Petroleum Systems and Geologic Assessment of Oil and Gas in the San Joaquin Basin Province, California

Chapter 3

A Brief History of Oil and Gas Exploration in the Southern San Joaquin Valley of California

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Contents

Introduction

The Golden State got its nickname from the Sierra Nevada gold that lured so many miners and settlers to the West, but California has earned much more wealth from so-called "black gold" than from metallic gold. The San Joaquin Valley has been the principal source for most of the petroleum produced in the State during the past 145 years. In attempting to assess future additions to petroleum reserves in a mature province such as the San Joaquin Basin, it helps to be mindful of the history of resource development. In this chapter we present a brief overview of the long and colorful history of petroleum exploration and development in the San Joaquin Valley. This chapter relies heavily upon the work of William Rintoul, who wrote extensively on the history of oil and gas exploration in California and especially in the San Joaquin Valley. No report on the history of oil and gas exploration in the San Joaquin Valley would be possible without heavily referencing his publications. We also made use of publications by Susan Hodgson and a U.S. Geological Survey Web site, Natural Oil and Gas Seeps in California (http://seeps.wr.usgs.gov/seeps/index.html), for much of the material describing the use of petroleum by Native Americans in the San Joaquin Valley. Finally, we wish to acknowledge the contribution of Don Arnot, who manages the photograph collection at the West Kern Oil Museum in Taft, California. The collection consists of more than 10,000 photographs that have been scanned and preserved in digital form on CD-ROM. Many of the historical photographs used in this paper are from that collection.

Finally, to clarify our terminology, we use the term "San Joaquin Valley" when we refer to the geographical or topographical feature and the term "San Joaquin Basin" when we refer to geological province and the rocks therein.

First Production

When Europeans finally arrived in California's San Joaquin Valley, petroleum had already been in use by Indians for about 13,000 years (Hodgson, 2004). Artifacts made with asphalt, oil altered by exposure to the air, were found at the Tulamniu Village excavation site on what was the southern shore of Lake Buena Vista dating back 1,300 to 1,600 years (fig. 3.1). The Tulumni Yokuts are known to have collected tar from natural seeps, still active today, at McKittrick, on the west side of

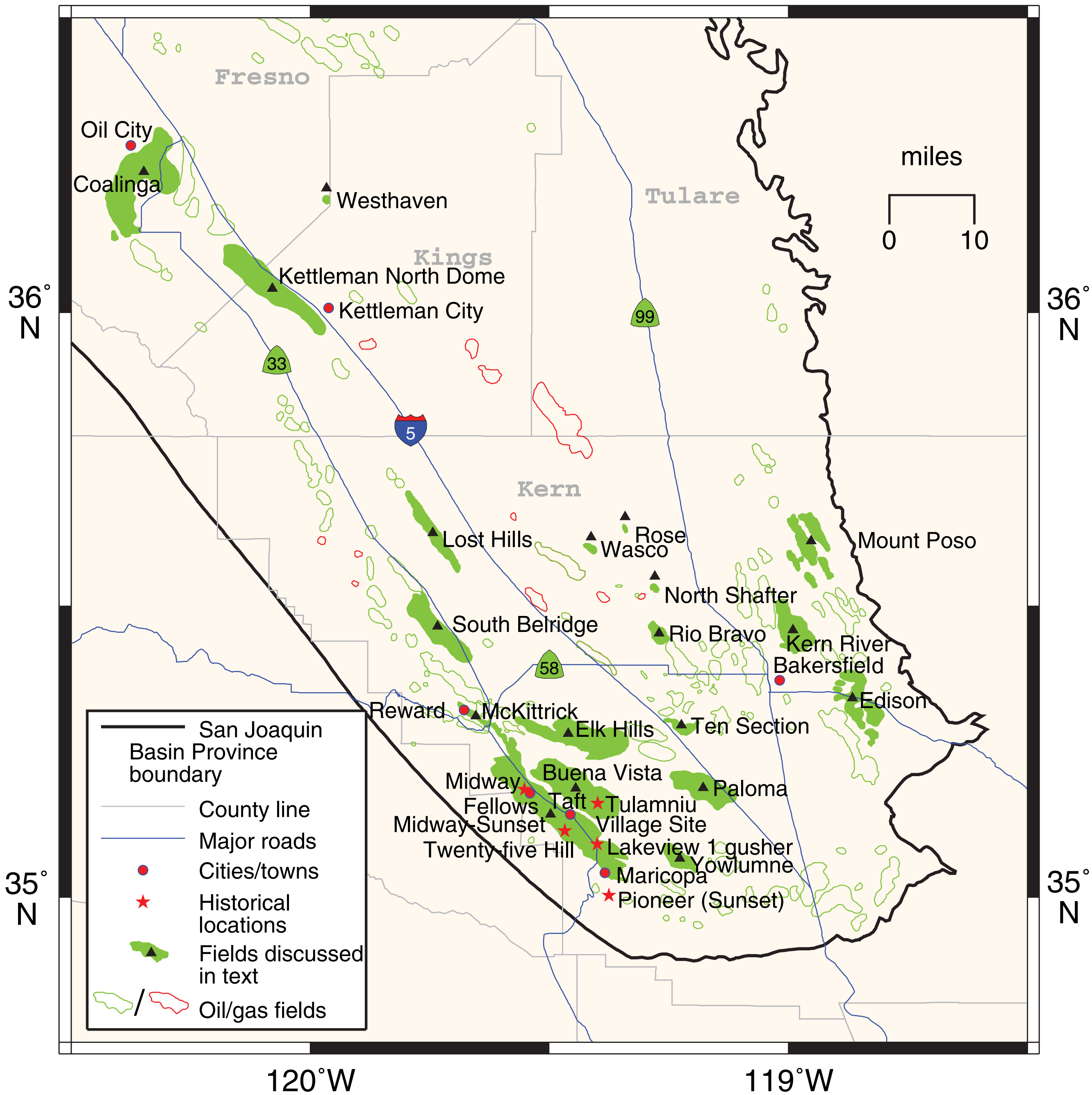

Figure 3.1. Historical locations and oil and gas fields in the southern San Joaquin Valley.

the valley (figs. 3.2 and 3.3) (Elliott and others, 1968). Many California Indians used the petroleum in various ceremonies and rituals. For example, mourners wore necklaces made from lumps of asphalt, and shamans painted their faces with oil because of its supernatural powers. Additionally, fist-sized cakes of tar were traded to neighboring tribes. High-viscosity oil was used for waterproofing and gluing baskets (fig. 3.4), for making wooden canoes called "tomols," and for fastening arrowheads or edged tools to shafts and handles (fig. 3.5). Asphalt was even used as chewing gum. Brushes were made from plant fibers glued with asphalt (fig. 3.6). The asphalt was also used as the matrix for decorative inlays made with bits of abalone shell on pottery, knives, masks, and game pieces (fig. 3.7) (Rintoul, 1976; Hodgson, 1987, 2004).

In the 1500s, explorers used petroleum to seal the hulls of their ships, and Spanish, Mexican, and American settlers in

California used it to waterproof their roofs, for lubrication, and as a lamp illuminant (California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, ftp://ftp.consrv.ca.gov/pub/oil/history/History_of_Calif.pdf; Hodgson, 1987). In the 1850s and 1860s travelers along the western side of the San Joaquin Valley collected oil from seeps along the route to grease the hubs of their wagon wheels (Kirk, 2000). In 1862 Thomas “Coal Oil Tommy” Harvey began selling the tar-like oil he dug from pits near what is now the Coalinga oil field to local farmers for use as a lubricant (Kirk, 2000).

The Kerosene Business and Mining for Asphalt

In the early 1860s, when John S. “Uncle John” Hambleton rode down from the gold mining town of Bear Valley, he noted the extensive asphalt outcrops and oil seeps on the western side of the San Joaquin Valley (Kirk, 2000). Judge Josiah Lovejoy, who accompanied Hambleton on some of these trips, formed the Buena Vista Petroleum Company in 1864 to market the oil they recovered from pits near present-day McKittrick and Reward (fig. 3.8) (Kirk, 2000). In 1865 Lovejoy’s Buena Vista refinery went into operation; mule-drawn wagons hauled petroleum to the primitive still, located near the modern intersection of Lokern Road and Highway 33 (State Historical Landmark 504) about 10 miles north of McKittrick (fig. 3.1). The plant produced kerosene for lamps, lubricants for wagon wheels, waxes for candles, and a then-useless clear liquid byproduct called gasoline. The refinery reported a 400-gallon yield of 50 percent kerosene from its first batch of crude (San Joaquin Geological Society, http://www.sjgs.com/tarpits_hist.html; last accessed July 26, 2006). By 1866, the Buena Vista refinery was producing 2,500 to 3,000 gallons of kerosene per month (Kirk, 2000). However, this first kerosene boom ended abruptly in 1867 when overproduction brought high-quality Pennsylvania oil to San Francisco at prices lower than any California operator could meet (California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, ftp://ftp.consrv.ca.gov/pub/oil/history/History_of_Calif.pdf).

Demand for asphalt took off in the 1890s as Americans began to realize the quiet, dustless benefits of paved and oiled roads. Asphalt was produced to pave streets and sidewalks in San Francisco and to lubricate log runs in the timber country. The San Joaquin product was considered to be better than asphalt from Trinidad, which was then the world’s main supplier (San Joaquin Geological Society, http://www.sjgs.com/tarpits_hist.html; last accessed July 26, 2006).

Using their gold mining experience, prospectors applied hard-rock techniques to the oil industry, digging pits to mine the asphalt (fig, 3.9). In 1891 Solomon Jewett and Hugh Blodget began mining asphalt from quarries dug on leases acquired from the Sunset Oil Company in what would become known as “Old Sunset” (fig. 3.10) (Kirk, 2000).

Figure 3.2. An active oil seep near McKittrick, California.

Because of noxious fumes and summer temperatures that could reach 140°F, quarry workers could only stay in the pits for 20 minutes at a time. They worked naked, and at the end of each shift they scraped off the tar with wooden scrapers normally used on racehorses and then washed with distillate. To save time they ate lunch in the nude, sitting on newspa-

Figure 3.3. Close-up photograph of an oil seep near McKittrick.

Figure 3.4. A 14-inch basket affixed to a stone mortar (center) with asphalt. Photograph by J. Spriggs. From Natural Oil and Gas Seeps in California (http://seeps.wr.usgs.gov/seeps/index.html).

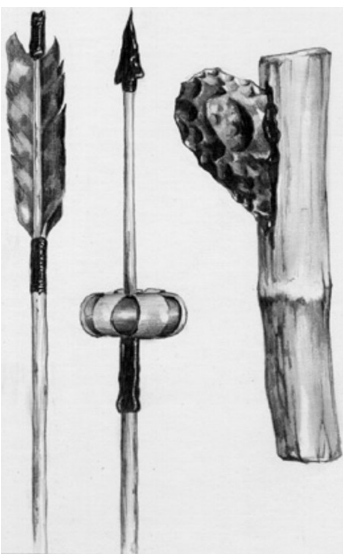

Figure 3.5. Yokut Indians' hunting tools are held together and waterproofed with asphalt. Drawing by J. Spriggs from a photograph by J. Garcia. From Onshore Oil and Gas Seeps in California (http://seeps.wr.usgs.gov/seeps/index.html).

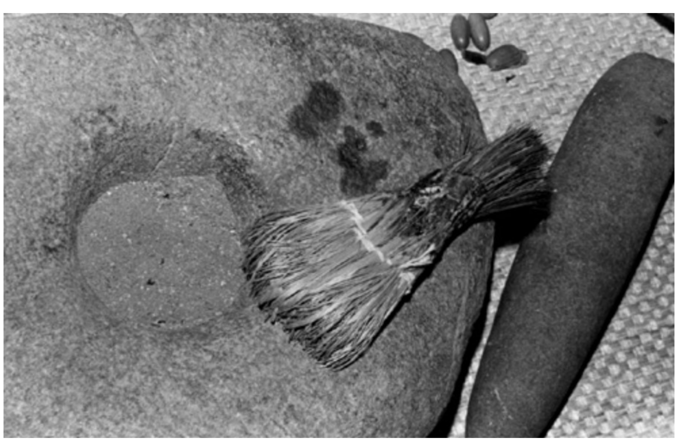

Figure 3.6. Mortar and brush for preparing acorn meal. The soap-root fibers in the brush are glued together with asphalt and laced with string. Photograph by J. Spriggs. From Onshore Oil and Gas Seeps in California (http://seeps.wr.usgs.gov/seeps/index.html).

Figure 3.7. Walnut-shell dice made by the Yokut Indians. Black walnut shells are filled with asphalt and decorated with abalone shell chips or beads. Photograph by J. Spriggs. From Onshore Oil and Gas Seeps in California (http://seeps.wr.usgs.gov/seeps/index.html).

Figure 3.8. Asphalt was first mined by digging open pits where seeps occurred, in this case near McKittrick, in Kern County. Drawing by J. Spriggs, from Onshore Oil and Gas Seeps in California (http://seeps.wr.usgs.gov/seeps/index.html).

pers at the camp mess. The newspapers would stick to their bodies and on their way back to work they could be seen doing "war dances" in their newspaper loincloths (Rintoul, 1976).

Jewett and Blodgett built their refinery south of Pioneer (fig. 3.11), where the quarried asphalt was melted in large kettles, mixed with crude oil, and packed in boxes. Because there was no rail transportation on the western side of the valley, wagons drawn by teams of 16 to 24 horses hauled the boxed-up asphalt to Bakersfield. The drivers took pride in how they handled these large teams; in the 1890s large crowds would gather to watch the spectacle and make bets as the teams made their U-turns on Chester Avenue in Bakersfield (Rintoul, 1976). The asphalt was shipped by rail from Bakersfield to Portland, Denver, Kansas City, and other towns across the country.

Figure 3.9. This mineshaft in the McKittrick asphalt mine, Kern County, was built in the1860s with redwood timbers. Photograph by W. Rintoul, from Onshore Oil and Gas Seeps in California (http://seeps.wr.usgs.gov/seeps/index.html).

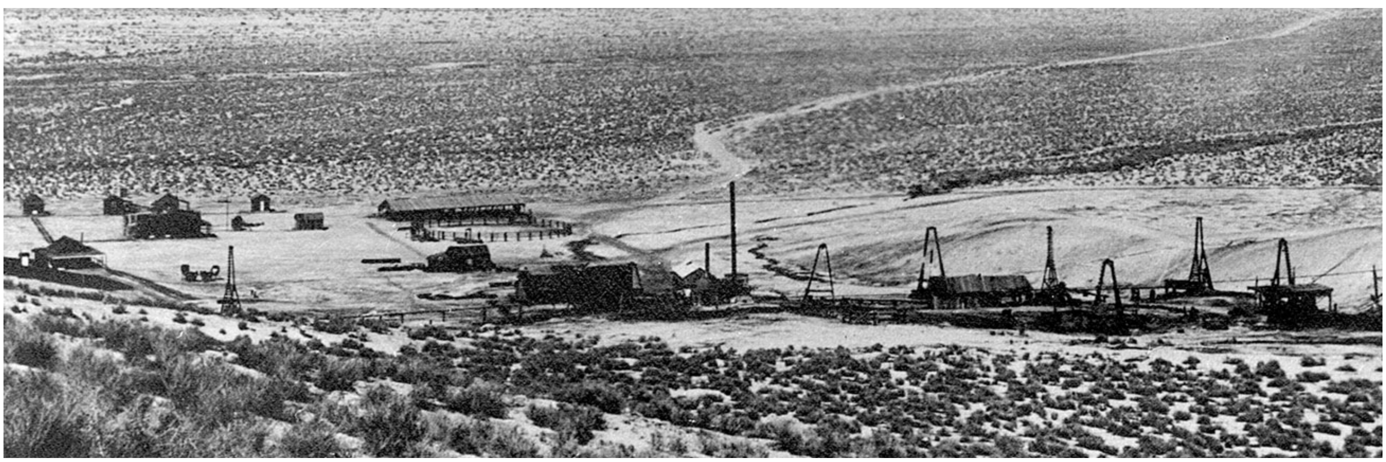

Figure 3.10. Very early petroleum production site of Jewett and Blodgett in 1894, near Maricopa. Photograph courtesy of Don Arnot, West Kern Oil Museum.

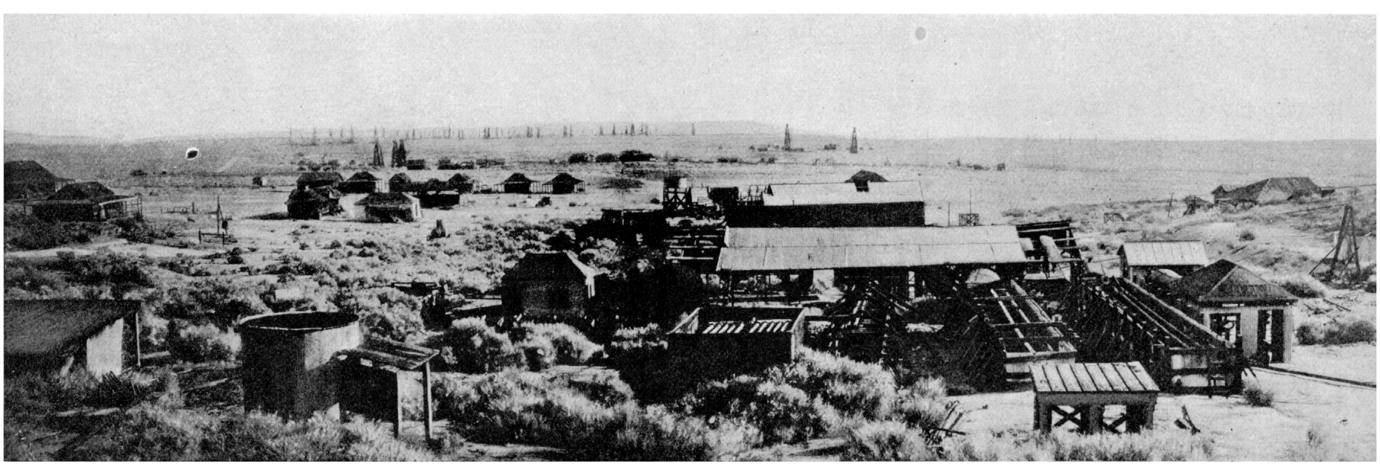

Figure 3.11. Jewett and Blodgett built this asphalt refinery south of Pioneer sometime after 1894. Photograph from Pack (1920).

Early Drilling for Oil

The first wooden derrick in Kern County was constructed in 1878 at Reward by Bill Tibbett and Keny Pool (Rintoul, 1976; San Joaquin Geological Society, http://www.sjgs.com/history.html#california; last accessed July 26, 2006). Throughout the 1870s and 1880s wildcatters, using the same cable-tool technology used by Colonel Drake in Pennsylvania, drilled near Coalinga and in the Midway and Sunset districts of the southern San Joaquin Valley. Jewett and Blodgett drilled some of the earliest wells in the valley to get flux oil, which is oil mixed with asphalt to reduce its viscosity (fig. 3.12).

Cable Tool Rigs

Cable-tool rigs descend from Chinese technology dating back to the third century. Originally developed to drill brine wells for salt production, cable-tool rigs worked by affixing a sharpened drilling bit to the ends of bamboo poles that were repeatedly raised and dropped into a hole. In the standard drill rigs used in the San Joaquin Valley, a steam engine supplied power to turn a band wheel that moved a large wooden walking beam, balanced in the center like a seesaw. The cable was wrapped around the bull wheel and then attached to the stem (an iron bar) and the drill bit. The walking beam pulled the drilling cable up and down and the rock at the bottom of the hole was pulverized by the force of the falling bit. At regular intervals the drilling was stopped so that water could be poured into the hole and the bailer, a long pipe with a gate-like door, was attached to the cable and dipped into the well to remove cuttings, mud, and water. The bit would then be returned to the cable and drilling would continue (figs. 3.13 through 3.20) (Rintoul, 1976).

In 1887, Home Oil Company completed the “Wild Goose,” a 10-barrel-per-day well near Oil City (fig. 3.1) that discovered the Coalinga field and demonstrated the potential for oil production in the northwestern part of the basin (San Joaquin Geological Society, http://www.sjgs.com/gushers.html#other; last accessed July 26, 2006). In the same year the Sunset Oil Company drilled the first producing well in what is now known as Midway-Sunset field. The well was drilled 100 feet into a brea, or tar-sand outcrop, and produced oil from the Tulare Formation. This well was probably drilled by Jim Hambleton, son of “Uncle John” Hambleton (Del Mar, 1996). The Sunset Oil Company was established by Jim Hambleton and

Figure 3.12. Very early derrick used to drill shallow wells that supplied the Jewett and Blodgett asphalt refinery in the 1890s. See also figure 3.11. Photograph from Pack (1920).

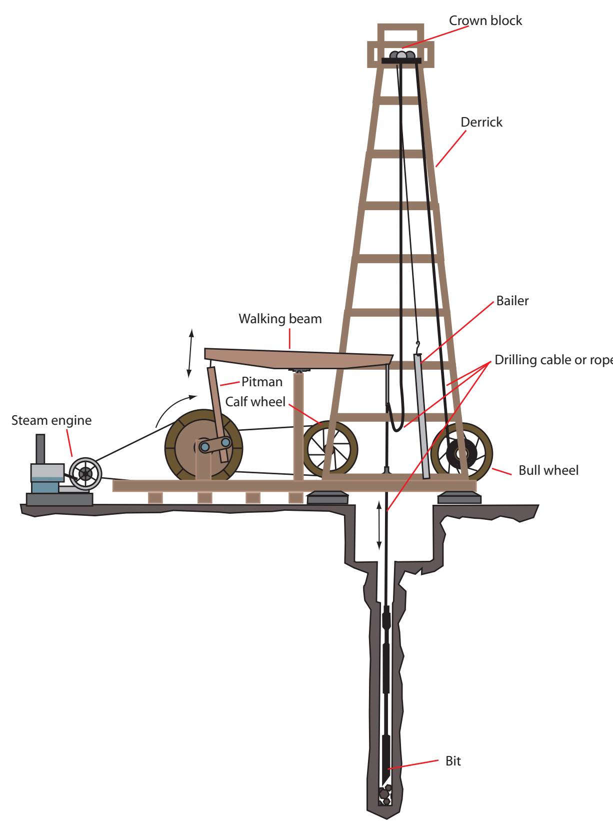

Figure 3.13. Schematic diagram of a typical cable-tool drill rig. Modified from Ritzius (1956).

Figure 3.14. A wooden derrick, site unknown, typical of those used during much of the early oil exploration of the San Joaquin Valley. Photograph courtesy of Don Arnot, West Kern Oil Museum.

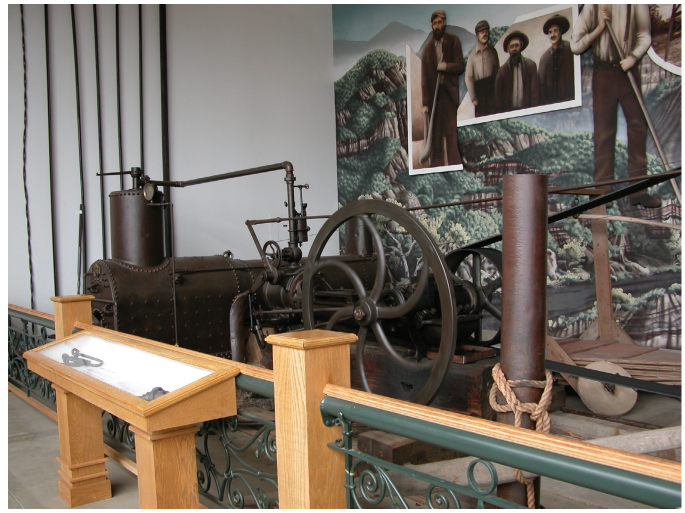

Figure 3.16. Boiler, steam engine, and belt drive used in early steam-powered drilling rigs.

included, among others, Solomon Jewett, Hugh Blodget, and Josiah Lovejoy, who is credited with calling the area "Sunset" after the beautiful evening skies he observed in the area (Del Mar, 1996; Kirk, 2000).

Although the 1890 discoveries of Sunset field in Kern County (now Midway-Sunset field) and Coalinga field in Fresno County opened large, potentially productive areas for exploration, production from their discovery wells was small and large-scale development of the fields had not yet occurred; the San Joaquin Valley's impact on statewide production was yet to be felt (California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, ftp://ftp.consrv.ca.gov/pub/oil/history/History_of_Calif.pdf). By 1894 Jewett and Blodgett had completed 16 wells in the Sunset District, near what is now Maricopa (Rintoul, 1976), which produced

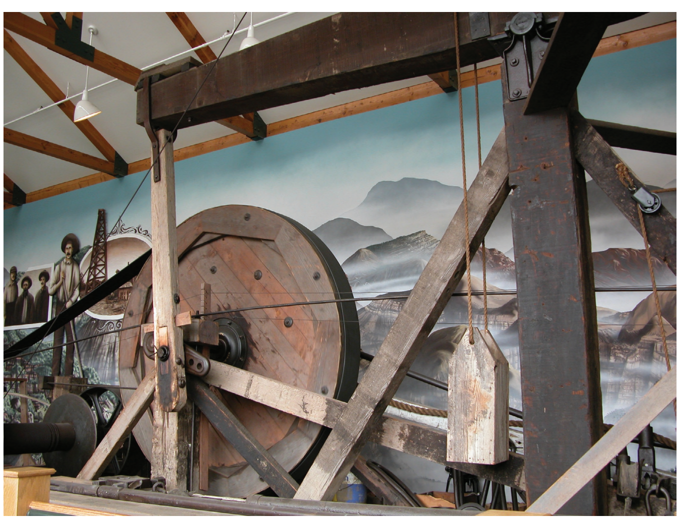

Figure 3.15. A partial view of the flywheel and beam used in early steam-powered drilling rigs. This is an authentic, cable-tool drill rig that has been reconstructed and is on display in the California Oil Museum in Santa Paula, California.

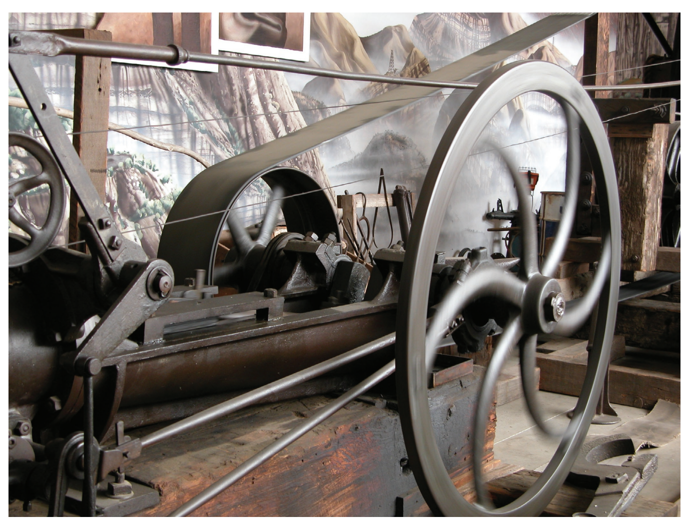

Figure 3.17. Belt-drive used on early steam-powered drilling rigs.

Figure 3.18. Wooden band wheel and belt used in early steam-powered drilling rigs.

a total of 30 barrels of oil per day. The wells ranged in depth from 80 to 1,300 feet. In some wells, steam was injected to bring the thick, heavy oil to the surface (Pack, 1920).

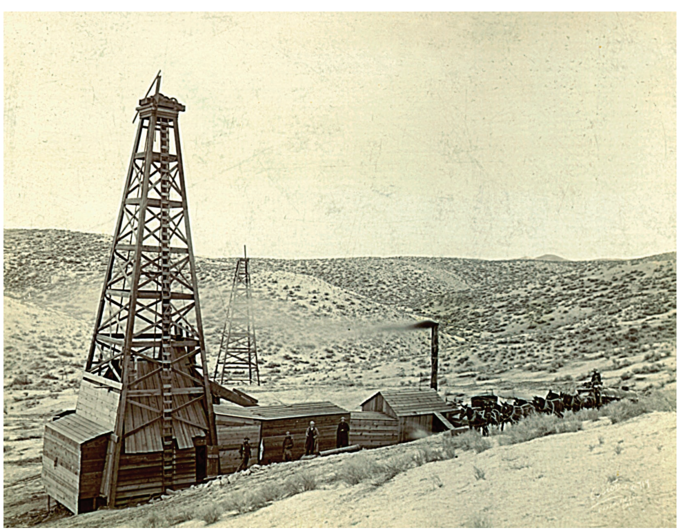

Figure 3.19. Wooden derrick and sheds housing the steam drilling rig. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Figure 3.20. View of the cable mechanism used on early steam-powered drilling rigs.

In 1896, the McKittrick field graduated from mines and open pits to a full-fledged oil field when the Klondike Oil Company hit the Shamrock gusher, which flowed 1,300 barrels per day (San Joaquin Geological Society, http://www.sjgs.com/tarpits_hist.html; last accessed July 26, 2006). In 1898 the Home Oil Company well 3, "The Blue Goose," was completed in the Oil City portion of the Coalinga field. The well initially produced more than 1,000 barrels per day from a depth of 1,400 feet (California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, ftp://ftp.consrv.ca.gov/pub/oil/history/History_of_Calif.pdf; Ritzius, 1956).

Kern River Field

Jonathan Elwood and his son James are credited with discovering the Kern River oil field in May 1899. Their employee, Milton McWhorter, used a hand auger to drill into the bank of the Kern River 7 miles northeast of Bakersfield on property belonging to Thomas Means (fig. 3.1). For years Means had been claiming there was oil on his 20-acre parcel. Nearby, on John Barker's property, a spring produced natural gas that could sustain a flame (Rintoul, 1990). At first no one took any of this seriously. Even after the initial discovery was announced, many people thought that oil from the McKittrick district was being used to “salt the find,” or embellish the discovery on the Barker property (Rintoul, 1999c). However, the skeptics were silenced when a steam rig was brought in to drill deeper. The rig used oil from the hand-dug shaft for fuel (Rintoul, 1999c; Kirk, 2000).

The first crude oil was hauled out of the Kern River field in four whiskey barrels. Angus Crites, a well-respected oil man who had worked for Jewett and Blodget at Maricopa, said he had seen whiskey barrels, milk cans, kerosene tins, and beer kegs filled with oil at the Kern River site. His advice was to hurry out to the river and buy up land ahead of the boom that was sure to come (Rintoul, 1976). He was right, of course. In May 1899, Edward L. Doheny, already famous for his discovery of oil in downtown Los Angeles, bought up land surrounding the Elwood find (Kirk, 2000). By the end of July, 134 more wells had been started and the Kern River field was producing nearly 1,000 per day (Kirk, 2000).

The oil coming from the Kern River field brought national attention. The Southern Pacific and Santa Fe Railroads promoted round-trip tours from Los Angeles, Sacramento, San Francisco, and other cities to the oil fields. The rapidly proliferating oil companies also promoted many excursions, which included hotel accommodations and buggy trips to the oil fields in addition to the rail fare (fig. 3.21). At the turn of the century, a sightseeing journey on the Southern Pacific Railroad from San Francisco to the Kern River field cost about $10.60 per person (Rintoul, 1999c; Kirk, 2000).

At the time of the Kern River field discovery, Los Angeles City field was the most productive oil field in California, producing 1.4 million barrels in 1899 (Kirk, 2000). By 1901, however, Kern County was producing twice as much crude as Los Angeles, doubling state production to 8.8 million barrels (Kirk, 2000). In 1903, California for the first time led the country in petroleum production with 24.38 million barrels, ahead of Ohio and Texas with 20.48 and 17.96 million barrels, respectively, and accounted for nearly one-fourth of U.S. production. Kern River, Midway-Sunset, and McKittrick fields provided 75 percent of California production (Rintoul, 1990; Kirk, 2000). After 4 years and the formation of more than 200 oil companies, Kern River production reached 17 million barrels per year, making it the top-producing field in the United States (Kirk, 2000).

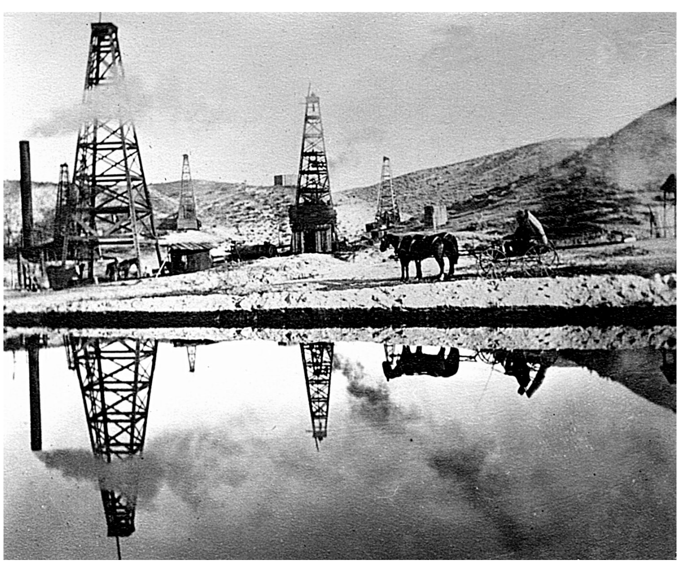

Figure 3.21. A horse and buggy ride through the oil fields. Location and date are unknown. Photograph courtesy of Don Arnot, West Kern Oil Museum.

During those early days of oil production, workers were well paid. A cable-tool driller at the Kern River field earned $5 for a 12-hour day, and he was expected to work 7 days a week. The workers paid 75 cents a day for a bunk and three meals. A trip into Bakersfield was a big event; transportation by horse and buggy cost $2.50 for the first passenger and 50 cents for each additional passenger. On any given Saturday afternoon, 150 men might be working in the Kern River area, but only 20 might show up for work the following Monday morning—perhaps a reflection of the “rest and recreation” in the oil patch (Rintoul, 1999f).

Oil Prices

From 1899 to 1902, about 2,400 new oil companies were incorporated in California, but only half of them ever built a derrick. The average price for a barrel of California crude oil in the southern San Joaquin Valley fell from 94 cents per barrel to 57 cents in 1901 and to 30 cents in 1903, driving many of the new companies into ruin (Kirk, 2000). This was mainly due to the large supply of oil in Kern County. In 1903, oil in the southern San Joaquin Valley sold for 21 cents per barrel, a third the price paid in other areas of the state. Prices continued to slide through 1904; in August, a barrel of oil sold for less than 12 cents. Three-quarters of the wells at the Sunset field were “shut-in” and none of the pumps were operating (Kirk, 2000). In spite of all this, California led the nation in petroleum production with 29.6 million barrels, a third more than second-place Texas (Kirk, 2000).

Access to markets was difficult, adding to the operating costs. Mule-drawn tank wagons carried oil to the nearest railhead (fig. 3.22). Efforts were made to improve access to markets by building rail lines to the west side of the San Joaquin Valley and constructing pipelines. However, this was not enough to save many of the smaller oil companies. At times water used for generating steam and for the workers to drink cost more than the operators could get for their oil. For more than a year, water was 25 cents a barrel while oil sold for 20 cents or less (Del Mar, 1996; Kirk, 2000).

By 1900, the interest in oil had switched from kerosene for illumination to fuel oil. With the invention of a successful oil burner in 1882, railroads, shipping lines, and industry had begun converting from coal to oil. In 1902, the arrival of the railroad made development of what is now Midway-Sunset field economically feasible (San Joaquin Geological Society, http://www.sjgs.com/history.html#california; last accessed July 26, 2006). The announcement of a rail line from the coast to the Sunset fields and a pipeline from the terminus of the Sunset Railroad through the district to the Midway field (so named because it was halfway between Sunset and McKittrick to the north) provided some encouragement and improved access to markets (Pack, 1920; Kirk, 2000). By 1904, every railroad in California ran on oil (Kirk, 2000), and demand grew as shipping, railroad, and industry needs increased. The price finally began to rise. In 1905, the statewide average price of crude oil was just under 25 cents per barrel, but by 1908 oil was selling for an average price of 50 cents per barrel (Kirk, 2000).

America's Most Spectacular Gusher

In those early days of exploration, oil accumulations were often found at very high natural pressures, but with no effective technology available for well control, new-field discoveries were often marked by spectacular "gushers," when oil would burst out of the well under high pressure. The first big gusher in the San Joaquin Valley was a well drilled in 1896 by the Klondike Oil Company and named the Shamrock Gusher, which flowed at 1,300 barrels per day (San Joaquin Geological Society; last accessed July 26, 2006). Later, in September 1909, near Coalinga, the Silvertip 1 well struck oil and flowed out of control at 10,000 to 20,000 barrels per day for about a week before sand plugged the well (Rintoul, 1976). In November 1909, the Chanslor-Canfield Midway 2-6 well, the Midway Gusher, blew out near Fellows and flowed at 2,000 barrels per day. This was the first of the big wells from the Midway-Sunset field (Pack, 1920; Rintoul, 1990) (fig. 3.23). Mays Consolidated drilled a well near Taft that started flowing on March 7, 1910, at uncontrolled rates as high as 10,000 barrels a day (fig. 3.24) (Pack, 1920). However, this was just a preview of what was to come.

These wild discoveries spurred further oil exploration and land speculation (San Joaquin Geological Society, http://www.sjgs.com/gushers.html#other); last accessed July 26, 2006). In March 1908, a group of Los Angeles investors decided to drill the Lakeview 1 well on a $5 lease in the Midway-Sunset oil field, about 2 miles north of Maricopa (fig. 3.1). A grocer named Julius Fried picked the site because to him a stand of red grass indicated good oil land. The Lakeview Oil Company spudded the well on New Year's Day, 1909; after 6 months of effort the company had drilled to 1,655 feet and had exhausted its finances. The Union Oil Company of California was working nearby wells and offered to help by taking over the drilling operations, but only in their spare time when crews were available. In return they acquired controlling interest in the Lakeview Oil Company and ownership of their land, on which they wanted to construct storage tanks. Drilling continued

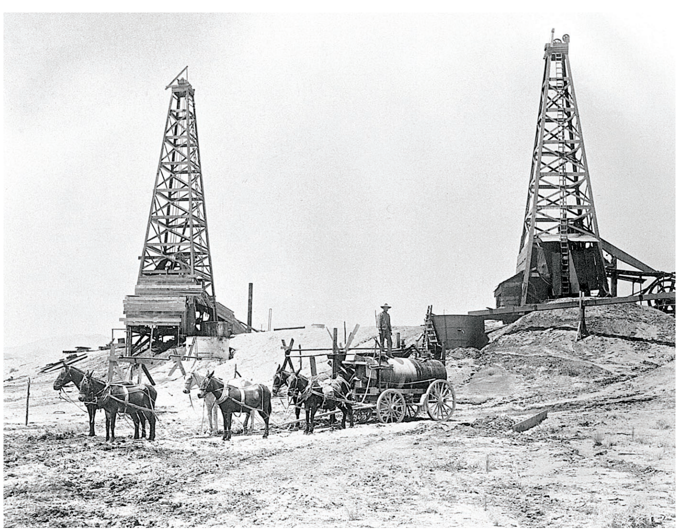

Figure 3.22. Mule-drawn tank wagons hauled oil to the railhead. Location and date are unknown. Photograph courtesy of Don Arnot, West Kern Oil Museum.

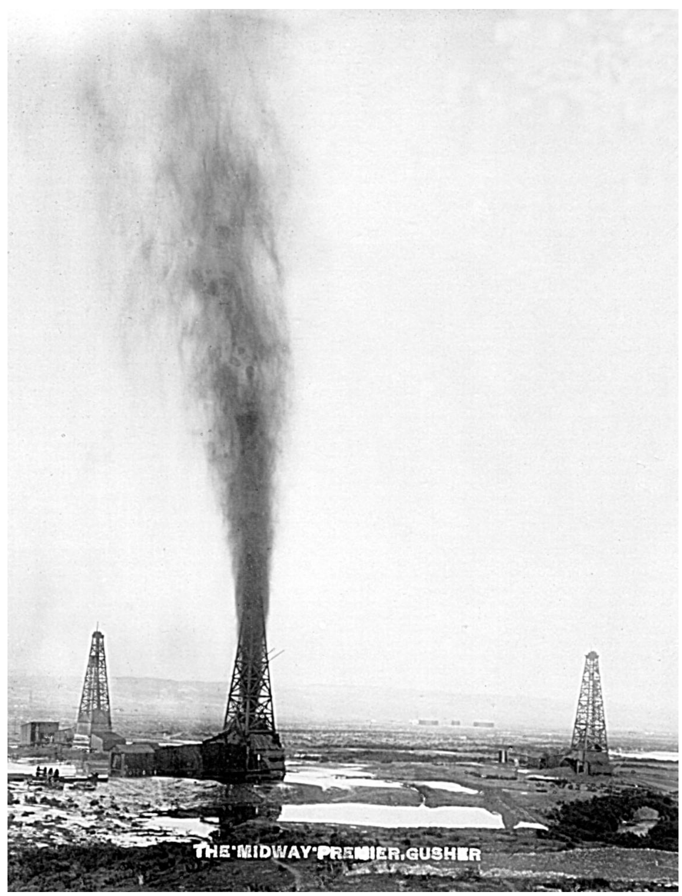

Figure 3.23. The Midway gusher in 1909. Photograph courtesy of Don Arnot, West Kern Oil Museum.

intermittently (Rintoul, 1976; 1999b; San Joaquin Geological Society, http://www.sjgs.com/lakeview.html; last accessed July 26, 2006).

“Dry Hole Charlie” Woods, a driller with a legacy of dry holes, was assigned to the Lakeview 1 well to continue drilling. It had taken 14 months to pass 2,000 feet depth, and it must have seemed that Lakeview 1 was going to be another of Charlie’s failures. Oil company officials decided to stop drilling, but no one told the production superintendent, Walter Barnhart. When he arrived at the drill site on the morning of March 14, 1910, he tied his horse next to the wooden derrick, and Roy McMahon, the driller, told him the bailer had gotten stuck. Barnhart ordered McMahon to free it by reversing power to take the strain off the cable. Charlie’s nickname became obsolete when gas pressure blew the bailer up through the crown block and the well came in with a roar from 2,225 feet deep. A twenty-foot wide column of oil and sand shot 200 feet into the air; the initial uncontrolled flow, which has been estimated at 125,000 barrels a day, was visible for 30 miles (figs. 3.25 through 3.30) (San Joaquin Geological Society, http://www.sjgs.com/lakeview.html; last accessed July 26, 2006). The horse took off and disappeared for a week. Spray drifted across the valley, and sand from the well buried the engine house, bunkhouse, and coal shack. The gusher could be seen at night, lit by flames from the Tight Wad 3 well burning on Twenty-Five Hill, 4 miles away (San Joaquin Geological

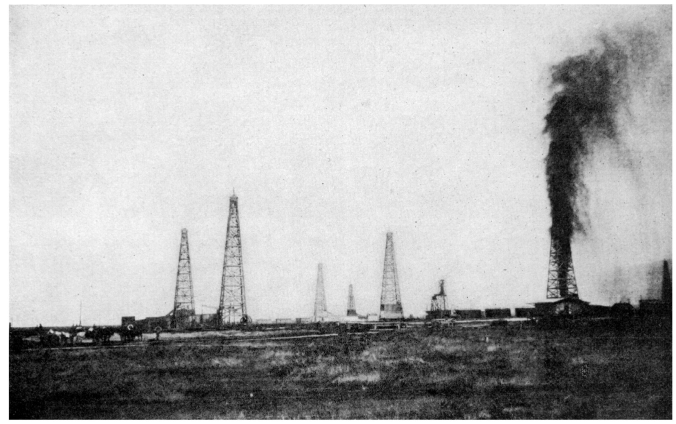

Figure 3.25. Well 1 of the Lakeview Oil Company, the famous Lakeview gusher, taken the day the well came in. Photograph from Pack (1920).

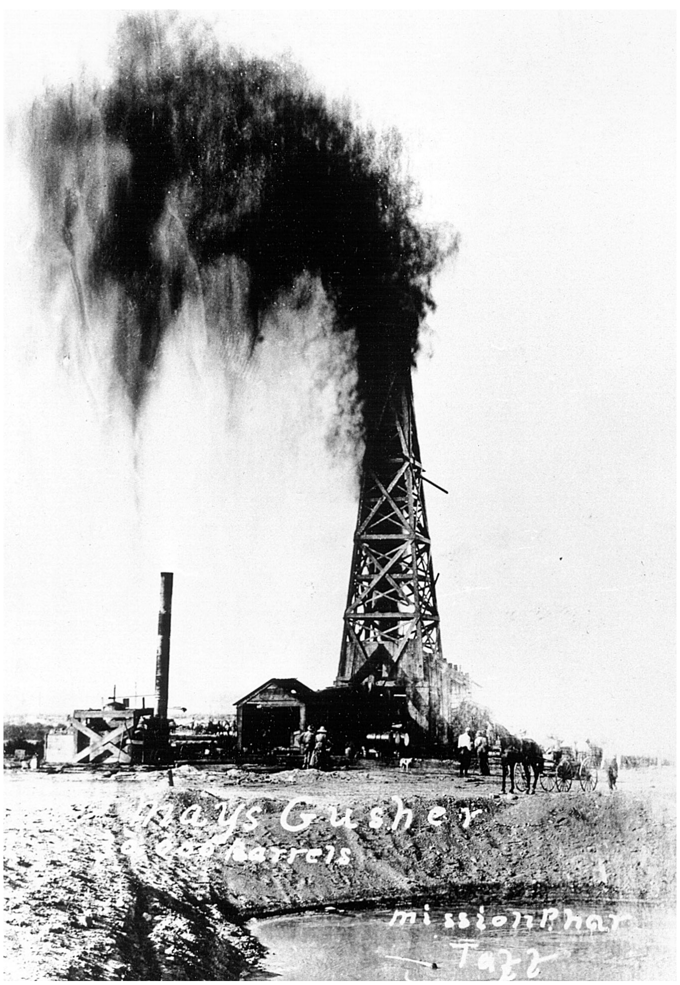

Figure 3.24. The Mays Consolidated gusher in 1910. Photograph courtesy of Don Arnot, West Kern Oil Museum.

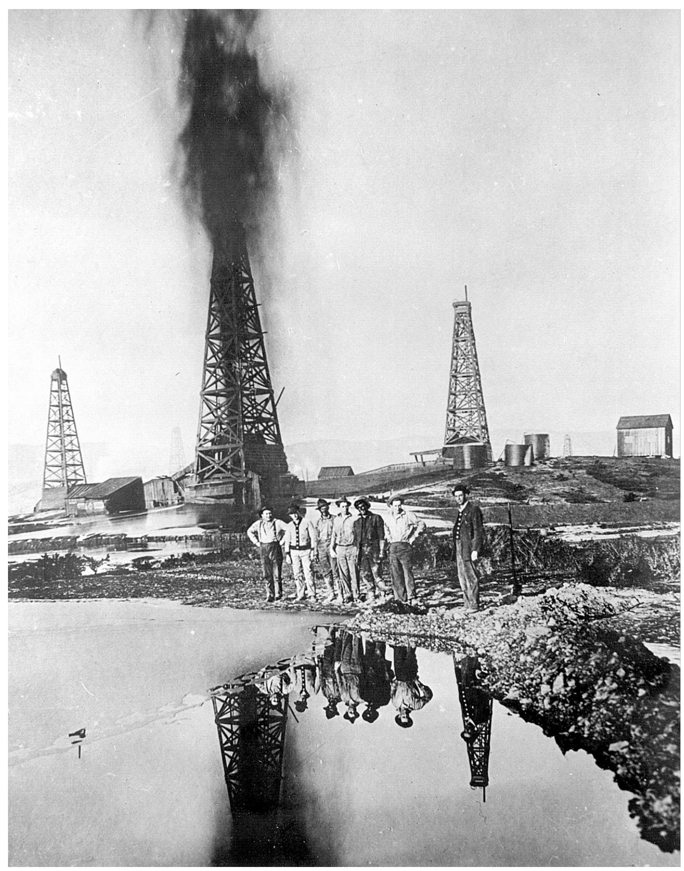

Figure 3.26. The famous Lakeview gusher. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Society, http://www.sjgs.com/lakeview.html; last accessed July 26, 2006).

The threat of fire became so extreme that activity at all other wells in the area was halted, and food for the crew was prepared in Maricopa to avoid any open flame (Rintoul, 1976, 1999b). The gusher grew stronger each day, and the crater forming around the well swallowed up the drilling equipment. After 30 days the well flow was estimated at 90,000 barrels a day. The inexhaustible gusher brought crude prices down to 30 cents a barrel (San Joaquin Geological Society, http://www.sjgs.com/lakeview.html; last accessed July 26, 2006).

The stream of oil from the Lakeview gusher, called the "trout stream," threatened to flow into Buena Vista Lake, the local source of irrigation water. The efforts of about 400 men and every available team of horses and scrapers (horse-drawn earth movers) working day and night were required to build 20 open-air sumps covering about 60 acres at a cost of more than $350,000. Sandbags and sagebrush were put together to build the levees needed to contain the crude (Rintoul, 1999b; San Joaquin Geological Society, http://www.sjgs.com/lakeview.html; last accessed July 26, 2006) (fig. 3.31). In a further attempt to contain the flow, a wooden box built of massive timbers was pulled over the gusher with heavy cables (fig. 3.32), but the oil still flowed at 48,000 barrels a day and the ever-widening crater at the base of the well swallowed the container (fig. 3.33) (Rintoul, 1976, 1999b).

An embankment of sandbags, 100 feet in diameter, was built around the well and the crater, finally bringing the gusher under control in October 1910. The embankment, 20 feet tall, allowed an oil pool to form over the crater deep enough to reduce the oil flow to a bubbling stream (fig. 3.34). Nearly a year later, on September 10, 1911, the bottom of the hole caved in, finally killing the gusher. By that time, Lakeview 1 had produced 9.4 million barrels of oil in the 544 days that it flowed. Less than half of it was recovered; the remainder was lost to evaporation and ground seepage (Rintoul, 1976; San Joaquin Geological Society, http://www.sjgs.com/lakeview.html; last accessed July 26, 2006).

The Union Oil Company dug 100 feet down to find the well's casing and redrilled the well, but Lakeview 1 never again flowed more than 30 barrels a day and was finally aban-

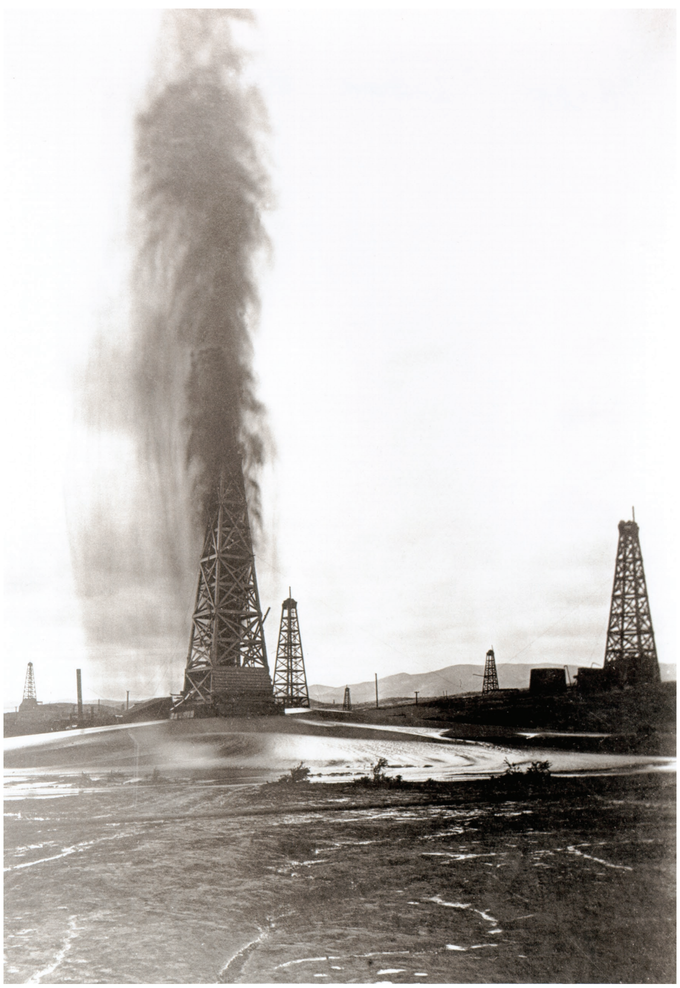

Figure 3.27. Another view of the famed Lakeview gusher. Photograph courtesy of Don Arnot, West Kern Oil Museum.

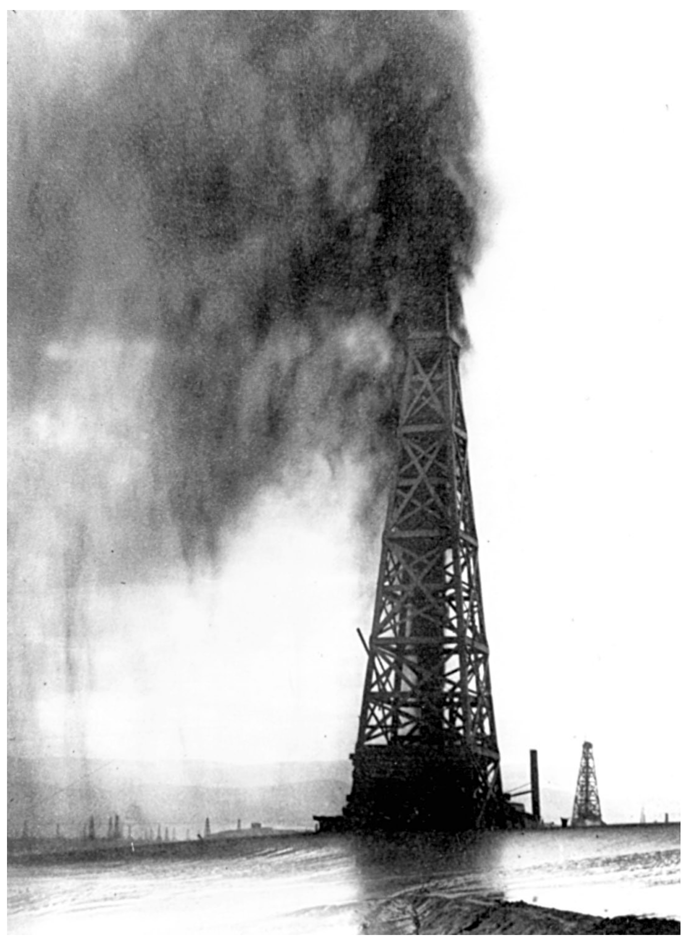

Figure 3.28. The Lakeview gusher out of control. Photograph courtesy of Don Arnot, West Kern Oil Museum.

doned. Deeper wells drilled nearby missed the oil reservoir that was apparently the source of the gusher, and two new wells that did penetrate the reservoir found it dry (Rintoul, 1999b). The Lakeview reservoir was evidently a narrow, oil-filled channel of sandstone, only a few feet wide and about a mile long. It stood on edge and ran perpendicular to the other sands in the area. Lakeview 1 had actually missed the sandstone by several feet, but oil broke through to the well because of high reservoir pressure (Rintoul, 1976; San Joaquin Geological Society, http://www.sjgs.com/lakeview.html; last accessed July 26, 2006).

The Lakeview 1 gusher site is a short side trip off Highway 33 on Petroleum Club Road (County Road 277T) between Kerto and Cadet Roads, 1.5 mi north of Maricopa along the old Taft-Maricopa Highway. There a part of the casing (figs. 3.35 and 3.36) and the oil-encrusted, sand-bagged crater can still be seen (figs. 3.37 through 3.39). The Native Daughters of the Golden West, the Kern County Historical Society, and the Kern County Museum placed a bronze plaque commemorating "America's most spectacular gusher" at the Lakeview site in February 1952. It is State Historical Landmark 485 (figs. 3.40 and 3.41).

Figure 3.29. The Lakeview gusher 14 days after it blew. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Figure 3.30. The Lakeview gusher reflected in a lake formed by the oil it produced. Photograph courtesy of Don Arnot, West Kern Oil Museum.

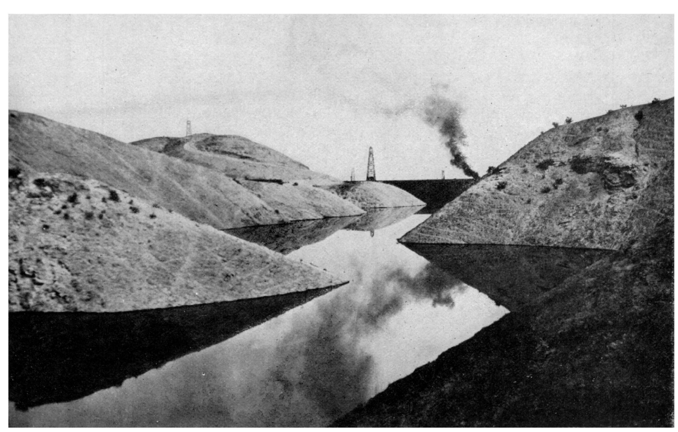

Figure 3.31. Produced oil was stored in a sump built by putting an earthen dam across a gulch north of Maricopa to contain oil from Lakeview 1 in October 1910. Photograph by W.C. Mendenhall in Pack (1920).

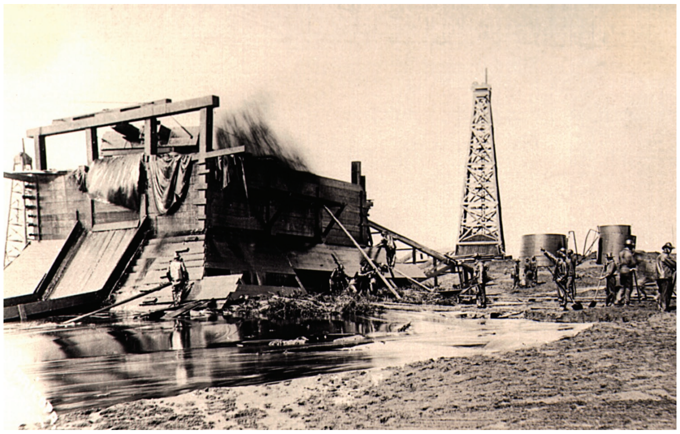

Figure 3.32. A box made of large timbers was pulled over the Lakeview gusher with cables. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Figure 3.33. The box was not able to contain the force of the gusher. Photograph courtesy of Don Arnot, West Kern Oil Museum.

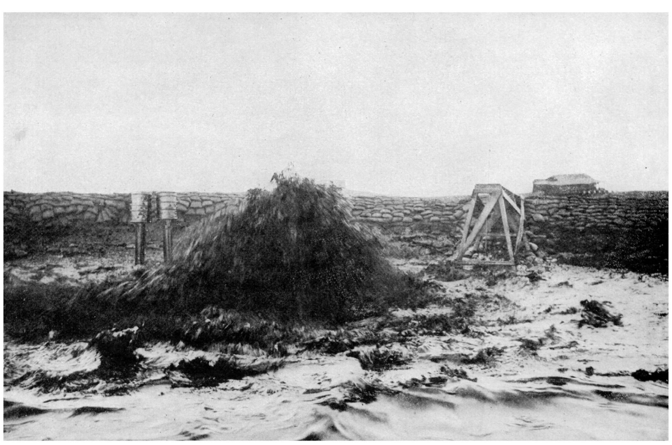

Figure 3.34. A dam of sandbags was built around the Lakeview 1 well. This photograph was taken on October 2, 1910. Photograph by W.C. Mendenhall in Pack (1920).

Figure 3.35. Don Gautier of the U.S. Geological Survey stands next to the remains of Lakeview 1 today. Photograph taken in 2003.

Figure 3.36. A closer view of the Lakewood 1 well casing as it appears today.

Figure 3.37. Remnants of the embankment built to contain the Lakeview gusher. Note the pieces of sandbags in the lower right.

Figure 3.39. Remains of the embankment built to contain the Lakeview gusher.

Boomtown Life

A variety of facilities were built to accommodate the oil-field workers, who generally lived in the oil fields near the wells (figs. 3.42 through 3.44). Initially, tent hotels were opened to cater to the workers. A night's lodging was 35 cents and a good meal could be had for 45 cents (Elliott and others, 1968). Later the workers and their families lived on or near the drill sites (figs. 3.45 through 3.47). At the Kern River field, Oil Center was the name given to the cluster of workers' homes in the center of the 10-square-mile oil field. In 1914 Oil Center had a population of 7,000, exceeding Bakersfield's population at the time the field was discovered. Oil Center had rooming houses, general stores, a grade school, a post office, a justice of the peace, and about 160 homes (Christie, 1999b).

Many of the fields had central "jack plants" that used a central steam engine to provide power to pump several wells at once. Cables ran from the jack plant to each of the pumps.

Figure 3.38. Wooden structure that was part of a dike built to contain the oil from Lakeview 1.

Figure 3.40. Don Arnot of the West Kern Oil Museum standing next to the bronze plaque commemorating "America's most spectacular gusher."

The cables could run as far as a half mile. When no one was looking, the cables also served as playgrounds for the local kids, who swung from them as they moved back and forth (Rintoul, 1976).

The booming oil towns of the west side of the San Joaquin Valley had more to offer than typical boomtown drunkenness, shootouts, and harsh living (figs. 3.48 through 3.50). Natural gas was used for cooking in Reward five years before it was available in Los Angeles. Cultural opportunities included world-class performances at the Blaisdell Opera House in Taft and boxing matches in Taft and McKittrick featuring well-known boxers (Rintoul, 1968, 1978).

Around the turn of the twentieth century, the demographics of the oil-field workforce began to change as college-educated geologists and engineers started to appear. At first their presence was barely tolerated, if not treated with outright hostility by the field men. But by the 1920s it was clear to everyone that companies that ignored the contributions of the geologists and engineers would be out of the running (Rintoul, 1976, 1990).

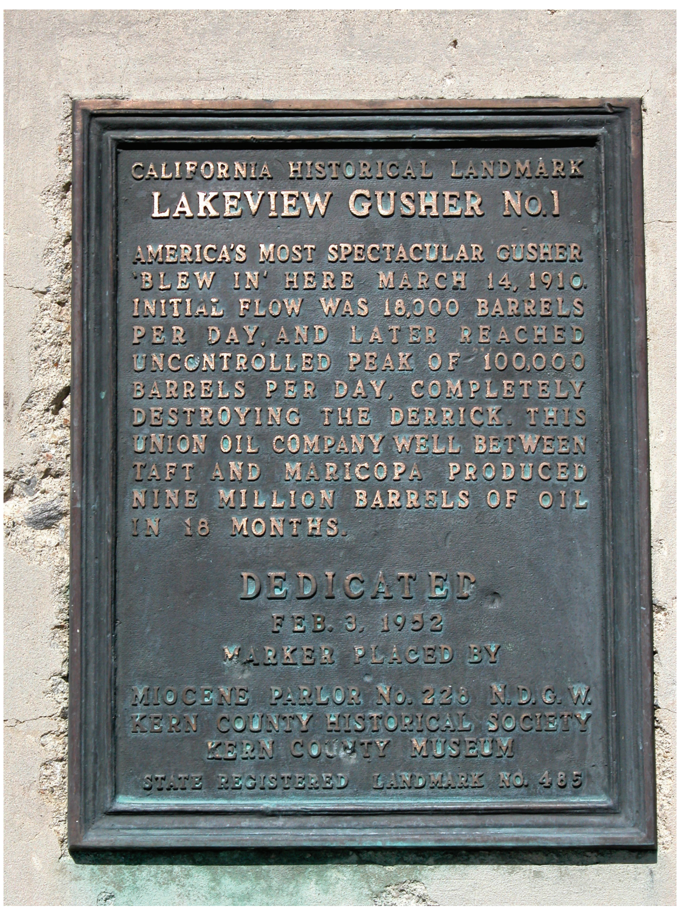

Figure 3.41. Close-up of the Lakeview 1 commemoration plaque.

Figure 3.42. A view of Taft, California, probably taken in the 1920s or 1930s, illustrating oil-camp setting. Photograph courtesy of Don Arnot, West Kern Oil Museum.

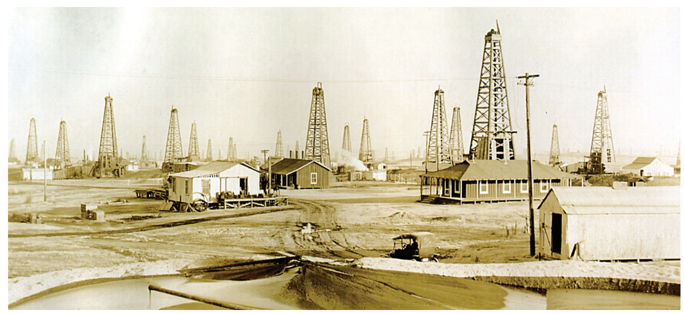

Figure 3.43. A typical oil-camp setting. Date of this photograph is uncertain, but note the vintage of the car in the foreground. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Figure 3.44. Another more recent oil-camp view, judging from the truck on the left. Location and date are unknown. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Regulating the Industry

In the early part of the twentieth century most of the prospective areas on the southwestern side of the San Joaquin Valley, including Midway-Sunset and Elk Hills fields,

Figure 3.45. Taft, California. Date of this photograph is uncertain. Photograph courtesy of Don Arnot, West Kern Oil Museum.

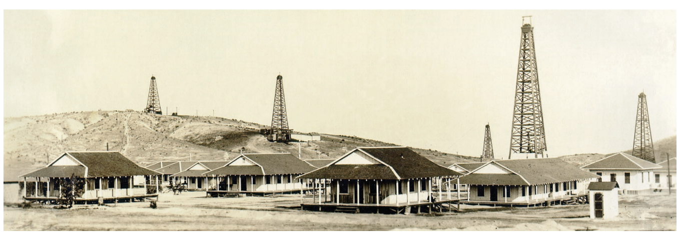

Figure 3.46. Oil field offices and accommodations. Location and date are unknown. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Figure 3.47. Another view of oil-camp facilities. Location and date are unknown. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Figure 3.48. Maricopa, California. Date of this photograph is uncertain. Photograph courtesy of Don Arnot, West Kern Oil Museum.

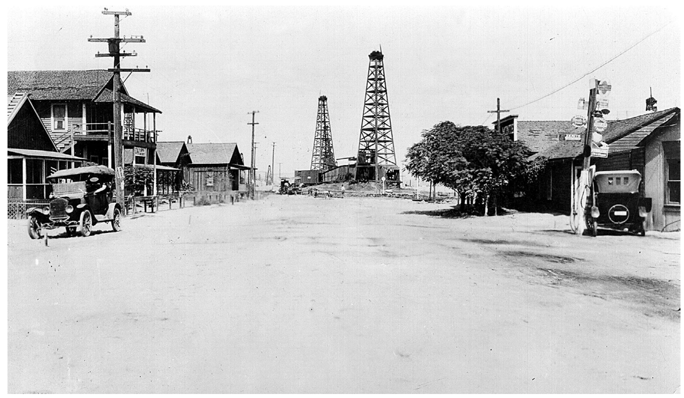

Figure 3.49. A street scene in Maricopa, California. Date of this photograph is uncertain, but note the vintage cars. Photograph courtesy of Don Arnot, West Kern Oil Museum.

Figure 3.50. Downtown Maricopa, California. Date of this photograph is uncertain. Photograph courtesy of Don Arnot, West Kern Oil Museum.

were in the public domain. Existing laws were inadequate to govern the disposition of oil and gas resources on Federal lands; attempts to apply laws written for the disposal of agricultural and mining lands led to conflicts and reckless drilling. Mining laws required an actual discovery before a patent would be granted. As a result, rival claimants drilled simultaneously. The first to drill a well that hit oil or gas received title to the tract. There was no protection from resources being drained by adjacent wells or from wells introducing water or draining gas pressure from hydrocarbon reservoirs in adjacent tracts (Rintoul, 1990).

From 1903 onward, various attempts were made to regulate petroleum exploration and production. In September 1909, to ensure a supply of fuel oil for the Navy, the Secretary of the Interior issued orders withdrawing prospective public lands from selection, filing, entry, or disposal under the public-land laws to form the Naval Petroleum Reserve 1 (now Elk Hills field) (Rintoul, 1990). State legislation, local associations, and self-policing were all tried, culminating in August 1915 with the formation of the Department of Petroleum and Gas in the California State Mining Bureau. The department's mission was "…to supervise the drilling, operation, maintenance and abandonment of petroleum or gas wells in such manner as to prevent damage to the petroleum and gas deposits of the state from infiltrating water and other causes" (Rintoul, 1990).

In 1910, the Mays Oil, St. Lawrence Oil, Pioneer Midway Oil, United Oil, Chanslor-Canfield Oil, Midway Oil, Mammoth Oil, Eagle Oil, Premier Oil, and American Oilfields companies were among these companies that drilled successful wells in the north part of Midway field (now Midway-Sunset field). The Standard Oil Company and the Honolulu Consolidated Oil Company drilled successfully in the Buena Vista Hills. Three of the largest oil fields in the valley, Elk Hills, Lost Hills, and South Belridge, were discovered in 1910 and 1911 (Pack, 1920). South Belridge field was discovered in April 1911, when the Belridge Oil Company completed well 101. Described initially as a minor field by the State Mineralogist in a report on California fields (Ritzius, 1956; Rintoul, 1999d; California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, ftp://ftp.consrv.ca.gov/pub/oil/history/History_of_Calif.pdf), recoverable oil in the South Belridge field is now estimated at nearly two billion barrels (CDOGGR, 2001). The development of existing fields and the search for new fields continued to increase oil production for many years, but the exciting days of the oil boom were over and all of the San Joaquin Valley's giant fields (> 100 million barrels of oil) were discovered by the end of 1938 (Tennyson and Klett, this volume, chapter 23).

Rotary Rigs

A rotary rig uses a rotating drill bit, similar to a hand drill. Weight is placed on the drill bit as it is turned. In a rotary rig, an engine provides the power to turn a round, flat turntable, or rotary table, set horizontally in the center of the derrick floor. The drill pipe goes through the center of the rotary table and down into the hole where the bit is attached. The table turns the pipe and bit, which drills through the rocks below. The pipe is lowered as drilling proceeds and additional sections of pipe are threaded onto the top of the drill string as needed. Drilling mud is pumped down through the drill pipe and out at the drill bit. The mud picks up the cuttings around the bit and carries them up the sides of the hole to the surface. There the cuttings are filtered out and the mud is returned to the mud pit, where it is picked up by the pumps and recirculated down the hole (fig. 3.51).

Robert Beart patented the first rotary rig in England in 1844. However, the technique was not applied to oil drilling until the 1890s. The first rotary-drilled well was completed in Texas in 1895, but no rotary well was completed in California until 1908, when Standard Oil Company completed a well in the Midway-Sunset field. In January 1910, the Standard Oil Company brought in the first gusher in California from a well drilled by a rotary rig. Cable-tool drillers understandably viewed the technology as a threat; they called the rotary drillers "swivel-necks" and viewed them as interlopers. But like them or not, by the 1920s rotary rigs dominated the California oil fields (Rintoul, 1976; San Joaquin Geological Society, http://www.sjgs.com/history.html#california; last accessed July 26, 2006).

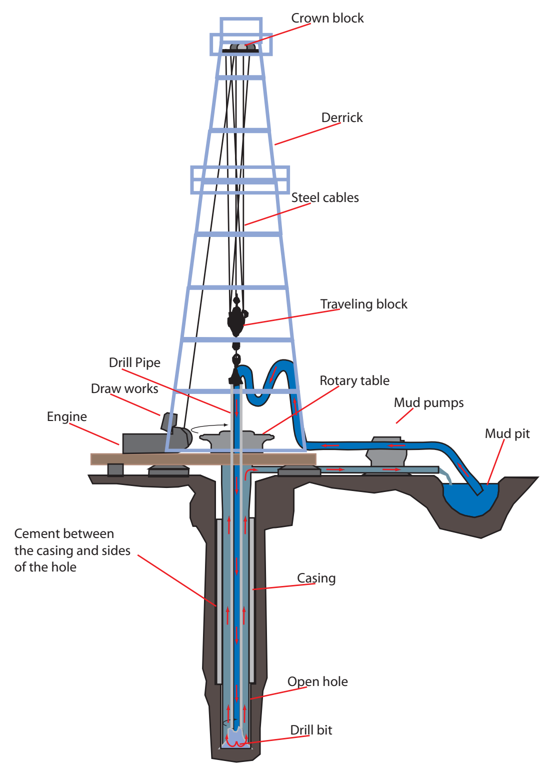

Figure 3.51. Schematic diagram of a typical rotary drill rig. Modified from Ritzius (1956).

The First World War and Fears of an Oil Shortage

When the United States entered World War I, California's oil industry was the nation's largest supplier of petroleum. Military demand spurred exploration and raised fears of sabotage. Oil companies doubled their guards; some even installed searchlights and machine gun turrets to protect their fields.

World War I demonstrated not only the importance of oil to national security, but also that oil was not as abundant as desired. The United States supplied 80 percent of the oil used by Allied forces during the war. However, California production fell from a peak of a little more than 300,000 barrels per day in 1914 to 260,000 per day the following year. Average daily production per well fell from about 40 barrels per day to 30 (Rintoul, 1990). This led to concerns about meeting the growing demand for petroleum products. By the end of June 1917, of the more than 2,200 wells drilled in the Sunset-Midway field, 1,840 were producing (Pack, 1920). Standard Oil Company took out half-page advertisements in the newspapers to show the disparity between current California oil production and the projected need in just a few years. In 1918 total national production was 350 million barrels, but Standard predicted that by 1927 some 700 million barrels of petroleum would be required nation-wide (Rintoul, 1999a).

It was in the context of a looming shortage that in 1918 Standard Oil Company began exploring the "school section" at the Elk Hills field (so-called because it had been granted to the State of California for the development of the state's school system), a section that they purchased in 1909. Up to that point $3 to 4 million had been spent by various companies on unproductive shallow drilling in various parts of the Elk Hills field. In the fall of 1918, Standard Oil Company built a wooden derrick on the school section, 9 miles north of Taft, and set up a rotary rig to drill the Hay 1 well. On January 11, 1919, they struck high-gravity (light) oil at 2,480 feet, flowing at 200 barrels a day (Rintoul, 1999a). This flow rate was not impressive when compared with contemporaneous wells drilled in the nearby Buena Vista field, where certain wells had initial flow rates of 7,000 barrels a day. Standard Oil Company persevered and completed a second well for 400 barrels a day and a third for 850 barrels a day. In 1992, the Elk Hills field would become the fifth California oil field to exceed one billion barrels of cumulative oil production (Rintoul, 1999a).

On July 26, 1919, the Hay 7 well at Elk Hills field came in flowing at 50 million cubic feet of gas per day (MMCFD). It caught fire, creating a pillar of flame high into the air and burning out of control for 26 days. It was finally extinguished with a dynamite blast and capped, at which point the well was producing at an estimated rate of 140 MMCFD. The well produced 43 billion cubic feet of gas over the next 7 years and is considered the greatest gas well in the United States (San Joaquin Geological Society, http://www.sjgs.com/gushers.html#other; last accessed July 26, 2006).

Throughout the 1920s the petroleum industry responded to the threat of an oil shortage. By 1929, California was producing more than 800,000 barrels per day, an increase of more than 524,000 barrels per day from the beginning of the decade, but a potential 190,985 barrels per day were not produced for various reasons. Several giant discoveries were made during the 1920s in the southern San Joaquin Valley: the Mount Poso field, north of the Kern River field in July 1926; the Edison field east of Bakersfield in July 1928; and the Kettleman Hills field (now known as Kettleman North Dome field), west of Kettleman City in November 1928 (fig. 3.1). Increased exploration and production had produced a surplus of oil, allaying fears of shortages (Rintoul, 1990).

California had always been a place to try new technology. In the 1920s, gas engines began to replace steam engines on the rotary rigs because they were cheaper to operate and more portable. Improvements in drilling muds, drill bits and pipe, and other technologies allowed for deeper drilling, placing more stress on the wooden derricks. By the 1930s steel had completely replaced wood for derrick construction (Rintoul, 1976).

The Great Depression and World War II

In the 1930s the search for new oil in the San Joaquin Valley began to shift from new geologic concepts to application of new technologies and better development geology of existing fields. The result was an expansion of the definition of "recoverable oil." This new understanding is still redefining the industry. The list of scientific and technological innovations that have been developed in the San Joaquin Valley and exported to the wider petroleum world is one of the most remarkable stories in the petroleum industry.

The Great Depression had taken its toll on the oil industry in California, with sharp drops in building permits, reduced work schedules, and shortened shifts during the early months following the October 1929 stock market crash. New well notices in the state dropped from 1,256 in 1929 to 918 in 1930, reaching a low of 279 in 1932. Selected exploration efforts did continue, such as the Mascot 1 well on Twenty-Five Hill, just south of Taft (fig. 3.1). The well reached a depth of 9,629 feet in March 1930, making it the deepest in the world. By 1933 the economic recovery was beginning and new well notices climbed to 596. Exploration activity also increased. The North Kettleman Oil and Gas Company drilled a well 10,944 feet deep in the Kettleman Hills field (now known as Kettleman North Dome field) and brought the world depth record back to California. In June 1934, the record was reset when the General Petroleum Corporation drilled the Berry 1 well in the South Belridge field, reaching 11,377 feet (fig. 3.1) (Rintoul, 1990).

The Gas Act was passed in 1929 to reduce gas wastage. Venting of excessive amounts of gas directly to the air could cause a loss of oil production due to the reduction of reservoir pressure and needed to be controlled, because the actions of one operator could easily affect the resources being produced by a number of operators working the same reservoir. In the following years, additional laws were passed dealing with bonding and well-spacing issues (figs. 3.52 through 3.54). In 1931 a law was passed requiring a $5,000 bond for drilling, redrilling, or deepening wells to ensure proper well abandonment. Well spacing was also regulated to control drilling and improve recovery.

Many innovations appeared in the San Joaquin Valley during the 1920s and 1930s. Coring techniques used in the coalfields of Holland were applied, after considerable modification, to recover a column of rock being drilled from a well; this was common practice by 1922 (Rintoul, 1976). In 1929, Shell Oil Company employed the Schlumberger brothers, who used a downhole device to make the first electrical log in the United States (Schlumberger, http://www.slb.com/content/about/history.asp; last accessed July 26, 2006) at the Boston Land Company 1 well at Westhaven field (Rintoul, 1976). Reflection seismic techniques were introduced to the San Joaquin Valley in 1935. In this procedure an explosive charge was set off in a shallow hole, and the resulting shock waves were measured by sensors placed at various distances from the blast. The shock waves would reflect off the various rock layers below the ground at different rates, depending on the depths of the rock layers. By repeating this process throughout the area of interest it was possible to develop a set of seismic profiles, or images of the structure and depths of the layers in the subsurface.

Shell Oil Company was one of three companies who shot seismic lines in the Kern River delta on the valley floor southwest of Bakersfield, an area once widely believed to be fruitless for exploration—“a wildcatter’s graveyard” (Rintoul, 1976). Only Shell Oil Company seemed to seismically image a structure there, and they proceeded to drill the Stevens A 1 well, thereby discovering the Stevens sand of Eckis (1940; hereafter referred to as Stevens sand) reservoir in the Ten Section field. The Stevens A 1 well tested at 1,200 barrels per day of condensate and 15 to 18 million cubic feet of gas at 7,880 feet depth.

The Stevens sand became one of the richest oil reservoirs in the area (Rintoul, 1990; San Joaquin Geological Society, http://www.sjgs.com/gushers.html#other; last accessed July 26, 2006). Union Oil Company drilled the Kernco 1-34 well to explore the Stevens sand at the Rio Bravo field, but finding nothing there, the company continued drilling to the Vedder Sand at a depth of 11,302 feet. Here the well came in at 30,000 barrels per day. Besides being the discovery well for the Rio Bravo field, the Kernco 1-34 well was the first well in California to produce oil from deeper than 11,000 feet. At that time it was the deepest producing oil well in the world (Rintoul, 1976, 1990). In April 1938, the Continental Oil Company drilled the K. C. L. A-2 well to 15,004 feet, discovering the Wasco field. Producing 3,000 barrels per day, this well was the first in the world to penetrate deeper than 15,000 feet. The field only produced 5 million barrels before it was abandoned in 1960, but it became a proving ground for deep-drilling tools and techniques (Musser, 1939; Rintoul, 1990).

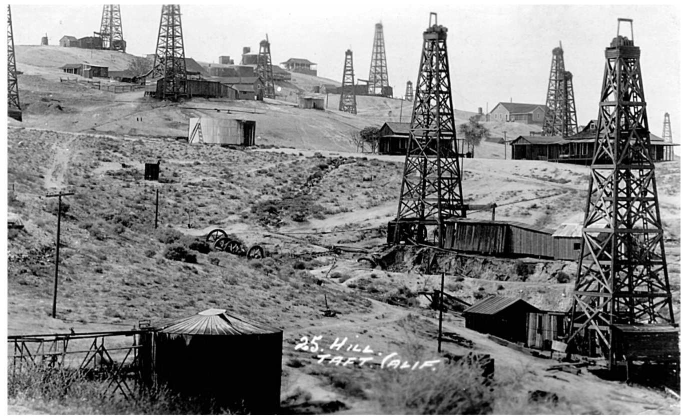

Figure 3.52. Drilling and production activity at Twenty-five Hill near Taft, California. Note the dense well spacing. Photograph courtesy of Don Arnot, West Kern Oil Museum.

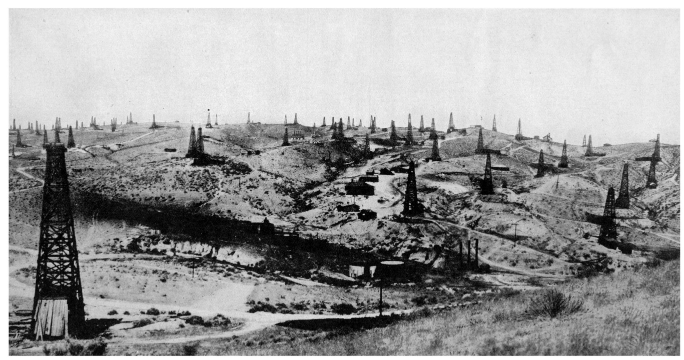

Figure 3.53. Twenty-five Hill in Midway-Sunset field shows the dense drilling activity. Photograph from Pack (1920).

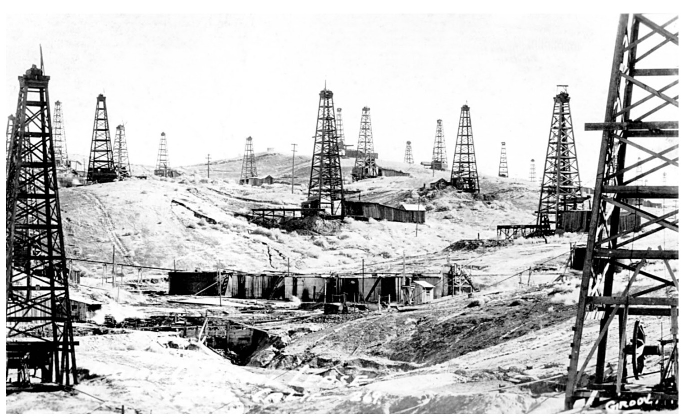

Figure 3.54. Another view of Twenty-five Hill in Midway-Sunset field. Photograph courtesy of Don Arnot, West Kern Oil Museum.

The requirements of World War II led to efforts to maximize production and protect facilities in the San Joaquin Valley. Supporting the war effort called for increased production despite labor and material shortages. Changes in production strategies and priorities were also made to make optimal use of existing resources. For example, a 26-inch gas pipeline from Kettleman North Dome field to San Francisco was converted to an oil pipeline. The gas production at Kettleman North Dome field was reduced and the produced gas was injected into the Temblor Formation. At the same time, the Rio Vista gas field, located between the San Francisco Bay Area and Sacramento, came on production to make up the difference. A previously depleted pool at Kern River field was brought back online by the Tide Water Associated Oil Company by pumping water out of the formation faster than it could accumulate. While new well notices increased, abandonments also increased, enabling recycling of the used casing. The Navy opened all of the Naval Petroleum Reserve 1 (now called Elk Hills field) to drilling. The Stevens sand proved to be the largest oil reservoir in the reserve. California's annual oil production in 1945 totaled 328.3 million barrels, up from 229.7 million barrels in 1941 (Rintoul, 1990).

The booming postwar economy once again spurred oil and gas exploration. In 1953 the Ohio Oil Company drilled California's last world-depth record holder, the KCL-A 72-4 well in Paloma field, which reached 21,482 feet. The $2,250,000 well was not commercially successful and was abandoned in 1954 (Rintoul, 1990).

In spite of the advances in technology, the oil and gas fields of the San Joaquin Valley were still operated at the end of World War II in much the same way as they always had been. Many of the operators lived in the oil fields in company housing. The oil, accompanied by large amounts of water and sand, would flow from the pumps into large open sumps dug into the ground, where the water and sand would settle out (figs. 3.55 and 3.56) (Christie, 1999b). This situation was about to change.

Steam Heats Up The Valley

By the late 1950s, many billions of barrels of viscous, heavy oil had been found in the San Joaquin Valley that could not be produced profitably with existing technologies. At the time, it was estimated that less than 10 percent of the heavy oil would ever be recovered (Rintoul, 1990). Several techniques were tried to produce these heavy oils, all centering on heating the oil to reduce its viscosity. These included fireflooding, bottom-hole heaters, and steam flooding.

The technique of fireflooding involves an injection well centered among several producing wells. Air is pumped into the reservoir via the injection well to start and sustain combustion of the oil. The heat thins the oil in the reservoir, making it easier to produce. In 1956, fireflooding began with a $1 million pilot project funded by a group of 11 oil companies in the South Belridge field. Four producing wells, spaced 330 feet apart, were drilled around one central well through which air was injected to support combustion. A similar project was tested at the Midway-Sunset field. Results indicated an increase in production of up to seven times the preburn rates. However, the cost per barrel of oil produced via fireflooding was substantially higher than from conventional wells because of high startup costs, increased maintenance, decreased reliability as a result of corrosion, and high temperatures and pressures (Rintoul, 1990).

At the same time, bottom-hole heaters appeared, which provided heat to the producing formation. The technology involved a heating unit on the surface that pumped hot water or

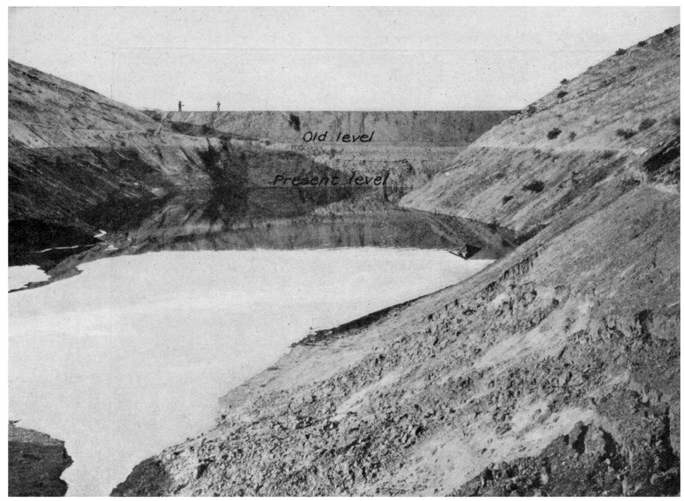

Figure 3.55. A sump used to contain oil from the Miocene 1 well in 1914. The light-colored horizon above the oil pool shows the level attained when the sump was used to contain oil from the Lakeview gusher. Photograph from Pack (1920).

Figure 3.56. Typical oil sump. Location and date are unknown. Photograph courtesy of Don Arnot, West Kern Oil Museum.

oil to the bottom of the well to a heat exchanger, which radiated heat into the reservoir. The heater had a startup cost of only $3,000 versus the $1 million for the still unproven fireflood setup. In 1957 and 1958, Tidewater Oil Company installed heaters in 54 wells in Kern River field, increasing production by nearly 500 percent. Production at Kern River increased by 2,000 barrels per day over a two-year period, the increase directly attributable to the installation of heaters. Although these results were encouraging, they indicated that heaters were too small to effectively heat the entire formation for large-scale production and that the heat needed to be delivered deeper into the oil sand (Rintoul, 1990).

Steam had been tried on the viscous Kern River oil in the early 1900s and was used successfully with asphalt in the late 1800s; steam flooding became widely used in the 1960s. In March 1961, Shell Oil Company began steam injection at the Coalinga field but did not release results. However, the subsequent expanded use of the technology in the Coalinga field had clear implications (Rintoul, 1990). In August 1961, Tidewater Oil Company began field tests with hot-water injection, followed by a larger hot-water injection project in Kern River field the following year. This improved the test well's production from 7 barrels per day to as much as 100 barrels per day. The program was stopped because of technical problems, but the value to production had been demonstrated (Rintoul, 1990).

For competitive reasons the companies were concerned with security, and not much information about steam flooding was released. However, during this time oil properties suitable for steam applications became highly sought after, with more than 300 wells changing owners in a 10-month period. By the end of 1962 producing leases were sold for as much as $9,000 per barrel. A property that produced 20 barrels of oil per day would sell for $180,000, double the price of the year before, in spite of a 30-percent reduction in the price of Kern River crude (Rintoul, 1990, 1999e). Often, the new owners were Shell Oil Company or Tidewater Oil Company, who both happened to be leaders in steam recovery methods (Rintoul, 1990).

More than 300 wells were brought into production in the Kern River field in a 10-month period. Rumor had it that steam methods were increasing production from 4 to 10 times the presteam rates, with only a $30,000 startup cost (Rintoul, 1990). Economics highly favored steam over fireflooding. The most popular method, "huff and puff," injected steam into a well for a certain period of time, 10 days or so, then allowed it to sit for a similar period before production resumed. Another method was steam drive or steam flood, in which one well was used to continuously inject steam into a reservoir to heat and push oil towards several producing wells. As the use of steam became more widespread, the secrecy surrounding the technique faded (Rintoul, 1990, 1999e).

In the summer of 1964, an employee of Occidental Petroleum Corporation put up a sign beside an oil-field access road northwest of Fellows. The sign read: "Danger, Steamflood in Progress. Enter at Your Own Risk." That was probably the first general, public acknowledgement by an oil company of the use of a recovery method that would enable billions of barrels of additional oil to be produced from California fields (Rintoul, 1990, 1999e). In 1966, annual production in the Kern River field exceeded the presteam record of 17.2 million barrels set in 1904. In 1986 annual oil production in the Kern River field was 47.8 million barrels, setting a new record. The new record was almost six times the 8.6 million barrels produced in 1961, the year steam was first used in the Kern River field. In 1972, annual production in the Midway-Sunset field exceeded the presteam record of 34.4 million barrels set in 1914. In 1988, 58 million barrels were produced at the Midway-Sunset field, nearly 3.5 times the 16.6 million produced in 1963, the first year steam was used there (Rintoul, 1990).

Workers who lived at the fields were crowded out by the new steam technology, which used the space previously occupied by dwellings and bunkhouses for tighter well spacing, steam generators, pipelines, and storage tanks that replaced the open sumps (figs. 3.57 and 3.58).

The large oil-fired steam generators could consume as much as 40 percent of the crude pumped from the field, and the inefficiently burned, unrefined oil produced large amounts of air pollutants, particularly nitrous oxide and sulfur dioxide. Expensive water treatment plants were eventually brought in to treat the produced water, allowing it to be used for irrigation (Christie, 1999b, a).

When oil prices fell in the early 1980s, more efficient methods were needed to extract the oil from the reservoirs.

Figure 3.57. Lines route steam where needed in this oil field near Coalinga, California.

Cogeneration plants were developed to produce both electricity and steam using cleaner burning natural gas, thus reducing air pollution. The electricity was sold to outside utilities, helping to offset the cost of running a steam plant. Steam was the key to fields like Kern River field that had produced only about 10 percent of the original oil in place during its first 60 years of operation. Not only was the life of the field extended by decades, but steam was making it possible to extract as much as 70 to 80 percent of the oil in place (Christie, 1999b).

Recent Developments

Compared with the middle decades of the twentieth century, few genuine wildcat wells are being drilled in the San Joaquin Valley these days. Indeed some of the most important operators decided explicitly to forego exploration in the valley in favor of the highly profitable increased development of existing fields. Given the vast number of wells that have been drilled, the San Joaquin Valley is widely viewed as a highly mature petroleum province, where maximum-recovery efficiency is the remaining goal. Nevertheless, the basin is large and highly charged with petroleum, and surprises still lurk in the subsurface. The Yowlumne oil field was discovered in Kern County in 1974, and by 1979 it was the ninth largest producer in the state. By 1980, although no longer on the list of the 10 largest oil producers, Yowlumne field was the third largest California producer of associated natural gas (California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, ftp://ftp.consrv.ca.gov/pub/oil/history/History_of_Calif.pdf). More recently, production has been demonstrated from diagenetically trapped oil in siliceous facies of the McClure Shale Member of the Monterey Formation in Lost Hills, North Shafter, and Rose fields.

Figure 3.58. Steam lines and other equipment associated with steam technology take up space in this oil field near Coalinga in areas once used to feed and house oil-field workers and their families.

Recently, attention has once again focused on the possibilities at depth in the San Joaquin Basin. In a scene reminiscent of the days when blowouts were common, the Bellevue 1 well, a wildcat well drilled into a subthrust play below Lost Hills field, blew out at a depth of 17,657 feet and erupted in flame on November 23, 1998. The blowout lasted for 14 days, burning high-pressure condensate from the Temblor Formation at estimated rates of 40 to 100 million cubic feet of gas per day, raising hopes for the first major San Joaquin Basin discovery in more than a decade (San Joaquin Geological Society, http:// www.sjgs.com/gushers.html#other; last accessed July 26, 2006). The out-of-control well destroyed the rig, the mud-log trailer, and everything else on the well site. Flames shot up 300 feet and were visible 40 miles away. The fire only went out when water began to flow with the gas. A high-pressure mixture of gas, condensate, and water continued to flow uncontrollably for six months, until it was finally stopped by drilling an intercepting well and pumping in heavy (17-pound) mud. A replacement well, the Berkeley Petroleum E.L.H. 1-6, drilled to evaluate the potential of this deep, high-pressure gas accumulation is currently the deepest production well in California (San Joaquin Geological Society, http://www.sjgs.com/gushers.html#other; last accessed July 26, 2006).

Conclusions

The history of oil and gas exploration in California is replete with booms and busts, the rise and fall of financial empires, and changes in technology and society. It is populated with wild and interesting characters, from the rich and powerful to the poor and struggling—all seemingly willing to take enormous risks in search of fortune in the oil fields of the San Joaquin Valley. At the same time, the valley has become a model of production efficiency, and the demonstrated growth of reserves in existing fields has focused international attention on the San Joaquin Valley, as operators make record profits from these old fields.

In an early paper on the Midway-Sunset field, Robert W. Pack, a U.S. Geological Survey geologist said, “The search for new pools, which is today occupying the full attention of most of the petroleum geologists of the country, will become increasingly keen as the production of oil decreases and the demand continues to increase, but the geologist will in the future render his chief service to the petroleum industry through intensive studies of the productive fields, made for the purpose of aiding in the efficient extraction of the oil” (Pack, 1920). Evidently some things have not changed.

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