The History and Petroleum Systems of the Humble Field, Harris County, Texas

Julie Jarvie-Jones¹
Daniel M. Jarvie¹
Albert Maende²
Don Rocher³

¹ Worldwide Geochemistry, LLC
² Wildcat Technologies, LCC
³ Geomark Research Rock Lab

Humble, Texas

Humble Oil & Refining Company founded in 1910 in Humble, Texas

The most common question about the city of Humble is:

“Was it named after Humble Oil & Refining Company?”

The answer is simple: No!

Humble Oil & Refining Co. merged with Carter Oil Co. and Jersey Standard to eventually become ExxonMobil.

In fact the Exxon Production Research Co. or ExxonMobil Upstream Research Co. building on Buffalo Speedway here in Houston has a cornerstone plaque reading “Humble Oil & Refining Company Research Center”
Rather, Humble, Texas is named after Pleasant Smith Humble, who arrived in Humble ca. 1864 and opened the Humble post office in 1904.

Pleasant Smith Humble
Ref: Humble Museum

---

Interesting facts about Humble

- The town name is pronounced Um-bull as this is how Mr. Humble’s last name is pronounced.

- The present-day Humble High School mascot, the Wildcat, does not originate from the animal. But from the oil term “wildcatters” and the original mascot was an oil derrick named “The Gusher”.

Ref: Humble Museum
Mr. Humble operated a ferry across the San Jacinto River that currently separates Humble from Kingwood. He moved from near the river to near the present-day downtown location of Humble after experiencing flooding near the properties along the river. During the 1994 flood water reached the level of the bridge crossing the river at Highway 59.

The importance of the river in petroleum exploration is due to the sighting of gas bubbles and oil seeps near the river.

Up until 1904, the Humble area was noted primarily for its lumber. Humble is just south of the present-day Sam Houston National Forest indicative of large southern pine that thrive in the area.
Apparent consensus of opinion is that the Gulf Coast petroleum is unsuited for the production of illuminating oil, and it is doubtful if it can be made to yield a good lubricating oil on a commercial basis. (4)

Texas oil was a “freak and would soon go to water” (History of the Texas Oil Industry by J. Edgar Pew)

Oil prospectors who were encouraged by gas and sulfur found in water wells and by paraffin dirt found on the surface (14)

Despite these rather dire predictions, these early oil men were not deterred and...

along came oil

One of many Humble Field gushers

The first highly successful oil well was the 1905, D. R. Beatty #2 Fee that reached a total depth of 1,012 ft in the salt dome caprock and flowed

8,500 bopd
Prospecting for Oil circa 1900s

Prospectors looking for oil in the Texas Gulf Coast by simple criteria such as:
- Seeps – bubbling gas or oil
- Slight elevations in the landscape
- The presence of paraffin dirt (a flakey, blackened soil)

• All these indicators were found near the site of the Humble salt dome

Salt basins and salt diapir provinces in the USA

Williston Basin
Denver Basin
Paradox Basin
Permian Basin

Michigan Basin
Appalachian Basin
Gulf Coast

Smith et al., 1973
Salt Dome Fields, Gulf Coast
having > 10 million barrels of oil production

Block Diagram of Salt Domes in the Texas Gulf Coast
There are four major oil plays associated with Gulf Coast Salt Domes

- Cap rock
- Yegua salt dome flanks
- Yegua deep salt dome crests
- Frio deep salt dome crests

As of 1983 salt dome reservoirs of at least 10 million barrels have yielded cumulative production totals of 3.46 billion barrels of oil (Galloway et al., 1983)

Humble Field Exploration

The oil fields themselves are usually associated with small hills or elevations, which are rarely more than two miles in diameter.

At places in the field small low mounds, popularly called “gas mounds”, rarely more than 30 feet in diameter.

Center of the field is roughly marked by Moonshine Hill, a low elongated elevation rising barely more than 20 ft above the surrounding plain.
The first discoveries of gas and oil from the Humble salt dome were from the porous cap rock of the dome that contained gas under high pressure causing gas blowouts.

Depths to the caprock are from ca. 500 to 3500 feet.
Moonshine Hill
Early 1900’s

Picture taken 30 January 2012

Location of Humble Field Discovery
Moonshine Hill

Picture taken 30 January 2012
The invention of blowout preventer in 1905, D.R. Beatty used on the #2 Fee well which gave up the first gusher with a potential of 8,500 barrels of oil a day from a depth of 1,012 ft. (2)

Some of the earlier wells in the cap-rock made as high as 12,000 barrels of oil daily. (5)

Between 1905 to 1913, activity was confined to cap-rock area, in this district the wells averaged a total depth from 1100 to 1500 ft. (5)

1902 George Hart, TD at 700 ft, Miocene gas blowout
1904 C.E. Barrett, TD at 700 ft, Miocene gas blowout
1904, Higgins Oil, TD at 700 ft. Miocene gas well
1905, D. R. Beatty #2 Fee, TD at 1,012 ft, in caprock, 8,500 bopd
1913, Producers Oil #11 Carroll, TD at 2700 ft. in Miocene, 10,000 bopd
Deepest well: Texas Co., #2 Bender Estate, TD at 13,728 ft in Wilcox
Famous People involved in the Humble Salt Dome Development

- Howard Hughes, Sr. – patented the rotary bit (and leased it rather than selling it outright – later becoming Hughes Tool Co.)
- Howard Hughes, Jr. – born in Humble and attended Rice University (briefly)
- Ross Sterling, co-founder Humble Oil & Refining Company, later governor of Texas
- H. R. Cullen, well known philanthropist in Houston, who succeeded in obtaining production from the flanks of the Humble salt dome

Rough Start for Humble Field

- Started a fire which burned for 10 hours and cost about $50,000 - $100,000 in March 1905 (3)
- Started a fire which burned for 10 hours and cost about $50,000 - $100,000 in March 1905 (3)

- TEXAS OILFIELD ABLAZE.
- Cigarette Starts a Fire Which Gas and Oil Helps Along.
- Special to The New York Times.
- December 1904 (1)

- HAVOC IN AN OILFIELD.
- Subterranean Disturbances in Texas—Machinery Sinks Out of Sight.
- Special to The New York Times.
- April 1905 (13)
How was oil stored in the earliest 1900s?

• Why?
  – No other means of storage
  – Due to overproduction a lot of water and sand/silt was produced and this served as a separation tank with oil floating on water

Lessons Learned

Lightning struck a tank and it exploded, Texas Company (Texaco) lost 2 million barrels of oil. The fire spread to earthen tanks and covered at least 104 acres and probably at least twice that. July 1905 (16)

Lessons Learned: Consequences of poor tankage and close spacing (16)

Up to this point all tanks were topless – Texaco put wooden roofs and built dams around each oil tank (17)
... then a lot of drilling and oil.

Transportation and storage of oil created a dilemma for operators...

Overproduction

Because no Texas fields were prorated before 1930, no regulations prevented operators from overproducing the field (14).

This resulted in wasted production and wells watered out very quickly as early as 1905-1906.
Salt Water

Excessive overproduction extracted a toll on the field by bringing salt-water encroachment in wells by damaging the gas cap drive of the reservoir, and by forcing crude prices as low as $.16 per barrel (14) and often as low as $0.05/bbl.

History - Down Deeper

When deep production was found on the dome flanks at Sour Lake field, east-northeast of Humble, operators in Humble field drilled into zones below 2,500 ft., hoping to emulate the success (2).

November 1913
Well No. 11 Carroll
Producers Oil Company
• Rated at 10,000 barrels initial production
• Depth of about 2700 ft. (5)
Production Keeps Growing...

• With the addition of pay zones from the deep flank sands, Humble became an important coastal dome field by 1915 when more than 11 million barrels of oil were produced.(14)

• In 1935 the Wilson Oil House Well #1 came in at 1500 bopd from the 2,500 ft. sand on the north flank of the field. (2)

Jackson Sands Production

Jackson production was first established with the drilling of the lateral sands at Humble in 1914. Contains oil of light gravity of entirely different character from that found in Oligocene sands, containing larger proportions of gasoline and kerosene than the normal so-called “Grade A” oil of the Humble deep sands(10)
In 1929, H.R. Cullen went beyond the limits of proved production on the southeast side of Humble and completed a well below the “black shale”, producing from the Upper and lower Saline Bayou formations of the Yegua, at a depth of 5,347 ft. This was the first time that production in substantial amount was obtained from this formation. (10)

At present (1934 article) the Yegua is the most important producing formation of the Gulf Coast (10).

Pay is in limestone caprock with variable porosity development.
Caprock pay is sour whereas other pay is sweet.
All other pay is in sandstone.
Oil gravities range from 16 to 44°API.
Total wells 2,825.
Wells currently producing: 265.
EOR (enhanced oil recovery) activities include:
- Saltwater injection (water flood)
- Steam injection
- Gas injection for attic recovery

Ref: John F. Simpson, independent geologist.

Total production to date: ca. 169 million barrels of oil
1904-1910 (only 4 listed in IHS database)

1904-1925 (147 wells)
1904-1950 (965 wells in IHS)

1904-1975 (2033 wells)
Present-day Humble Salt Dome Field
Humble, Harris County, Texas

"Humble" (Houston)
Bush airport (IAH)

Jarvie residence
Geochemistry lab location

Houston
(19 miles south of Humble)

Pump Jack
operating near Highway 59N
New Pump Jack
operating near San Jacinto River

Aspen Operating Bissonet #7
Out of nowhere comes a bubbling oil... with a little help from a friend

Chevron Stevenson Fee 163
(off Woodland Hills Drive on eastern flank of dome)
Humble Field is a piercement salt dome. Various faults around the perimeter of the dome provide both migration pathways and stratigraphic traps.

Seismic Section of the Liberty Salt Dome illustrating the salt diapir and the steeply sloping sediments on its flank.
Cross Section through Humble Salt Dome

Production History of the Humble Field

<table>
<thead>
<tr>
<th>Years</th>
<th>Oil (bbls)</th>
<th>Casinghead Gas (cubic ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1905-1914</td>
<td>40,166,968</td>
<td></td>
</tr>
<tr>
<td>1915-1924</td>
<td>53,032,611</td>
<td></td>
</tr>
<tr>
<td>1925-1934</td>
<td>23,084,000</td>
<td></td>
</tr>
<tr>
<td>1935-1944</td>
<td>10,254,752</td>
<td></td>
</tr>
<tr>
<td>1945-1954</td>
<td>10,212,041</td>
<td></td>
</tr>
<tr>
<td>1955-1964</td>
<td>12,446,945</td>
<td>1,832,423,000</td>
</tr>
<tr>
<td>1965-1974</td>
<td>13,207,169</td>
<td>6,587,592,000</td>
</tr>
<tr>
<td>1975-1984</td>
<td>7,444,660</td>
<td>5,345,468,000</td>
</tr>
<tr>
<td></td>
<td><strong>169,849,146</strong></td>
<td><strong>13,765,483,000</strong></td>
</tr>
</tbody>
</table>
For any petroleum reservoir rock there are numerous characteristics that are extremely important to operators:

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Cap rock</th>
<th>Miocene</th>
<th>Anahuac</th>
<th>Frio</th>
<th>Yegua</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porosity</td>
<td>32%</td>
<td>34%</td>
<td>32%</td>
<td>32%</td>
<td>33%</td>
</tr>
<tr>
<td>Permeability (millidarcy)</td>
<td>3500-1000</td>
<td>1000</td>
<td>630</td>
<td>1420</td>
<td>345</td>
</tr>
<tr>
<td>Net Pay (ft)</td>
<td>20-40</td>
<td>8</td>
<td>9</td>
<td>na</td>
<td>29</td>
</tr>
<tr>
<td>Original Reservoir Pressure (psi)</td>
<td>340</td>
<td>500</td>
<td>1100</td>
<td>1260</td>
<td>1250</td>
</tr>
</tbody>
</table>

Petroleum Systems

- Components
  - Source rock
  - Migration pathway
  - Trap
  - Seal

- Processes
  - Overburden/burial
  - Generation
  - Expulsion/Migration
  - Retention
  - Preservation

Unconventional petroleum systems have most of the same components and processes except retained petroleum is produced from the source rock or juxtaposed organic lean lithofacies.
Dan Jarvie Sampling the Startap OHS 23 well along Will Clayton near Humble HS (Feb 2012)

Collecting a leaky well head oil sample inactive Harrell lease well
Geochemical data was collected on oils from these fields. The goal was to compare deep Wilcox oils to shallow Frio oils produced present-day from the Humble field.
Collected oil samples

<table>
<thead>
<tr>
<th>API Number</th>
<th>Operator</th>
<th>Well Number-Name</th>
<th>Field</th>
<th>County</th>
<th>State</th>
<th>Basin</th>
<th>Reservoir</th>
<th>Depth (ft)</th>
<th>API Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>42201304090000</td>
<td>Seco Petroleum</td>
<td>14-Harrell</td>
<td>Humble</td>
<td>Harris</td>
<td>Texas</td>
<td>Gulf Coast</td>
<td></td>
<td>782</td>
<td>18.9</td>
</tr>
<tr>
<td>42201808620000</td>
<td>Startap</td>
<td>21-RHLA</td>
<td>Humble</td>
<td>Harris</td>
<td>Texas</td>
<td>Gulf Coast</td>
<td></td>
<td>2243</td>
<td></td>
</tr>
<tr>
<td>42201018220000</td>
<td>Startap</td>
<td>23-RHLA</td>
<td>Humble</td>
<td>Harris</td>
<td>Texas</td>
<td>Gulf Coast</td>
<td>Frio 'B'</td>
<td>1850</td>
<td></td>
</tr>
<tr>
<td>42201808670000</td>
<td>Startap</td>
<td>84-RHLA</td>
<td>Humble</td>
<td>Harris</td>
<td>Texas</td>
<td>Gulf Coast</td>
<td>Frio 'A'</td>
<td>2000</td>
<td></td>
</tr>
</tbody>
</table>

Gas Chromatographic Analysis
“oil fingerprint” shows a biodegraded oil

An oil fingerprint provides the yield (vertical axis) and distribution (horizontal axis) of resolvable hydrocarbons in the oil.
Tracking Oil History Using Biomarkers:
by inference shallow sands correlate to deeper Wilcox oils and source rocks

Shallower Frio and Yegua sands have biomarker yields comparable to Wilcox sourced oils.
They have similar:
- Ts/Tm ratios
- Oleanane yields
- overall biomarker distributions

Note 3 similar Ts/Tm ratios and one opposite (South Currie)
GC/MS/MS Analysis:
carbon number distribution of Humble Field oils

- Determining the carbon number distribution of the C\textsubscript{27} thru C\textsubscript{30} steranes is a basic application of MS/MS technology. The results indicate that these oils are genetically related.

Humble Field sunset operations
ongoing enhanced oil recovery

Sunset over Humble Field

Thank you!