locality, accommodated this industry. The waterways provided convenient transportation; logs and sawed wood were lashed together and floated to downstream destinations, including some of the numerous iron furnaces found in the county.

After the discovery of petroleum in the region, small towns sprang up along many of the streams, principally as shipping sites for supplies and equipment entering, and oil leaving, the region (Figure 2). Oil shipments added considerably to the traffic on the waterways. Oil spills occurred with regularity and frequently amounted to slicks of thousands of barrels of oil coating the river and its environs. The bustling oil industry brought about undesirable changes in the characteristics of the region’s roads as well, most of which paralleled the streams on flat terraces. Wet weather contributed significantly to the rapid deterioration of these roads to muddy ruts. Rocks and soil sliding down the steep hillsides, oil drip-



Figure 2. Mather photograph of Oil Creek at Petroleum Centre in 1864. The creek was littered with debris and probably had a scum of oil on the surface. Photograph courtesy of the Drake Well Museum.

ping from leaking barrels being hauled to market, and other debris typical of human habitation, such as the occasional horse carcass, added to the slop.

Railroads brought relief and order to the people and freight traffic moving through the region. Raw materials such as lumber, oil, and pig iron could now be transported directly to major industrial and shipping centers such as Pittsburgh, Philadelphia, and Cleveland. Like the roads, the early railroads skirted the edges of the river on the shelflike remnants of the old riverbed; they were also located on new flats blasted out of the mountains. Transportation of oil via the mid-1800's innovation of railroad tank cars and pipelines led to significant improvements in the quality of the regional waterways and roads as frequent large oil spills became a thing of the past.

OH, BEAUTIFUL (AND FUNCTIONAL) FOR SPACIOUS SKIES. It has taken many years, but Venango County and the surrounding oil country have made a dramatic comeback from the days when derricks were as thick as trees on the otherwise barren, oil-soaked hillsides. The creeks and the river now are major recreational playgrounds for fishing, canoeing, kayaking, swimming, or just lolling back on a stone beach and basking in the summer sun (Figure 3). The tree-covered mountains and the shrub-lined stream banks are replete with wildflowers, waterfowl, and game. Oil Creek valley is now a state park catering to visitors' historical and recreational pursuits. Small, but scenic waterfalls, once servicing the iron industry, dot the countryside (Figure 4). Yet as idyllic as this sounds, industry has not vanished. Venango County oil wells still produce about 700,000 barrels of oil per year; drilling and production of natural gas, oil refining, and chemical manufacturing play significant roles; bituminous coal and limestone are mined in the southern part of



Figure 3. The Allegheny River south of Franklin. The hills are once again forested, and wildflowers thrive on the riverbanks.

Figure 4. Freedom Falls on Shull Run in Rockland Township. In 1832, Andrew McCaslin constructed the Rockland iron furnace about 100 yards downstream from this site and built a flume to transport water from the elevated part of the creek to the furnace's waterwheel.



the county, gravel in the western part, and sandstone in the eastern part; and that old mainstay, lumbering, once again provides many jobs. Tourism related to the oil heritage and recreation has become very important to the local economy.

Venango County is proof that the once glorious landscape that early settlers found in northwestern Pennsylvania can return and coexist with normal human endeavors. All it takes is an understanding of the importance of the land to the future of humanity, that and the one commodity geologists understand only too well—time.

The Origin of Oil

by Christopher D. Laughrey
Bureau of Topographic and Geologic Survey

The historic Drake well near Titusville is the best-known landmark of Pennsylvania's Oil Heritage Region. After touring the exhibits at the Drake Well Museum, tourists can stop by the gift shop and purchase mementos of their visit, including their very own sample of Pennsylvania "black gold" for only 94 cents (Figure 1). This is quite a bargain. Crude oil is one of the most remarkable substances found on our planet. Providing almost 40 percent of the world's energy, it powers our automobiles, warms and cools many of our homes, fuels and lubricates our factories, generates much of our electricity, and provides the raw materials for thousands of essential products ranging from synthetic fabrics and plastics to medicines. Thanks to its natural lubricating qualities, refined Pennsylvania Grade crude oil provides some of the best motor oil avail-

able in this country (Figure 2). That little 94-cent vial of Pennsylvania Grade crude also contains some marvelous chemicals that have helped scientists to understand some of the history of life on our planet.

WHAT IS IT? In 1859, promoters attempting to raise money to drill the Drake well collected a sample of oil from a natural seep near Titusville and gave it to Dr. Benjamin Silliman at Yale University to determine its value. Silliman accomplished his task by placing the oil in a distillation flask and boiling off eight separate fractions. He described each fraction in detail and concluded that the Venango County crude could yield an illuminating oil that would be superior to most of the available oils of the time (mostly whale oils). Silliman's analyses ensured the financing of the Drake well. Distillation is the principal method employed today for separating crude oil into its multitude of useful products.

Distillation separates crude oil into compound groups of different sizes. Chemists recognize different types of molecules in oil by their structure. The hydrocarbon molecules contain only carbon and hydrogen atoms; the carbon atoms may be arranged in straight chains, branched chains, rings, or in combinations of these. Nonhydrocarbons in the crude are composed mainly of carbon and hydrogen too, but also contain one or more of the elements nitrogen, sulfur, or oxygen, and trace amounts

of metallic elements, such as vanadium and nickel. Approximately 500 different compounds are known to occur in crude oil; about one third of these are non-hydrocarbons (Brownlow, 1979).

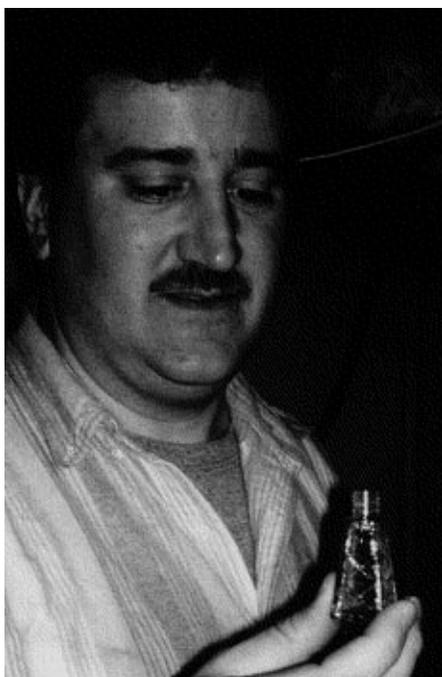


Figure 1. Derrick-shaped bottles of Pennsylvania Grade crude oil such as this once were used by the City of Oil City and the Oil City Area Chamber of Commerce as inexpensive mementos of the area. They are now rare. Visitors to the Drake Well Museum can still obtain a small amount of oil, but in a simpler vial. Photograph courtesy of Oil Heritage Region, Inc.

Figure 2. Many brand-name lubricants still emphasize their origin as Pennsylvania Grade crude oil. Photograph courtesy of Oil Heritage Region, Inc.



IDEAS ON ORIGIN FROM ANCIENT TIMES TO MODERN. Many years of scientific research on the occurrence and composition of oil have provided us with a clear, consistent, and generally accepted concept of how crude oil forms in the earth's crust. It was not always so, however, and some dispute about the origin of oil continues today. In general, hypotheses of origin can be separated into two camps: inorganic and organic.

One of the earliest inorganic hypotheses originated with the Arabic peoples, who, in about 850 A.D., suggested that water and air combined with fire produced sulfur and mercury. The sulfur and mercury then combined with "earth" and at great subterranean temperatures yielded "naft" (naphtha) and "qir" (asphalt).

Two celebrated nineteenth-century scientists, Gay-Lussac and Humboldt, proposed that oil formed as a result of impregnation of marine sediments by subaqueous hot springs of volcanic origin. Another nineteenth-century idea suggested that oil formed by the combination of hot alkalis with carbon dioxide deep in the earth's interior. The famous Russian chemist Dmitri Mendeleef argued that percolating water encountered iron carbide deep in the earth, generating hydrocarbons. Other workers, noting that methane occurs in trace amounts in volcanic gases and in fluid inclusions in igneous rocks, assumed that it was sweated out of the earth's interior throughout geologic time, rose in the crust, changed into heavier hydrocarbons, and finally accumulated into the petroleum deposits we exploit today.

Hypotheses suggesting an organic origin for oil are also quite old. Oil and coal were linked by some naturalists as early as the sixteenth century. Chemists discovered that oil could be distilled from coal in the laboratory and postulated that this occurred in nature as well. Geologists working in Pennsylvania had problems with this idea, however, because

the primary oil-producing strata lacked associated coals, and oils produced in Venango County were chemically different from oils derived from the distillation of coal. A great many mid-nineteenth-century workers, including then Pennsylvania State Geologist J. P. Lesley, advocated that oil was derived from terrestrial vegetation washed into the sea and deposited with the sandstones containing the petroleum. Problems with this idea include the fact that some oil is produced from rocks containing only marine fossils, and the observation that the high temperatures needed to convert wood into liquid organic matter are not geologically reasonable. Lesley later expanded his ideas to include marine plants and animals as a source of oil (Hedberg, 1969). This train of thought became popular in the late 1800's and early 1900's and led to the view that oil represents an accumulation of hydrocarbons that originally were produced by living organisms.

IT CAME FROM OUTER SPACE. The occurrence of hydrocarbons in meteorites has been well known to scientists since the mid-1800's. In the early 1930's, investigations revealed that methane is a major component of the large outer planets Jupiter, Saturn, Uranus, and Neptune. Because scientists believed that all the planets in our solar system were closely related in origin, some researchers concluded that the raw materials for hydrocarbons must have been present in the substances from which the primordial earth accreted 4.6 billion years ago. By the 1950's, such reasoning led astronomer Fred Hoyle to argue that the deep earth must contain vast untapped reserves of oil just awaiting our technological ability to find and exploit them (Pratt, 1956). This view is still held by a small group of scientists (see review by Gold, 1993).

THE MODERN VIEW. A great body of scientific evidence suggests that oil was formed in the geologic past from a combination of hydrocarbons synthesized by living organisms plus those formed from thermal alteration of organic matter in sedimentary rocks (Hunt, 1996, p. 109). About 10 to 20 percent of the oil in the earth's crust forms via the former mechanism, while 80 to 90 percent forms via the latter. Marine plankton are the major players in both pathways of oil formation.

Several lines of evidence support this contemporary view of the origin of petroleum: (1) oil is rarely found in rocks that formed before life developed on the earth; (2) oil contains compounds derived from the pigments of living organisms; (3) the distributions of carbon isotopes in oil is similar to those in organic matter; (4) hydrocarbon compounds found in oil affect polarized light the same way that hydrocarbons and other compounds synthesized by living organisms affect polarized light; and (5) the structures of many oil compounds are similar to those of fats and waxes found in living organisms and, therefore, could be formed from them (Krauskopf and Bird, 1995).

SOURCE ROCKS AND OIL GENERATION. So, how do we go from living organisms to Pennsylvania Grade crude oil? When organisms die, bacteria attack their remains. These bacteria require oxygen, and if oxygen is plentiful, destruction of the organic remains is complete. Abundant remains of marine plankton, however, sometime accumulate along with mud in stagnant underwater environments. The aerobic bacteria use up any dissolved oxygen very quickly. Anaerobic bacteria, which obtain their oxygen from dissolved sulfur compounds in the pore waters of the mud, then take over. These bacteria consume most of the easily decomposable compounds in the organic matter, such as proteins and carbohydrates. As the muds continue to be buried, further physical and low-temperature chemical reactions transform the chemical structure of much of the organic matter. As the temperatures increase with even deeper burial, the transformed organic debris decomposes to form crude oil. The muds compact and become shale. Petroleum migrates from the shale and travels through more porous and permeable strata until it encounters a trap.

A FINITE RESOURCE. Modern ideas about the origin of oil are based on a long history of scientific investigation. Some perceptive geologists intuitively reached the same conclusions over 100 years ago. For example, Henry D. Rogers, the first State Geologist of Pennsylvania, thought that Devonian black shales were the source of the oil found in the sandstones of the Oil Heritage Region, and he suggested that "...the greater portion of the oil and gas is derived from the marine [fossil organic matter in the] carbonaceous shales..." (Rogers, 1863). So why the appeal of so many other, sometimes fantastic, hypotheses about the origin of oil? Some historians note that the inorganic hypotheses were based on laboratory experiments by chemists and, therefore, offered both scientific validity and the reassurance of an inexhaustible supply of oil. An inexhaustible supply was implied in the cosmic hypotheses too. The organic theory, on the other hand, infers that a limited quantity of oil is available to us.

Forecasters predict that crude-oil production will be able to supply increasing demand until peak world production is reached in about the year 2020 (Edwards, 1997). Conventional crude-oil production should terminate in the United States in the year 2090, and world production should be near exhaustion by the year 2100 (Edwards, 1997). Colonel Drake launched a remarkable industrial era in 1859, but the end of that era is clearly in sight. The recognition of the organic origin of oil is an acknowledgment of the finiteness of the resource upon which we depend for the quality of our lives. Let us hope this recognition compels us to use what remains of this resource prudently and to properly manage the challenges and changes ahead.

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Oil Creek's Riparian Wells

by Samuel T. Pees

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America's pioneer oil well drilled by Colonel Edwin L. Drake in 1859 was a *riparian* well. The word "riparian" strictly means "on the bank of a stream," but in the broad sense it seems reasonable to include the adjacent flats that are subject to frequent flooding, low islands, gravel bars, and the streambed itself. Many of the wells that were drilled after Drake's well in the first decade of oil were also riparian. Drake drilled in the flats about 150 feet from the east bank of Oil Creek (Figure 1). The site was on an artificial island created by a race for the Brewer and Watson Company lumber mill and the course of Oil Creek. When the creek was in spate, the waters would flood the flats. Now, the site of the Drake well, consisting of a replica of the engine house and derrick, is protected by an earthen dike built by the American Petroleum Institute in 1931.

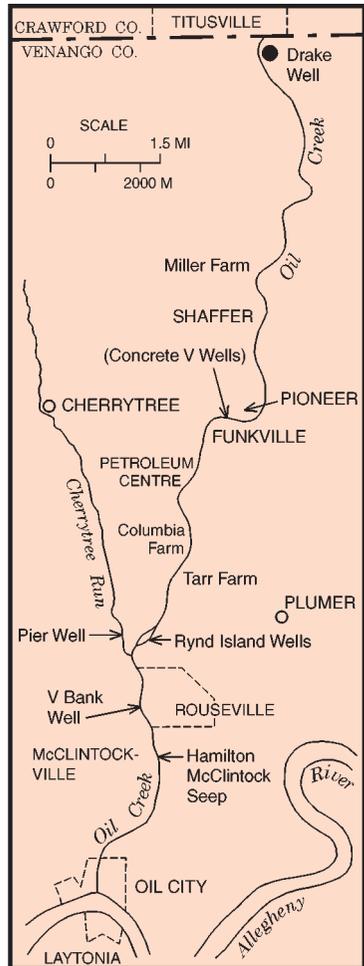
After Drake struck oil on August 27, 1859, at a total depth of 69½ feet, would-be oilmen crowded the valley and commenced a drilling spree that saw wells fill the flats, the islands, and finally, here and there, in the creek itself. Some were drilled a short distance up the cascading tributaries, often directly in the narrow runs themselves. The same drilling scheme took place along the banks of the Allegheny River and on its islands. Watercourses were hugged during the very first years by most operators; bottomlands and stream banks were favored localities, a notion unwittingly set by Drake. His selected site was on a well-known oil seep, but it also happened to be on bottomland and near the creek

bank. It was a while before the first oilmen left the creek valley and tested the plateaus in earnest. Even on the higher land, the first operators preferred to locate their wildcat wells on drainage courses. Another possible reason for early “creekology” may have been the need for water for the boilers.

The incentive to drill closely spaced wells in the highly competitive days of the first boom in Oil Creek valley was the phenomenal production of flowing wells that were brought in at rates of 1,000 to 4,000 barrels of oil per day from depths of only 450 to 550 feet. Names of the giant wells quickly found their place in history books: Empire, Buckeye, Noble, Fountain, Sherman, Phillips-2, Coquette, and many more. These wells tapped the Venango Third sand, which contained the great volumes of oil and high pressures that caused the gushers. Flowing riparian wells at Pioneer, Funkville, Petroleum Centre, and Tarr Farm required enormous efforts to contain, but they made enormous profits too. Other producing sands in this belt were the Venango First and Second, the latter often prevailing after the Third sand was lost.

Efforts to get as close to the giants as possible led to drilling in the creek or behind barricades that diverted the stream waters. Seeps were favored localities. One famous seep was in the middle of Oil Creek at the Hamilton McClintock farm below Rouseville. Ham had collected oil at his seep via baffles since the early 1800’s. He made up to 20 or 30 barrels in a season. Covetous eyes eventually caused a well to be drilled offshore at that seep site (Fig-

Figure 1. Map of the stretch of Oil Creek from Titusville to Oil City, about 16 miles, taken in part from Beers (1865). This was America’s first oil belt, beginning August 27, 1859, with the completion of the Drake well. Gathering of oil from local seeps occurred long before then. The McClintock oil seep, riparian wells, and place names (many now ghost towns) are shown. Modified from Pees (1996, Figure 3).



ure 2). Afterwards, not much was said about it. William Phillips remembered rainbow colors at a spot in the creek at Tarr Farm. He leased a narrow strip of land along the east bank and drilled the Phillips No. 2 well in 1861. It came in for 4,000 barrels of oil per day and required a virtual army to dig pits to hold the flow; oil from the well shortly overwhelmed the containers anyway and flowed copiously into Oil Creek.

Some early riparian wells in the late 1800's, also during World War I and through the 1930's, were encased by fieldstone and timber foundations that held the pumping apparatus and wooden separator tank aloft. Some of these have survived many floods and "ice-outs" (complete jamming of the creek by ice floes), but production ceased long ago. Rynd Island wells are examples of these early wells (Figure 1).

Eager to "make land" in the shallow creek next to the flats where good production had been proven, operators built concrete or wooden V-shaped barriers with the V pointing upstream. They drilled behind the V barricade. Some of these constructions are still there, on the creek banks or at the tips of the islands that they created over time (Figures 3 and 4).

Another way to get "into the creek" was to build a pier that would jut out from the bank. One of these, on a tributary of Oil Creek, still bears a well capable of producing from the Second sand (Figure 5).

Riparian wells ruined the chances for secondary recovery in a number of places in Oil Creek valley. Left to corrode, some of the wells were



Figure 2. A well believed to be in the locality of the Hamilton McClintock seep in the middle of Oil Creek. The V has snagged some driftwood. Photograph courtesy of the Drake Well Museum.



Figure 3. A concrete V pointing upstream at Pioneer. This barricade has been shifted by floods and ice-outs. A well was drilled behind the V and originally was protected by it. The island was created by the reduction of flow velocity behind the V.



Figure 4. An overturned concrete V probably dislodged by ice flows in the Pioneer area. The well is “lost” in the creek.

eventually invaded by fresh water, causing massive accidental flooding of the reservoir. Unfortunately, the Third sand was usually the victim.

Stories of riparian wells in the Pennsylvania oil belt are legion. The most interesting facet of this method of production is that traces of the wells still exist. From what the writer has seen of Oil Creek, a boat could grind over one or two of the wells. Another early well casing, which juts out of the water, could upset an unwary canoeist. Some wells are on gravel bars that are inundated during high water (Figure 6).



Figure 5. A pier jutting into Cherrytree Run, a tributary of Oil Creek. Note the Oklahoma-type pumping jack. This pier well can produce from the Venango Second sand. Photograph by Ellsworth “Pete” Sparks.



Figure 6. An abandoned gravel-and-cobble-bar well in Oil Creek at Pioneer. This bar is often under water.

It is no wonder that oilmen eventually ventured offshore into the world's oceans and its larger lakes. A precedent had already been set in the waters of Oil Creek in the 1860's and later.

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As the Drill-Bit Churns

by Kathy J. Flaherty

Bureau of Topographic and Geologic Survey

Many a fortune-seeker abandoned home, family, and job to try his hand at drilling in hopes of striking it rich with a prolific oil well. Fortunes were made; many, also, were lost. As if the process of poking holes in the planet in hopes of puncturing a pocket of crude were not risky enough, the roller-coaster economics of the early oil industry could drive even a successful oil prospector to abandon the fields for something more secure.

Will Shaw (Figure 1) is a fictitious geologist. He was a recent college graduate, eager to use his education to prove himself and win the hand of his beloved. Will's quest was twofold. First, he wanted to find oil and get rich. More important to us was his second goal: to find oil by using geological principles that were still very much in the formative stage as far as subsurface exploration was concerned. While Will's contemporaries in the oil fields were ready to embrace the current drilling fads, Will was convinced that application of basic geological principles would guide his exploration endeavors successfully, and he set out to prove it!



My dearest Elsbeth,

April 4, 1868

I am hopeful that this greeting finds you in good health and good spirits. I have arrived in Pleasantville, Pennsylvania, having had an uneventful journey. Accommodations are scarce, and I regard myself as fortunate to have found a bed in a clean and dry boarding house near the center of the drilling activity. The room is shared by several gentlemen who are also seeking their fortunes in the oil patch, but as it is away from the mud and hustle and bustle of the oil-field workings, it is quite satisfactory.

From the window in my community room, I glance over the countryside with amazement. The hills are barren of all but mud and oil-well workings; trees have been replaced by wooden derrick towers and shrubs have changed into barrels to collect and store oil. Muddy ruts make up the road passages, and already I find that heavy boots and thick woolen socks are a necessity.

It is my observation that there is no requirement of a comprehension of geology to conduct drilling enterprises. Since my arrival, I have become acquainted with other occupants of the boarding house. The prior pursuits of these gentlemen who are now in search of the financial rewards of successful petroleum endeavors are as varied as

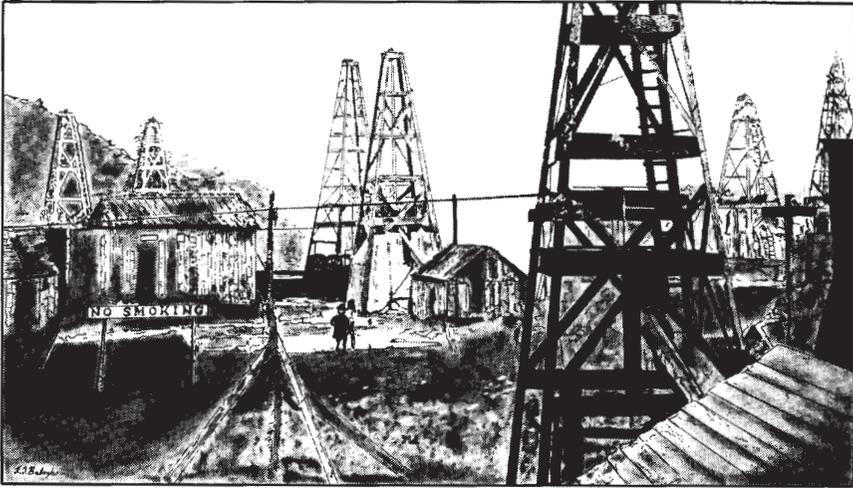


Figure 1. Fictitious geologist Will Shaw stands among the derricks in the oil patch. Drawing by Lajos J. Balogh.

they could be. Among their numbers are a former county treasurer, railroad executive, blacksmith, several farmers, merchants, jeweler, and even a piano tuner, all hopeful for a big strike. I have not yet met another geologist, and when an inquiry is made of my profession, I am too often treated as a curiosity. I do believe they regard the concept of using science to locate a likely supply of petroleum as laughable.

Conversing with some gentlemen in the dry-goods store, I have learned that the task of leasing property to drill for oil consists of whatever agreement can be made between the landowner and the leasee. Such agreements seem to be inconsistent and depend in part on the sophistication of the landowner. Some are clever enough to demand $3/4$ of the revenue of the well, although the more common arrangement is that the landowner receives $1/8$ of the well's production. A few stories are circulating about landowners who demanded their payment in oil, already in barrels, instead of in cash dollars. The demand for barrels is so extreme, and the price so dear, that to provide them costs more than the value of the oil itself! I have been warned by these men to beware of leases offered by enterprising leasing agents who have taken oil leases from the landowners. Frequently, they have promised the landowner $1/8$, or even as little as $1/10$, of the royalty and keep $1/3$ to $1/2$ plus a large bonus for themselves, merely for providing the lease to a driller! I promise you, dear Elsbeth, that I will not become engaged in such a deal as will be self-defeating for want of economics, for then I shall neither amass my fortune nor receive the blessings of your father to take your hand, and happiness will continue to elude me. Hopeful that when next I correspond I will be able to give you a substantial report of my progress, I am

Ever your humble servant,

Will Shaw



My dearest Elsbeth,

May 11, 1868

As always, my fondest thoughts are with you. I thank you most sincerely for your correspondence. I relish news of home and your activities there.

I have at last secured a lease upon which to begin putting down a well. It is on a farm of 23 acres fairly near here. Although the farm had been leased in 1866, a well was never completed there. A group of local farmers had pooled their funds and started a well, only to run into troubles with tools stuck in the hole and other costs that they did not anticipate. Their life's savings poured into the hole and thereby depleted, they were forced to abandon the effort, never reaching near the oil sands. In deciding where to sign a lease, I was much influenced by the reports of the quality of the 5th sand, which drillers nearby have described as a very pebbly rock unit. I believe that a rock of these characteristics is most desirable, as it is likely to readily store and surrender petroleum upon penetration by the drill. A drilling crew of 6 able men has been secured, and they will work in 2 shifts of 3 men each. The rig and hardware are nearly fully assembled, and I believe we will be in a position to begin drilling on the morrow.

Our costs thus far total \$4,290 for the supplies, hardware and some crew wages. I am making a careful accounting, as I have been entrusted with the funds of several investors who are certain to hold me responsible. Wages and the 10-horse-power engine are the most costly items: pipe is \$6 per foot, and coal to power the engine is \$0.50 per barrel. If we experience no unforeseen obstacles, I expect our enterprise will not exceed \$5,000.

Once drilling has commenced, I will spend the most amount of time possible at the well site, stopping only for rest and nourishment in town. As drillers are apt to carelessly race through the rocks with as much speed as is mechanically possible, it will be necessary that I temper their haste. I must convince them that it is essential to cease drilling to take frequent, careful depth measurements, and to collect the drill cuttings for my scientific analysis. We will be using a diamond drill to penetrate the rock. It has the effect of cutting cylinders of solid material from the earth. These cylinders are then brought to the surface by means of clamps lowered into the hole. I have seen examples of rocks withdrawn by this method, and find them to be ideal for geological study. The rocks remain somewhat intact, and fissures, changing characteristics, and bedding planes can be examined.

Please forward my most sincere regards to your kin. I trust that your Father will consider my progress in this endeavor a good faith effort to fulfill the promises I made in anticipation of our betrothal. Eagerly anticipating your joyous receipt of this news, I am

Your humble oil-field servant,

Will Shaw



My dearest sweet Elsbeth,

September 29, 1868

Your kind words and reassurances of a more pleasant encounter when next I meet your Father have sustained me through the most tedious days at the well, when we only progressed 10 feet per day. I can only hope that your Father will find a new respect for my work with my success in bringing in a productive well of both financial and geological merit.

We have completed the drilling of our first well on this farm and have realized a profitable well from which we pump nearly 200 barrels per day, very consistently. The production is from the 5th sand, which was coarse and pebbly as I had predicted based on geological characteristics. It was first encountered at 820 feet below the mouth of the well, and 14 feet into the coarse sand, we reached the oil pocket concealed therein. I am somewhat vindicated and have been approached by no less than 17 companies to assist them in determining locations based on geology for their future wells! Please be assured, sweet Elsbeth, that I will do nothing that will inhibit our financial development or delay our joyous reunion. While I am relishing this new-found respect in the oil community, the success is a coup for the science of geology in so practical an application. Use of geological science is a far cry from use of a witch-hazel divining rod, or recitation of incantations, or any of the many other whimsical approaches that have been so frequently employed here.

I negotiated a premium price of \$4.25 per barrel for the sale of our oil, as the market here is currently very strong. We have, after only a few weeks of production, paid for the drilling of this first well and have paid a small dividend to our investors. We have begun the construction of another drilling site and will commence to drill within a fortnight.

I am confident that the coarse nature of the 5th sand, so prolific here, continues on the far side of this lease and beyond, as it is found also in wells drilled a few miles from here in the same direction. A belt such as this can only be accurately followed through careful documentation of the rocks encountered as the drill proceeds. It is critical that records be kept in a methodical fashion, with all details noted objectively. I truly believe that only through the most thorough and painstaking diary of every measurable characteristic will we gain an understanding of the attributes that constitute oil-producing rock reservoirs.

Our second well should be completed by the Winter Solstice, and I am planning to return to you in time to celebrate the Holidays. I will once again request an audience with your Father to request your hand in marriage. It is my only desire to bring you to oil country as my wife when I return to drill a new prospect in the Spring. With blissful anticipation of our Holiday encounter, I remain

Your most humble oil-field servant,

Will Shaw

Our geological hero proved that a successful prospect could be defined and drilled based on science. His achievement won over his sweetheart's father, and so Will and Elsbeth were married on the feast of St. Valentine in 1869. They lived happily in the town of Franklin for several years, where they raised a family of two sons and seven daughters. Will continued to drill profitable wells in his new-found career as a petroleum geologist. Having amassed a fortune in Venango County oil, Will and Elsbeth turned the business over to their children in 1904, and they pursued philanthropic interests.

The Pit and the Petroleum¹

by John A. Harper

Bureau of Topographic and Geologic Survey

OIL, OIL EVERYWHERE . . . BUT WHERE? When the modern oil industry was still in its infancy in the 1860's, many of those involved had no idea what they were doing beyond putting a hole in the ground so that the oil could flow out. And put holes in the ground is what they did—thousands of them, some so close together you could spit between drilling rigs.

Wells were drilled in creek valleys, on hilltops, and anywhere in between where there was a patch of unused ground. One operator would swear on the necessity to drill along a creek bed because he was convinced the oil flowed in a cavern or fissure below the creek. A competitor would announce that drilling on uplands made more sense because the newly devised anticlinal theory claimed oil accumulated at the tops of folded rocks, typically associated with mountains. Yet another competitor would hasten to say that both the preceding ideas were hogwash. He knew for certain that the oil accumulated in straight-line “belts” or “trends” that ran across country without regard to the landscape. It would be another 10 to 15 years before John F. Carll began working for the Second Geological Survey of Pennsylvania, using the Survey as a publishing outlet for his pioneering concepts about subsurface geology and petroleum technology. Not that it would have mattered—Carll's ideas were virtually ignored until the early 1900's because they did not include a single unifying theory of where to find oil (Harper, 1990). This was not Carll's fault, however, because time and experience have shown

¹ With apologies to Edgar Allan Poe.

that there is no such theory. Oil and gas are found in a wide variety of geologic settings.

In the 1860's, most of the oilmen in Venango County knew that oil was found in rock; they just did not know how the oil got there, or why it came out when they drilled into the rock. Many thought the oil occupied large holes and fractures, or even formed underground lakes. Others realized it saturated the rocks like water in a sponge and decided the oil could be gotten more quickly in a large pit than from a well. Thus began the modern concept of mining for oil.

DIG THAT BLACK GOLD! Digging for oil was not a new idea even when Drake drilled his famous well. Shafts and pits had been used successfully in Europe and Asia for centuries (Dickey, 1939). The early Indians of Venango and Warren Counties had dug pits along Oil Creek and other streams so long ago that it was not remembered by their descendants when the Europeans moved into the area in the 1600's. James M. Williams was digging producing oil shafts in Ontario in 1857, and in 1858, Colonel A. C. Ferris unsuccessfully sunk an oil shaft 220 feet deep at Tarentum in Allegheny County, Pa. The Pennsylvania Rock Oil Company's first attempts at commercial oil recovery along Oil Creek included digging pits

and trenches to channel and trap the oil seeping out of the sand and gravel of the floodplain. So there was nothing new about the basic concept of mining for oil when the first attempt at deep mining in northwestern Pennsylvania was made in the Triumph Streak oil field at Tidioute in 1864.

IT'S ALL IN YOUR MINE. The Tidioute oil shaft was located across the Allegheny River from Tidioute in Warren County, about ¼ mile downstream from the bridge over the river (Carll, 1883). Begun in 1864, the 8- by 12-foot shaft encountered the oil reservoir, 5 feet of conglomeratic Venango Third sandstone (Figure 1), at 152 feet. Oil oozed from the 200 square feet of reservoir rock exposed in the floor and walls, but never enough to be productive. The company had wanted to run horizontal shafts into the sandstone, but the proj-

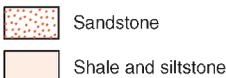
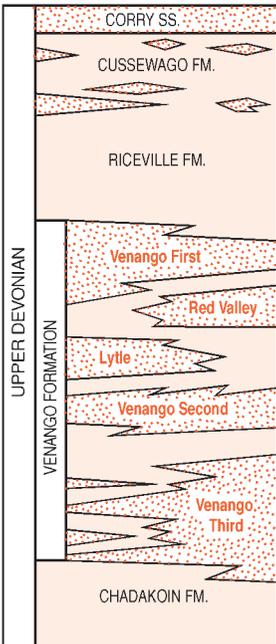


Figure 1. Generalized geologic column of the sub-surface rocks of Venango County and adjacent areas.

ect was abandoned in the fall of 1865 when the foreman was killed in an accident and the workers refused to reenter the shaft.

At least five attempts at mining for oil were made in Ohio in 1865, three near Powers Corners, Trumbull County (Carll, 1880), and two near Macksburg, Washington County (Minshall, 1888). Because each shaft was dug at great expense, but only limited quantities of oil were recovered, they were all considered unsuccessful.

Perhaps the best known early experiment in oil mining, and the most ambitious, was the “Great Petroleum Shaft” at Petroleum Centre in 1865. It was also the least successful. The Petroleum Shaft and Mining Company hired 14 men for the project, including some Welsh miners from Schuylkill County, Pa. (Mong, 1994). The company planned a large pit to be dug 7 by 17 feet wide (12 by 17 feet according to some sources) and 500 feet deep to the prolific Venango Third sandstone reservoir (Figure 1). Diggers dug, and stonecutters and masons worked boulders into stable frameworks for the machinery. However, after only two months and at 73 feet “the funds ran out, gas threatened to asphyxiate the workmen, the big pumps could not exhaust the water and the absurd undertaking was abandoned” (McLaurin, 1896, p. 133). The fiasco became a local dump. Today the site (Figure 2), which is located in Oil Creek State Park on the southwest side of the road from Petroleum Centre to Plumer, about 1,000 feet southeast of the park office, is a circular pit that has been mostly filled in to protect farm animals.



Figure 2. All that remains of the Great Petroleum Shaft is a 30-foot-deep depression and some stonework near the Oil Creek State Park office.

A CENTURY LATER. The Great Petroleum Shaft might have been an “absurd undertaking,” but it certainly was not the last word in oil mining. With improved technology and a better understanding of subsurface geology, numerous companies around the world eventually tried and succeeded at mining for oil. Even Venango County was given two more chances, coincidentally at about the same time. In 1944, Northern Ordnance attempted a 580-foot shaft with a horizontal tunnel in the Venango Third sandstone along Bull Run, a tributary of Oil Creek, but the exorbitant cost of digging proved too much, and the project was abandoned at only 67 feet (Pees, 1989).

The Venango Development Corporation, a consortium of companies with familiar names such as Pennzoil, Quaker State, and Kendall, acquired a 400-acre lease about 3 miles north of Franklin. Then in 1942, they sank a 370-foot shaft near the center of the lease (Elder, 1944). The 8-foot-wide shaft was walled with steel and concrete. At the bottom, workmen excavated a room 27 feet in diameter and 59 feet deep, bringing the total depth of the shaft to 428.8 feet (Lytle, 1959). From this room, three rows each of 24 holes, each hole 6 inches in diameter, were cast into the concrete walls to be used for horizontal drilling into the Venango First sandstone (Figure 1). A tower supported an elevator that allowed workmen and equipment to enter and exit (Figure 3). The first oil flowed into a storage tank upon completion of the horizontal holes in 1943. The enterprise proved to be expensive, but eventually successful. The Franklin oil mine changed hands several times over the next 20 years, and an explosion in the 1950’s damaged the project to the point where the main system had to be abandoned, and the project converted to a “conventional” oil well (Pees, 1989). Pennzoil, the final owner, ceased operations in 1967, and the project was finally plugged and abandoned in 1997.



Figure 3. The Venango Development Corporation oil mine near Franklin as it looked in 1960. The tower supported the pipelines and elevator shaft. Photograph by William S. Lytle.

Valiant efforts often are in vain, but not always. The global oil industry had proven that oil could be extracted profitably by mining, and even in the nearly depleted oil fields of Pennsylvania, it became proven technology for a time. Is there another oil mine in Pennsylvania's future? Only time, and economics, will tell.

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The Science of Drilling Oil Wells

by Kathy J. Flaherty
Bureau of Topographic and Geologic Survey

**¹All around the walking beam,
The drillers search and toil.
That's where all the money goes. Blop! Goes the oil!**



The location of Drake's famous oil well, and many of the wells that followed, were initially determined by the presence of promising "surface indications." Desirable surface indications included oil seeps that oozed from the surface of the earth and accumulations of oil that occurred in ancient pits dug by early Indian inhabitants. This primitive prospecting evolved into the pseudoscience of "creekology," or drilling near creek beds—or even in the creek. Creekology reflected the idea that oil accumulated in areas of low surface topography. Later, drillers

¹To the tune of "Pop! Goes the Weasel."

believed that unless an open crevice was encountered during bedrock drilling, success was unlikely. This “crevice” theory represented the whimsical thought that oil occurred in underground streams, and shows an evolution in exploration approach from relying on surface observations toward utilizing subsurface data. Theories of oil occurrence and accumulation continued to unfold, guided by the creative imagination and monetary pursuits of the driller. Some geographic areas were revisited to test the new theories and the investors’ billfolds; others were left to be “rediscovered” much later.

No matter what the current fad, the fact remained that drillers were paid to drill holes. In the frenzy to make wells profitable, drilling activity was not recorded. Time was of the essence, and the lure of strong oil flow created intense competition among drillers to be quicker with the drill bit. Without written observations of the subsurface penetrations, however, investors were literally rolling the dice with each new well. Poor records—or more likely, no records—led to haphazard drilling techniques, as evidenced by numerous dry holes in the same area and rapid reservoir depletion caused by needless and heedless overdrilling.

**A dollar an acre pays the lease. More a deal will spoil.
That’s the way the money goes. Blop! Goes the oil!**



The early cultural and economic climates in the Pennsylvania oil fields were not conducive to creating records of the rocks encountered. John F. Carll, a geologist with the Pennsylvania Geological Survey during the early oil era, argued strongly for collection and maintenance of drilling data. In his 1880 report, Carll estimated that for every 100 wells drilled, less than one useful record was voluntarily submitted for the public files. Carll cited as causes of the unreliability of records the vast number of wells drilled (about 4,000 in 1877 in the oil fields of Pennsylvania and southern New York!) and the fact that so much data were recreated from memory long after the wells were completed. Drillers made money by drilling quickly, and sometimes the contracting company paid incentives to the driller and his crew to minimize drilling time. A low-cost, productive well was the goal of the contracting company. It took the budding industry many years to recognize that the path to success is geologic knowledge and interpretation through detailed observation.

**Drill it quick with nary a thought.
To science they were not loyal.
A record may prove the theory wrong! Blop! Goes the oil!**

Carll (1880) discussed the interests of the driller in “doctoring” well records. Paid by the number of holes completed, a shrewd driller could

stretch the work for himself and his crew by merely drilling two or three “dry holes” first! Because the contracting company representatives rarely spent any appreciable time at a well site, a driller could easily misrepresent the results of a well by claiming a dry hole for a well that was not even drilled deep enough to reach the productive formation, or by misstating the characteristics of or the presence of the productive sandstone layers.

“Geological confusion” was not difficult to foster or maintain. Typically, drillers ignored the upper rock strata when drilling, and that readily led to stratigraphic correlation errors. Disorder was the order of the day: First, Second, Third, and Stray were prefixes assigned to sandstone layers without regard to where they occurred in the geologic section. Drillers introduced local subsurface rock names that led to problems of impossible correlation, including productive reservoirs seemingly isolated and distinct from each other. Carll recognized these frustrations and problems and sought to correct the situation by standardizing drilling records and by requesting that all bedrock encountered be described and measured during the drilling process. To the driller, this was an unreasonable demand on his time and on his earning potential!

Generally, records for wildcat wells were more complete and more accurate than those in development areas. However, no area was immune from the creative driller’s record! The drillers’ fear of investors recognizing their scam led to “fixed” records that appeared to follow the logical principals of the theory currently in vogue. With risk of exposure so high, records were forced to fit the picture the driller was trying to draw.

Landowners, too, had incentives for doctoring the drilling records. News of a dry hole did not inspire a company to pay rental on leases, drill, or pay royalties. It was typical for a landowner to say that an unproductive well on his land was not drilled deep enough to reach the oil sands!

A gusher is hard to hide in the hills. Publicity will foil. The best kept secret is over the top! Blop! Goes the oil!

Very successful wells—oil spurting over the top of the derrick and drenching everything in close proximity in a bath of crude (Figure 1)—made sensational news. As with all such events, sensation spreads quickly. Nothing was worse for the oil business than publicity, because publicity brought competition. News of good wells brought a scramble for nearby acreage, which the owner of the discovery well would want to secure for himself. Bizarre as it may seem, news of dry holes also brought competition for acreage, especially after the advent of the “belt” theories, in which it was thought that the productive oil sands occurred in linear trends. If a well was a duster, the belt must trend in a different direction,



thus making the acreage in that direction more desirable. So, even with a dry hole there was a need to accumulate more acreage. Many a fortune was probably made by letting other drillers define productive limits of oil sand units by drilling mistakes! Even controlling a productive lease was no assurance that additional wells could be developed. Competitors crowded lease lines, infringing on the economics of offsetting prospects—an old “art” still very much practiced today.

To compete effectively, good, accurate, and timely geologic information was essential. In an industry shrouded in secrecy and deception, obtaining information became a specialized job: that of Well Scout. These enterprising folks were the oil-field spies and had the responsibility of discovering the status of wells in progress or the results of recently completed wells. They could be found snooping around a well in the woods—and in at least one case, a scout had to be rescued from under the floorboards of a derrick where he had become wedged after wriggling in in an effort to overhear and observe firsthand the goings-on at the well.

**Accurate records,
carefully kept,
Of rocks and depth
and soil.
GEOLOGY should
guide the drill! Blop!
Goes the oil!**

It became increasingly apparent that the consequence of selfishly guarding details of drilling and well results was an inefficient and ineffective use of resources for everyone. Carll was determined to solve the problem and created a “form” to be filled out during the drilling of each well. After all,

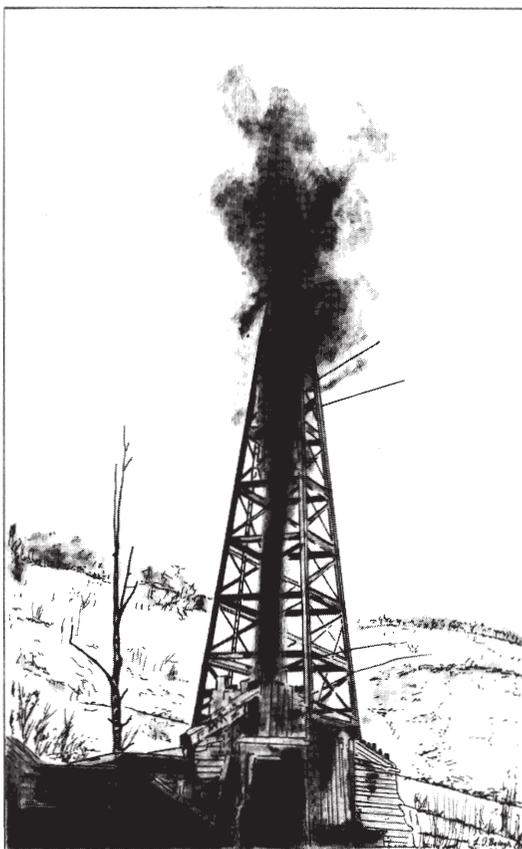


Figure 1. “Gushers” always made big news—and a big mess. Drawing by Lajos J. Balogh.

if accurate records were kept, there would be no excuses for dry holes! Particularly, Carll considered the depth and thickness of each type of rock drilled and the descriptions of the drill cuttings to be important. The value of collecting this data on a well-by-well basis was the foundation for building an understanding of the subsurface geology. This eventually and ultimately led to selecting drilling sites based on science rather than on whimsy. Comparing the drilling records of a sequence of wells could indicate a thickening or thinning trend in rock units, reveal uniform or changing characteristics in the oil reservoir rocks, and aid in correlation of local and remote areas by noting persistent marker beds. The concept was great, but Carll did not convince the drillers that such effort was worthwhile. In frustration, in 1876, Carll finally hired his nephew to visit certain well sites and take detailed notes and measurements for his personal study. Contracting companies eventually began to require measurements and details from drillers. Various methods of obtaining the information were employed, with varying degrees of accuracy; these methods gradually became more standardized and more reliable.

**Many have drilled hither and yon,
To find a prospect royal.
There are still surprises in them thar hills!
Blop! Goes the oil!**



Modern energy exploration, through the science of geology, has overcome many of the early problems to conscientiously and honorably meet the growing needs of society. Technology, coupled with keen observation and creative reasoning, has yielded oil where it was never before thought to have accumulated.

The role of the oil and gas industry in developing the science of geology and the technology of drilling should not be downplayed or misjudged. Much of what geologists know today about sedimentary rocks has only been gleaned through the efforts of energy companies and the scientists they employ. The search for subsurface hydrocarbons has yielded a treasure chest for understanding planet earth.

Modern exploration and drilling techniques have provided the tools to reassess the areas that deserve a new look. Although some areas of Venango County are already teeming with century-old boreholes, these are exciting and challenging times in the oil and gas industry, for much is yet to be discovered!

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ANNOUNCEMENT

Survey Sponsors “Geology Day” at Oil Creek State Park and Releases New Park Guide

The Bureau of Topographic and Geologic Survey, in cooperation with the Bureau of State Parks, the Bureau of Conservation and Recreation, and the Oil Heritage Region, Inc., will sponsor a “Geology Day” at Oil Creek State Park on Saturday, June 13, 1998. Geology Day is an opportunity for park visitors to learn about the geologic features of the Oil Heritage Region, including glaciation and the evolution of the landscape, local rock strata, fossils, erosion and other ongoing geologic processes, and the geologic story of Pennsylvania Grade crude oil. Events include, but are not limited to (1) a 19.4-mile bike hike along a well-paved former railroad grade from the park office at Petroleum Centre to the Drake Well Museum and back, with stops to look at rocks, fossils, landscapes, and oil history; (2) scheduled hikes along the moderately strenuous Geology Trail; (3) a fossil show-and-tell; and (4) an orienteering course (how to find where you are and where you are going using a topographic map and a compass), which includes demonstrations of a global-positioning-system (GPS) device. Staff from the Survey and Oil Creek State Park will be on hand to lead the events and answer questions. This is a great opportunity for individuals, families, and groups such as schools, scout troops, and clubs to learn about the geology of northwestern Pennsylvania and experience the wonderful outdoor environment of Oil Creek State Park.

A complete schedule of events is posted on the Survey’s web site at www.dcnr.state.pa.us/topogeo/ and is also available from the Pittsburgh office of the Survey (see facing page for address and telephone number).

Visitors to the park will be able to obtain a copy of the Survey’s most recently published park guide in the “Trail of Geology” series. Park Guide 22, **Oil Creek State Park, Venango County—Ice and Oil Shape the Land**, by Survey geologist John A. Harper, was prepared in cooperation with the Bureau of State Parks. In the two-color, 12-page guide, Harper explains the effects of the Ice Age on the creek and the park’s landscape and summarizes the geology and the history of the oil industry in the area. A centerfold map shows the locations of many sites of geologic interest. Park Guide 22 is a free publication and is available at Oil Creek State Park, or upon request from the Bureau of Topographic and Geologic Survey, P. O. Box 8453, Harrisburg, PA 17105–8453. It is also posted on the Survey’s web site.

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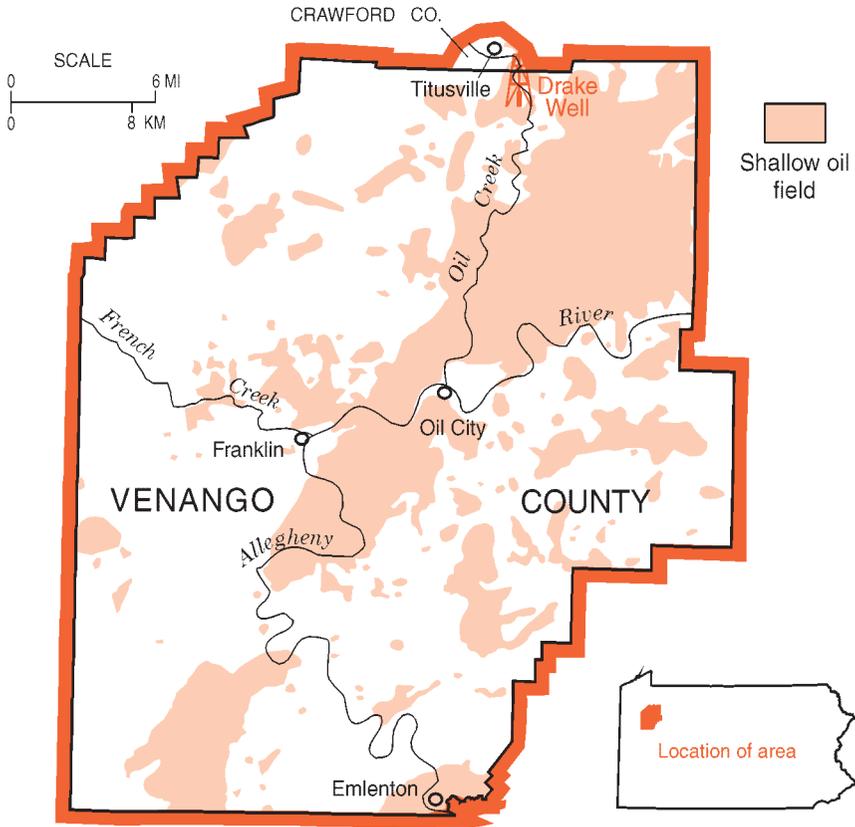
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