

Oil Under Foot

Some of the most productive oil and gas acreage ever discovered lie adjacent to the site of this year's AAPG National Convention in Long Beach. Separated by only 5 km, the "old, nearly depleted" Long Beach and Wilmington oil fields still offer exploitation opportunities despite the challenges of operating in an urban environment.

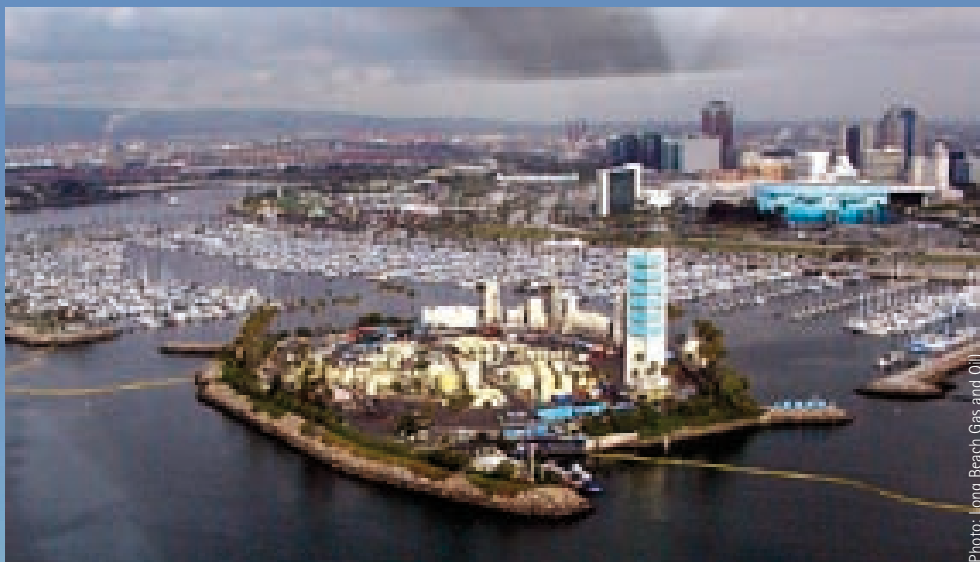


Photo: Long Beach Gas and Oil



Oil is found in far away
locations and can be accomplished.
AAPG Convention. Pictured are the
being produced in a busy neighborhood.

an example
of this year's
Long Beach

Oil seeps have been utilized by Native Americans for thousands of years in the southern California area. It was not until 1892 that the first large oil strike was made by Edward Doheney and Charlie Canfield near the corner of Colton Street and Glendale Boulevard in downtown Los Angeles. Using the sharpened end of a eucalyptus tree to drill to a depth of 140m, the Los Angeles field was discovered. By 1897, the field was actively producing from 500 wells and is still producing today.

The Oil Rush

The discovery of three major fields in 1920-21, Long Beach, Santa Fe Springs and Huntington Beach, created a real oil boom in the Los Angeles basin. The Long Beach discovery well gushed oil 35m into the air and then was plugged by an ensuing cave in. After the well was cleaned out, it produced 1,000 bopd (160 m³pd) and would eventually produce over 700,000 barrels (111 Mm³) of oil.

At the time of the discovery, Signal Hill was being subdivided into residential lots, creating an onslaught of potential homeowners to become oil drillers. The parcels of land were quite small and soon Signal Hill would be so densely covered with derricks that the legs of many were actually intertwined. The field proved so prolific that most of the people that bought shares in wells actually made money. Even the relatives of persons buried in the Sunnyside Cemetery would receive royalty checks for oil drawn from beneath family plots.

The Long Beach field has produced nearly 1 Bbo and is the most productive field per acre ever discovered (about 1 MMb per acre). Over 3,000 wells have been drilled on this faulted anticline that has an area of only 2.4km by 6.4km. The maximum production was reached in December 1923, of 224,000 bopd (36 Mm³pd) from 329 wells. Today's production is 3,850 bopd (612 m³pd) from 285 producing wells.

Oil is not always found in far away places nor does it have to be an ugly blight. These examples of how oil production can be accomplished in an urban environment lie next to the sight of this year's AAPG Annual Convention. Pictured are Grissom Island in Long Beach harbor, the City of Long Beach, and oil being pumped in a busy neighborhood.

Subsidence caused by an oilfield

One of the most dramatic cases of land subsidence caused by oil production occurred at the Wilmington field. Appreciable subsidence was observed in 1938, six years after the Wilmington discovery. Major subsidence was measured in the 1940's that was thought to be associated with the pumping of underground water at Terminal Island Naval Shipyard. However, the area continued to sink after groundwater pumping ceased. Subsidence exceeded 0.6m per year and, by 1958, affected 35 km². Total subsidence reached 9m.

Something had to be done as the effects of subsidence were destroying the area. Wharves were inundated by the sea; rail lines and pipelines were warped or sheared; buildings and roads were cracked and displaced. It was determined that oil, gas and water production caused pressure losses and the weight of the overburden compacted the oil sands, at the same time lowering the surface. Research indicated the only way to stop the subsidence was to repressurize the reservoirs through water injection and, at the same time, more oil could be recovered from the field.

Before water injection could be started, the area had to be unitized to ensure that all operators would comply. These mitigation measures took effect in 1960 and the area was stabilized 7 years later.

Once the subsidence was controlled, a vote by the citizens of Long Beach lifted a drilling ban that allowed for the development of the eastern portion of the field extending under the City and the harbor

areas. In addition, restrictions were placed on development of the wells and oil facilities to ensure that subsidence would not occur and the natural beauty of the shoreline would be protected.

The area is monitored daily for subsidence and water injection volumes greater than the total fluids withdrawn are required. "Subsidence is still a big issue. If we ever stop injection and continue production, we would have immediate subsidence problems again. My job is to make sure we are putting the injection in the right locations," says John Jepson, geologist for the City of Long Beach.

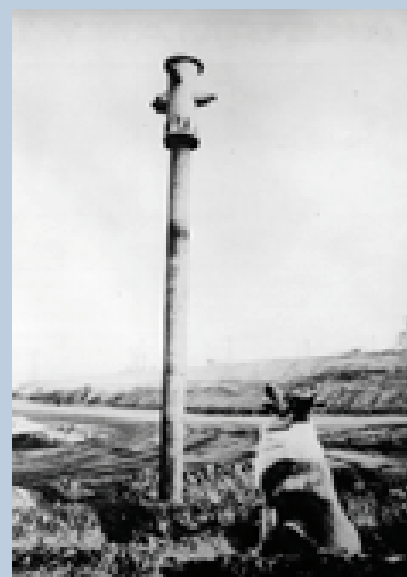


Photo: Long Beach Gas and Oil

Subsidence from oil production had devastating consequences to the area, requiring mitigation.



Photo: Long Beach Gas and Oil

Signal Hill about 1930, 10 years after the Long Beach field was discovered. The 110 m high hill located behind the City of Long Beach was used by local Native Americans to send smoke signals to surrounding locations, hence the name.

The oil column is over 2,300m thick, starting at 800m from the surface to a depth of 3,100m. Production is from Miocene to Pliocene turbidite sandstones divided into 7 zones similar to the productive zones in the Wilmington field discussed below. The location is more proximal, resulting in a much thicker reservoir sand section than what is present at Wilmington, 5km to the south.

A recent second boom, the building of new homes, is now impacting Signal Hill. Since 2000, 10% of the city's single-family homes have been built and sold here and is the last remaining view property in the city. Many of the new homes are built over wells and while this building is going on, so is oil production.

The 86-year-old field is still being explored with a 3-D seismic survey planned for 2007 or 08. The owners have also ordered a specially designed drilling rig to reduce impacts to urban areas and hope to be drilling sometime in 2007. It has been nearly 30 years since the last well was drilled.

The Big Find

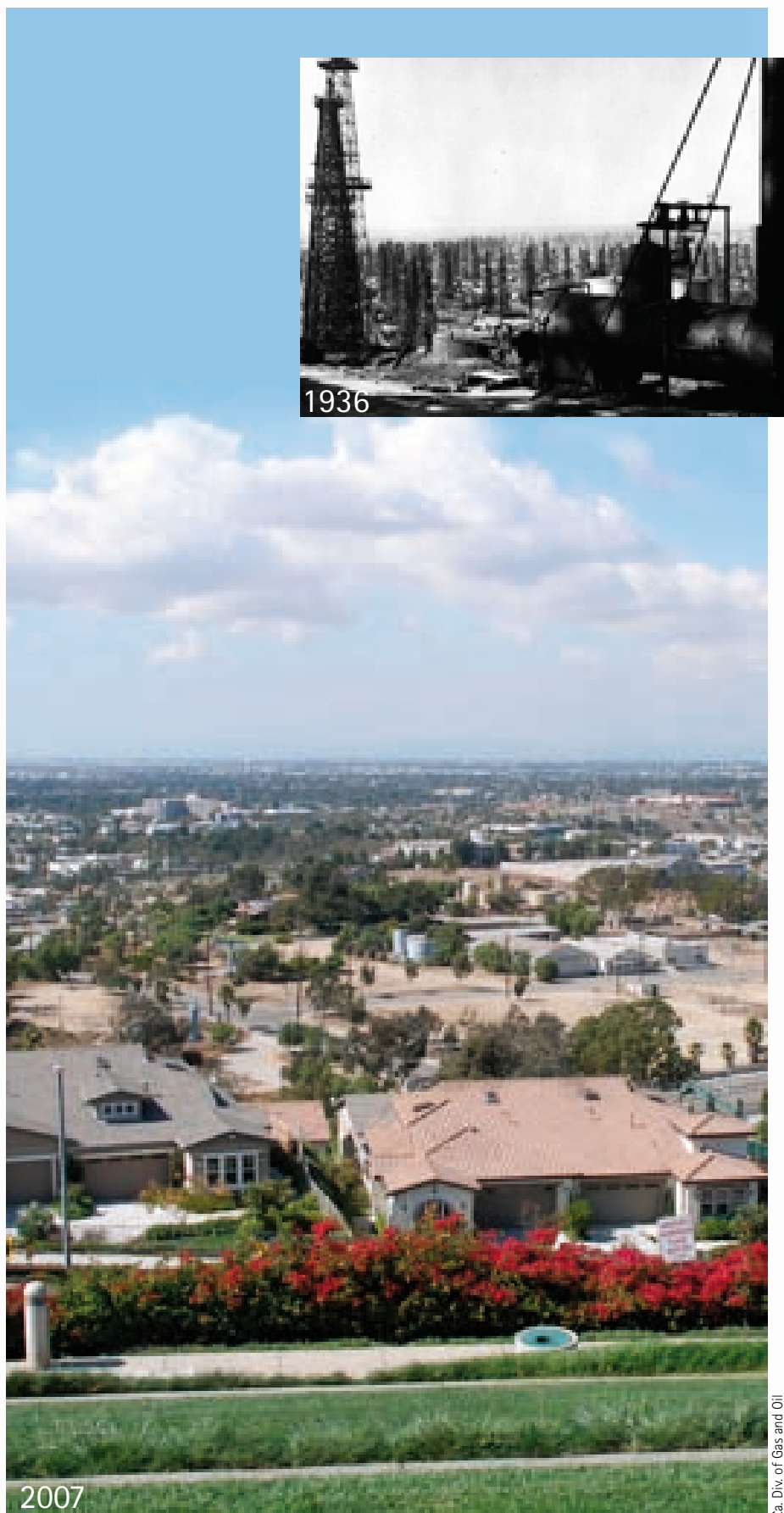
Discovered in 1932 with recoverable oil estimated to be 3 Bb (0.5 Bm³), the Wilmington field is the largest in the Los Angeles basin and the third largest in the United States. It has already produced over 2.6 Bbo (0.4 Bm³). Approximately 6,150 wells have been drilled within this field and about 3,400 of these are land-based, with the

"I am amazed by the amount of oil left behind in these old fields," says Dr. Hilario Camacho of Signal Hill Petroleum, "and a lot of it can still be recovered."

remainder drilled from offshore locations. The field is currently producing 46,000 bopd (7300 m³pd) from 1,550 wells.

The field is confined to a 5 km by 20 km northwest-southeast trending anticline that extends offshore beneath Long Beach harbor. A pier and 4 man-made islands were built in 1964 to extract oil from the offshore portion of the field.

The City of Long Beach was granted ownership to its tideland properties by the State of California in the early 1900's.

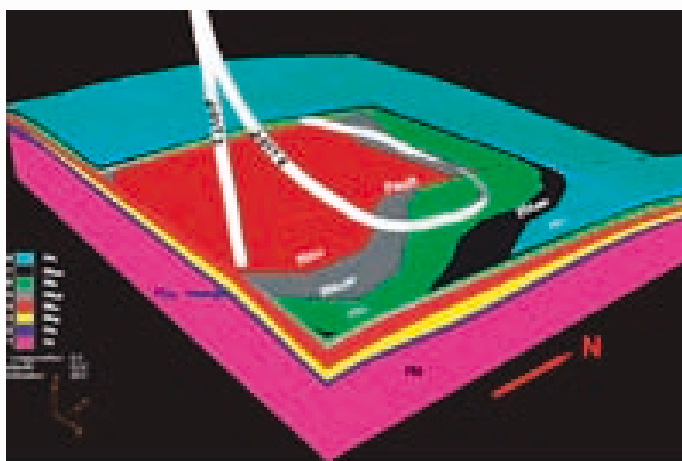


Pictured from near the same location, Signal Hill in 1936 and today. Homes are now being built over the old wells.



Location of Long Beach and Wilmington fields in the Los Angeles Basin.

Illustration: Ca. Div. of Oil, Gas, and Geothermal Resources



Map view of a tight-radius horizontal well penetrating a turbidite reservoir to recover bypassed oil.

Illustration: Tidelands Oil Production Co.

When it became certain that the Wilmington discovery extended under city owned land, the City's Harbor Department created a Petroleum Division. Now called the Department of Oil Properties, it is designed to protect city assets and act as primary operator in the oil field. Production here has generated over \$450 million for the city and \$4.25 billion for the state.

The average well in the Wilmington field produces 50 bopd (8 m³opd) and many are as are nearing their economic limits with 96% water cuts, yet several new wells have come in at 800 bopd (127 m³opd). Three-dimensional reservoir modeling, along with new completion technology, makes such successes possible.

The field produces from Miocene to Pliocene basin turbidite sandstones. The anticline is highly faulted. With new data, reservoir characterization has subdivided the 7 productive zones into 52 subzones and detailed mapping has identified areas to exploit bypassed oil. Tertiary and secondary recovery techniques utilizing steam

are successful in the heavy oil reservoirs. Tight-radius horizontal wells deeper in the formation are also capturing bypassed oil, while three-dimensional models help isolate data inconsistencies. Once the final geologic model is created, 3-D visuals are used to accurately locate horizontal wells through improved drilling techniques and directional control.

Thanks to Don Clarke, Consultant and John Jepson, Long Beach Gas and Oil.

THUMS Long Beach Company

is named for the original field contractors: Texaco, Humble, Union, Mobil, and Shell. To develop the eastern portion of the field, which lies offshore in Long Beach Harbor, 4 man-made islands were built. These islands were constructed to resemble resorts and blend into the surrounding coastal environment. They were named after the astronauts that lost their lives during the early years of the U.S. space exploration (Grissom, White, Chaffee, and Freeman). Pictured is Grissom Island.

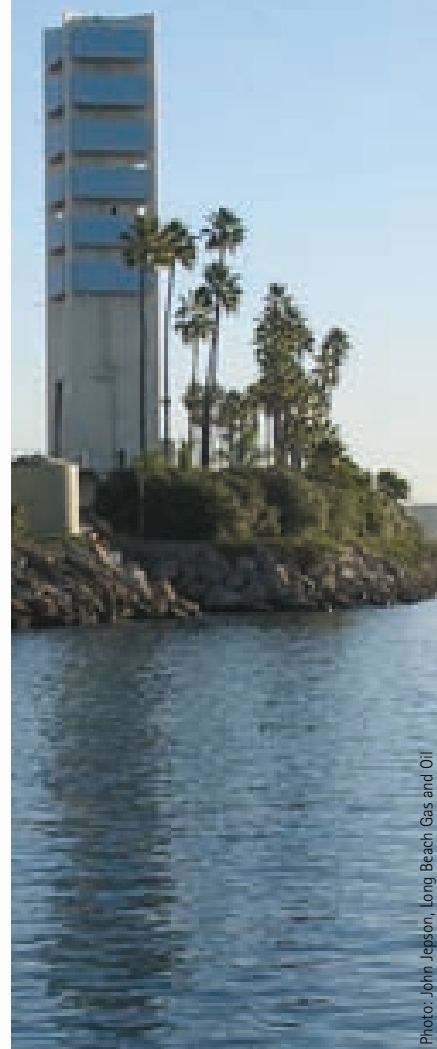


Photo: John Jepson, Long Beach Gas and Oil