Monterey Formation as a Groundwater Resource*

Jordan Kear

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1Kear Groundwater, Santa Barbara, California (jordan@keargroundwater.com)

Abstract

Extensive data, publications, and field examples exist regarding the Monterey Formation and its petroleum capacity, fluid flow, fractured porosity and permeability. Recent demands for drought- and regulatory-compliant water resource development has steered significant investment in groundwater exploration in bedrock formations, specifically the Monterey. Given the history of exploration for petroleum, several new projects have relied on detailed, though often antiquated, notes of oil drilling and development in the Monterey Formation to justify the exploration of the groundwater resource. While results of production rates and groundwater quality can vary, deeper fractured sections of Monterey that have correlative exposures to recharge areas, have a history of "lost circulation" in petroleum exploration, and have geophysical log data that suggest a freshwater-bearing target have been most successful. Methods of feasibility assessment include research for the above, and case studies in the South Mountain (Ventura County) area and Lompoc (Santa Barbara County), among others, offer recent prime examples of melding petroleum geology exploration history and modern groundwater exploration and development.
Monterey Formation as a Groundwater Resource

PSAAPG Convention 2019
Long Beach, California

Jordan Kear, PG, CHG
02 April 2019
Discussion Outline

• Anecdotal evidence
• Early petroleum finds
• Increased demand
  • Drought
  • Regulatory limitations
• Protection of resource
• Potential recharge of by-product water
Monterey Formation

Exposed around and beneath many groundwater basins in southern coastal California

Central to California Oil exploration and production

Well studied

Porcelainitic, cherty, shales fracture tremendously well leading to high permeability to air, oil, gas, and water

Source: http://sjvgeology.org/geology/formations/Monterey%20Formation%20map.jpg
Selected Recent Monterey Water Well Projects

- Sulphur Mountain
- Arroyo Grande
- Thousand Oaks
- Lompoc
- Malibu
- Buellton
- South Mountain
- McClure Valley
1900s-era California Exploration and production

“Obvious” fields
Anticlines, domes, Monterey

Detailed logging and mapping that remains valid and useful

Limited Geophysical logs
“Antique” by modern petroleum standards

Source: Bramlette, 1946
Inverse of petroleum trap

Syncline storage and collection of water

Aquifers Recharged in human time

Aquifers: Bedrock Aquifers only
Secondary Porosity

Aquifer — A body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant quantities of groundwater to wells and springs.
Sulphur Mountain

- Turn-of-century wells encountered too much water to continue search for oil...
- Syncline along mountain crest core of Monterey
Thirty days after completion well produced | barrels of oil per day.
The gravity of oil was | \( \text{roes } \) BuA. Water in oil amounted to | \( \text{per cent.} \)

<table>
<thead>
<tr>
<th>Names of Dollars</th>
<th>Names of Tool Dealers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marathon Co.</td>
<td>Well No. 1</td>
</tr>
<tr>
<td>W. Heath</td>
<td>2-6 N-54 W</td>
</tr>
<tr>
<td>J. Jackson</td>
<td>043-04510</td>
</tr>
<tr>
<td>J. Rinvon</td>
<td></td>
</tr>
</tbody>
</table>

Date drilling started | December 25, 1929 |
Date well was | abandoned May 5, 1930 |

**Formations Penetrated by Well**

<table>
<thead>
<tr>
<th>Depth to</th>
<th>Thickness</th>
<th>Name of Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of Formation</td>
<td>0</td>
<td>650</td>
</tr>
</tbody>
</table>
| 0 | 0 | Hard opal and siliceous shale and limestone interbedded. |<br>(Cored; 163-126, 305-306, 356-354, 645-646.)<br>Hole cored continually from this point: average recovery %
| 650 | 650 |
| 650 | 0 | Olive-brown brown shale with occasional hard gray limestone-breaks. Abundant fish scales and remains. |<br>Very hard formation, well rounded pebbles in ditch. (Not cored.)
| 1087 | 1087 | 1580 | 493 |
The summary on this page is for the **original condition of the well**

1st sand from...
2d sand from...
3d sand from...

**IMPORTANT WATER SANDS**

1st sand from...
2d sand from...

Casing Record

<table>
<thead>
<tr>
<th>Size of Casing</th>
<th>When Laid</th>
<th>When Cas.</th>
<th>Weight Per Foot</th>
<th>Thrust Per Inch</th>
<th>Kind of Shoe</th>
<th>Make of Casing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>9&quot;</td>
<td>672</td>
<td>607</td>
<td>40.5</td>
<td>8</td>
<td>DEX</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cementing or Other Shut-off Record

<table>
<thead>
<tr>
<th>Casing, Etc</th>
<th>Sets</th>
<th>Time Set</th>
<th>Marked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Plugs and Adapters

- Heaving Plug: Material Length Where set
- Adapters: Material Size

Rotary Tools were used from... to...

Cable Tools were used from... to...

Perforations

- State clearly whether a machine was used or casing was drilled by shop
Well spudded December 25, 1929.
Unable to maintain circulation from 0 - 691.

9½ RHX-40 casing landed at 622 to regain circulation. During later operations 276 bbl of cement were put in hole to obtain circulation. The casing was unintentionally cemented at this time.

The hole was drilled to 4550' at which depth it was abandoned without encountering showings of oil or gas.

The hole was filled with heavy mud to 700'. 70 bbl of 8.750 W cement was pumped in through 4' drill pipe at 700'.

Top of plug was located at 500' and plug sustained the weight of the drill pipe (This operation was witnessed by W. E. Heaber).

The hole was then filled with heavy mud, capped and abandoned.
Modern Water Well

- Elog similar to 1950s oil wells
- Establish correlation of high porosity zone
- Water quality appears favorable
- Outside of groundwater basin
- All Monterey Formation
• Hydrogeologist’s “Gusher”
Lompoc Deep Monterey Well
January 2019 meq/l

TDS 1430 ppm
Aquifer Protection during oil well drilling, stimulation, injection, discharge, etc.:

- Demonstrate adequate distance from wells
- Demonstrate presence/absence/activity of water wells
- Demonstrate adequate sealing of usable groundwater (10,000 ppm)
Recharge Potential

Proximity to oil fields
Beneficial use
Processed brine water
Injection as a benefit, not a waste
Typical deep water levels allow for significant storage
Outcrop of Monterey Formation can yield surface water impoundments for recharge